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RECREATIONAL BENEFITS FROM WATER QUALITY IMPROVEMENTS: THE CHICAGO RIVERS CASE*

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ABSTRACT

There has been increasing attention paid to the recreational benefits from cleaning up waterways. This paper briefly reviews the theoretical and empirical aspects of estimating benefits from water quality improvements. Two pragmatic approaches for estimating river related recreational benefits are presented and applied to rivers in the Chicago Standard Metropolitan Statistical Area.

INTRODUCTION

The purpose of this paper is to review briefly the theoretical and empirical aspects of deriving recreational benefits from water quality improvements, and to determine an approximate estimate of these benefits for the river system in the Chicago Standard Metropolitan Statistical Area (SMSA). In arriving at an estimate of the approximate recreational benefit from the improvement of water quality in all rivers within the Chicago SMSA the important consideration is the magnitude of the benefits rather than their exact dollar amounts.

In attempting to obtain a measure of recreational benefits there are two basic ways of approaching this problem. The dollar benefit of a river or stream at a given level of water quality can be determined by simply listing all uses which

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both affect and are affected by water quality, by valuing each use individually and by summing up the resultant values. In practical terms, this is easier said than done, since it is often very difficult to place a value on each of the individual cases.

An alternative way of estimating the recreational benefits is to consider the demand for clean water. What would an individual be willing to pay for clean water? If each person could specify what he would be willing to pay for each quality of water, a schedule could be derived showing the community's total willingness to pay for each degree of water quality. Then, since all individuals are consumers of the same environmental quality, the total willingness to pay would be the sum of the individual amounts. Unfortunately, it is very difficult to obtain unbiased information about direct willingness-to-pay because individuals have difficulty in answering purely hypothetical questions, and may well give self-serving answers in accordance with the free rider principle. However, an indirect willingness-to-pay function can be constructed by asking people how much they would pay to carry on a given recreational activity, such as swimming at a particular beach. If the amount changes when the quality of the water at a particular beach is improved, the people have indirectly expressed the value of this cleaner water [1]. In cases where the effects of the water quality are not fully realized by the public and when the benefits (or damages) are primarily aesthetic, it can only be evaluated as the sum of their subjective worth to each individual.

The estimation of recreational benefits via changes in demand is the approach normally taken. Consequently, in the next section, we present the theoretical rationale for using this approach.

THE THEORETICAL FRAMEWORK

The rational individual desires to purchase a bundle of commodities, Q_1, $Q_2, \ldots, Qn_1$ from which he derives the highest level of satisfaction. His problem is one of maximization constrained by his limited income.

As usual, let

$$U = U(q_1, q_2), \qquad q_1, q_2 \geqslant 0$$

be a recreationalist utility function where q_1 indicates the number of recreation-days the recreationalist enjoys per period of time and q_2 represents all other goods and services available. The values of recreation-days commodity and non-recreation commodity can be expressed as p_1q_1 and p_2q_2 respectively. Following Reiling, let's suppose that there exists a certain extra charge c if the recreationalist bids for any units of q_1 [2]. This c is mostly the travel costs getting to and from the recreation site. Then, his budget constraint can be written as:

$$B^o = p_1q_1 + c + p_2q_2.$$

Note, however, that c will be zero if and only if $q_1 = 0$. If $c = o$, the budget constraint takes on a new form of $B^o - p_2q_2$ for $B^o, p_2 > 0$, and $q_2 < 0$. The following La Grange function is then formed from the utility function and the budget constraint:

$$\text{Max } V = f(q_1q_2) + \lambda(B^o - p_1q_1 - c - p_2q_2).$$

Taking the partial derivatives with respect to q_1, q_2, and λ, and setting them equal to zero,

$$f_1(q_1, q_2) - p_1 = 0$$
$$f_2(q_1, q_2) - p_2 = 0$$
$$B^o - c - p_1q_1 - p_2q_2 = 0$$

the following first order condition is obtained:

$$\frac{f_1}{f_2} = \frac{p_1}{p_2}.$$

The first-order condition states that when the utility function is maximized, the ratio of marginal utilities associated with recreation and non-recreation must equal the ratio of the corresponding prices.

In general, the consumer's ordinary demand function for q_1 is written as

$$q_1 = \phi(p_1, p_2, B^o, c)$$

or, assuming that p_2, B^o and c are given parameters, then,

$$q_1 - D(p_1).$$

Figure 1 shows two hypothetical willingness-to-pay (demand) functions for a beach. The lower curve DD shows the number of people who would swim at this beach for each hypothetical admission charge (p_1). The upper curve D'D' is the same relationship, but with use of cleaner water. The shaded area between the curves and above the actual admission charge M is the implied public demand function for this improvement in water quality [1].

THE EMPIRICAL SPECIFICATION

In the case of water-related recreational demand, the days of recreation per visit (q_1) may include in its argument an additional vector representing a water quality index. In general, it can be hypothesized that the total visits a_1 is functionally related to various factors: the water quality (w_i), average travel cost (c) of recreationalists residing in the area, the average income (Y) of recreationalists from the area, the characteristics of the site (SI), the social characteristics of the recreationalists such as race, age, sex, etc. (S), and the total population living in the area (POP).

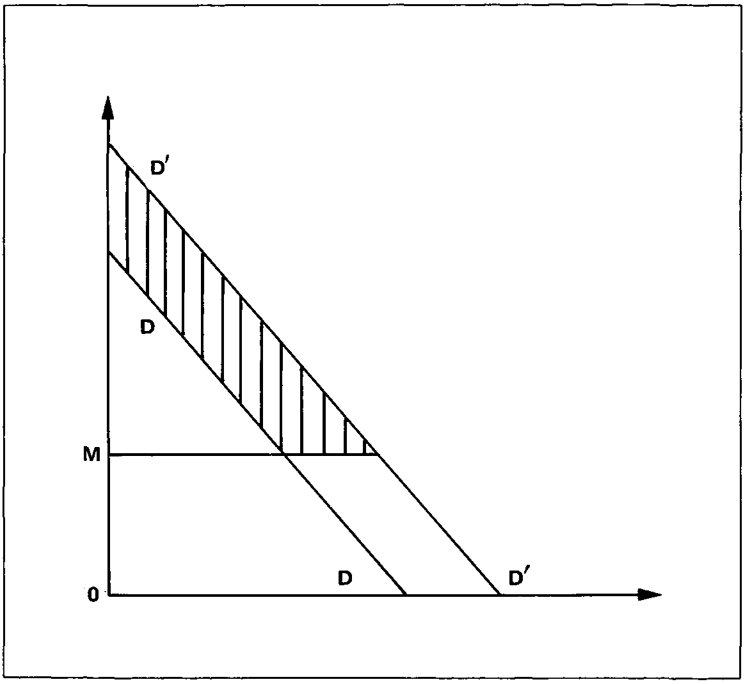

Figure 1. Benefit of a water quality improvement as determined by a shift in the demand function for a beach.

Thus, an empirical demand model can be specified as

$$q_1 - q_2\ (w_i, C, Y, SI, S, POP, etc.),$$

where w_i is the water quality index and $i = 1, 2, \ldots, n$. The monetary value of the partial derivative of q_i with respect to water quality variable (w_i) is the social recreational benefit of water quality improvement. Water quality data should include dissolved oxygen, BOD, turbidity, pH, temperature, and so on. Once such data are available we can expect a rapid increase in our knowledge of the nature of the benefit function.

A review of the literature reveals that the demand for a recreational resource has been measured by several interesting techniques which can be adapted to measure the benefit from an increase in the quality of a resource. Clawson and Knetsch developed a method for estimating the willingness-to-pay function on the basis of the imputed costs of using a facility [3]. They calculate the cost of the trip for various distance zones by calculating a cost per mile for the round trip, and food and lodging costs using statistics on the visits per thousand population by distance travelled to the site. If more than one site is visited on a particular trip or more than one activity engaged in, the costs of the trip must be allocated among the different sites or uses. They then assume that people show the same response to a one-dollar increase in admission charge as they do to a one-dollar increase in travel costs. This allows the calculation of a hypothetical attendance figure for each admission charge by applying the frequency-of-use statistics for the further regions to the closer regions.

Davidson, Adams, and Seneca used multiple regression analysis, explaining the frequency of participation in a particular activity by such characteristics of the respondent as age, sex, race, income level, education, life cycle, the availability of water per capita and an expert's rating of the quality of the facilities available [4]. Their regression gave very unsatisfactory results for swimming, boating, and fishing. But they did obtain a significant relationship between the amount of water per capita and the probability of participation in boating and fishing. The demographic data for the Delaware estuary area were then used with the regressions to predict the change in participation rates that would result from making water quality of the estuary suitable for boating or swimming. Moreover, relying on dissolved oxygen only as a measure of water quality, they postulated that a dissolved oxygen level of three milligrams per liter (Mg/l) was adequate for boating, 4 Mg/l for fishing and 5 Mg/l for swimming.

ESTIMATING RIVER RELATED RECREATIONAL BENEFITS IN THE CHICAGO SMSA

We used two approaches to estimate the recreational benefits from improving the water quality in the Chicago Standard Metropolitan Statistical Area (SMSA) river system. The major obstacle we faced was the lack of detailed data. In order to estimate total recreational benefits in the Chicago rivers in the absence of data, we estimated a set of average number of days per person engaged in a particular activity by using per person outdoor activity days data in North Central States and the assumed percentage of river-related activity days to total outdoor activity days in Chicago SMSA. Multiplying average number of activity days per person by total population gives total day's usage per year in a particular activity.

Following Davidson, Adams, Seneca, a set of arbitrary factors (call it x dollars per activity day) are then chosen for converting units of calendar days into units of benefits [4]. The Chicago SMSA population was estimated to be 7,523,000 (as of 1970). The results of this sensitivity analysis for three recreational activities (boating, fishing, and swimming) are summarized in Table 1. To interpret the table, let's suppose that before cleaning up (average DO level 3 ppm, for example) average number of activity days per person per year were boating 0.301, fishing 0.280, and zero swimming. Now, when dissolved oxygen level increases to 5 ppm in all rivers as a whole, assume that average activity days are boating 0.401, fishing 0.420, and swimming 0.180. At x = $1, the marginal recreational benefit is calculated as follows:

Table 1. Sensitivity Analysis for River-Related
Recreational Activity in Chicago SMSA

(a) Assumed average number of days per person in All Chicago rivers engaged in the listed activities[a]:

	I	*II*	*III*	*IV*
Boating	0.502	0.401	0.301	0.201
Fishing	0.692	0.550	0.420	0.280
Swimming	0.180	0.180	0.180	0.180

(b) Day's Usage Per Year (1970):

	I	*II*	*III*	*IV*
Boating	3,776,550	3,016,723	2,264,420	1,512,120
Fishing	5,205,920	4,137,650	3,159,166	2,106,440
Swimming	1,354,140	1,354,140	1,354,140	1,354,140

(c) Gross Recreational Benefit Schedules:

		I	*II*	*III*	*IV*
	(x = $1	3,776,550	3,016,723	2,264,420	1,512,120
Boating	(x = $2	7,553,100	6,033,446	4,528,840	3,024,240
	(x = $3	11,329,650	9,050,169	6,793,260	4,536,360
	(x = $1	5,205,920	4,137,650	3,159,660	2,106,440
Fishing	(x = $2	10,411,840	8,275,300	6,319,320	4,212,880
	(x = $3	15,617,760	12,412,950	9,478,980	6,319,320
	(x = $1	1,354,140	1,354,140	1,354,140	1,354,140
Swimming	(x = $2	2,708,280	2,708,280	2,708,280	2,708,280
	(x = $3	4,062,420	4,062,420	4,062,420	4,062,420

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[a] The assumed percentages of river-related activities to respective total outdoor recreation activities are as follows: (I) Boating, 50%; Fishing, 50%; Swimming, 5%; (II) Boating, 40%; Fishing, 40%; Swimming, 5%; (III) Boating, 30%; Fishing, 30%; Swimming, 5%; (IV) Boating, 20%; Fishing, 20%; Swimming, 5%.

Boating = (3,016,723 - 2,264,420) = 752,303
Fishing = (3,159,660 - 2,106,440) = 1,053,220
Swimming = (1,354,140 - 0) = 1,354,140

Therefore, the marginal recreational benefit due to water quality improvement is estimated as \$3,159,663 while the absolute benefit is \$7,530,523 for all three activities. These values are illustrative and give an indication of the magnitude of the benefits.

Table 2. Total River-Related Recreational and Aesthetic Benefits in Chicago SMSA

	(1) *Activity Days (In Millions)*	*(2)* *Estimated % All Rivers-Related Activities*	*(3)* *(1) x (2)*	*(4)* *Assumed River-Related Activities in Chicago (Per Person)*
Walking for Pleasure	221.9	10%	22.2	.409
Picnicking	107.5	20%	21.5	.396
Sightseeing	105.6	20%	21.1	.388
Birdwatching	36.5	40%	14.6	.269
Nature Walks	30.7	50%	15.4	.283
Photography	5.3	50%	2.7	.050
Swimming	195.9	5%	9.8	.180
Fishing	75.2	50%	37.6	.692
Boating	54.6	50%	27.3	.502
Water Skiing	15.2	5%	0.8	.015
Canoeing	7.7	70%	5.4	.099
Sailing	5.6	30%	1.7	.031
Ice Skating	33.0	20%	6.6	.121
Camping	28.3	30%	8.5	.156
Hiking	13.3	30%	4.0	.074
TOTAL	936.3		199.2	3.67

Population in North Central States (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas) in 1962 and 1969.

Great Lakes	36,927	39,904
Plaines	15,657	16,202
TOTAL	52,584	56,106 (Thousand)

AVERAGE: 54,345,000

Based on the assumptions made in Table 1, the gross benefits could be in the range of five to thirty-one million dollars for boating, fishing, and swimming.

Table 2 shows the results from a related approach in estimating recreational benefits in the Chicago SMSA. Table 2 was constructed based on published data for recreational activity days in North Central States (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas) [5], and the assumed percentage of all river-related activity to total outdoor activities in the Chicago SMSA. Dividing these two products by the average population of the North Central States in 1962 and 1969, we obtained for the listed recreational activities the assumed river-related activity days per person for all the Chicago-rivers (see Column 4 of Table 2).

Assuming the average value of cleaning up the river ranges from $.10 to $1 per activity day, depending on the degree of clean-up and individual tastes, the benefit per person per year was estimated to range from $.37 to $3.70. Multiplying these figures by the upper bound of the population (7,523,000) in the study area gives a total annual recreation benefit from a pollution clean-up of all the rivers of $2,783,510 to $27,835,100. Again, these values, although they may not be unreasonable, are meant to be illustrative.

CONCLUSION

One of the most important benefits of pollution abatement in heavily populated areas is the increase in the recreational use of the improved water. Due to the availability of Lake Michigan for recreational activities and other uses, the importance of Chicago river waters for recreational purposes has in the past been largely ignored. This is reflected in the lack of data regarding the recreational value of rivers in the area. However, in a society increasingly concerned with "leisure time" goods and services, attention must be given to river waters. We have suggested an empirical framework to further explore the recreational demand for river basins. In the absence of data needed for empirical estimation, we have demonstrated two pragmatic approaches for approximating river-related recreational benefits in the Chicago SMSA. The study has been illustrative in nature and the empirical conclusions must be considered tentative. More accurate data covering water quality indexes and recreational activity days related to river water need to be provided. Once such data are available, it will be possible to better estimate the recreational benefit from an improvement of water quality.

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