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WATER QUALITY AND THE DEMAND FOR RECREATION†

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This paper considers the linkage between one facet of environmental quality and utilization of the environment. Following a simple theory of market demand for recreational sites we attempt to quantify the relationship between water quality and visits to parks using Illinois data for 1976. The main conclusion is that weak responses of the demand for recreation are detected for changes in water quality parameters leading us to believe that statistical analysis of better data would show stronger responses.

1. INTRODUCTION

Understanding the effect of changes in water quality on recreational activity is recognized to be essential to environmental benefit estimation. Yet, Freeman[1] observes that little is known about the linkage between such environmental improvements and the utilization of the environment. Turner[2] reaches a similar conclusion suggesting that incomplete source material and inappropriate data are the primary impediments to the economic evaluations of improved water quality.

In this paper we present a modest attempt to quantify the relationship between water quality and visits to parks. In the first section the theoretical foundation is presented. In the second section the data are described and the statistical analysis is presented. Concluding remarks follow with the main conclusion of the empirical work being that weak responses of the demand for recreation are detected for changes in water quality. The results lead us to believe that statistical analysis of more appropriate data would show stronger and statistically more significant responses.

2. THE THEORY OF THE DEMAND FOR WATER QUALITY

In this study we examine the evaluation of water quality by one group of water users—recreationists. Water quality is determined subjectively by each user. However, we employ objective measureable water quality parameters which are assumed to be positively related to subjective evaluation. Ultimately, we are interested in the weight assigned by the water users to each parameter when water quality is evaluated and its equivalence is monetary units, for only with this information can we compare projects, policies and regulations related to water quality. Rosen[3] offers a framework of implicit markets and hedonic prices in which we could explain recreationist useage of parks by various park traits including water quality, generate the implicit prices (using travel costs incurred to enjoy the site as well as the hedonic coefficients etc.), and finally estimate the demand for each trait in the usual manner providing a link between changes in water quality traits and the monetary value of them.[4,5] However, such an analysis is beyond the scope of this paper in that we attempt only to determine the way in which various water quality parameters affect recreational useage.

Regardless of whether one takes the conventional Marshallian approach to the demand for commodities or the new approach[6,7] one obtains a demand equation specifying the quantity demanded to be a function of the price of the specific bundle of attributes, the prices of other bundles and of income. The price (income) variables are the market prices (income) or the full prices (income), i.e., including the opportunity cost of time, depending on the approach taken. If the commodity is a park whose vector of attributes $V_1, V_2, \ldots V_m$ stand for camping facilities and water quality etc., the quantity demanded of the park will be less the further away it is from the residential location because of a higher travel cost and if the V's are measuring positive attributes the demand would be higher for $V_i^1 > V_i^0$ everything else con-

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stant. Let us assume that $V_1 \ldots V_m$ are measureable and known for each park. The quantity of recreation demanded of a particular park is indicated by the product of the number of visits and the intensity of recreation. A simple measure of the latter is the number of days stayed in the park per visit. A reasonable measure of the full price is the distance travelled since the price is a positive function (perhaps increasing at a decreasing rate) of the distance between home and recreation site.

Given the above framework and that the potential population of recreationists is located at one point while the recreation sites are distributed along a radius vector, if all sites are of identical quality (the V vector is identical) all visits would occur in the nearest park (if we disregard potential congestion, see Cicchetti and Smith[8]). This could also occur if the V vectors are not identical, but the nearest park is most desirable or:

$$\sum_{i=1}^{n} (\partial U/\partial V_i)(V_{ij} - V_{i0}) < 0 \qquad (1)$$

where U denotes the utility function in which the park qualities appear as arguments, V_{ij} is the quantity of attribute i in park j and V_{i0} the quality of attribute i in the nearest park (distance scaled as 0). Thus sufficient conditions (each by itself) for a distribution of visitors over all parks are : (1) not all visitors reside at the same residential location; (2) the V vector is not identical over parks and (3) visitors do not have the same utility function. We attempt to explain the differential visitation by differences in the distance between residential and park locations and by differences in park attributes ignoring differences in preferences.

Consumer equilibrium implies that the marginal costs of visiting a particular site are equal to the marginal utility (divided by the marginal utility of income) of the attributes of the site. In the context of decision making with regard to several sites the consumer is in equilibrium (i.e., indifferent between the sites) when the worth of the differences in utility derived from park attributes equals the differences in costs of visiting the parks or:

$\sum_{i=1}^{n} (\partial U/\Delta V_{ijk})/\lambda = \Delta C_{jk}$ where λ is the marginal utility of income, $\Delta V_{ijk} = V_{ij} - V_{ik}$ is the difference in trait i between parks j and k and $\Delta C_{jk} = C_j - C_k$ is the difference in user costs between the two parks. Following the distance travelled approximation to cost $\Delta C_{jk} = f(D_j - D_k) = g(D_k)$ where D_j, D_k denote distance.

This formulation leads to the following specification of the demand for recreation services rendered by a given site: quantity demanded is a function of user distance from site, population at that distance, and site attributes. The model is thus a market demand function for a given site. It differs from the conventional demand analysis which is representative of an individual consumer for a given commodity. We have aggregated over all consumers introducing their common characteristic—distance from the site—as an argument in the demand function.

One application of the analysis of the demand for park services is the trade-off between distance and water quality and among the water quality variables. For simplicity we assume constant marginal rates of substitution between any two attributes or between distance and any attribute. This implies a linear demand function for the site

$$Y_j = \alpha_0 + \beta_1 X_{1j} + \beta_2 X_{2j} + \beta_3 X_{3j} + \cdots + \beta_m X_{mj} + \varepsilon_j \qquad (2)$$

where the X_{1j} is the distance, $X_{2j} \ldots X_{mj}$ are attributes of site j, and Y_j is the quantity demanded of the site. β_i/β_1 is the marginal rate of substitution between distance and attribute i and β_i/β_j is the marginal rate of substitution between attribute i and j keeping the quantity demanded constant. One might view β_1 as the marginal cost of distance. Its value might differ from that calculated by simple accounting methods (cents per mile travelled) since β_1 is the subjective marginal value of the distance, the difference being the marginal value of the road itself. If the consumer of recreation services is indifferent with regard to the road travelled (landscape), β_1 is the marginal travelling costs which should be charged to the site. The value of a marginal unit of water quality defined as attribute s is β_s/β_1, and which is the absolute weight we would assign to it.

3. DATA AND STATISTICAL ANALYSIS

To investigate the relationship between water quality and recreation activity, the attendance (number of visits) at 74 Illinois state parks and recreation areas in 1976 is analyzed. Only areas with a lake or river are considered so as to estimate the effect of water quality on the level of recreational use. The types of variables considered include water quality, facilities and nonwater

TABLE I

Description of variables

Name	Mean	Standard deviation	Units
Annual attendance (ATT)	3098	3237	Hundreds of people
Annual median dissolved oxygen (DO)	9.326	1.756	Milligrams/liter
Annual Fecal Coliforms (NFEC)	−563.8	1228	(Minus) bacteria/100 milliliters
Distance from Chicago (CHIC)	180.6	88.38	Miles
Number of Nearby Urban Centres (UC)	3.068	1.995	Centres
Interstate Nearby Park (ISN)[a]	0.311	0.466	—
Distance to Nearest Park (DNPK)	16.66	9.713	Miles
Number of Nearby Private Campgrounds (NNPC)	0.608	0.699	Campgrounds
Historical Museum Facility (MUSEE)[a]	0.122	0.329	—
Boating Facilities (BOAT)[b]	3.054	2.093	—
Horseback Riding Facilities (HORSE)[a]	0.162	0.439	—
Hunting Permitted (HUNT)[a]	0.405	0.494	—

[a]Each variable takes the value 1 if the facility is present and 0 otherwise.

[b]BOAT is an index which has a range from 1 to 6. 1 indicates boating is permitted. One is added if there is a launch and another 1 if there are rentals. To this sum, with a maximum of 3, 1 is added if only electric motor trolling is permitted; 2 if motors up to 10 horsepower are permitted; and 3 if there are no restrictions.

Sources: ATT, MUSEE, BOAT, HORSE and HUNT—Data supplied by the Illinois Department of Conservation.[9] DO and FEC—Illinois Environmental Protection Agency, *Water Quality Network, Summary of Data,* 1976.[10] CHIC, DNPK, NNPK and UC—Illinois Department of Business and Economic Development *Illinois Camping Guide* 1975,[11] Rand McNally *Road Atlas* 1975.[12]

attributes, and distance. The definition and summary statistics for each variable are given in Table I. The results of the regressions of park attendance on these variables are reported in Table II. In general, the results are quite reasonable with explanation of 54 percent of the variation in annual attendance and significance at the 99 percent level.

Distance is found to be quite important as an own-price variable as is shown by the highly significant (99 percent level) coefficients of the linear and quadratic variables (CHIC and CHIC2) of the highway distance from Chicago. The positive signs for UC, the number of cities with population greater than 50,000 within 100 miles of the park and for ISN, the presence for an interstate highway within seven miles of the park, also indicate the importance of convenience. UC is not significant at any usual level. ISN is significant at the 90 percent level. (A highway distance variable for St. Louis was part of the original specification, but is not reported, as the t values were 0.3 and the other coefficients differ little.) The price of substitute recreation sites is important in explaining attendance at a particular site. DNPK, the distance from the site to the nearest state recreation area, has a positive sign and is significant at the 99 percent level. NNPC, the number of private campgrounds within ten miles of the state recreation area was included though it is not clear *a priori* whether private (non-state) campgrounds are substitutes or complements to the state-run area. The low t value for NNPC reflects the ambiguous net effect of these campgrounds. The availability of a historical museum, boating facilities and provisions for horseback riding (MUSEE, BOAT and HORSE) tend to increase attendance since each has a positive sign. HUNT, the allowance of hunting which by its low visitor-density nature decreases attendance, is not statistically significant: for Eq. 1 and is significant at only the 80 percent level for Eq. 2.

Water quality is found to be have the expected, but rather weak effect on recreational activity. NFEC, defined as minus one times the average annual count of active bacteria per 100 milliliters, has the expected positive sign and is significant at the 90 percent level. D0, the median annual milligrams of dissolved oxygen per liter, has the expected positive sign, but it is not significant at any reasonable level. The regression results in column 2 consider the possibility of a damage

TABLE II

Estimated park attendance, ATT

Variable	Coefficient (Absolute t value) (1)	(2)
CHIC	− 62.09	− 64.98
	(3.57)	(3.82)
CHIC 2	0.115	0.162
	(3.27)	(3.41)
UC	248.7	255.4
	(1.24)	(1.28)
ISN	1189	974.3
	(1.54)	(1.38)
DNPK	86.24	92.49
	(2.61)	(2.90)
NNPC	284.7	265.6
	(0.63)	(0.59)
MUSEE	1868	1993
	(2.00)	(2.17)
BOAT	208.6	221.1
	(1.29)	(1.44)
HORSE	1702	1001
	(1.52)	(1.44)
HUNT	− 230.2	− 360.1
	(0.33)	(1.44)
DO	95.76	
	(0.50)	
NFEC	0.377	
	(1.36)	
DNFEC		1707
		(1.45)
CONSTANT	1330	760.1
	(0.47)	(0.42)
R^2	.543	.542
F	5.47	6.01
SER	2415	2397
N	74	74

The critical t values for significance for a one-tail test are 1.282 for 90 percent, 1.645 for 95 percent, 1.960 for 97.5 percent, 2.326 for 99 percent and 2.576 for 99.5 percent. The one-tail test is appropriate for all but NNPC and HUNT. NNPC is not significant at any usual level. HUNT is not significant at any usual level for Eq. 1 and is significant at only the 80 percent level for Eq. 2.

threshold for fecal coliforms. Using the 1976 Illinois standard of 200, DNFEC takes on a value of 1 if fecal coliforms are between 0 and 200 (clean water) and 0 for counts above 200 (polluted water). Again cleaner water is found to increase attendance. The level of its significance is approximately 90 percent.

4. CONCLUDING REMARKS

In this paper we have made a modest attempt to quantify the effect of water quality on recreational activity as an intermediate step in benefit estimation. Regression analysis of Illinois park attendance showed that the number of annual visits depends upon travel costs (CHIC, ISN and UC), the price of complements and substitutes (DNPK and NNPC), and the attributes of the park (MUSEE, BOAT, HORSE, and HUNT). Also found to be important was water quality (DO, NFEC, and DNFEC) which increases attendance. However, drawing conclusions about the effect of water quality must be done with great care because of the low level of statistical significance. Three shortcomings of the data could well account for the insignificance.

First, we would like to measure the demand for the recreation area by visitor-days which accounts for length of stay as well as the number of visitors entering (and leaving) the park. Our measure, ATT, considers only the latter. Hence, the intensity effect is not considered while it might be the main variable that is affected by water quality. Second, we need better data on water quality. Perhaps the greatest shortcoming of these variables is related to the location of the monitoring station relative to the park. The stations are often more than five miles away and the variation in water quality over stretches can be tremendous. These measurement errors would bias the water quality coefficients downward. We did repeat the attendance regression (column 1) for a sample of 29 recreation areas which had a monitoring station within five miles of the park with virtually no change in the coefficients or t values. We were prevented from decreasing the distance further by the lack of degrees of freedom. A third problem with respect to water quality is related to seasonality. The annual median might be misleading if it is determined mainly by measurements during the off season (winter) something which varies between parks in the north and in the south where the summer is longer. With better data we could concern ourselves with more complex models which would take into account the simultaneous effect of recreational use on water quality.

While our work evidences the limitations imposed upon those attempting to quantify water quality policy benefits, it also provides indications that water quality does affect the level of recreational activity. Furthermore we do suggest that the hedonic price-trait demand approach would reveal this effect and enable its monetary quantification. For that purpose different data (distance travelled by users, users income) and more precise data are essential.

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