PAPER TITLE: "VALUING WATER QUALITY CHANGES AT CONNECTICUT LAKES WITH CONTINGENT PRICE DATA"

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Abstract:

A survey based approach is proposed to augment the property value method when historical information on water quality variation is unavailable. Data from three Connecticut lakes is used to illustrate this approach. The impact of hypothetical water quality changes on recreational and aesthetic values is assessed and analyzed.

I. Introduction

Recreational activities by the general public, such as boating, fishing, jet-skiing and swimming, may contribute importantly to the valuation of lake water quality changes. Much of the impact from these changes, however, may accrue to private owners of waterfront properties. Not surprisingly, a property value approach has frequently been used to value water quality changes. In the absence of historical information on water quality variation for a particular lake or waterbody, researchers often rely on cross-sectional data involving several lakes with differing characteristics (David, 1968; Darling, 1973; Young and Teti, 1984; Steinnes, 1992; Michael, Boyle, and Bouchard, 1996; Leggett and Bockstael, 1998). This paper presents an alternative approach in which a survey based method is used to capture the impact of water quality changes on property prices for a given lake. Since these values are for marketed goods, we refer to them as contingent prices. We argue that, if the valuation questions are phrased carefully, this exercise may yield valuable information to state regulators and policy makers making decisions to allocate public funds for water quality protection and restoration.

We applied our proposed valuation approach to three lakes in Connecticut. Each lake has significant public access and a densely developed waterfront. We surveyed waterfront property owners at these lakes and asked them to value their properties under four different scenarios regarding lake water quality. Public site users were asked their willingness to pay an annual usage fee for the lake with the four different water qualities.

The paper is organized as follows. Section II gives a brief overview of the methodology used and places it in the existing literature. Section III discusses the valuation question employed in the mail and on-site surveys. Section IV describes the study areas and data collection procedures. Section V reports the survey results. Section VI reports on the aggregation of the results from the respondents to the entire population of waterfront properties around each lake and public site users. Section VII summarizes our major findings and offers some concluding remarks.

II. Methodology and Literature Review

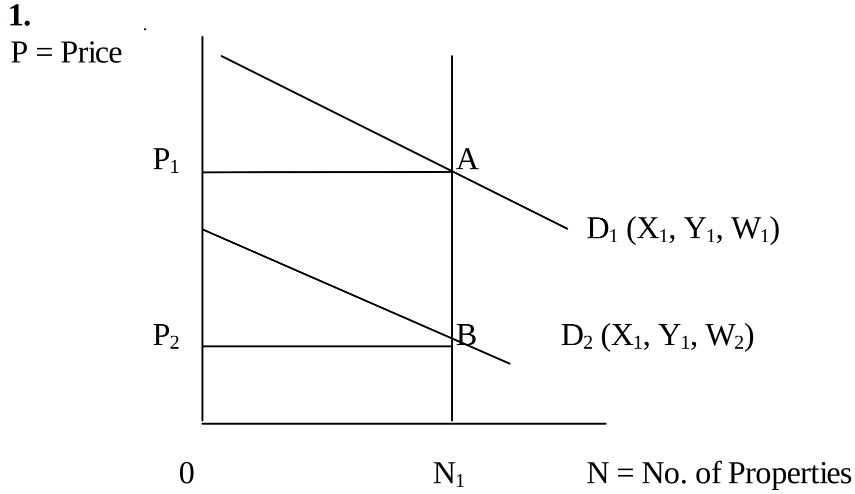
Following standard practice, the economic value of a lake water quality change may include use and non-use value components (Freeman, 1993). Implicit in the purchase price of a residence is the value of the bundle of benefits one enjoys by living at that specific location.

One would expect that property prices are higher for waterfront properties than non-waterfront properties, assuming that the water quality is relatively good. Following Lancaster (1966), Griliches (1971), and Rosen (1974), hedonic price models have been developed to infer the implicit price of water quality while controlling for other attributes. The partial derivative of a hedonic price function with respect to water quality gives the implicit price of water quality. However, this approach is valid only if water quality changes are marginal, the area over which the water quality change occurs is small, moving costs are zero (Bartik, 1988; Freeman, 1993) and there is no shift in the hedonic price function due to the water quality change. It should also be noted that the validity of the hedonic price approach has been questioned regardless of the extent of water quality changes (Maler, 1977, Kanemoto, 1988). Nonetheless, these critiques have failed to prevent applied researchers from continuing to employ the hedonic property value method.

Applications of the hedonic price method to water quality are based on either cross-sectional data from a relatively large number of lakes (or other bodies of water) with different levels of water quality (David, 1968; Young and Teti, 1984; Michael, Boyle, and Bouchard, 1996; Leggett and Bockstael, 1998); or on time series data at a particular lake (Falcke, 1982; Lansford and Jones, 1995). In this paper, we develop a straightforward alternative approach that may be used when data on water quality variation data is not available.

To further examine the implications of our approach, consider the following simplified scenario. Let there be an absence of taxes and a fixed supply of residential properties around a lake. Assume that the demand for properties is a function of property price, P, characteristics of the properties, **X**, socioeconomic variables **Y**, and lake water quality, W. Figure 1 illustrates this function for two values of W and given values of **X** and **Y**. The equilibrium value of P decreases with a lowering of water quality from W^1 to W^2, and if the demand curves are linear in P and W, then the area P^1P^2 AB captures the change in social welfare. This simple partial equilibrium framework seems to underlie the very basic applications of the property value method in which the differential P^1P^2 conveys all of the useful information and the demand curve need not be estimated. Typically, the researcher collects data on property prices and aggregates using a formula such as $\Delta SW = \sum PP_iN_i$, where ΔSW is change in social welfare, 'i' is a characteristic category (e.g. location or size), N_i is the number of properties in that category and PP_i is the average property price differential in the category. In the analysis of waterfront properties, the change in social welfare is the loss in value of the asset due to water quality deterioration (Leggett and Bockstael, 1998).

Figure 1.



Our method is a variation of the contingent valuation method (Mitchell and Carson, 1989), and produces a set of contingent prices for a marketed good at different quality levels for an environmental resource. The contingent price data allows us to expand the number of observations in the data set. Such augmentation of observed data with contingent information has been carried out by Englin and Cameron (1996) in the context of travel cost models of recreation demand.

Care must be taken to avoid double counting that may occur when more than one evaluation technique is used for the same lake. McConnell (1990) addresses this problem when hedonic property value and travel cost methods are used.

III. Valuation Questions

The valuation questions pertained to changes in the current water quality, which was described as fitness of the water for swimming, fishing, fish edibility and boating. Waterfront property owners were asked the current market value of their properties and the percent change in the value of their homes, with three different water quality changes: loss of swimmability, loss of fish edibility, and loss of swimmability and fish edibility. Similarly, public site users were asked to state their maximum annual willingness to pay for use of the lake with each of the four water quality levels. The two survey questionnaires are available from the authors upon request. In addition, details regarding survey procedures and results are reported in Fishman, Leonard and Shah, 1998.

IV. Study Areas and Data Collection

The three Connecticut lakes included in this study have a wide variety of recreational uses at privately owned waterfront properties and at public sites. Bashan Lake in East Haddam has 276 acres, Crystal Lake in Ellington and Stafford has 200 acres, and Highland Lake in Winchester has 444 acres. Water quality in all three lakes is considered safe for swimming, boating, fishing and eating of fish caught. Maintenance of this quality has involved a continuing effort to control non-point sources of pollution and has included installation of sanitary sewers at two of the three lakes. All of the lakes have a state boat launch and 2 of the 3 lakes have public beaches. There is dense residential development of the lakes' waterfront. Beyond the lake area, these towns have a rural/suburban level of development. Two of the lakes, Crystal and Highland, are managed by the state as trout fisheries.

Data Collection from Waterfront Property Owners. In the winter of 1995-96, mail surveys were sent to waterfront property owners and property owners with deeded rights-of-way to the lake.[1] Only those properties with a house were included in the study. The surveys were anonymous and did not ask for information about the size or physical characteristics of the house. Test surveys had indicated that property owners were hesitant to answer questions that could identify their property. The survey included questions about use of the property, lot size and features, recreational activities, and household income level. The initial mailing was followed by a combination "thank you" and "reminder" letter with an offer of a replacement questionnaire upon request.

Data Collection from Public Site Users. Interviews were conducted on-site, at public access points during the summer of 1995. The sampling was without replacement in that respondents returning at a later date were not interviewed a second time. Waterfront property owners using public access sites were identified by a screening question at the beginning of the public site survey and the interview was discontinued.

In both surveys, responses for all four water qualities were required for inclusion in our analysis. Missing values for independent variables were set at the mean or median value for the corresponding lake.

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[1] Assessors' records and conversations with Realtors indicated a substantial price premium for waterfront locations. In the absence of either lake frontage or a deeded right-of-way to the lake there is no clear evidence of a relationship between property value and distance from the lake. The findings of other studies are

V. Survey Results

A. Results of Waterfront Property Owners Survey

The initial mailing and subsequent reminder to 699 property owners at the three lakes resulted in 340 replies with 237 sufficiently complete for use in the analysis. The reply rate was 48.6%, while the effective response rate was only 33.9%. This difference is due to use of only those responses that provided estimated property values for each of the four water quality categories.

Property value estimates at each lake indicate a greater concern about loss of swimming than loss of fish edibility. The three-lake weighted average property values from the surveys of estimated property value are: $183,535 with swimmable water quality and edible fish; $118,452 without swimmable water quality; $148,303 without edible fish; and $105,510 with neither swimmable water quality nor edible fish. The relationships between estimated property value and water quality category are consistent among lakes. This consistency is especially apparent when attention is focused on percentage losses in value associated with shifts from water quality Category A (current water quality) to each of the other water quality categories.

Relationships between property value and related independent variables were estimated with the following hedonic price model: [2]

$$P_i = \beta_{i0} + \beta_1 D_{i1} + \beta_2 D_{i2} + \beta_3 D_{i3} + \beta_4 D_{i4} + \beta_5 D_{i5} + \beta_6 D_{i6} + \beta_7 D_{i7} + \beta_8 D_{i8} + \alpha_{i0} X_{i0} + \beta_9 D_{i9} + \beta_{10} D_{i10} + \beta_{11} D_{i11} + \beta_{12} D_{i12} + \beta_{13} D_{i13} + \beta_{14} D_{i14} + \beta_{15} D_{i15} + \varepsilon_i$$

inconclusive. Willis, Foster and Sewall (1983) found distance to be insignificant while Darling (1973), Brown and Pollakowski (1977) and Lansford and Jones (1995) found it to be significant.

[2] Willingness to pay functions for each lake were also estimated. See Fishman, Leonard and Shah, (1998).

Table 1. Determinants of Estimated Property Values

Variable	Coefficient (T-Ratio)
CRYSTAL	-15.851 (-2.235)*
HIGHLAND	8.651 (1.741)
WQ-B	-65.081 (-11.710)**
WQ-C	-35.227 (-6.341)**
WQ-D	-78.024 (-14.040)**
YR-RESIDENCE	51.223 (12.040)**
DOCK	39.621 (6.167)**
S-BEACH	21.368 (4.828)**
L-LOTSIZE	20.364 (9.123)**
BOATING	-3.050 (-0.413)
FISHING	-1.651 (-0.330)
INCOME-B	-5.225 (-0.469)
INCOME-C	5.448 (0.521)
INCOME-D	9.811 (0.943)
INCOME-E	22.338 (1.958)
INCOME-F	54.462 (5.114)**
CONSTANT	48.949 (3.208)**
SAMPLE SIZE	948
ADJUSTED R^2	0.411

Table 2. Determinants of Willingness To Pay at Public Sites

Variable	Coefficient (T-Ratio)
CRYSTAL	2.37 (0.35)
HIGHLAND	15.96 (2.41)*
WQ-B	-43.24 (-7.62)**
WQ-C	-29.88 (-5.27)**
WQ-D	-56.78 (-10.01)**
TOWN-R	14.07 (2.64)**
TRAVEL-T	0.03 (0.16)
VISITS-Y	0.11 (2.39)*
HOURS-V	1.67 (2.04)*
HOUSEH-S	-0.09 (-0.06)
SWIMMING	-7.91 (-1.42)
BOATING	22.34 (4.74)**
JETSKIING	75.13 (6.09)**
FISHING	1.11 (0.21)
GENERAL-0	-5.42 (-1.02)
WINTER	51.85 (6.56)**
LAKES	-4.16 (-2.44)*
RIVERS	-1.95 (-0.36)
OCEAN	-8.76 (-1.66)
INCOME-B	12.43 (1.68)
INCOME-C	15.14 (2.16)*
INCOME-D	11.40 (1.42)
INCOME-E	71.31 (8.00)**
CONSTANT	25.46 (1.94)
SAMPLE SIZE	1692
ADJUSTED R^2	0.200

where, $i = (1,\ldots n)$ is the ith respondent, ε_i is the error term, and

P_i = Property value in thousands of dollars
D_{i1} = 0,1 dummy for Crystal Lake [CRYSTAL]
D_{i2} = 0,1 dummy for Highland Lake [HIGHLAND]
D_{i3} = 0,1 dummy for water quality B [WQ-B]
D_{i4} = 0,1 dummy for water quality C [WQ-C]
D_{i5} = 0,1 dummy for water quality D [WQ-D]
D_{i6} = 0,1 dummy for year-round resident [YR-RESIDENCE]
D_{i7} = 0,1 dummy for dock [DOCK]
D_{i8} = 0,1 dummy for sandy beach [S-BEACH]
X_{i0} = natural log of square footage lot size [L-LOTSIZE]
D_{i9} = 0,1 dummy for boating [BOATING]
D_{i10} = 0,1 dummy for fishing [FISHING]
D_{i11} = 0,1 dummy for income $20,000 - $39,999 [INCOME-B]
D_{i12}= 0,1 dummy for income $40,000 - $59,999 [INCOME-C]
D_{i13}= 0,1 dummy for income $60,000 - $79,999 [INCOME-D]
D_{i14}= 0,1 dummy for income $80,000 - $99,999 [INCOME-E]
D_{i15}= 0,1 dummy for income $100,000+ [INCOME-F]
β_{i0} = constant [CONSTANT]

Results of the OLS regression are shown in Table 1. The coefficients of all three water quality variables (WQ-B, WQ-C and WQ-D) are significant at the 0.01 level. Property values are more closely related to type of residential use (seasonal or year-round) and lot size and features (dock and sandy beach) than to recreational activities (boating, fishing). The general consistency among lakes is reflected in the statistical insignificance of the coefficients for HIGHLAND, along with significance of the coefficient for CRYSTAL only at the 0.05 level.

B. Results of Public Site Users Survey

The three-lake weighted averages of annual willingness to pay at public sites are $69.13 with swimmable water quality and edible fish; $29.12 without swimmable water quality; $39.02 without edible fish; and $15.88 with neither swimmable water quality nor edible fish. The willingness to pay estimates at each lake indicate a greater concern about loss of swimming than loss of fish edibility. For two of the three lakes there is greater than 50% drop in willingness to pay when the water is not swimmable. Reductions in willingness to pay from loss of fish edibility range from 40% - 47%.

Relationships between willingness to pay and related independent variables were estimated with the following model:[3]

$$P_i = \beta_{i0} + \beta_1 D_{i1} + \beta_2 D_{i2} + \beta_3 D_{i3} + \beta_4 D_{i4} + \beta_5 D_{i5} + \beta_6 D_{i6} + \alpha_{i0} X_{i0} + \alpha_{i1} X_{i1} + \alpha_{i2} X_{i2} + \alpha_{i3} X_{i3} + \beta_7 D_{i7} + \beta_8 D_{i8} + \beta_9 D_{i9} + \beta_{10} D_{i10} + \beta_{12} D_{i11} + \beta_{12} D_{i12} + \alpha_4 X_{i4} \quad \beta_{13} D_{i13} + \beta_{14} D_{i14} + \beta_{15} D_{i15} + \beta_{16} D_{i16} + \beta_{17} D_{i17} + \beta_{18} D_{i18} + \varepsilon_i$$

where, $i = (1,\ldots n)$ is the i[th] respondent, ε is the error term, and

P_i = Annual willingness to pay in dollars
D_{i1} = 0,1 dummy for Crystal Lake [CRYSTAL]
D_{i2} = 0,1 dummy for Highland Lake [HIGHLAND]
D_{i3} = 0,1 dummy for water quality B [WQ-B]
D_{i4} = 0,1 dummy for water quality C [WQ-C]
D_{i5} = 0,1 dummy for water quality D [WQ-D]
D_{i6} = 0,1 dummy for year-round resident [TOWN-R]
X_{i0} = travel time to site [TRAVEL-T]
X_{i1} = number visits to site annually [VISITS-Y]
X_{i2} = number of hours per visit [HOURS-V]
X_{i3}= household size [HOUSEH-S]
D_{i7} = 0,1 dummy for swimming [SWIMMING]
D_{i8} = 0,1 dummy for boating [BOATING]
D_{i9} = 0,1 dummy for jetskiing [JETSKIING]
D_{i10} = 0,1 dummy for fishing [FISHING]
D_{i11} = 0,1 dummy for general use [GENERAL-O]
D_{i12}= 0,1 dummy for winter use [WINTER]
X_{i4}= Number of substitute lakes: 0, 1,2 or 3** [LAKES]
D_{i13}= 0,1 dummy for substitute rivers [RIVERS]
D_{i14}= 0,1 dummy for ocean substitute [OCEAN]
D_{i15} = 0,1 dummy for income $20,000 - $39,999 [INCOME-B]
D_{i16} = 0,1 dummy for income $40,000 - $59,999 [INCOME-C]
D_{i17} = 0,1 dummy for income $60,000 - $79,999 [INCOME-D]
D_{i18} = 0,1 dummy for income $80,000 + [INCOME-E]
β_{i0} = constant [CONSTANT]

** The LAKES variable is 0, 1, 2 or 3 depending on the number of substitute lakes a respondent indicated. The number 3 was entered if the respondent mentioned more than three substitute lakes.

Results are reported in Table 2. The significant variables at the 0.01 level of confidence are the water quality variables (WQ-B, WQ-C and WQ-D), TOWN-R, BOATING, JETSKIING, WINTER and INCOME-E. Again, the general consistency among lakes is reflected in the statistical insignificance of the coefficient for CRYSTAL and the statistical significance for HIGHLAND at only the 0.05 level.

VI. Aggregate Benefit Estimation and Analysis

The annual loss in social welfare from a decline in water quality is estimated to be the sum of the decrease in annual willingness to pay by waterfront property owners and public site users.

[3] Willingness to pay functions for each lake were also estimated. See Fishman, Leonard and Shah (1998).

A. Waterfront Property Owners

A property value is a capitalized value. In order to compare the welfare losses of property owners with public site users, the price information must be for the same time period. Annualizing the property values was preferred to capitalizing the public site users' willingness to pay responses because of risk and uncertainty in forecasting future behavior.

The annual cost of owning a property includes interest paid and/or earnings foregone on invested capital and property taxes. Some of these costs are offset by deductions in Federal income tax. We have no basis for a precise estimate of income tax reductions associated with home mortgage interest deductions, or the opportunity cost of capital to owners. A conservative estimate of the annual opportunity cost of capital cost is the average yield on a 5 year U.S. Treasury note in the summer of 1995, 6.15%.[4] The Federal income tax advantage of the property tax deduction is based on a 28% marginal tax bracket.

The annual willingness to pay for residential waterfront property with alternative water quality categories was estimated as follows:

$$A = V(i + 0.72t)$$

where:
- A = annual willingness to pay
- V = aggregate property value
- i = interest rate of 0.0615
- t = the 1995 tax rate times 0.70 to adjust for assessment at 70% of market value

Table 3 shows the aggregate annual values of residential waterfront property at each lake with alternative water quality categories. These values are estimated by multiplying the annualized mean property values by the number of residential waterfront properties.

[4] *Appraiser News*, published by the Appraisal Institute, Chicago IL, Sept. 1995, Oct. 1995, Nov. 1995.

Table 3. Estimated Annual Willingness to Pay for Residential Waterfront Properties with Alternative Water Quality Categories

	Bashan	Crystal	Highland
Number of Properties	221	103	375
Water Quality			
A	$3,123,066	$1,379,762	$5,813,595
B	$2,014,943	$942,988	$3,707,835
C	$2,558,267	$1,085,468	$4,694,910
D	$1,782,739	$837,765	$3,314,235

B. Public Site Users

The results from the public site users are for a single household. In order to estimate the total value for all recreational users of a lake we needed to estimate the number of households using the lake. Information regarding number of visits and number of visitors was obtained from site managers with the Connecticut Department of Environmental Protection (DEP) for the three boat launches, and town beach user counts from the town recreation departments. The number of households visiting each boat launch was estimated by dividing the DEP estimate of the annual number of visits by the average number of visits per household per year of the respondents surveyed at that site.

The total number of households using public sites was estimated at 417 at Bashan, 860 at Crystal and 395 at Highland. The total number of households using public sites annually is multiplied by the mean willingness to pay figure for each water quality level. The aggregate annual use values for public site users are shown in Table 4.

Table 4. Estimated Annual Willingness to Pay for Use of Public Sites with Alternative Water Quality Categories

	Bashan	Crystal	Highland
Number of Users	417	860	395
Water Quality			
A	$16,376	$54,197	$36,747
B	$9,091	$18,894	$11,638
C	$9,691	$32,792	$19,639
D	$4,349	$9,374	$9,259

C. Social Welfare

Estimates of the annual loss in social welfare from a shift from water quality A to each of the other water quality categories are shown in Table 5. Each loss is the sum of the corresponding decreases in willingness to pay by waterfront property owners and public site users. The vast majority of recreational and amenity benefits accrue to the waterfront property owners. The loss in value to the public site users' from a change in water quality is a small percentage of the total loss in social welfare, less than 2% in all cases.

Table 5. Annual Loss in Social Welfare by a Shift from Water Quality A to Alternative Water Quality Categories

Water Quality	Bashan	Crystal	Highland
B	$1,115,408	$472,077	$2,130,869
C	$571,434	$315,699	$1,135,793
D	$1,352,354	$586,820	$2,526,848

VII. Conclusion

This study provides a way to value changes in lake water quality, using contingent prices when data on actual variation in environmental quality is not available and a conventional hedonic property value approach is, therefore, not feasible.

A hedonic price equation and a willingness to pay equation were estimated. In both equations, the coefficients on the water quality variables were significantly different from 0 at the

0.01 level. Estimates of the annual loss in social welfare from a decline in water quality is the sum of the corresponding decrease in annual willingness to pay by waterfront property owners and public site users. Our results show that waterfront property owners incur much higher monetary losses when water quality deteriorates than do public site users.

The results of our analysis may be useful to policy makers in analyzing water quality improvement and recreational use projects on other Connecticut lakes with similar residential density and recreational use potential.

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