Marginal Price of Lake Recreation and Aesthetics: An Hedonic Approach

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Abstract

Efficient allocation of water requires knowledge of water's value in both consumptive and nonconsumptive uses. This study estimates the marginal value of water in lake recreational and aesthetic (RA) use. An hedonic price equation (employing the Box-Cox functional form) indicates lake front location, distance to lake, and scenic view are significant RA characteristics of housing. Water front properties command a premium price for the private access they offer. Beyond the water front, the marginal RA price falls rapidly with increasing distance, becoming asymptotic to some minimum. Twenty-two percent of housing price is found to be attributable to the RA component.

Key Words: aesthetic, Box-Cox, hedonic, housing, lake, nonmarket, recreation, water

Statement of Problem, Objectives, and Methodology

Allocation of water within Texas' Colorado River Basin has historically focused on quantities demanded by traditional consumptive uses such as municipal, industrial, and agricultural uses. As the quantity demanded by these users grows, efficient allocation of water among competing consumptive and nonconsumptive uses becomes more critical *(LCRAb)*. Among the nonconsumptive uses are the recreational and aesthetic services provided by the river and lake waters. This study takes some initial steps toward filling the dearth of information on lake recreational and aesthetic value.

Economic theory suggests that resources be allocated such that marginal value product or benefits are equated across uses such that total returns or social welfare are maximized (Gibbons). In the case of water, which has public good characteristics and nonmarket uses, the problem of efficient allocation becomes more difficult than the classical private good, competitive market setting. Water is an input not only in agricultural and industrial activities, but can also be described as an input in the household production function of consumers. Among other things, households use water in production of meals, personal hygiene, and recreation. Estimation of marginal prices of water in recreational use requires nonmarket valuation methods such as the contingent valuation, travel cost, or hedonic (implicit) price approach. The principal advantage of the hedonic approach is the use of actual market transactions.

This study employs a hedonic price approach to examine components of the recreational and aesthetic (RA) value of a lake in the central Texas chain called the "Highland Lakes." The study addresses the implicit recreational and aesthetic price placed on Lake Austin by homeowners living near it. It is hypothesized that within a certain proximity around a lake, residential property values reflect the recreational and aesthetic benefits received from a lake by the residents. The

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study attempts to isolate this value from the numerous valuable attributes and amenities that compose the total value of a residential property. There are three primary objectives: (1) estimate the marginal value of proximity to lakes via the hedonic pricing method, (2) identify those factors influencing the variation of property value among lake front properties, and (3) estimate the total nonmarket, implicit price of recreational and aesthetic benefits to residential properties in relatively close proximity to the lakes.

"Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them" (Rosen). According to hedonic price theory, the implicit price of each characteristic is imbedded in the price of the composite good. Thus, the hedonic technique provides a method for estimating the price of components not explicitly offered in the marketplace. This is especially true of goods that have some public good characteristics. A hedonic price study of the recreational and aesthetic (RA) benefits of water in lakes contributes information towards efficient allocation of the water resource.

A hedonic study of shoreline and "near the lake" properties will capture an important component of the recreational and "amenity" (aesthetic) values that are provided by the existence of such a lake. To estimate the total recreational and aesthetic value, other components must be added to the hedonic study component. These include: (1) the value to persons living outside the immediate area who travel to the lake to enjoy its benefits and (2) a component for existence, bequest, and option value by those who never visit the lake yet who believe it to be beneficial. An hedonic study may place a lower bound on the total recreational and aesthetic value of a lake.

Methodology

Selection of an appropriate functional form to use in hedonic study estimations is the subject of several analyses (Bender, Gronberg, and Hwang; Halvorsen and Pollakowski; Milon, Gressel, and Mulkey). These analyses rely upon the Box-Cox transformation. "A hedonic price equation is a reduced-form equation reflecting both supply and demand influences. Therefore, the appropriate functional form ... cannot in general be specified on theoretical grounds" (Halvorsen and Pollakowski). Studies comparing goodness of fit and measures of error often reject the traditional functional forms in favor of Box-Cox transformations (Cropper, Deck, and McConnell; Goodman; Halvorsen and Pollakowski). Since some degree of model misspecification is likely in empirical work (Ohsfeldt), "the linear Box-Cox function, rather than the quadratic, appears to be the functional form of choice when estimating hedonic price functions" (Cropper, Deck, and McConnell). The model used in this study is specified as a linear Box-Cox transformation. Its general form is given by

$$\frac{Y^{\lambda}-1}{\lambda} = B_o + \sum_{i=1}^{k} B_i \frac{X_i^{\theta}-1}{\theta} + \sum_{j=1}^{m} \delta_j D_j + \varepsilon \tag{1}$$

where λ and θ are Box-Cox transformation parameters to be estimated, B_o, B_i, and δ_j are parameter estimates, ε is the residual, Y is the selling price of a residence, the X_i are non-negative, continuous variables, and the D_j are dummy variables or discreetly measured characteristics of housing. ε is assumed to be normally distributed with mean, zero, and variance, σ^2.

For notational convenience let

$$Y^{\lambda} = \frac{Y^{\lambda}-1}{\lambda} \quad \lambda \neq 0$$
$$= \ln Y \quad \lambda = 0 \tag{2}$$

$$X^{\theta} = \frac{X^{\theta}-1}{\theta} \quad \theta \neq 0$$
$$= \ln X \quad \theta = 0 \tag{3}$$

The log-likelihood function (in matrix notation) to be maximized is:

$$L^{*}=\ln(L)=-\frac{N}{2}\ln(2\pi)-\frac{N}{2}\ln(\sigma^2)$$
$$-\frac{1}{2\sigma^2}\sum(Y^{\lambda}-X^{\theta}B-Z\delta)'(Y^{\lambda}-X^{\theta}B-Z\delta)$$
$$+(\lambda-1)i'\ln(Y)$$

where i'=[1 1 1...1] (Spitzer 1982, p.308),

$$\sigma^2=\frac{(Y^{\lambda}-X^{\theta}B-Z\delta)'(Y^{\lambda}-X^{\theta}B-Z\delta),}{N} \quad (4)$$

and N=number of observations.

Using iterative ordinary least squares *(IOLS)* a computer program performs a grid search over specified ranges of λ and θ in order to maximize the log-likelihood function. The search covers values of λ and θ over the range -1 to 1, first in increments of 0.1, then in increments of 0.01. The computational ease of *IOLS* is offset by the under-estimation of the true standard errors of the B's (Spitzer). This problem is circumvented using the Hessian of second order conditions to obtain consistent estimates of the true, unconditional covariance matrix (Ozuna; Spitzer). This solution also provides the true standard errors of λ and θ allowing valid hypothesis testing via t-tests. Computation of the value of the estimated log-likelihood function for various functional forms allows use of the likelihood ratio test for best functional form.

The nonlinear functional form causes marginal prices to depend upon every independent variable. The marginal prices of X_i are given by

$$\frac{\partial Y}{\partial X_i}=\frac{1}{\lambda}[\lambda(B_0+\sum_{i=1}^{k}B_i\frac{X_i^{\theta}-1}{\theta}+\sum_{l=l}^{M}\delta_l D_l)+1]^{\frac{1}{\lambda}-1}\lambda B_i X_i^{\theta-1}. \quad (5)$$

Although this nonlinear form makes interpretation more cumbersome, it may also supply more accurate marginal price estimates.

Sample Data

A properly specified hedonic pricing model for housing includes all the important characteristics of that housing. Physical characteristics of the housing, as well as, neighborhood characteristics and environmental characteristics of the area must be considered. Size of the dwelling, size of the lot, quality of construction, condition of the improvements, and garage or carport space are key structural features. Location is an important attribute of real estate in general. Location of housing around lakes is important since location defines accessibility to and view of the lake. Proximity to employment, shopping, leisure, and other economic activities are other important locational features.

Neighborhood characteristics, such as, municipal and school services are often important factors. Likewise, community property such as parks and boat ramps exclusively for the use of residents within a particular subdivision may be influential neighborhood characteristics.

Environmental characteristics may affect only a few residences, but more often affect a larger area such as a city or county. The presence of relatively clean, freshwater lakes and their associated amenities are considered important to RA value. However, the study area around the lake in question is rather homogeneous with respect to environmental factors, thus measurement of environmental factors is minimal.

Selection of variables to be included is based on conversations with realtors, real estate appraisers, and ad valorem tax appraisers, plus personal inspection of the area. The primary source of sales of single family residences and the characteristics of those residences is the Travis Central Appraisal District (*TCAD*). This data are supplemented with information provided by an Austin, Texas realty and appraisal company. Data are also obtained from deed records in the Travis County Courthouse. Water level of the lake at the time of sale is obtained from the Lower Colorado River Authority (*LCRAa*). Finally, various maps, including topographical maps are used to locate sales and measure distances. A complete list of variable names and definitions is given in table 1.

Table 1. Variable Names and Definitions

Name	Definition
TIME	Month of Sale; January 1988 - December 1990 are numbered 1 - 36, respectively.
SPRICE	Sale Price.
IMPSF	Improved area Square Feet or heated area (excluding garage and porches, etc.)
SPPERSF	Sales Price per Square Foot; *SPRICE / IMPSF*.
GARAGS	Garage spaces; 1, 2, 3, or 4 car.
CPORTS	Carport spaces; 1, 2, 3, or 4 car.
FRONTFT	Front Feet of the lot; number of linear feet of street frontage.
CQUAL	Construction Quality; potential quality ratings range from 1 (poorest) to 7 (best).
HCON	High Condition; houses in excellent condition - near new.
ACON	Average Condition; houses in average condition.
LCON	Low Condition; houses in poor condition - poorly maintained.
PCNTGOOD	Percent Good; 1.00 minus any functional or economic obsolescence found by *TCAD*.
WATFRT	Water Front; value = 1 if property is on the water front, zero otherwise.
BLUFF	Bluff location; value = 1 if property is on a bluff on the water front, zero otherwise.
VIEW	Scenic View; value = 1 if property has a scenic view, zero otherwise.
LDIST	Lake Distance; distance from property to lake in feet.
LDUM2	Lake Distance Dummy variable; *LDIST* < 2000 feet, value = 1; otherwise = *LDIST*.
CDIST	Central City Distance; distance from property to downtown Austin in feet.
AISD	Austin Independent School District.
EISD	Eanes Independent School District.
LTISD	Lake Travis Independent School District.
LISD	Leander Independent School District.
CITY	City location indicator; value = 1 if property is within a city, zero otherwise.
COAUS	City of Austin.
COWLH	City of West Lake Hills.
CORW	City of Rollingwood.
LLDEV	Lake Level Deviation; deviation from average water level at time of sale.

Previous research regarding proximity of residences to lakes found that the contribution of a lake to property value approached zero between 2,000 and 4,000 feet (Dornbusch and Barrager). The selected *TCAD* map grids encompass all properties within approximately a mile to two and one-half miles of the lakes. Sales information for all sales occurring from January 1988 through December 1990 within these areas are included in the data set.

Descriptive Statistics

There are 609 viable sales included in the sample (table 2). Month of sale is numbered sequentially from "1" for January 1988 to "36" for December 1990. The average time of sale is March 1989 (*TIME* = 15.54). Square feet of living area (*IMPSF*) and sale price (*SPRICE*) vary over a relatively large range. The typical house has two garage spaces (*GARAGS*) but few have carports (*CPORTS*). The mean lot size is about 113 feet in width (*FRONTFT*). *TCAD* house construction quality ratings (*CQUAL*) vary from three to seven within a mean of 4.78. Most of the sampled houses are in average physical condition (*ACON*) with some being superior (*HCON*) and others below average (*LCON*). *PCNTGOOD* equals one when no economic or functional obsolescence is found. *PCNTGOOD* equals one minus the percentage (expressed in decimal form) of total obsolescence estimated by *TCAD*. Few residences suffer obsolescence. Thirty-eight homes are on the water front (*WATFRT*) and seven of these are on bluffs (*BLUFF*) overlooking the lake. Many residences have a scenic view (*VIEW*) of the lake, the country side, or both. The average distance (*LDIST*) to the lake is about 4,100 feet and the distance to the central business district (*CDIST*) ranges approximately one to fourteen miles. *LDUM2* is a slope change variable intended to capture any change in slope of the hedonic function beginning at 2,000 feet from the lake. It is equal to *LDIST* at distances greater than 2,000 feet but is assigned a value of 1.0 at lesser distances.[1]

Table 2. Descriptive Statistics of Sample Residences

Name	*N*	Mean	Standard Deviation	Min.	Max.	Sum
TIME	609	15.54	8.84	1	32	9,464
*SPRICE**	609	188.050	127.620	14.000	905.000	114,520.200
*IMPSF**	609	2.557	1.084	0.640	9.603	1,556.901
SPPERSF	609	69.68	25.39	13.622	260.91	42,434.87
GARAGS	609	1.787	1.061	0	4	1,088
CPORTS	609	0.238	0.665	0	4	145
FRONTFT	609	112.9	192.98	31	4,755	68,756.97
CQUAL	609	4.78	0.80	3	7	2,909
HCON	609	0.107	0.309	0	1	65
ACON	609	0.888	0.315	0	1	541
LCON	609	0.005	0.070	0	1	3
PCNTGOOD	609	0.994	0.032	0.710	1	605.37
WATFRT	609	0.062	0.242	0	1	38
BLUFF	609	0.012	0.107	0	1	7
VIEW	609	0.207	0.405	0	1	126
*LDIST**	609	4.099	3.138	1	15.680	2,496.058
*LDUM2**	609	3.851	3.393	.001	15.68	2,345.058
*CDIST**	609	31.610	15.416	4.640	73.575	19,250.440
AISD	609	0.310	0.463	0	1	189
EISD	609	0.593	0.492	0	1	361
LTISD	609	0.061	0.239	0	1	37
LISD	609	0.036	0.187	0	1	22
CITY	609	0.424	0.495	0	1	258
COAUS	609	0.343	0.475	0	1	209
COWLH	609	0.058	0.233	0	1	35
CORW	609	0.023	0.150	0	1	14
LLDEV	609	-0.104	1.712	-6.400	0.68	-63.34

* Expressed in thousands (000).

Sales are divided among four school districts, Austin, Eanes, Lake Travis, and Leander Independent School Districts (*AISD, EISD, LTISD,* and *LISD*, respectively). Forty-two percent of the sales are located within municipalities. Eighty-one percent (209 of 258) of these are within the City of Austin (*COAUS*). The Cities of West Lake Hills (*COWLH*) and Rollingwood (*CORW*) are located on the western edge of the City of Austin. About fifty-eight percent of the residences can be considered to be rural since they are not located within the taxing jurisdiction of a city (*CITY*).

Finally, lake level deviation (*LLDEV*) shows an average deviation in water level in the three months prior to the sale date of one-tenth foot below the long term average level. Lake Austin is considered to be a constant level lake and the water level seldom varies more than a foot except for planned, temporary draw-downs.[2]

Estimated Hedonic Price Functions

The estimated hedonic price function resulting from the Box-Cox routine is presented in table 3. Using the log-likelihood function value (*LLF*) the likelihood ratio test indicates the estimated transformation parameters ($\lambda = 0.08$ and $\theta = 0.35$) differ significantly from the log-log ($\lambda = 1, \theta = 1$) and semi-log ($\lambda = 0, \theta = 1$) forms. So it is inappropriate to reduce this function to a simpler, traditional form. More than half the parameter estimates are significant at the $\alpha = 0.05$ level. Furthermore, the signs on the parameters are as expected in all cases for which there is a particular expectation.

Zarembka shows that the Box-Cox procedure is not robust with respect to heteroskedasticity. Unfortunately, attempts to estimate unbiased coefficients with a weighted least

Table 3. Estimated Hedonic Price Functions for Lake Austin via Box-Cox Transformation

Variable Name	Estimated Coefficient	Standard Error
WATFRT	0.54922**	0.10547
VIEW	0.13725**	0.03601
BLUFF	-0.05383	0.14809
LTISD	-0.09550	0.08683
EISD	-0.03376	0.04678
LISD	0.03866	0 09558
CITY	-0.16165**	0.05038
HCON	0.10749**	0.04613
LCON	-0.26154	0.20117
GARAGS	0 06623**	0.01720
CPORTS	0.02660	0.02363
PCNTGOOD	2 4143 **	0.43246
LLDEV	0.00747	0.00952
IMPSF	0.38767**	0.01812
CDIST	-0.07212**	0.00687
LDIST	-0.03650**	0.01512
CQUAL	0.84119**	0.08047
TIME	-0.02902**	0.00972
FRONTFT	0.04455**	0.01328
LDUM24	0.00940	0.00832
CONSTANT	1.1702 **	0.48501
λ	0.08	0.00130
θ	0.35	0.00
*LLF****	-3,013.20	
adj R^2	0.8774	
F	218.48	
MSE	0.1137	
N	609	

* Denotes significance at the $\alpha = 0.10$ level.
** Denotes significance at the $\alpha = 0.05$ level
***LLF denotes Log-likelihood Function Value.

squares routine developed by Ozuna failed to converge. Examination of the estimated equations using the Harvey and Breusch-Pagan-Godfrey (B-P-G) tests implies heteroskedasticity. White's correction mechanism is employed to remedy the problem (White). The standard errors are adjusted but the parameter estimates are unchanged. All parameter estimates retain significance at the same α levels as shown in table 3.

Analysis of the relative size of the estimated coefficients is hindered by the nonlinear (Box-Cox transformation) functional form. That is, the values of the coefficients cannot be directly compared. Relative contribution of individual characteristics is evidenced by marginal price estimates discussed in the next section.

Twelve of the twenty variable coefficients are significant at the $\alpha = .05$ level. Furthermore, signs on the parameter estimates are consistent with expectations. Homes on the water front, with a view, without obsolescence, with more square feet, higher quality, and a larger lot sell at higher prices. This is also true of homes with more garage spaces and in superior condition. On the other hand, the further from the water and from the central business district, the lower is the price. Being inside a city lowers the selling price. The time parameter indicates declining prices over time (consistent with general real estate price patterns during this period).

Signs on non-significant parameters are still consistent with expectations. For example, the negative coefficient on *BLUFF* indicates that water front homes located on a bluff sell for less than non-bluff homes. The negative sign for *LCON* signifies a reduction in price for poorer condition. The positive parameter on *CPORTS* implies a larger price if carport spaces are present. The slope dummy coefficient (*LDUM2*) is not statistically significant but is positively signed as expected. This implies that at greater distances (2,000 + feet) the lake has less influence on price.

Parameter estimates reflecting marginal RA prices are the focus and will be discussed at greater length. Water front properties receive a significant premium from buyers. Water front location is hypothesized to be of considerable value because of the lake access that it affords. Lake Austin water front properties located on bluffs are indicated to sell for less than non-bluff properties. The negatively signed *BLUFF* coefficient indicates a loss of access. The lower portion of Lake Austin is characterized by relatively high bluffs with practically vertical cliffs. "Water front" residences located on these bluffs often have beautiful scenic views but, for all practical purposes, have no direct access to the water. The loss in RA value due to bluff location is correctly reflected in the model.

Another statistically significant (α = 0.05) housing characteristic that reflects RA value is scenic view. Unfortunately, the data are not available to distinguish lake view from other scenic views.

Distance from the lake (*LDIST*) reflects part of the RA value of housing. *LDIST* is significant and negatively signed, indicating the expected inverse relationship between RA value and distance to the lake. Summing the coefficients (*LDIST* + *LDUM2*) indicates that at distances of 2,000 feet or more from Lake Austin, the lake distance coefficient becomes -0.02710. The implication is that RA price continues to decline beyond the hypothesized slope change distance but at a reduced rate. Decline curves and tables presented later show the marginal RA prices corresponding to various distances from the lake.

Lake level deviation from the long-term average level (*LLDEV*) is the final housing characteristic potentially reflecting a portion of the RA value of lake area housing. The parameter estimate on *LLDEV* is not significant (table 3). This is apparently due to the practically constant water level of the lake.

Marginal Price Estimates

Marginal prices are the implicit prices of individual housing characteristics obtained from the first partial derivatives of the hedonic price function with respect to each characteristic. The nonlinear functional form implies marginal prices that are dependent upon all characteristics. For this reason, the analysis focuses on marginal prices of a typical (hypothetical) residence. The marginal price estimates shown in table 4 are for a typical 2,550 square foot house with a two car garage on a 100 front foot lot outside an incorporated municipality. This house is of construction quality level five, has no obsolescence, and is in average condition. The time of sale is December 1990. The house (described in table 4) is 32,000 feet from downtown Austin, is located in the Eanes Independent School District (*EISD*) and is 2,000 feet from the lake.

The premium paid for water front property, $59,826, is within the expected range. Those water front lots located on a bluff are estimated to sell for approximately ten percent less than those with better access (table 4). However, bluff locations often provide the best panoramic views of Lake Austin and the surrounding countryside and it is hypothesized that the enhanced view value partially offsets the loss in access.

A key component of lake recreational value is proximity to the lake. Recreational value is shown to decline at the rate of $4.21 per foot (table 4). However, this is only a point estimate. The marginal price of proximity falls at a decreasing rate throughout the range. At the water front the marginal price is $1,248 per foot but declines rapidly to $32.59 per foot at 150 feet and becomes only $3.17 per foot at a distance of 3,000 feet. There is little change beyond approximately 2,000 feet, *ceteris paribus* . The dummy variable coefficient indicates a slowing of the rate of decline in housing price at distances beyond 2,000 feet.

Rather than focusing solely on a hypothetical, "typical" house, it is also helpful to examine the RA value indicators for larger and

Table 4. Estimated Marginal Values of Housing Characteristics for Residences in Proximity to Lake Austin

Characteristic Name	Marginal Value	Characteristic Name	Marginal Value
WATFRT	59,826.0	*CDIST*	-1.85/foot
VIEW	14,951.0	*LDIST*	-4.21/foot
BLUFF	-5,863.0	*CQUAL*	32,189.0/increment
CITY	-17,608.0	*TIME*	-308.0/month
GARAGS	7,214.0/space	*FRONTFT*	108.63/foot
CPORTS	2,898.0/space	*IMPSF*	51.45/sq.ft.
LLDEV	814.0/foot		

Table 5. Predicted Sale Prices of Three Different Size Residences at Varying Distance from Lake Austin.

House Square Feet	Water Front	Distance from the Lake: 150 Feet	300 Feet	450 Feet	1,000 Feet	1,500 Feet
1,500	$191.0	$123.8	$121.0	$119.1	$114.6	$111.8
2,550	278.5	182.9	179.0	176.3	169.7	165.8
3,600	367.9	243.9	238.8	235.2	226.7	221.5

Predicted house prices are in thousands of dollars.

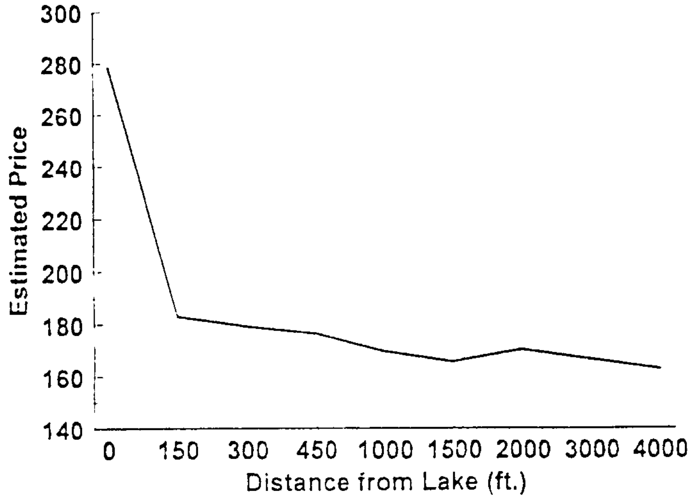
smaller residences. Table 5 shows price estimates for the average size residence plus residences approximately one standard deviation below and above the average. All other housing characteristics are held constant. The sale price estimates drop $64,700 - $119,700 between water front location and location 150 feet from the shore, reflecting the water front premium. Thereafter, prices decline more slowly, becoming asymptotic to some minimum. This relationship is depicted graphically in figure 1. Prices declined rapidly near the lake and more slowly with increasing distance, indicating a hyperbolic curve.

The estimated hedonic price function for housing around Lake Austin fits the data well and most of the parameter estimates are statistically significant and of the expected sign. Marginal value estimates appear to be reasonable for the amenities estimated. Those marginal prices related to recreational value of the lakes are shown to be significant components of total property market price. The water front property premium, view premium, and marginal value of proximity are all components of that portion of the recreational value of a lake reflected in housing prices. Water front lots have the largest portion of lake recreational value. Recreational value is found to decline rapidly as distance to a lake increases. A house with a view, whether it be of the lake or other scenery, is indicated to sell for a significantly higher price than a house without this attribute. Aggregation of recreational price estimates across homesites to estimate a total market value (price) of lake recreational benefits is the final study objective.

Total Market Price of Residential Recreational Benefits

Aggregation of marginal recreation values across households in proximity to a lake provides a market value estimate of RA benefits. Water front

Figure 1. Estimated Price of the Average Sample House at Varying Distance from Lake Austin[3]



premium, bluff location, and distance from the lake capture the price of proximity or access (a measure of consumer preference for water related recreation). This measure is not a measure of consumer surplus or an exact welfare measure. Nevertheless, knowledge of factors affecting RA value and an estimate of total market price may be of significance to water managers and other policy makers.

The aggregate price of RA amenities can be computed using the results of the estimated hedonic model. Proximity is the key characteristic. Estimating the price of a home absent the RA benefits is accomplished by increasing the "distance to lake" variable (*LDIST*) to that distance at which "distance to lake" is no longer significant ($LDIST_{max}$). The difference between the status quo market price and the estimated market price (of an otherwise identical home located) at $LDIST_{max}$ provides a market price estimate of the RA benefits to that home.

A key question is, at what distance from the lake do home buyers no longer pay for recreational benefits? Previous work (Dornbusch and Barrager; Brown and Pollakoski; Milon, Gressel, and Mulkey) and conversation with local Travis County officials and appraisers (Corey; Welcome; Nuckles) indicate a potential range of a few hundred feet to 4,000 feet. Inspection of the marginal prices of *LDIST* and previous research, especially that Dornbusch and Barrager, suggest that a distance of 2,000 feet may be reasonable. Marginal price of proximity changes little beyond this distance.

The price of each residence within 2,000 feet is estimated "as is" and again as if it were located 2,000 feet from the lake.[4] Summation of the differences suggests a total price of recreational benefits reflected in single family housing prices.[5] The aggregate market value of residential recreational benefits is $65,860,596 (table 6). Approximately 1,561 single family residences located within 2,000 feet of the shore have an average RA price of $42,191. On average, RA price is estimated to be 22 percent of the current location price. Although these prices and the RA component of the price may appear to be relatively high, they are not believed to be unreasonable considering the setting.

Further investigation shows that within 2,000 feet of Lake Austin, 87 percent of the estimated RA market price is captured in the price of water front properties. One-third (520) of the affected residences are on the water. By way of contrast, for residences located 1,001 to 2,000 feet from the water's edge, the percent of sale price attributable to RA price is only two percent. The small percentage of total value attributable to more distant homes implies that $LDIST_{max}$ could be

Table 6. Marginal Value of Recreational and Aesthetic Value Summary Statistics for Lake Austin. Residences within 2,000 Feet of the Lake

Variable	*N*	Mean	Standard Deviation	Maximum Value	Minimum Value	Sum
Predicted Price in Current Location	1,561	193,444	153,582	1,395,602	14,486	301,966,809
Predicted Price at 2,000 Feet	1,561	151,253	110,918	940,434	9,718	236,106,213
Estimated RA Price	1,561	42,191	64,991	524,722	55	65,860,596

several hundred feet more or less and have no significant impact on the aggregate price estimates.

Summary and Conclusions

The hedonic price approach is employed to estimate the implicit price of recreational and aesthetic benefits. An hedonic price model specifying housing characteristics hypothesized to be important components of housing price is estimated using the Box-Cox functional form. The estimated price equation indicates several statistically significant characteristics of housing, among which are distance to the lake, scenic view, and water front location.

Analysis of marginal values indicates that proximity to a lake is the most important component of recreational and aesthetic value. Water front properties command a premium price for the private access they offer for enjoyment of the public lake waters. Beyond the water front properties, the marginal recreational and aesthetic price falls rapidly with increasing distance from the lake. An aggregation of marginal RA values of all homes within 2,000 feet of the lake indicates 87 percent of indicated RA price resides in lake front property and composes more than 20 percent of the total market price of housing.

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Endnotes

1. LDUM2 is essentially a dummy variable, however, since it has also been designated a transformation *(Xi)* variable, it cannot equal zero because transformed variables are undefined at zero.

2. Variation in water level has been found to be a significant variable on another Highland Lakes area lake (Lansford).

3. The increase in estimated price starting at 2,000 feet occurs due to model specification; specifically, because LDUM2 = LDIST starting at 2,000 feet. This temporary aberration, caused by the model, disappears as distance from the lake increases.

4. Using the map grid system employed by Travis Central Appraisal District and their data base of houses, all houses within grid blocks located within 2,000 feet of the lake are identified and included in the aggregation.

5. Note that the lake view is not considered since the data are unavailable to differentiate lake views from other views.