AN INDEXATION APPROACH TO MEASURING CONGESTION EXTERNALITIES AND OPTIMAL ADMISSION FEES.

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LUNDGAARD, ERIC LIN
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AN INDEXATION APPROACH TO MEASURING CONGESTION EXTERNALITIES AND OPTIMAL ADMISSION FEES

by

Eric Lin Lundgaard

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D C Cory | 5-5-82
D. C. CORY | Date
Professor of Agricultural Economics

What is truth? The young boy trying to trick the old man brought him a bird clasped between his hands. "Old man," the boy cried, "is the bird alive or is it dead?" The old man knew that if he said "alive," the boy could crush the bird between his hands, revealing a lifeless mass of feathers. If the man were to say "dead," the boy would open his hands, releasing the bird to fly away. Finally, the man said, "It is in your hands."

ACKNOWLEDGMENTS

Much time has passed since beginning my masters program. Perspective and purpose have changed too many times to mention. My gratitude will always remain for those who helped me.

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ABSTRACT

Rationing the use of fixed capacity facilities subject to congestion costs by using fees is complicated in practice by the difficulty of estimating quality-adjusted demand schedules for the facility. Previous approaches to measuring congestion costs have met with limited success. An alternative methodology based on indexation techniques is presented and then applied to a popular urban lake in Arizona. It is concluded that estimating quality-adjusted user fees through the use of indexation techniques has several advantages over earlier approaches.

CHAPTER 1

INTRODUCTION

The economic literature concerning congestion has generally dealt with its effect on producer's supply decisions (Freeman and Haveman 1977). Economists have less frequently modeled congestion as a consumption externality. While initial attempts at modeling in a consumption framework have provided theoretical insight, the empirical results have been less promising. Lacking a consensus, economists have been unable to establish a methodology to provide consistent measurements of the qualitative aspects of congestion. Further study of the empirical specification of congestion and the measurement of this external effect in a consumption framework should therefore prove useful.

Recent literature regarding congestion at fixed capacity facilities has focused on modeling users of recreation facilities. Following that direction, this study addresses congestion at a recreation site. While the model developed herein is applied to a recreation site, the analysis applies to any facility with a fixed capacity, such as highways and museums.

Problem Statement

When the users of a recreation facility regard contact with other users as reducing the quality or value of the experience, external effects are generated by facility use. These effects are caused by the marginal user who will participate if he expects his benefits to exceed the costs he incurs from the visitation, while not considering the costs his use imposes on those already present. The inframarginal users (those already present) experience a decrease in the quality of the service when the marginal user arrives. This decrease in quality or value constitutes an external cost to inframarginal users for which compensation is not paid. A loss of net benefits from the service flow will occur when the marginal user imposes on the inframarginal users a congestion cost greater than the benefit derived from his visitation.

Efficient use of a facility subject to congestion costs requires that net benefits derived from the service flow be maximized. A level of use that equates congestion costs to benefits at the margin is therefore desired. Since there exists a cost (external effect) that the marginal user does not incur, unrestricted use based on his decision to participate will create a supraoptimal level of use. That is, realized net benefits are less than net benefits that can be obtained by restricting use.

To establish a level of use where marginal benefits more closely reflect the external cost of congestion, users can be charged a fee equal to the marginal congestion cost. To estimate this fee, a methodology is needed to isolate the decrease in value of the experience that is attributable solely to the external effect of congestion. To the extent that an unbiased estimate of this effect is derived, and a fee charged equaling that estimate, net benefits can be maximized.

The measurement of congestion cost depends on a consumer's perception of the quality of his experience at a facility. As congestion varies with levels of use, estimates must isolate the effect these changes have on consumer demand for the entire range of use that is relevant to policy decisions. Isolation of the effect of congestion on demand is difficult for three reasons: First, congestion is an external effect resulting from the marginal user's participation decision; second, the characteristics that establish the quality of the experience are numerous and therefore difficult to specify; and finally, the enhanced quality provided at lower levels of use cannot be estimated with conventional demand curves.

The estimation problem is illustrated in Figure 1. As the number of facility users increases, additional congestion costs are incurred. For a relatively homogeneous group of users, this can be illustrated by willingness to pay schedules falling with level of facility use, WTP_1 ... WTP_N (Fisher and Krutilla 1972). Notice that none of these individual willingness to pay schedules constitutes a demand function for the facility since only one point on each schedule will be observed. The quality-adjusted demand curve is generated by varying the participation price and computing the resulting number of facility users (Freeman and Haveman 1977). For example, when an admission fee of F_1 is charged, Q_1 individuals will participate since only that number of users have a willingness to pay in excess of F_1 when the level of facility use is Q_1. Thus, point "a" lies on the quality-adjusted demand curve (D). Repeating this process, a series of points lying on this curve can be identified.

The unrestricted level of use occurs at Q_N where the uncongested willingness to pay of the marginal user equals the average congestion cost and no fee is charged. Typically, the resource manager has information about WTP_N, the willingness to pay of facility users at the

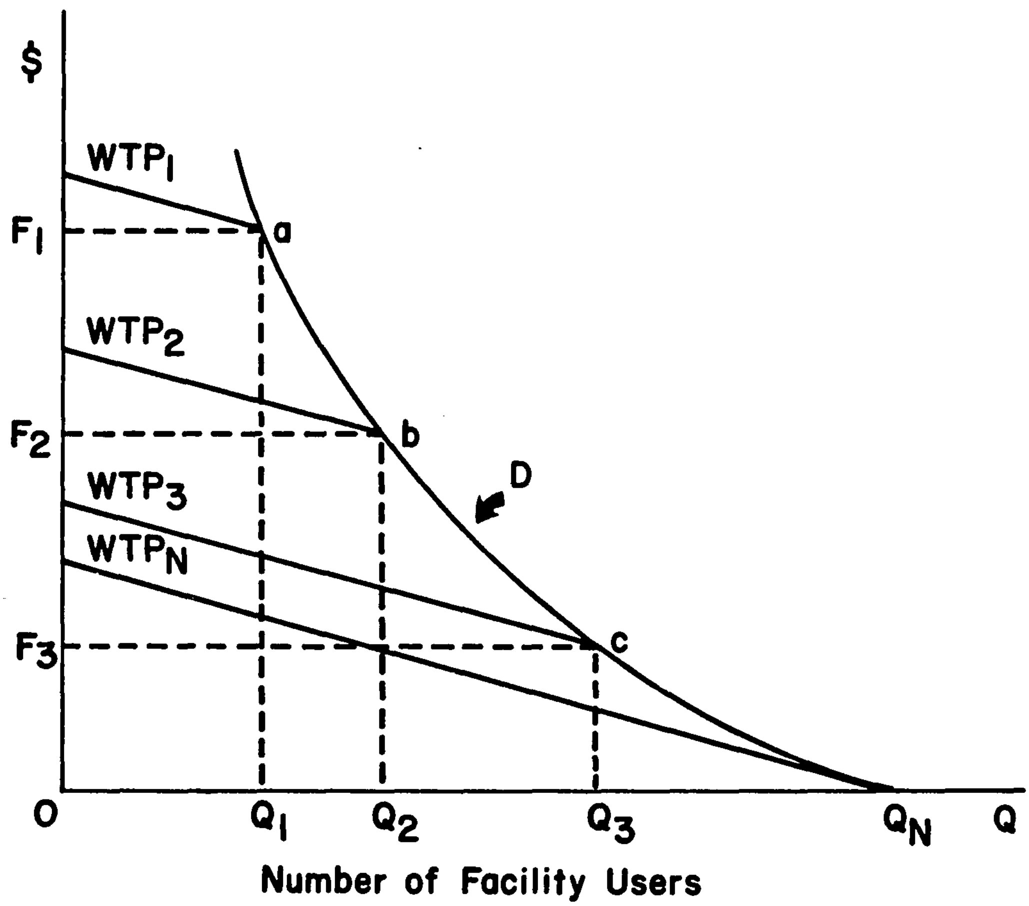

Figure 1. Derivation of a quality-adjusted demand curve.

unrestricted level of use. Imposing a fee based on this information in an attempt to lower facility use to a prespecified level will result in a supraoptimal number of users participating.[1] For example, if the level of use were to be limited to Q_2, WTP_N would indicate that a fee of F_3 would be sufficient when in fact a fee of F_2 is required. The difference between these two fees reflects the quality improvement associated with the reduction in average congestion costs experienced by the users when the level of use is reduced from Q_N to Q_2.

The implementation problem facing the use of fees to ration the use of a fixed capacity facility subject to congestion costs arises directly out of the difficulty of estimating how congestion costs will be reduced as participation rates decline. In particular, an estimate for the change in average congestion cost is needed so that a quality-adjusted demand curve can be estimated from the readily available schedule of unrestricted willingness to pay.

Historical Perspective

Using the economic theory of production, Walters (1961) modeled highway congestion by the time taken for traffic to travel between two points. In doing so, walters provided a more general version of Pigou's (1920) classical account of congestion in Wealth and Welfare. The familiar Pigouvian tax is the strategy Walters (p. 677) offered as the

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1. "Optimal" admission fees in this context are efficient in a second-best sense. Unless the administratively selected level of use is the level which maximizes net benefits of facility use, optimality in the first-best sense will not be attained. For a discussion of equity-efficiency tradeoffs relevant to selecting a target level of use see Cory 1979-80.

solution to "equate marginal private cost to marginal social costs," thereby always keeping traffic below capacity. Capacity was defined by Walters as the maximum level of traffic that can be maintained over long periods. Johnson (1964) further refined the use of marginal cost pricing to reflect spatial and temporal variance in highway traffic. By showing the importance of both time and money costs on a traveler's decisions, Johnson set the stage for analysis of the congestion phenomenon in recreation models.

More recently, Clawson and Knetsch (1966) and Fisher and Krutilla (1972) extended congestion analysis to the problem of recreation resource overuse. Clawson and Knetsch described overcrowding at recreation sites. Fisher and Krutilla developed an efficient management scheme for wilderness areas which necessitates a charge to recreationists equal to marginal congestion and environmental costs. Fisher and Krutilla explained that congestion costs are determined in terms of a product of constant quality while environmental costs are assessed in terms of carrying capacity (the maximum number of individuals of a species that can be sustained under conditions of maximum stress in a specified area). Fisher and Krutilla (p. 420) explained the relationship between the two costs in terms of use: "Quality deterioration through what is referred to as the external effects of congestion may exceed the permissible level for optimal intensity of use, in an economist's sense, substanstially before the carrying capacity in the ecologist's sense is reached."

As in the example of highway congestion, efficient levels of use at recreation facilities should be established using constant quality measures. The importance of maintenance and environmental costs will depend on the degree that greater levels of use increase these costs more rapidly than congestion costs. This condition is more likely to occur at the more fragile recreation sites than at other fixed capacity facilities such as highways or museums.

The previous authors agreed upon the use of marginal cost pricing as the solution to the external effects of congestion. These effects are recognized as perceived quality deterioration that remains uncompensated for as use of a good or service increases. The models, established from a producer's point of view, maximize net benefits from the facility by equating marginal benefits and costs.

Until recently, less attention has been paid to congestion from a consumer's perspective. The earliest articles leading to the models of congestion as a consumption externality include Buchanan (1965) and Lancaster (1966). Buchanan's Theory of Clubs established the principle that a decrease in quality can be associated with increased participation. Lancaster enhanced our understanding of the conventional "good" that a consumer demands by dividing it into its inherent characteristics. The division allowed research to focus on these characteristics such as encounters, solitude, or quiet. For fixed capacity facilities, the more solitude desired as a quality of the facility, the greater the associated congestion costs. Thus, the important aspect of Lancaster's addition to congestion externality theory is the focus put on the psychological services a good renders.

Later, Rothenburg (1970) and Haveman (1973) discussed the source of congestion externalities by addressing the source of diversion between private and social costs. Rothenburg (1970) attempted to generalize the definition of congestion with his term "generic congestion." By his definition, generic congestion could be attributed to all common property goods. Haveman (1973, p. 284) pointed out that congestion and common property externalities both result from differing social and private cost functions, but that the source of the divergence is different:

> In the congestion case, overuse is encouraged because real crowding costs imposed by users on each other are not reflected in marginal use decisions. In the common property resource case, excessive output is stimulated by the negative user cost that is generated by the existence of producer's quasi-rent, which is not appropriable under conditions of free entry.

Haveman (p. 283) further clarified the congestion phenomenon when he reported that it:

> . . . is perceived by users as a deterioration in the quality of the services rendered by the facility. In effect, incremental use of the facility reduces the marginal utility function of the individuals who consume the services of the facility. An allocative efficiency problem results because unrestricted use of the facility generates costs in the form of utility reductions that are not borne by marginal users.

Furthermore, for the case of environmental pollution, the external effect does not alter the level of production which may allow the economic welfare generated by the activity to be negative. Contrasting this with the common property and congestion cases, Haveman (p. 287) stated that "consumer's surplus remains positive and equal to the net economic welfare generated by the activity. Similarly, because the consumer's surplus of each user must be equal to or greater than zero in the congestion case, aggregate consumer's surplus must be positive at the equilibrium level of output." Haveman's definition of congestion was akin to Rothenburg's "pure congestion" which focused on decreased quality with incremental use increases.

Continuing to describe congestion in terms of constant quality, Oakland (1972) focused his discussion of congestion away from the pure public or pure private good by showing that optimal conditions are intermediate to those for pure private and pure public goods. He thereby strengthened the argument for rationing with user charges which was difficult to justify for pure public goods. Such pure public goods are provided with general tax revenues as a social want, implying the consumption services supplied to one must be supplied to all (Samuelson 1954).

Using an application of Lancaster's consumer theory, Cicchetti and Smith (1973) attempted to estimate congestion in a Montana wilderness. When they used encounters as the determinant of quality and congestion, they found that user willingness to pay for the wilderness was dependent upon expected and realized experiences. Later, McConnell (1977) varied from the Lancaster framework by measuring congestion at a Rhode Island beach using hourly measures of use. He found that congestion was dependent on the expectation of the user. Finally, Deyak and Smith (1978), like McConnell, measured congestion using the number of visitors to a facility. Unlike the other two studies, a household production function was estimated with congestion modeled as a cost to households desiring constant quality recreation experiences. The two previously mentioned studies measured congestion as it affected individual demand. These three studies are discussed more thoroughly in Chapter 3, following the construction of the theoretical model in Chapter 2.

Objectives

This thesis is written to satisfy two objectives. In order to maximize net benefits at a recreation facility, benefits and costs should be equal at the margin. The first objective is to develop a methodology to provide estimates of the marginal cost of congestion. The methodology developed, the second objective is to apply the model to a recreation site. Two levels of use are used to isolate the effect of levels of use on the willingness to pay. The application is concerned with isolating the difference in users' value for recreation experiences at Chaparral Lake, a popular urban lake in Scottsdale, Arizona. Weekend and weekday users provide the exclusive samples of users for the two levels of use.

The amount a recreationist is willing to pay for a given level of use represents his value for his expected experience at the lake. Differences between the two groups are controlled by partitioning the sample of users and indexing remaining determinants of willingness to pay other than congestion that differ between the groups. Ignoring any changes in consumer preferences for the period of study, any remaining differences in willingness to pay between two groups of users can be attributed to a difference in the average cost of congestion. A quality-adjusted demand schedule based on this information is then calculated.

Procedures

To apply the methodology to the measurement of congestion, a congested and uncongested sample of users was taken from the total group of anglers at Chaparral Lake. The primary division was made by separating weekday and weekend anglers. These anglers were asked to provide a value for willingness to pay for their six-month urban fishing permit. Since institutional constraints such as employment established two temporally exclusive groups of anglers, it can be reasonably assumed that anglers visiting during the weekend on average experienced a higher level of use than weekday anglers. The lower quality, more congested experience available on weekends was then compared with the higher quality experience available on weekdays.

The estimates of willingness to pay are based on the following inverse demand function:

$$WTP = F(X,C)$$

Socioeconomic characteristics such as income, age, race, and characteristics related to the experience such as type of fish caught and fishing success are included in X. By accounting for all such differences in willingness to pay, except congestion, the measures of congestion are obtained from the remaining difference in willingness to pay between weekend and weekday users. These estimates of the remaining differential caused by congestion are found using Laspeyres and Paasche indexes.

Summary of Findings

Weekday anglers at Chaparral Lake were found to be willing to pay an average of 19% more for their six-month fishing permits than weekend anglers. After accounting for the differences in willingness to pay caused by X, an unexplained differential of 15% remained between the two groups. This unexplained portion of the difference in willingness to pay was assumed to be caused by congestion. To restrict the weekend level of use of weekday use, a fee of $1.24 would need to be charged above the fee based on the estimated willingness to pay function for weekend users. Intermediate fee adjustments are provided in Chapter 5.

CHAPTER 2

USER FEES AND QUALITY-ADJUSTED DEMAND CURVES

Rationing a fixed capacity resource by imposing a user fee is complicated in application by the difficulty of estimating a quality-adjusted demand curve. As the level of facility use declines, congestion costs decline, causing the willingness-to-pay of facility users to rise. The benefit of enhancing the quality of the experience to users as participation levels and congestion costs decline must be reflected in the estimated demand curve or user fees will be systematically under-estimated.

This chapter develops the estimation problem and the quality-adjusted demand curve, to apply to the problem. Using estimates of a quality-adjusted demand curve, the effect of prices on use can be more closely approximated than was previously possible.

The Estimation Problem

If it is assumed that congestion is the sole cost experienced by users visiting a facility, and that all users have similar tastes for congestion avoidance, then for a relatively homogeneous group of users the estimation problem can be illustrated with demand curves falling with level of facility use. Each demand curve represents a discrete user experience with use increasing and quality decreasing from WTP_1 ... WTP_N (Figure 2).

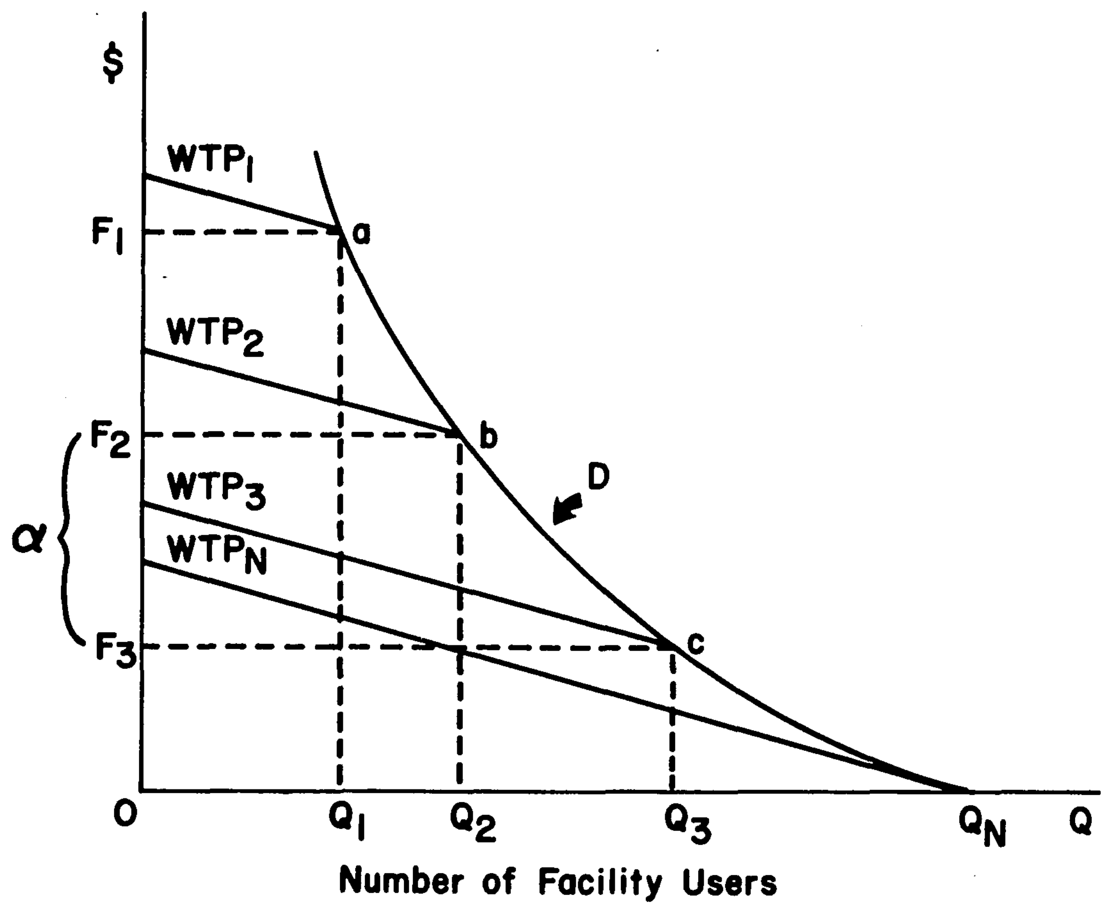

Figure 2. The quality-adjusted demand curve and the adjustment factor.

All users experience the same average congestion costs due to similar tastes and the discrete experience available. Then WTP_N is the average willingness to pay of participants when use is unrestricted at Q_N. Other constant quality willingness to pay curves are illustrated to portray average congestion costs decreasing with the enhanced quality available at lower levels of use (Fisher and Krutilla 1972).

Each willingness to pay schedule represents a different level of quality associated with changing participation. None of the schedules represents a demand function since only one level of use is observed. To associate the isolated levels of use and willingness to pay, a quality-adjusted demand curve is needed.

The Quality-Adjusted Demand Curve

Freeman and Haveman (1977) constructed the quality-adjusted demand curve by varying the participation price and computing the resulting number of facility users. For example, when an admission fee of F_1 is charged, Q_1 individuals will participate since these are the only individuals with a willingness to pay greater than or equal to F_1 with use is Q_1. Point "a" therefore lies on the quality-adjusted demand curve (D). Points "b" and "c" are found by repeating the process for the specific levels of use Q_2 and Q_3. Since congestion costs are assumed to fall equally on all individuals, WTP_1 ... WTP_N are parallel.

When no fee is charged, facility use is Q_N where the marginal user's willingness to pay equals the average congestion cost. Typically, the resource manager has willingness to pay information taken at this unrestricted level of use, Q_N. Fees based on this information systematically establish participation rates greater than those desired. For example, if Q_2 is selected as a level of use, WTP_N would indicate a charge of F_3 while the necessary fee is F_2. The difference in these fees reflects the quality improvement associated with the reduction in average congestion costs experienced by the users when use decreases from Q_N to Q_2. A methodology is needed to measure the difference between WTP_N and WTP_2 at Q_2. Specifically, an adjustment factor (α) must be estimated to account for the increased quality experienced by users when the use declines from Q_N to Q_2.

The implementation problem facing the use of fees to ration the use of a fixed capacity facility subject to congestion costs arises directly out of the difficulty of estimating how congestion costs will be reduced as participation rates decline. In particular, an estimate for the change in average congestion cost is needed so that a quality-adjusted demand curve can be estimated from the readily available schedule of unrestricted willingness to pay.

A Summary of the Fee Rationing Problem

Policymakers faced with congested facilities generally have information to estimate WTP_N. That information, when used to ration a facility with fees, establishes a higher level of use than the level of use that is optimal. This error in pricing can be corrected by estimating the adjustment factor α to account for changes in quality from changes in use. The measurement problem is one of establishing the difference between D, the quality-adjusted demand curve, and willingness to pay for unrestricted use, WTP_N.

In the next chapter, three previous methodologies for measuring congestion are discussed. Evaluations are made about both the users' willingness to pay responses and the methods used to estimate congestion, in terms of accuracy and bias.

CHAPTER 3

A SUMMARY AND CRITIQUE OF THREE PREVIOUS APPROACHES TO MEASURE WILLINGNESS TO PAY DIFFERENTIALS ATTRIBUTABLE TO CONGESTION

This chapter reviews three empirical methodologies used for measuring changes in willingness to pay associated with congestion. The models are introduced, the data and data gathering procedures are discussed, the findings presented, and the methodologies critiqued.

All used a proxy variable for congestion in multiple regression studies. The choice of a proxy varied. Cicchetti and Smith (1973) used encounters (unexpected meetings of other recreators) in their consumer utility model to estimate the effect of congestion of individual demand in a wilderness area. McConnell (1977) attributed congestion to the number of users at a site in his individual consumer utility model of urban beaches. Similarly, Deyak and Smith (1978) modeled congestion using the number of users visiting an area in their household production function model of recreators by regions of the United States.

A major focus of these studies was the decision to participate and the timing of the decision in relation to optimal management strategies for the study areas. The studies addressed the specification of the congestion variable to a lesser extent. Only Cicchetti and Smith attempted to select congestion variables that directly estimate the qualities of a recreation experience. The latter two studies relied solely on the number of visitors per acre to estimate marginal congestion costs. This chapter discusses possible problems with such variable specifications and the tradeoffs a researcher must address as he specifies congestion variables.

The Encounters-Individual Demand Approach: Cicchetti and Smith Methodology (1973)

The Model

Using a utility maximization framework, Cicchetti and Smith (C-S) modeled individual willingness to pay for use at a Montana wilderness as a function of number of days visited, number and type of trail encounters, number of nights of camp encounters, income of the head of the household, weeks of paid vacation of the individual, sex, years of school, and age. Willingness to pay for a unit of service provided by the wilderness was based on the total level of use perceived by the i^{th} user:

$WP_i = f(L_i, T_i, C_i, F_i, W_i, S_i, E_i, A_i)$, where

WP_i = willingness of pay of the i^{th} individual.

L_i = length of stay in days.

T_i = number of encounters on the trail per day.

C_i = number of nights of camp encounters.

F_i = income of the head of the household in thousands of dollars.

W_i = weeks of paid vacation.

S_i = sex of the individual.

E_i = education in years of schooling.

A_i = age of the individual.

The model represents marginal congestion costs to the i^{th} individual as the reduction in WP_i when C_i or T_i increases.

Data and Data Gathering Procedures

A mail survey was used to solicit willingness to pay for hypothetical combinations of the variable from previous visitors.[1] After two mailings of 600 surveys, 195 useable surveys were obtained. Each questionnaire had five different willingness to pay questions which were chosen from combinations of encounters and days of use. Sixty consistent combinations were selected for the questionnaire by limiting these variables to zero to three trail encounters, zero to four nights of camp encounters, and length of stay from one to five days.

Findings

After considering both linear and nonlinear specifications of the willingness to pay function, semi-log specifications were found to perform better. Citing unpublished work by Stankey, Cicchetti and Smith (p. 19) explained their reason for using this congestion-encounter relationship: "The effect of each additional encounter (trail or camp) upon satisfaction depends upon the total number of encounters the individual has experienced." A semi-log function measures increasing congestion costs at a decreasing rate to reflect this dependence.

C-S also addressed the attributes of a good or service as affected by congestion. To the extent that increased use disturbs the attributes, willingness to pay may be negatively affected. The revealed willingness to pay provided by the users was found to be affected by the congestion measure encounters. When C-S (p. 29) applied their model as

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1. Robert Lucas and George Stankey helped develop and administer the questionnaire.

a management tool for wilderness use decisions, they determined that "the results are sensitive to the assumed encounter-use relationship and, therefore, we conclude that more attention should be focused upon empirical derivations of these physical relationships."

A Critique of the Methodology

The Surveyed Response Issue. As are most recreation facilities, wilderness areas are non-market facilities. For the services provided at such non-market facilities, Fisher and Krutilla (1972, p. 437) state the two techniques available to determine the value users have for the service flow: "(1) an explicit set of questions put to the individuals requesting them to state the value of the experience; or (2) indirect inference of the value from some aspect of their observed behavior." The second (indirect) technique is generally preferred, since recreationists are unlikely to bias the travel and time costs incurred, which are the behavioral aspects most often used as surrogates of facility value. By comparison, surveyed responses to direct willingness to pay questions have a greater potential for bias since respondents do not have to fulfill their expressed desires.[1]

C-S utilized mail-survey willingness to pay responses, rather than time and travel costs. One probable reason is that travel costs are fixed for any individual while individual willingness to pay for combinations of the use-encounter variables are hypothetically variable. If the travel cost method had been used, more questions would need to be asked, making the survey more cumbersome. The longer the survey, the

1. See Freeman (1979) for a presentation of the sources of bias.

less likely respondents would tolerate the inconvenience, thus increasing the likelihood of bias or reducing the number of responses. Direct examination techniques always require a tradeoff between sampling more attributes, thereby incurring higher costs or risking biasing the model with omitted variables.

The Congestion Variable Specification Issue. The estimates of the coefficients for the variables in the C-S model were significant. However, the deviation in willingness to pay explained by the independent variables ($\bar{R}^2$) was very low, ranging from .043 to .064. Of particular importance in this study was the attempt to explicitly account for the quality changes experienced by users as congestion costs increase. The use of encounters as a proxy for congestion allows the quantity, quality, and location characteristics of congestion experiences to be varied. Overall, the use of encounters to measure congestion better captures the qualitative nature of congestion than level of use, which was the congestion variable used by McConnell and Deyak and Smith. The lack of sufficient qualitative characteristics to describe the experience could help explain the inability of the C-S functions to measure variation in willingness to pay. Also, the hypothetical combinations used to obtain user willingness to pay may have resulted in inaccurate responses, since the user may never have experienced any of the five variable combinations during his visit. The use of direct measurement techniques requires that more explicit approximations of the multidimensional nature of congestion be restricted by the need to remain as realistic as possible.

The Level of Use-Individual Demand Approach: McConnell Methodology (1977)

The Model

Within a utility maximization framework, McConnell modeled individual willingness to pay for visits to several Rhode Island beaches. Family income, per acre attendance, temperature, and per season visits were used to explain willingness to pay. Coefficients for the variables were calculated using ordinary least squares estimates for a semi-log functional form. A semi-log specification was also used by C-S. The congestion effect of use per acre is allowed to diminish as the absolute level of use increases, a condition that McConnell (p. 191) felt: "appeals to intuition." McConnell used the following function:

$WP_{ij} = f\ (y_i,\ q_j,\ t_j,\ x_i)$, where

WP_{ij} = consumer's surplus per visit of i^{th} individual to j^{th} beach.

y_i = family income of the i^{th} individual.

q_j = attendance per acre at the j^{th} beach.

t_j = temperature at the j^{th} beach.

x_i = per season visits of the i^{th} individual.

The marginal congestion costs to an individual are measured as decreases in WP_{ij} correlated with increases in q_j.

Data and Data Gathering Procedures

Observations of the variables were collected through surveys of beachgoers. Teams of four gathered the data. Two members of a team recorded temperature and entries and exits from the beach, while two administered the questionnaire. A total of 229 individuals on six beaches were contacted. The users were asked age, family income, education, occupation, place of residence, distance traveled to the site, and seasonal visits. Willingness to pay was obtained from a bidding game with $.50 increments.

Findings

Willingness to pay was correlated with increases in per acre attendance. The beaches required varying efficiency standards of use so that this diversity in crowding at the beaches would increase the social value. Expectations of users helped determine the optimal level of use for a particular beach. One beach was a social gathering spot where users expected to have contact with others while another beach was near a wildlife refuge where visitors desired a less congested experience. The standards of use established by the model for these two beaches were 2,127 and 28 users per acre, respectively. McConnell concluded by calling for research directed toward an enhanced understanding of interaction between capacity constraints and per capita demand resulting from the implementation of optimal standards.

A Critique of the Methodology

The Surveyed Response Issue. When no market exists for a facility, such as the urban beaches in McConnell's study, the two alternatives for determining a price have been established as: (1) an explicit set of questions soliciting a user's value for the experience; or (2) indirect inference of the value from some aspect of the user's observed behavior. McConnell selected an on-site survey. Although McConnell, as well as others,[1] expressed a preference for (2), with travel costs substituting as value, the marginal travel costs of a visit to an urban beach were not large enough to fully measure the consumers' surplus for that facility since the distance traveled, and therefore the expenditures incurred, were inconsequential.

By utilizing a bidding game, McConnell attempted to control for some potential sources of bias. To assure the desired response, the interviewee was told that his answers were only a test of preferences. However, since the users were not told that a pricing policy would be derived from their survey, overestimates of willingness to pay may have resulted.

The Congestion Variable Specification Issue. All coefficients for the variables were significant and the adjusted coefficient of determination was .29. While a coefficient of determination of .29 is fairly typical for research in recreation demand, a larger $\bar{R}^2$ might have resulted from the addition of characteristics attributable to the quality of the beach experience. Missing characteristics include the spatial arrangement of users, types of users encountered, the activities of nearby users, and other descriptors of the beach experience that deteriorate when use increases.

The only qualitative characteristic modeled was temperature, which was introduced to eliminate the bias resulting from the association of high temperatures with a more congested experience. A similar bias could have resulted from the absence of quality characteristics other

1. Dwyer, Kelly, and Bowes (1977).

than temperature. McConnell (p. 186) addressed the problem: "While it is possible to adopt the approach of Lancaster (1966), whereby the individual gets satisfaction from attributes of bundles of goods (such as solitude, cleanliness, etc.), the same results can be derived from the traditional approach."

The success of the traditional approach depends on the choice of a proxy variable to measure congestion. McConnell's choice, use per acre, may or may not measure the total effect of congestion on willingness to pay. To the extent that use per acre is correlated with changes in willingness to pay caused by perceived quality deterioration, the variable will measure congestion. However, if use per acre does not provide a good proxy, the resulting measurement of congestion will be poor compared with variable specifications that better capture the multi-dimensional nature of congestion experiences. While the addition of other variables can decrease bias in the measured congestion effect, adding other qualitative characteristics also increases length of time taken to survey users.

The Level of Use-Household Production Function Approach: Deyak and Smith Methodology (1978)

The Model

Deyak and Smith (D-S) modeled the effect of congestion on a household'a ability to produce constant quality service flows from the recreation facilities in their state of residence. The variables used in the model are presented in Table 1. Both price and quantity-participation equations were evaluated from the list of variables. Since

Table 1. Variables used in the Deyak and Smith (1978) model of congestion.

Name	Variable Description	Format
OTHER VEH	Ownership of camper type vehicle	Yes=1; No=0
WKND	Weekends available	Yes=1; No=0
WKND-WKDY	Weekends and weekdays available	Yes=1; No=0
SMSA	Live in SMSA	Yes=1; No=0
SUM HM	Have summer home	Yes=1; No=0
FINC	Family income	Actual #/100
$FINC^2$	Family income squared	
RACE	Race of sample person	Nonwhite=1; White=0
SEX	Sex of sample person	Female=1; Male=0
AGE	Age of sample person	Actual #
AGE^2	Age of sample person squared	
ED	Years of education--sample person	Actual #
MARRIED	Married sample person	Yes=0; No=1
CHK <12	Number of children less than 12 years of age	Actual #
CHK >12	Number of children greater than 12 years of age	Actual #
EMPLYD	Employed sample person	Yes=0; No=1
SUM EMPLOYD	Employed during summer sample person	Yes=1; No=1
WHT COLL	White collar job sample person	Yes=1; No=0
VAC DYS	Number of vacation days	Actual #
FAM TOT	Total # of persons in the family	Actual #
AGE H	Age of the head of the household	Actual #
ED H	Years of education--head of the household	Actual #
SEX H	Sex of head of household	Female=1; Male=0
EMPLYD H	Employed head of the household	Yes=0; No=1
NE REG	Live in Northeast region	Yes=1; No=0
NCEN REG	Live in Northcentral region	Yes=1; No=0
WST REG	Live in West region	Yes=1; No=0
CAMP S	Per capita campsites	Actual #
HK TR	Per capita hiking trail miles	Actual #
FOR AC	Per capita forest acres	Actual #
WILD AC	Per capita wilderness acres	Actual #
REG PK AC	Per capita regional park acres	Actual #
COMM PK AC	Per capita community park acres	Actual #
HIS CUL AC	Per capita historical cultural acres	Actual #
NAT PR AC	Per capita nature preserve acres	Actual #
WILD D	Wilderness area in state	Yes=1; No=0
CONG	Wilderness users per wilderness acre	Actual #

both travel costs and on-site costs were subject to choice, the price equation did not function well. Therefore, only the quantity-participation equations were presented. While these equations provided a more extensive model of consumer utility than the C-S or McConnell models, their congestion measure was admittedly "crude" (D-S, p. 79). This measure, wilderness users per wilderness acre, sampled only the gross quantitative effect use had on willingness to pay.

Marginal congestion costs were arrived at by minimizing the cost of service flows for a household which decided whether or not to participate, but had no control over the level of congestion. Increasing marginal congestion costs had the measured effect of decreasing the probability of participation.

Data and Data Gathering Procedures

The 1972 National Recreation Survey provided observations of the demand-determining factors of time availability, education, and socio-economic status. The Bureau of Outdoor Recreation and the Forest Service provided the recreational facility characteristics for the household's state of residence. Coefficients for the variables were estimated from 4,029 possible observations using ordinary least squares (OLS) and a linear functional form. After discussing possible problems inherent with the use of OLS in dichotomous models, Deyak and Smith (p. 73) summarized their discussion by stating that OLS "seems quite robust and offers ready interpretations for the estimated coefficients, . . ."

Findings

Both quantity of participation and level of participation equations were presented for remote and developed camping. Only the probability of participation was correlated with the congestion variable. This relation led D-S to conclude that once the decision to visit had been made, the level of participation was unaffected by congestion.

A Critique of the Methodology

The Surveyed Response Issue. Since indirect observations were used to determine both the probability and level of participation, one of the sources of bias inherent in direct surveys of willingness to pay was avoided. The bias that results from an individual associating the outcome of a survey with his income was avoided since willingness to pay for a recreation service was not solicited. Although this source of bias was avoided, the crude nature of the congestion proxy makes interpretation of the resulting congestion estimates obscure.

The Congestion Variable Specification Issue. A discussion of all the D-S results from their congestion proxy variable (seasonal averages of use at wilderness sites) is unnecessary for the purposes of this thesis. When developed camping areas substitute for remote camping areas, the demand for developed camping is likely to increase as levels of use increase at remote sites. In this case, the D-S congestion proxy variable would measure congestion effects at either type of recreation site. However, D-S (p. 78) explained that, "Because the congestion variable measures users of wilderness and primitive areas and given the inherent nature of the activity, we would expect a negligible effect on the probability of participating in developed camping." Since the two types of camping are inherently different, and due to the slight possibility that an individual expecting congestion at a remote site would in turn visit a developed site, the congestion variable cannot be expected to provide a satisfactory measure of congestion at developed campsites. The subsequent analysis of this approach is, therefore, limited to the five remote congestion coefficients in Table 2 and the equations from which they were derived.

The statistical results for the model were poor even for recreation research. The coefficients for the variables frequently lacked statistical significance with $\bar{R}^2$'s ranging from .08 to .17. While these coefficients of detemination are low, the broad nature of the survey data available precluded the use of a more qualitative approach. The model R had 37 variables which were readily obtained from the three sources cited earlier. Any additional qualitative facility characteristics would have had to be obtained by mail survey or from on-site surveys, thereby significantly increasing the information gathering costs.

A Summary of Previous Congestion Methodologies

Several problems resulting from the use of previous congestion models have been discussed in this chapter. The problems of bias with surveyed responses were evident in the C-S and McConnell research. The lack of characteristics modeling the full complement of qualities inherent in a recreation experience was evident in all the studies. Although C-S attempted directly to specify the qualities of a congested

Table 2. Empirical results for the reduced form Deyak and Smith (1978) model.

	OLS Estimates for the Probability of Participation Equations						OLS Estimates for the Quantity-Participation Level Equations[a]			
	Remote Camping			Developed Camping			Remote Camping		Developed Camping	
	Vacation	Trip 1	Trip 2	Vacation	Trip 1	Trip 2	Vacation	Trip 1	Vacation	Trip 1
Congestion variable	-0.0147	-0.0112	-0.0142	0.0101	-0.007	-0.0008	0.2564	-0.1851	1.4081	0.2321
t statistic	1.3816	1.9817	1.2597	1.4639	1.2509	0.1095	0.4538	0.1915	1.7612	0.4926
$\bar{R}^2$ for the equation	0.08	0.08	0.10	0.30	0.25	0.30	0.18	0.17	0.08	0.31

[a]The quantity-participation equations were estimated for a reduced form of the probability of participation equations. The t statistics are for the null hypothesis of no association. $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom.

recreation experience, their technique is hampered by the need to sample more characteristics while remaining cost effective.

The use of any direct approach necessitates several tradeoffs. While selecting encounters as a proxy variable allows the researcher to vary quality, quantity, and location of congestion, this flexibility is tied to the need to remain as realistic as possible. As the flexibility is exercised to a greater extent, significant increases in research time and resources are incurred. The proxy variable users per acre approach can lessen these costs, but fails to measure the full costs of congestion.

The following chapter deals with an indexation approach to measuring the quality-adjusted demand curve described in Chapter 2. This indexation approach avoids some of the problems discussed in this chapter, thereby avoiding the use of crude congestion proxy variables without increasing research costs.

CHAPTER 4

AN INDEXING APPROACH FOR MEASURING CHANGES IN WILLINGNESS TO PAY

This chapter presents an indexing method that applies a residual to measure willingness to pay changes from deterioration in the quality of the user's experience caused by the external costs of congestion. To demonstrate the method, the relationship between quality and changes in willingness to pay is developed, alternative techniques for indexing willingness to pay differentials are presented, and the indexing residual and constructs are developed from a previous application. The problems with the three previous approaches discussed in Chapter 3 are addressed as they are mitigated by the technique presented in this chapter.

Indexing for Quality Change Measurement

A paper by Nicholson (1967) developed several possible indexing techniques used to measure user value changes from attendant quality differences in a consumer good. Although Nicholson's remarks applied to the consumer price index, one of the techniques is well suited to the specific problems arising from the measurement of congestion externalities. Nicholson began by establishing an ideal index sample and then reported on the appropriate indexing technique to use with alternative sampling scenarios.

With respect to the service flow derived from a facility, assuming other attributes are constant, a consumer will be indifferent towards use at two different time periods if he expects the quality of the experience to be the same for either visit. The user is assumed to have his choice of time to visit so that he places the same value on either visit. The user is assumed to have his choice of time to visit so that he places the same value on either visit. However, if a user expects that visits during one time period will be of lower quality, he places a lower value on the lower quality experience which is reflected either by his decision to visit only during time periods of higher quality or by his lower willingness to pay for the lower grade experience. Since this user is assumed to be willing to pay more for one time period over another, the difference can be attributed to a true difference in quality. These conditions are ideal for measuring congestion.

For the visitor to a fixed capacity facility, only one level of quality can be observed at any one time period. In order to obtain different use levels and the attendant willingness to pay of users, Nicholson (pp. 513-514) offered a second method for indexing changes in quality requiring that the researcher ". . . try to take account of changes on the basis of relative prices at times when the different qualities are bought simultaneously." While this technique controls for variation in a respondent's tastes and preferences over time, it cannot reflect variation in facility quality since it is not possible for the user to "buy" two different qualities simultaneously unless willingness to pay is provided hypothetically. The Cicchetti and Smith study solicited willingness to pay for hypothetical wilderness use where different qualities were bought simultaneously, but obtained poor statistical results.

To obtain a representative measure of variations in congestion effects at a facility, the indexing technique to use should reflect actual quality changes and associated user value changes. Samples of individuals at different time periods are therefore necessary. In order to obtain unbiased estimates from samples of different users, all factors relating to or determining demand must either be controlled by partitioning the sample or indexing the factors as explanatory variables for demand at the facility. Nicholson (p. 513) described the reason these factors need to be considered: "The prices which different people are willing to pay may vary according to their needs and circumstances--incomes, age, size and composition of family, occupation, place of residence, etc.--and according to their habits and tastes . . ." By partitioning the sample, and indexing these factors as determinants of demand, the differential in willingness to pay that is correlated with each factor can be controlled, so that any residual differential is attributable to any factors remaining.

The Use of An Indexing Residual

To the extent that all exogenous demand determinants can be specified for a homogeneous sample of users, any difference in willingness to pay between the two groups of users can be attributed to a difference in the quality of the experience during their visitation. The third indexing technique Nicholson presented measures quality differences as a residual after indexing all other determinants of demand for otherwise homogeneous samples of users. Nicholson (p. 516) described the technique as ". . . an index of the change in prices of a specified set of qualities, which could be those available at either of the two dates (or some combination of them), in which case the value of any changes in quality would be obtained as a residue." The two dates, or times of visitation for a congestion study should differ in use so that any difference in demand can be measured. For example, weekends and weekdays should allow for the measurement of the willingness to pay differential.

The indexing "residue" or residual technique solves the sampling problems resulting from the need to obtain responses at differing use levels. Variations among users that affect demand for the facility can be partitioned to provide a homogeneous sample of facility users whose remaining determinants of demand can then be indexed to account for differentials in willingness to pay, leaving the one affixed to congestion.

The indexing residual technique allows the researcher to forego the selection of realistic hypothetical encounter scenarios in an attempt to fully account for quality differences at a facility. This simplification eliminates some research cost and a possible source of bias. To apply the indexing residual technique, the researcher has only to observe and account for similarities and (or) differences between the congested and uncongested samples of users.

Application of the Indexing Residual

The utility of indexing to measure congestion was presented in the previous section. The sample of users needed to measure congestion requires that questions be asked of different individuals visiting at different time periods. The appropriate indexing technique measures the residual willingness to pay difference between two otherwise homogeneous groups of users for the two time periods. This section describes a previous application of the indexing residual and how the technique is applied to estimating a quality-adjusted demand curve.

A previous application of the indexing residual technique by Gwartney (1970) should prove useful for expanding this methodology to the measurement of congestion externalities. Gwartney posited that income differences between whites and non-whites are a function of productivity factors and color discrimination. By stratifying the relevant white and non-white populations and indexing the productivity factors using the Laspeyres and Paasche indexes, he obtained two percentage differences in income that can be viewed as boundaries for the income differential attributable to color discrimination.

To account for income differences between whites and non-whites resulting from productivity factors, the sample was partitioned to include only employed urban males and then indexed to account for productivity factors. The remaining income difference (12% to 18%) was attributed to employment discrimination. A similar approach can be adopted for measuring willingness to pay differentials attributable to differences in congestion.

Just as an individual's income is determined by productivity factors and color discrimination, an individual's demand (willingness to pay) is a function of numerous demographic and socioeconomic factors (X) and the perceived quality of the service flow. Two samples of users, taken at differing levels of facility quality, demand the two service flows as a function of factors pertaining to X and congestion. For the measurement of congestion, individuals with similar X who differ only in the amount of congestion experienced while visiting the facility provide the appropriate comparison. To obtain this comparison, the total sample is partitioned to select individuals who were sampled while exogenous factors related to demand were similar. Remaining factors that determine demand are then indexed using the Laspeyres and Paasche indexes to account for differences in willingness to pay attributable to X. Any remaining differential in willingness to pay is the result of congestion differences between the two levels of use.

Two groups of individuals who differ only in the quality of the service flow while visiting can be expected to value the facility differently. Given the choice, any individual would be willing to visit the facility during times of low quality only when he can expect to pay less for his use. The less congested (higher quality) experience would always be preferred if the costs of any visit were the same. The respondent would be expected to be willing to pay more for the less congested experience. Greater differences in quality at one time compared with another create greater differences in willingness to pay. To obtain this differential attributable to congestion, the sample must first be partitioned. The following section describes this process.

Partitioning the Sample

Partitioning the sample accounts for the effects of exogenous factors on demand, thereby making a sample with comparable individuals. Gwartney's homogeneous sample included employed urban males of similar productive capacity who differed only in color. The relevant data concerning the specific sample (employed white and non-white urban males) was taken by Gwartney from the 1960 census and the Coleman Report.[1]

The sample was partitioned to obtain the male sample having individuals who differed only in productivity factors and color discrimination. In like manner, the effects of exogenous factors on demand at a congested facility can be partitioned so that the conditions related to demand are similar across respondents. Examples of facility characteristics partitioned for this congestion study are time of use, temperature, and fishing success. Gwartney's use of indexing should provide the information needed to apply the second step of the indexing residual approach.

Indexation of the Sample With Laspeyres and Paasche Indices

Gwartney (p. 398) used three criteria for choosing productivity factors relevant to the explanation of income differentials between whites and non-whites.

> First, only factors generally recognized as determinants of money income, or as closely correlated with income, were used in this study. Second, the factors chosen are _not_ directly related to employment discrimination as such. . . . Third, factors were either considered simultaneously, or chosen where the apparent relationship with other factors was one of independence.

Gwartney's criteria also apply to the selection of factors related to recreation demand. Factors were chosen as they were relevant to the explanation of willingness to pay differentials between users

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1. A study for the U.S. Office of Education by James Coleman et al., which estimated differences in scholastic achievement between whites and non-whites in terms of quantity of education (years of schooling) for three grade levels in metropolitan areas.

experiencing differing levels of congestion. First, only factors recognized as determinants of recreation demand, or closely correlated with willingness to pay, were selected. For example, the income of an individual is a determinant of recreation demand while the number of times he visits is closely correlated with his demand for the site. Both factors were therefore indexed to standardize their effects on the willingness to pay differential. Second, with the possible exception of income, the factors were not related to the congestion residual. Although a case can be made for correlation between income and congestion, omitting income from the factors would have seriously biased the results. The implications of this bias are discussed in the following chapter. Third, factors whose relationship was one of dependence were considered simultaneously, leaving the remaining independent factors to be indexed singly. For example, the relationship of occupation and income was determined to be strong enough to warrant their simultaneous consideration, while all other factors were considered individually.

In order to standardize the sample of users to account for the factors that are determinants of demand, the Laspeyres and Paasche indexes are applied to the stratified sample of users. The effect that indexing has on the sample for each explanatory variable X is to increase (decrease) the willingness to pay differential if the sign of any variable X is positive (negative).

The unadjusted index follows:

$\frac{\Sigma W_q \cdot \theta_a}{\Sigma W_b \cdot \theta_b}$ where

W_a = the average willingness to pay of individuals in the congested group of users who are within a willingness to pay determinant category (e.g., income, frequency of visits, or distance from site), other than congestion costs.

W_b = the average willingness to pay of individuals in the uncongested group of users who are within a willingness to pay determinant category, other than congestion costs.

θ_a = the percent of the congested group of users within a willingness to pay determinant category, other than congestion costs.

θ_b = the percent of the uncongested group of users within a willingness to pay determinant category, other than congestion costs.

The distribution of the users' willingness to pay on weekdays, a, is adjusted to equal that of the weekend users by forming the Laspeyres index:

$$L = \frac{\Sigma W_a \cdot \theta_b}{\Sigma W_b \cdot \theta_b} (100)$$

Similarly, the distribution of the users' willingness to pay for the weekend, b, is adjusted to equal that of the weekday users, by constructing the Paasche index:

$$P = \frac{\Sigma W_a \cdot \theta_a}{\Sigma W_b \cdot \theta_a} (100)$$

For example, age is a factor that can be correlated with willingness to pay differences between weekend and weekday users. The Laspeyres index is constructed to establish the hypothetical ratio of the median willingness to pay of weekday to weekend users, assuming both groups have the age distribution of the weekend users. The Paasche index is constructed to provide a similar hypothetical ratio assuming both groups have the age distribution of weekday users.

The Laspeyres and Paasche indexes are applied to the factors X for the relevant sample (a and b) to establish distributionally homogeneous groups for estimates of α (the factor which is used to adjust average congestion costs to approximate D[Q]). The two indexes provide marginal factor changes for the unadjusted ratio due to each factor X: the Laspeyres index gives all users the distributional characteristics of the weekend users while the Paasche index provides all users with those characteristics of the weekday sample of users. The indexed ratio established a lower bound for the Laspeyres index and an upper bound for the Paasche index.

In order to show how the Laspeyres and Paasche indexing residuals provide fully adjusted ratios of willingness to pay that are bounds to α, a system is needed to incorporate the marginal effect of each factor into the unadjusted ratio to reflect the simultaneous effect of all factors X. In order to estimate a residual that reflects an overall adjustment, the percentage change resulting from each factor is determined from the difference between the unadjusted ratio and the adjusted ratio of willingness to pay differences. The raw difference is then reported for the adjustment of the first factor; then other indexing adjustments to willingness to pay are obtained from the remaining factors by first measuring the difference between the relevant factor and the unadjusted ratio. Then this raw difference is added to the previously adjusted factor and the resulting difference is reported. Using this technique, noncongestion determinants of willingness to pay are used to adjust the differential in average willingness to pay between the two groups. The residual difference becomes an estimate for the difference in average congestion cost at the two levels of facility use.

The estimate for the change in average congestion cost determined by indexation can be used to estimate a quality-adjusted demand curve for the congested group of users. This relationship is illustrated in Figure 3. The estimated change in average congestion cost for a reduction in use from Q_c to the less congested level at Q_u is α. The willingness to pay of the congested group of users (WTP_c) is estimated to increase the amount α when the level of use decreases from Q_c to Q_u. The second point, a, on the quality-adjusted demand curve can now be located by adding α to WTP_c. A linear approximation of the quality-adjusted demand curve is shown as $\hat{D}$.

The Indexing Residual Technique and Previous Measurement Problems

Three problems were discussed with the previous approaches to measuring congestion in Chapter 3: (1) survey design problems as they related to the measurement of congestion externalities; (2) variable specification problems with the qualitative framework needed to measure congestion; and (3) costs of measuring the qualitative variables directly to provide that framework. From the presentation of the Gwartney technique and the sampling scenarios described by Nicholson, all three problems are mitigated or eliminated.

The survey design problem that occurs for direct questions of user value for a specific experience can be mitigated by the indexing residual technique. Any sampling scenario needed to measure congestion requires that users are sampled at no fewer than two levels of use. The

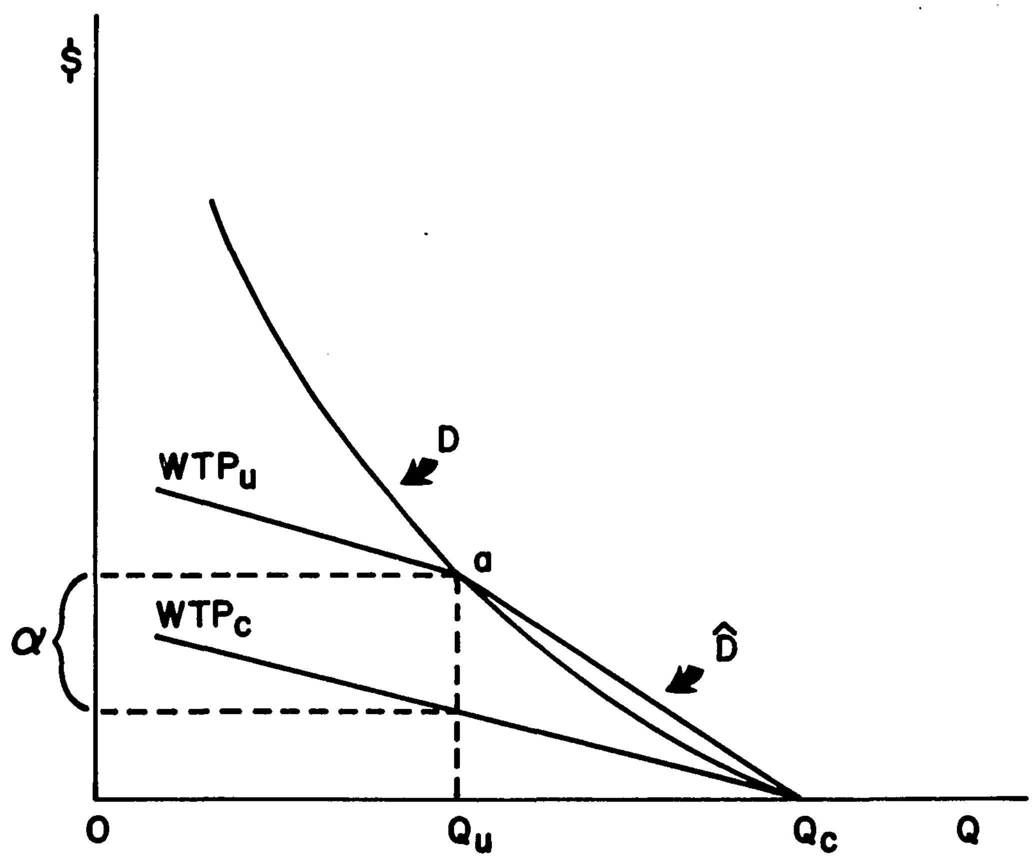

Figure 3. Linear approximation of a quality-adjusted demand curve.

willingness to pay responses solicited from users at differing time periods vary over time and between individuals, requiring that these effects be accounted for by any approach used to measure congestion. However, rather than attempt to enumerate and model all the characteristics which are perceived to deteriorate as use increases, all the willingness to pay differential associated with congestion differences is indirectly determined from a residual. Survey design is therefore simplified as the number of variables is decreased by using the indexing residual approach.

Furthermore, the need to model all the kinds of qualitative characteristics for the specific site is eliminated. The congestion variable specification problems associated with the qualitative characteristics become a simple partitioning and indexing problem. The elimination of these variables, such as levels of use and types of encounters, also reduces the costs of accurately determining congestion at a facility.

Review of the Gwartney Indexing Technique

From a paper by Nicholson, three possible scenarios were established for measuring quality differences as they relate to value differences for two grades of a commodity. With no unrealistic assumptions, unbiased estimates can be obtained for the adjustment factor described in Chapter 2 by using the indexing residual technique. The three problems dealt with in Chapter 3 were either mitigated or solved by the indexing residual technique. Those benefits are tested in the next chapter from use data on Chaparral Lake in Phoenix, Arizona, as they apply to the empirical application of the indexing residual technique.

CHAPTER 5

AN APPLICATION OF THE INDEXING TECHNIQUE: MEASURING CONGESTION COSTS AT AN URBAN PARK

This chapter applies the indexing methodology developed in Chapters 2 and 4 to measure congestion at an urban fishing site in metropolitan Phoenix, Arizona. Characteristics of the site and the users are reported. Next, several factors related to willingness to pay are partitioned, thereby controlling for some willingness to pay differentials between high (weekend) and low (weekday) use groups. The remaining non-congestion determinants are then accounted for by indexation. The procedure establishes the adjustment factor (α) required by a policy maker for accurate pricing policy determinations for Chaparral Lake.

Site and User Characteristics

Chaparral Lake, covering about 10.5 acres, is located in Scottsdale, Arizona, on Hayden Road between McDonald and Chaparral Roads. It is a part of the Indian Bend Wash Greenbelt system. Chaparral Park has other facilities, including a stadium, a municipal pool, picnic tables, and playing fields.

In July, 1977, the Arizona Department of Game and Fish began an experimental one-year program of stocking fish in the park lake. To make the program partially self-supporting, special urban lakes fishing permits were required of anglers. Cold water and warm water seasons were designated by planting trout from mid-November, 1977, to the end of

March, 1978, and carp, tilapia, and channel catfish during the rest of the year-long program.

The Survey

The sample for this study was selected from a larger data set solicited by personal interviews on the shores of Chaparral Lake.[1] The procedure used is explained in Martin, Garifo, and Gum 1980 (p. 53). Two weekdays and one day of the weekend were selected at random each week. Having determined the days, one of four time periods was randomly drawn. The day was divided into: morning from 6 a.m. to 10 a.m.; noon from 10 a.m. to 2 p.m.; afternoon from 2 p.m. to 6 p.m.; and night from 6 p.m. to 10 p.m., or closing of the park, whichever came first.

The interview and sample size were determined when the interviewer arrived at the lake. A count of all the people present at that instant (I) was made. If I was less than 10, all anglers were interviewed. When I was greater than 10, every n^{th} person was interviewed where,

$$n = \frac{I}{10}$$

rounded to the nearest integer. Since the highest level of use recorded was 99, no more than 10 interviews were taken for any day. The interviewer made one complete circle of the lake, recording all individuals on a tally sheet containing fishing characteristics of the day while soliciting responses to the questionnaire. For the one-year period, 471 adults were interviewed, which accounted for 12% of the 3,801 adult fishing permits sold in the Phoenix area.

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1. Arizona Game and Fish conducted the survey.

Two different questionnaires were used with willingness to pay values being solicited in one of two ways.[1] Either the answer was a direct response of the user's highest willingness to pay for the permit, or the answer was solicited from a 5 dollar auction. Sample partitioning made the use of both questionnaires necessary to obtain enough observations.

Characteristics relevant for partitioning the users were taken from the tally sheet of the daily characteristics pertinent to the anglers' fishing experience. The questionnaire consisted of 29 items, including willingness to pay for a 6-month permit, distance traveled to site, various demographic variables, and income levels. The interviewers recorded the number of people fishing, numbers and kinds of fish caught, the number of hours each angler spent fishing, race, sex, and age of anglers present. For indexing purposes, these data were partitioned so that several factors influencing willingness to pay differentials between weekday (low use) and weekend (high use) permittees could be controlled.

Determinants of Willingness to Pay Accounted for by Partitioning

Levels of use were the primary consideration for the partitioning process. A notable increase in use occurred during the winter months. Upon consideration of factors that could be correlated with the increased use, the fish plants were found to be closely related. Specifically, the type of fish (rainbow trout) and the 2-week frequency of plants was

1. Willingness to pay questions were asked for the fishing experience as is, for doubled creel limits, and no stocking. The results of willingness to pay estimations, as well as estimates of net program benefits are reported in Martin et al. (1980).

coincident with higher winter use and levels of use and success. Since these higher levels of use occurred on alternate weeks following the fish plants, the sample was partitioned to include only high success weeks of trout fishing.

Rainbow trout (Salmo gairdneri) were first stocked on November 16, 1977, with 1,000 more being planted at approximately 2-week intervals. The trout season was limited to November 16, 1977 to March 11, 1978 by these stocking procedures. High success fishing was found to last for one week.[1] Since weekend and weekday use was the primary partition, the comparison of willingness to pay differentials was restricted to weekday and weekend anglers who fished during high success periods. The average fishing success of the anglers was .29 and .26 trout per hour for the high success weekdays and weekends with no significant difference between the means.

The sample was further partitioned to daytime users to isolate the effects of institutional constraints on an angler's time that vary for day and night use much the same as they vary for weekend and weekday use. Night users were thought to be largely restricted to that time period due to employment during the day. Thus, the availability of time for fishing was different enough to warrant the partition.

One further partition was needed to account for the effect of income on willingness to pay. Anglers were asked their occupations. Incomes were derived from wage surveys taken in Maricopa County using

1. The null hypothesis of equal mean fishing success was tested at the .05 confidence level for high and low success to establish the stratification.

stated occupations. Data were therefore unavailable to determine income for students, juveniles, unemployed or retired respondents. Due to the importance of income for the explanation of willingness to pay, a further partition was made, leaving unemployed anglers out of the sample.

Participation levels were approximately 2.4 times higher during weekends than during weekdays. The mean willingness to pay for the former group was $6.79 while that of the latter group was $8.07. The unadjusted ratio of mean willingness to pay for the two groups was 1.187, indicating that the less congested weekday users were willing to pay 18.7% more on average for the fishing experience than the more congested weekend group of users.

A variety of factors can partially account for the 18.7% difference. Several of these explanatory factors were controlled for by partitioning the sample. Specifically, all users in the two groups were employed adults, fishing for trout during high fishing success periods in the daytime. Thus, differences in the type of fish caught, the rate of fishing success, employment status, or time of day participating did nto account for the willingness to pay differential between the congested and uncongested groups of users. A list of these factors is provided in Table 3. Moreover, interview days with unusually high levels of lake use (e.g., holidays), or unusually low levels of use (e.g., days with inclement weather) were omitted from the sample, to insure that the level of use within a group was comparable across individuals.

Average levels of use, calculated from the tally sheets, were determined to be 52 and 22 for weekend and weekday users, respectively,

Table 3. Willingness to pay of weekday users as a percentage of weekend users, adjusted for various determinants of willingness to pay differentials between weekday and weekend users of Chaparral Lake in 1977-78.

	Index of Willingness to Pay Differences		Marginal Effect of Factor	
	Laspeyres	Paasche	Laspeyres	Paasche
Unadjusted willingness to pay ratio (weekday/weekend)	118.7	118.7	-	-
Explanatory factors				
Income-occupation	116.2	103.2	-2.5	-15.5
Number of visits	119.4	122.0	3.2	18.8
Distance to site	96.3	101.9	-23.1	-20.1
Size of catch	116.5	104.6	20.2	2.7
Permittee age	124.5	106.8	8.0	2.2

Fisher ideal price index = 115.3

in the stratified sample. As expected, more juveniles visited on the weekends than on weekdays due to school. Average visitation was 31 adults and 21 juveniles on weekends and 10 adults and 2 juveniles on weekdays.

Determinants of Willingness to Pay Accounted for by Indexation

Having accounted for several factors influencing willingness to pay by selecting weekday and weekend anglers with similar fishing experiences, a willingness to pay differential of 18.7% still remained between the two groups. To isolate what portion of this differential is attributable to congestion cost differences, several additional factors influencing this differential were then accounted for through indexation.

Gwartney's (p. 398) three criteria were applied for the selection of factors to be indexed. First, only factors generally recognized as determinants of recreation demand, or as closely correlated with willingness to pay, were stratified. Second, the factors chosen were not directly related to congestion. Third, factors whose relationship was dependent were indexed simultaneously, with the remaining factors being indexed individually. Factors selected using these three criteria included income, occupation, visits per season, distance from residence to lake, total catch on day interviewed, and age.

A search of the recreation demand literature provided information to fulfill the first criteria. All seven factors were found to be related to demand for recreation facilities. In addition to this theoretical relationship, the empirical work of Martin et al. (1980) indicated the importance of these factors for determining the willingness to pay of Chaparral's anglers.

Income is the single factor that may have violated the second criteria. Freeman and Haveman (1977, p. 232) explain the implications for their model when income and congestion are related:

> The actual distribution of congestion cost is an empirical matter and will vary from case to case. However, for many facilities for which the quality of a visit would appear to be an important consideration for users, income is likely to be correlated with uncongested willingness to pay and the income elasticity of demand for avoiding congestion is likely to be greater than zero. In this case, the marginal user will bear less congestion cost than will the average facility user, and the optimal charge will be greater than that derived from the standard analysis based on the assumed homogeneous valuation of facility quality by potential users.

Thus, when income and congestion are correlated, the marginal user bears less congestion than the average user. Estimates based on the assumption of homogeneous valuations of congestion presented in Chapter 2 would underestimate the fee adjustment (α).

Since congestion is a composite of numerous characteristics, thereby making a reasonable test of income and congestion dependence difficult, the implications of heterogeneous congestion costs are not dealt with in this chapter. Secondly, since no clear empirical evidence exists, the assumption of homogeneous tastes for congestion avoidance and independent income and congestion variables were adopted.

While income and congestion are assumed independent, income and occupation are not. Following the third criteria, income and occupation were simultaneously indexed. This calculation prevented the double counting of willingness to pay differences that were caused simultaneously by income and occupation. For example, the service occupation group had lower than average incomes. Since the fishing at Chaparral was likely to have been an inferior good (Martin et al. 1980), lower income anglers would express higher willingness to pay relative to other groups. However, the effect is caused by a greater number of lower income users in service occupations. If the factors had been indexed separately, the income effect would be counted twice; once as the service group was indexed and again when the low income groups were indexed.

The definition of factors had a very important effect on the willingness to pay differential adjustment. Observations would be indexed in other cells when factor definitions were changed, thereby changing the degree and sometimes the direction of the adjustment. The range of observations was divided into cells using 1970 census categories for income-occupation and age factors. Cells correspond to blocks of data ranges in the histograms. Other factors were indexed by distributional considerations. When fluctuations or breaks in the frequency of anglers over the range of the variable occurred, cells were formed to reflect these characteristics. With the exception of the highest observations, all cells had the same range. In some cases, an extreme observation required the formation of a cell. For example, one angler traveled 196 miles to fish at Chaparral while all other anglers traveled less than 24 miles.

To summarize, the range of willingness to pay observations for each factor was divided into cells using the two criteria, convention and distribution. Since the number of observations was limited (15 on weekdays and 34 on weekends), finer division of the data was balanced with the resulting amount and direction a factor adjusted the willingness to pay differential. While adjustment for some factors caused large percentage changes in the willingness to pay differential (-20 and -23 for distance), the residual difference in willingness to pay after all factors were applied was a reasonable 7% to 24%.

The willingness to pay indexation adjustments were made using the mean of each cell, rather than the median observation used by Gwartney (1970). Means were used due to the small size of the stratified sample which often required placing one or two observations in a cell. Rather than using one of the two observations to approximate the true median, the mean value was thought to better reflect the true value for such a small sample.

For the partitioned sample, weekday users were willing to pay an average of 18.7% more for the average fishing experience. A portion of this difference in willingness to pay could be attributed to congestion. To standardize the effects of other factors that accounted for the remaining portion of the differential, the previously listed factors were indexed. A two-step procedure was used to discuss each factor and the adjustment process. First, the rationale for each factor's definition was given; second, the results were discussed in terms of direction of adjustment, degree of adjustment, and individual factor problems.

Income-Occupation Adjustment

Weekend respondents had a higher average income ($12,837) than weekday respondents ($12,391). A histogram of angler frequency over the range of income is provided in Figure 4, while the indexed factor, income-occupation, is provided in Figure 5.[1]

Occupations of interviewed users were exhaustively classified into five categories: professional and technical, managerial, clerical and sales, production, and service. For indexation, income and occupation differences between the two groups of users were treated simultaneously since the two factors are correlated. In particular, the income range of the users was divided into four $5,000 increments. Combining this classification with the five categories for occupation resulted in a 20 cell income-occupation distribution for lake users.

Imposing the lower income distribution of the weekday users on the weekend group resulted in an adjusted Paasche index of mean willingness to pay of 103.2 (see Table 3). Imposing the higher income distribution of the weekend users on the weekday group resulted in an adjusted Laspeyres index of 116.2. This amounts to marginal effects of -15.5 and -2.5 for the Paasche and Laspeyres indexes, respectively,

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1. The income data was determined from the "Maricopa County Employer Wage Survey" (Anderson, Kohler, and Helvie 1978) and the "Maricopa County Small Employer Wage Survey" (Porterfield and Curran 1978). The hourly wage by occupation obtained from the two sources was multiplied by a weekly average of hours worked for that occupation. The product was then annualized.

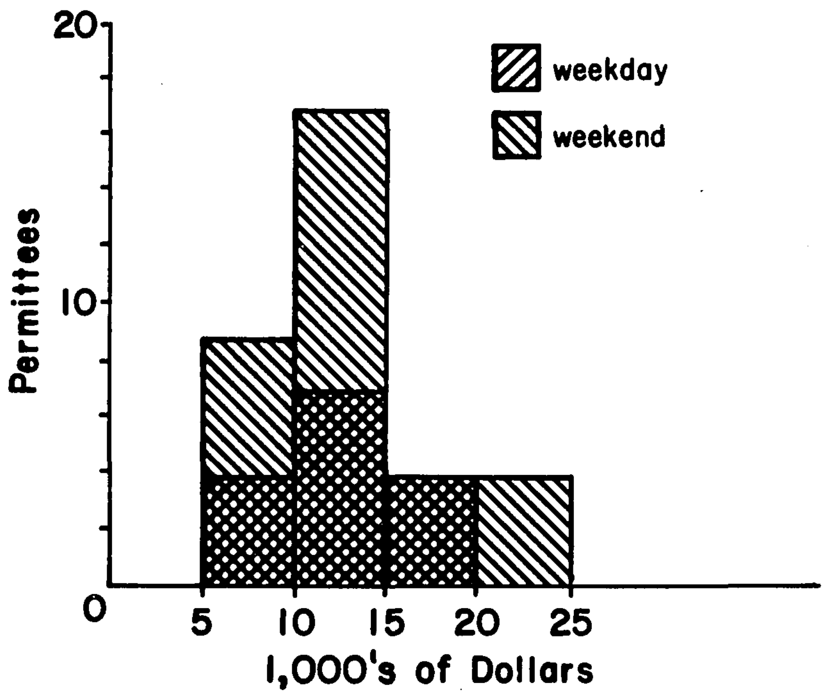

Figure 4. Histogram of permittees' income for partitioned weekday and weekend samples.

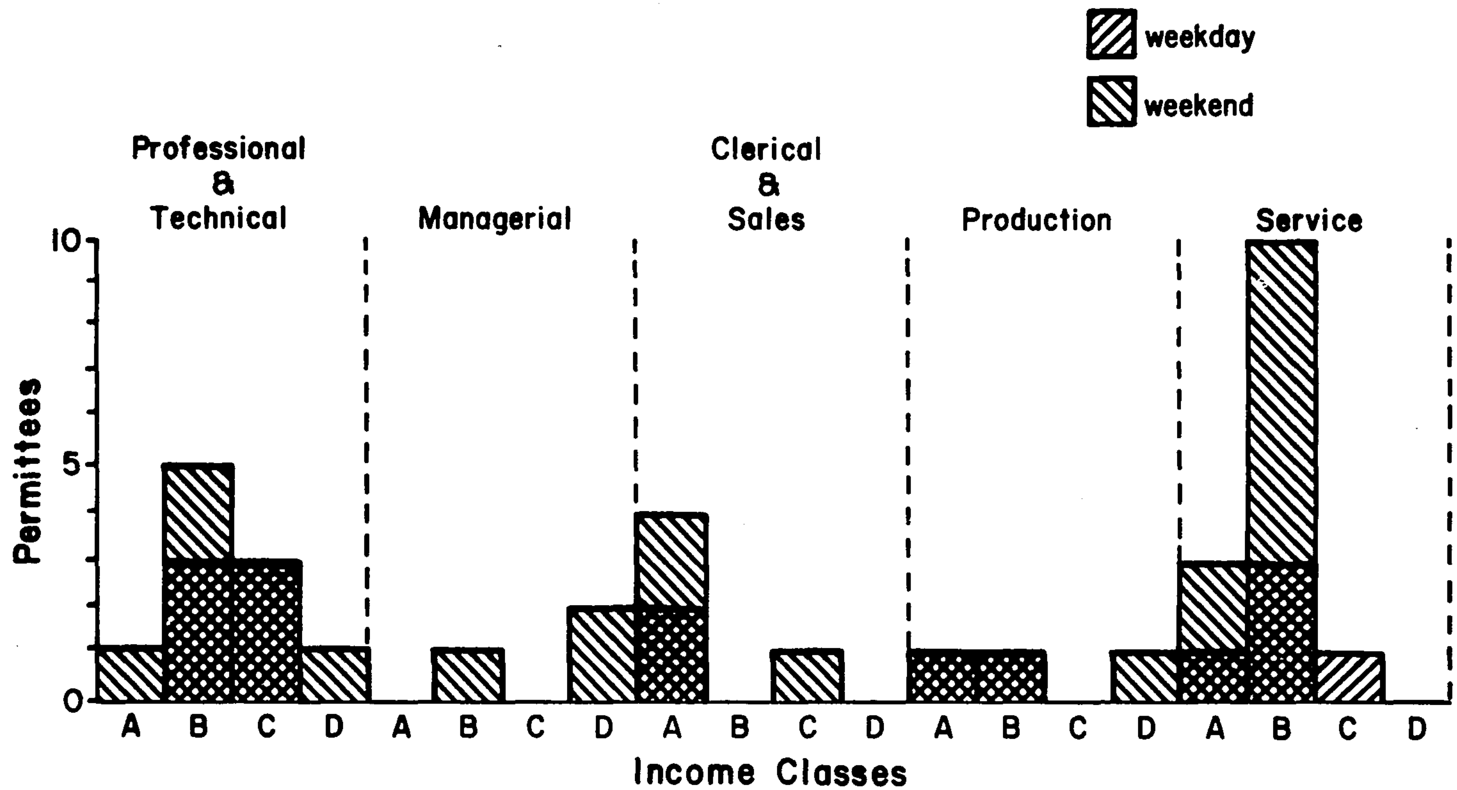

Figure 5. Histogram of permittees' income in occupation cells for partitioned weekday and weekend samples.--A. $5,000 to $9,999; B. $10,000 to $14,999; C. $15,000 to $19,999; D. $20,000 to $25,000.

compared with the unadjusted ratio of mean willingness to pay for the two groups of 118.7. That is, if the two groups of users had an identical distribution among income-occupation cells, the weekday users would still be willing to pay, on average, 3.2 to 16.2% more for the fishing experience. The downward adjustment of the unadjusted ratio after controlling for income-occupation differences is consistent with the empirical finding of Martin et al. (1980) that urban fishing at Chaparral Lake is an inferior good.

Visits Per Season Adjustment

Approximately 13% of the anglers in each group visited the lake in excess of 10 times per season. The remaining 87% attended less than 10 times per season, but the distribution among these users was markedly different. Only 6% of the weekday users attended more than five, but less than 10 times per season, while the remaining 81% of this group attended less than five times per season. In the weekend group, only 72% of the users fell into the five or less visits per season category. A histogram of these relationships is provided in Figure 6.

Since the weekend users had a relatively higher rate of participation, the willingness to pay for a season permit would be expected to be higher for this group on this basis. Imposing the higher participation distribution of the weekend users on the weekday group raised the Laspeyres index to 119.4, a marginal effect of 3.2. The adjusted Paasche index rose to 122.0 after imposing the lower participation distribution of the weekday users on the weekend group,

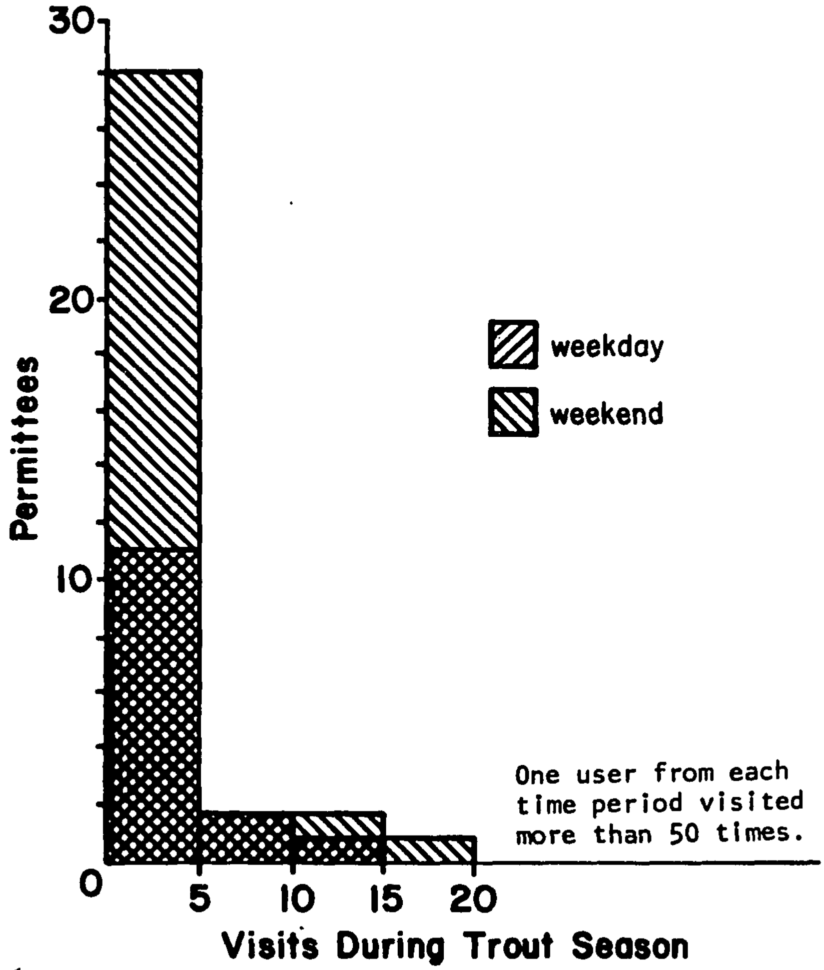

Figure 6. Histogram of projected permittee visits during trout season for partitioned weekday and weekend permittees.

constituting a marginal effect of 18.8. Thus, 3.2 to 18.8% of the differential between mean willingness to pay for the two groups can be accounted for by the higher participation rates of weekend users. Cumulatively, weekday users with income-occupation and participation rate distributions identical to those of the weekend group of permitees are estimated to be willing to pay between 19.4 and 22.0% more, on average, for the urban fishing experience.

Distance to Site Adjustment

Weekend users had less accessibility to the lake than the group of weekday users. While 62% of the weekend group of users had to travel in excess of 6 miles to participate, only 47% of weekday anglers fell into this category. Distance from residence to the lake was divided into four categories: 0 to 6 miles, 6 to 12 miles, 12 to 18 miles, and more than 18 miles. A histogram of the frequency of users visiting from various distances is provided in Figure 7.

Imposing the distribution of the more accessible weekday group of users across these distance categories on the relatively less accessible weekend group resulted in an adjusted Paasche index of 101.9, a marginal change of -20.1. The adjusted Laspeyres index fell to 96.3, a marginal change amounting to -23.1. Cumulatively, if the two groups of users had the same income-occupation, participation rate, and distance from site distributions (i.e., the two groups of users were made comparable with respect to these four factors), the willingness to pay of the uncongested weekday users is estimated to be approximately the same, on average, as the willingness to pay of the congested

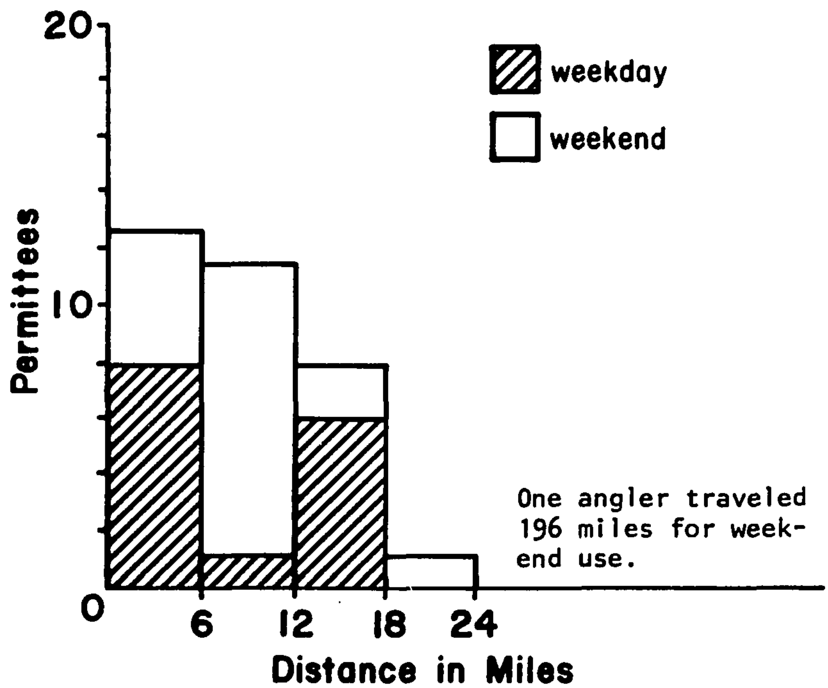

Figure 7. Histogram of permittees' distance from site to residence for partitioned weekday and weekend samples.

weekend group. That is, the mean willingness to pay of the former is between 96.3 and 101.9% of the mean willingness to pay of the latter.

Size of Catch Adjustment

The personal interview sample was stratified to eliminate interviews of permittees fishing in the second week after stocking. Since greater fishing success occurred in the first week after stocking, informed anglers could realistically expect a larger catch during this time. The actual number of trout caught, however, varied considerably among individuals in the two groups. A histogram of the frequency of anglers over the range of fishing success is provided in Figure 8.

While 27% of both groups had a catch in excess of the season average when interviewed, the remaining 73% in both groups fell below the average. The deviation below the average for the weekday users was more pronounced with 52% of this group having catches amounting to 50% or more below the average, compared with only 37% in this category for weekend anglers. Imposing the less successful distribution of catch size of weekday users on the weekend group resulted in the adjusted Paasche index rising to 104.6, a marginal effect of 2.7. The adjusted Laspeyres index rose to 116.5, a marginal change of 20.2.

Age of Permittees Adjustment

The final factor affecting willingness to pay differentials between the two groups of users considered in this study was the age distribution of the permittees in each group. The distributions of the two groups are very similar although the weekday users were

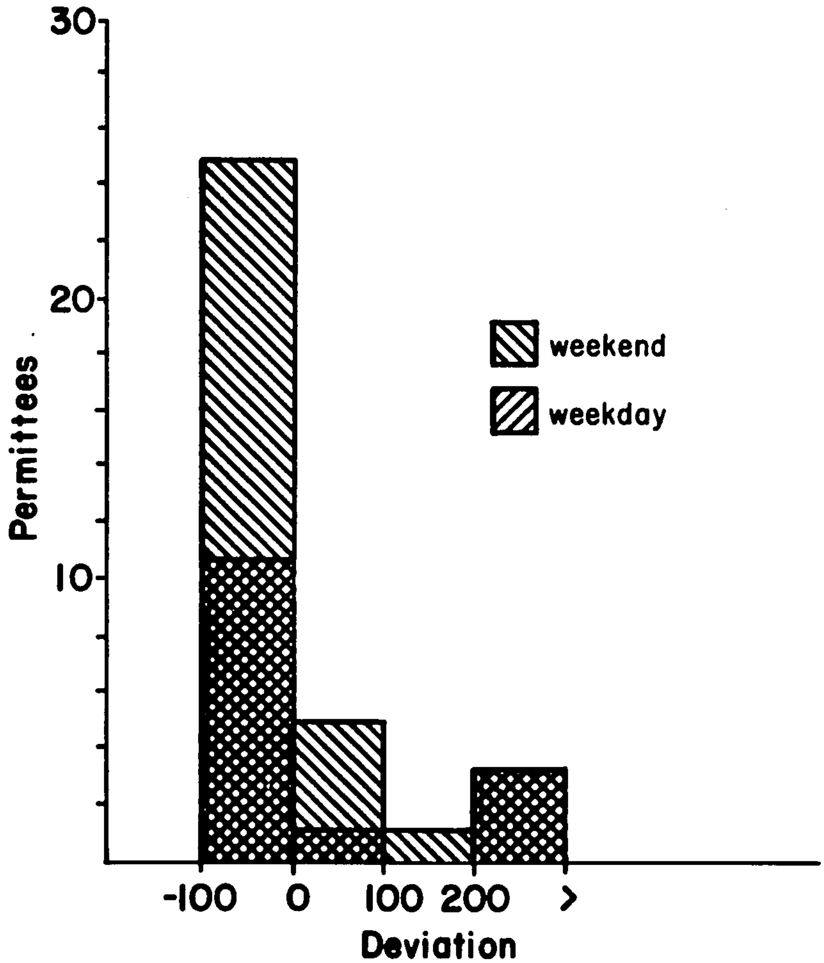

Figure 8. Histogram of permittees' deviation from average fishing success for partitioned weekday and weekend samples.

somewhat older (53% were between 45 and 75 years old compared with only 36% for the weekend group of users). The adjusted Paasche index rose to 206.8 and the adjusted Laspeyres index increased to 123.5. This constitutes marginal changes of only 2.2 and 8.0, respectively. Cumulatively, the less congested weekday users are estimated to be willing to pay between 6.8 and 24.5% more, on average, for the urban fishing experience than the more congested weekend users after controlling for six additional factors through indexation. A histogram of the distribution is provided in Figure 9.

Summary of Indexing Results

In summary, the two groups of users have been made comparable with respect to employment status, type of fish caught, high fishing success periods, and daytime use by selecting interviews conducted under these conditions (the partitioning process). The fishing experience is comparable with respect to these factors. In addition, six other factors which partially account for the mean willingness to pay differential between the two groups were evaluated through indexation. Giving the congested and uncongested groups the same distribution across income-occupation, number of visits per season, distance to site, size of catch, and permittee age categories, results in an adjusted mean willingness to pay of the uncongested group between 6.8 and 24.5% percent higher than that of the congested group. The result of the Fisher ideal price index was 115.3%. The price index is a geometric mean of the reported final index results that has

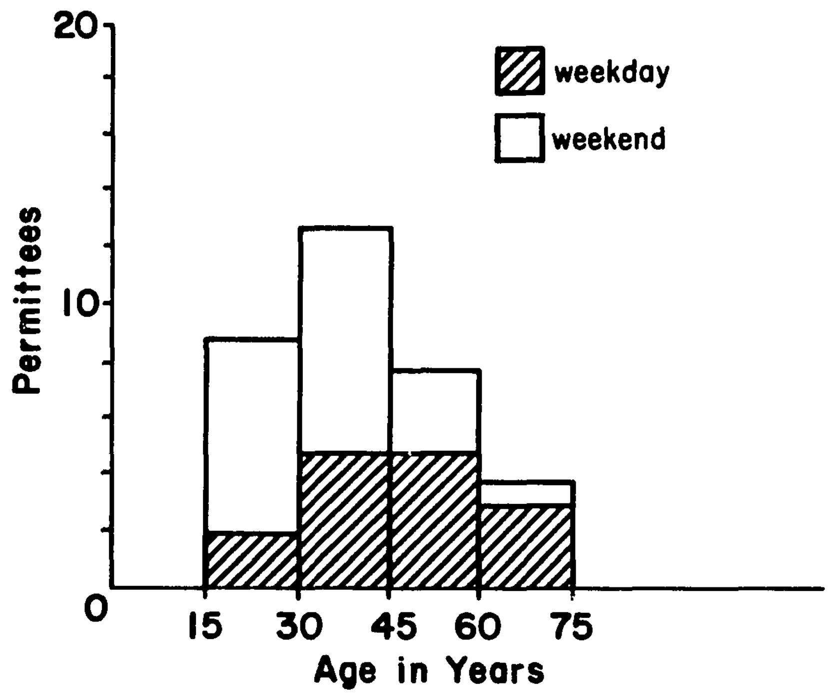

Figure 9. Histogram of permittees' age for partitioned weekday and weekend samples.

certain theoretical advantages described in Pfaffenberger and Patterson (1977). The form of the price index is:

$$(L \cdot P)^{\frac{1}{2}}$$

The Fisher ideal price index indicates that 15.3% of the difference in willingness to pay between weekend and weekday individuals remained unexplained after the indexation adjustment for six factors in the partitioned sample. That is, weekday users of Chaparral Lake were willing to pay 15.3% more than weekend users due to the less congested fishing experience.

Adjusting User Fees for Changes in Congestion Costs at Chaparral Lake

The elasticity of weekend users' average willingness to pay with respect to level of facility use ($\varepsilon_{\bar{w}}Q$) is assumed to be constant over use levels under consideration. The results of the empirical study of congestion costs at Chaparral Lake indicate that the average willingness to pay of weekend users ($\bar{w}$) increases by 15.3% when the level of facility use (Q) changes from the seasonal average for weekend use (52 anglers) to the seasonal average for weekday use (22 anglers). Reducing weekend use to the average weekday use would amount to a reduction of 57.7% in the level of weekend facility use. The estimated Q, then, is:

$$\begin{aligned} \varepsilon_{\bar{w}}Q &= \%\Delta\bar{w}/\%\Delta Q \\ &= 15.3\%/57.7\% \\ &= 0.265 \end{aligned}$$

The fee adjustment associated with the quality improvement at the lower level of use (α) is estimated change in average congestion cost ($\Delta\bar{w}$) at this less congested use level; that is:

$$\alpha = \alpha(Q)$$

$$= \bar{w}_o(\varepsilon\bar{w}Q)(\%\Delta Q)$$

where $\bar{w}_o$ is the average willingness to pay for weekend users at unrestricted levels of use. Substituting the estimated values for Chaparral Lake gives:

$$= \$8.07\ (0.265)\ (\%\Delta Q)$$

The $\%\Delta\bar{w}$ and α for various levels of weekend use below the unrestricted level of 52 permittees are presented in Table 4. If the weekend level of use were to be reduced to the average weekday level of use by imposing user fees, a 57.5% reduction in the number of anglers would result with an accompanying 15.3% increase in the weekend users' average willingness to pay. To reach this lower level of use, the user fee would have to be increased an additional \$1.24 to reflect the change in average congestion cost experienced by the users. An intermediate 29% reduction in use to 37 anglers could be obtained by adjusting the fee \$0.62. This adjustment is necessary to balance the associated 8% increase in willingness to pay that anglers have for this higher quality experience.

Other levels of use can be administratively selected from Table 4. The quality adjusted demand curve is a continuous schedule of such adjustments added to the estimated unrestricted willingness to pay function for weekend users. These curves are graphically

Table 4. Adjusted user fees for changes in congestion costs.

Administratively Selected Level of Use	Percentage Reduction in Use Levels (%ΔQ)	Percentage Increase in Average Willingness to Pay (%Δ$\bar{w}$)	Fee Adjustment ($) (α)
22	57.7	15.3	1.24
32	38.5	10.2	0.82
37	28.8	7.6	0.62
42	19.2	5.1	0.41
52	0	0	0

represented in Figure 10 and a schedule of fees based on the addition of the two curves is shown in Table 5.

Summary of the Application of the Indexing Technique

For a partitioned sample of users experiencing 2.4 times higher use on weekends than weekdays, weekday users were willing to pay 18.7% more, on average, for the fishing experience than the weekend users. Partitioning made the two groups employed adults, fishing for trout during high success fishing periods during the daytime. Indexation was used to account for income-occupation, number of visits, distance to site, size of catch, and permittee age leaving a 15.3% unexplained difference in willingness to pay. Using elasticity of willingness to pay with respect to level of facility use, a fee adjustment of $1.24 to the unrestricted weekend willingness to pay function was needed to lower weekend use 58% due to the 15% increase in willingness to pay for the higher quality experience at the weekday level of use. The adjustment necessitated a $8.62 fee rather than the $7.38 fee which would have been estimated in the absence of a quality-adjusted demand curve.

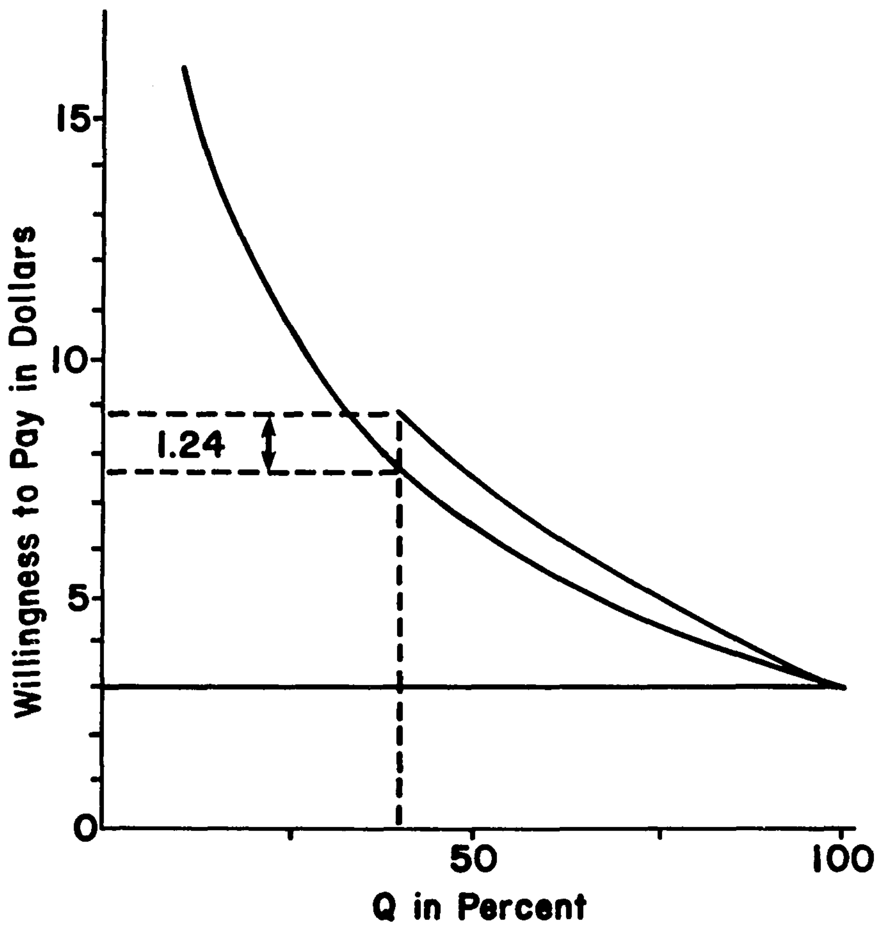

Figure 10. Estimated quality-adjusted willingness to pay curve for Chaparral Lake.

Table 5. Linear regression estimate of the quality-adjusted demand curve for Chaparral Lake.

Administratively Selected Levels of Use	Unadjusted[a] Willingness to Pay at Unrestricted Use Level ($)	Fee Adjustment ($) ($\alpha$)	Quality-Adjusted Willingness to Pay ($)
22	7.38	1.24	8.62
32	5.36	0.82	6.18
37	4.62	0.62	5.24
42	3.99	0.41	4.40
52	2.96	0	2.96

[a]Least squares regression was used to estimate the following:

$\bar{w}_o = -20.56 + 23.52\ Q^{-.2}$

$\bar{R}^2 = .94$, where:

$\bar{w}_o$ = willingness to pay for a six-month permit in dollars.

Q = cumulative frequency of anglers who would be willing to pay at least that amount in %.

CHAPTER 6

CONCLUSION

This chapter weighs the solution of the problem statement. That statement expressed a need for a congestion measurement approach for estimating a quality-adjusted demand curve D(Q) for optimal pricing policies at congested facilities. The problem was addressed using an indexing residual technique to estimate D(Q); thereby obtaining the market clearing price for an administratively selected standard of use. This indexation measurement technique is discussed in terms of the congestion cost calculated for a pricing policy compared with previous techniques and future application of the indexation measurement technique.

Problem Solution

For the stratified group of users at Chaparral Lake, a pricing schedule was developed for use levels between 22 and 52. The permit prices were applicable to employed adults visiting during daytime hours on weekends up to one week after trout were stocked. Obvious limitations exist for the establishment of a general permit pricing policy under these conditions. While the sample was necessarily limited, it was the most extensive data set available for the empirical application of the residual technique for estimating D(Q). If a year-round pricing policy was desired, the estimation process could be repeated for other samples. Fee differentiation must be balanced with the partitioning needed to obtain the accuracy desired.

In general, careful attention to the selection of samples of users with individuals having similar recreation experiences will greatly reduce the partitioning phase of this technique. Thus, sample design deserves rigorous definition to keep partitioning to a minimum and to account for all relevant determinants of willingness to pay other than congestion cost. Careful attention to sample design will eliminate unnecessary sampling and the omission of key factors. Estimates of the residual will then reflect true congestion costs. While the Chaparral sample was limited due to its intended application, the sampled variables were nevertheless applicable to the indirect indexing technique. The aforementioned sampling considerations should provide an even better sample in future applications of this technique.

The possibility for bias in indirect estimates of congestion remains, since the residual of the indexation is taken as the estimate of congestion. However, the difficulty in defining congestion poses a dilemma. Since present direct estimators are no better than encounters, and better information is available to define and model other variables, indirect measurement of congestion has value. When more is known about congestion, direct techniques may become more credible. The additional expense of turning to more realistic proxy variables, such as encounters, should then be weighted with the costs of obtaining the information indirectly. As shown in the Chaparral Lake application, general survey designs provide the necessary characteristics. One survey can therefore be used as a base for both indirect and direct estimation techniques, thereby providing a comparison of the congestion estimates.

While certain shortcomings are apparent, the indexing technique shows promise when compared with direct estimation techniques. The use of oversimplified proxy variables, such as number of users per unit of facility area, is completely circumvented. Moreover, the additional expense of turning to more realistic proxy variables, such as encounters, can also be avoided. Also, the specification of an *a priori* functional relationship between willingness to pay and level of facility use, required in multiple regression analyses, becomes unnecessary.

The assumption of constant elasticity of mean willingness to pay with respect to level of facility use can be relaxed by estimating changes in willingness to pay over several levels of use. The more levels of use vary, the more estimates of congestion can be refined. For all applications, the technique requires at least one less congested group. Thus, facilities where congestion costs do not vary cannot be evaluated with this technique.

The phenomenal growth in demand for outdoor recreation in the United States is well documented. Assessing the impact of congestion on consumer welfare in recreation facilities can realistically be expected to become increasingly important. Laspeyres and Paasche indexes of willingness to pay have been shown to be versatile evaluation tools for this purpose.

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