ANALYSIS OF WATER-BASED RECREATION MARKETS FOR TWO COMPETING LAKES IN THE MCCLELLAN-KERR ARKANSAS RIVER NAVIGATION SYSTEM UNDER ALTERNATIVE GOVERNMENT POLICIES

By

GEOFFREY M. CANNOCK

Bachelor of Science
Universidad Del Pacifico
Lima, Peru
1984

Master of Science in Agricultural Economics
Oklahoma State University
Stillwater, Oklahoma
1986

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Thesis Approved:

Dean F. Schreiner
Thesis Adviser

James N. Trapp

Francis M. Epplin

Keith D. Willett

Norman N. Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Background

Outdoor recreation research has focused mainly on the demand side because of the difficulty of measuring willingness to pay for a service that cannot be inferred directly from market data. The research effort has been fruitful but as Matulich, Workman, and Jukenville (1987) have recently stated, the supply side of outdoor recreation has not received sufficient attention in the literature since it has been generally assumed that there are no significant problems on model specification or empirical estimation. Recreation economics is a policy-oriented subdiscipline and it should incorporate management criteria in its research (McConnell, 1985).

Water and related land-based recreation benefits at the McClellan-Kerr Arkansas River Navigation System have been estimated by Schreiner, Willet, Badger, and Antle (1985) at $50 million annually for the Navigation System as a whole. Schreiner, Chantaworn, and Badger (1987) incorporate supply side elements into a methodology for planning optimum facility development in a multiple purpose water resource project. Results of their analysis yield information on optimum timing and level of investment for recreation facility development; on total visitor days by time period, and total costs of supplying recreation services; and on the distribution of private and social benefits and costs. Schreiner, Chantaworn, and Badger applied their methodology to Lake

Fort Gibson and their results show that the present value of marginal net benefits over the planning period 1975-2000 is about $49.5 million in 1975 prices if recreationists are charged all of the marginal costs of recreation facility development.

The present study builds upon previous work completed in the McClellan-Kerr Arkansas River Navigation System. Some of the existent limitations pointed out by Schreiner, Chantaworn, and Badger are relaxed. Competition between a local lake and a regional lake is introduced into the analysis. Likewise, cross price effects on competing demands for recreation are considered in the planning model methodology which are estimated using a discrete choice travel cost model that has a regional gravity component. Diseconomies of size in investment and externalities such as congestion are also specified.

The Investment Decision in Water Projects

This section is based largely on Randall (1987). River basins frequently cross over the boundaries of state and local government jurisdictions. The federal government, through the U.S. Army Corps of Engineers has jurisdiction over all navigable waters. Randall argues that given the massive size of river systems, the massive capital requirements for large-scale river system modifications, the tradition of homesteading and the family farm, and the vesting of ownership rights to rivers in the public sector, large-scale river modification projects must be carried out by the public sector.

The initial support for a new project or an extension of an existing project usually comes from the groups that have been traditional supporters of water programs or that feel they can benefit from it. Meanwhile, the federal water-resource agency, in this case the U.S. Army Corps of Engineers, will have prepared several investment plans to meet the needs of the clientele groups. From this process a project proposal emerges. Once the local or regional office of the agency prepares the project supporting documentation, it needs to persuade its headquarters of its advantages to present its project to the U.S. Congress for authorization.

The Congress may approve the project if it is shown that the benefits to whomsoever they accrue are greater than the costs. That is, the benefit-cost ratio must be greater than one. This criteria was placed in the Flood Control Act of 1936 which is identified by many as the origin of benefit-cost analysis in federal programs. It is important to note that the Agency proposes and evaluates the project itself, according with the guidelines set by the Water Resources Council, which is an entity whose members are appointed by the president. The Office of Management and Budget, a federal agency, may review the consistency of the project evaluation prepared by the Agency. The project evaluation may be examined by another federal agency which might have interest in its potential impacts.

The application for the authorization of the project has to go through a congressional subcommittee which holds legislative hearings. These hearings are open not only to the congressional staff and other government agencies, but also to anyone that may have an interest in the project.

An environmental-impact assessment (EIA) and an environmental-impact statement (EIS) must also be prepared and submitted according with the National Environmental Policy Act of 1969. The EIS reports the findings of the evaluation carried out by the EIA which focus on the potential effects that the construction and operation of the project would have on the region in which it is implemented. The guidelines for preparing the EIS include, among other aspects, the active solicitation of written comments from all interested individuals and groups, holding of public hearings, and circulation of the EIA draft to all interested parties. The National Environmental Policy Act permits litigation to challenge the EIS, but only on procedural or substantive grounds. That is, a project may be approved even though it has adverse effects on the environment. It is only required that the EIS be complete according to the procedures stated in the guidelines.

Congressional authorization of the Project must be complemented with adequate funds approved by Congress. The project cannot be implemented without funds allocation so that the congressional hearings concerning funding constitute another opportunity to express support or opposition to the project. Following the subcommittee approval, the project funds must be approved by the Congress and the budget allocation must have the President's consent. If the Congress allocates funds to the project, it is necessary to comply with additional requirements set by other agencies. Litigation is also possible under the Endangered Species Act if the project implementation jeopardizes the existence of a specie.

The state and local government role is not as well defined as the federal role in water-related projects. Many water programs require local governments to share certain components of the project costs. Moreover, there is a tradition of not implementing a project if it is opposed by the state and local government where the project will be located. Hence, individuals may influence the decision of undertaking the project at the state decision level.

Under the Reagan Administration the Water Resources Council has been abolished, and its regulations regarding benefit-cost analysis have been rescinded and replaced by guidelines. On the other hand, the Executive Order (EO) 12291 issued by President Reagan in 1981 has set more stringent procedures for benefit-cost analysis for new regulations and for major revisions of existing ones. The EO 12291 requires a full consideration of regulatory alternatives and a specification of winners and losers.

The U.S. Army Corps of Engineers prepares a facilities and site development plan for each project which is referred to as the Master Plan. It is used for purposes of long-term development of the project.

Problem Statement

Consider the problem that the policy maker faces in developing a project for a recreational site. He needs to determine if it is worthwhile to implement the project, and if so, he needs to know the amount and timing of the required resources, and what policies can influence private decision makers so that their behavior conforms to the desired social objective.

More specifically, he has to determine the following:

1) The demand for recreational services for the project. This step is not straight forward because the demand cannot be observed directly but must be inferred using indirect methods based on the market of a related input or by direct elicitation of willingness to pay. Moreover, in the outdoor recreation market consumers do not face a unique price, but each consumer faces a particular price according to his location with respect to the recreational site. Most of the research in the outdoor recreation literature has focused in developing methods for measuring the demand and benefits for recreational services, which have been useful for project managers in determining willingness to pay for developing sites. However, what project managers are ultimately more interested in knowing is if a project should be undertaken.

2) The average and marginal cost curves in the recreation market. In particular, if the average cost turns out to be decreasing over the relevant range, then this finding has important implications for the management policies of the site. Moreover, externality costs such as congestion may be an important variable in determining the optimal social attendance at the site.

3) The optimal timing for changing capacity at the recreation site. A delay in the expansion of current capacity has a positive effect on the discounted social benefits but potential benefits are also foregone.

4) What policies to enact to ration attendance at the recreational site given that social costs are higher than the private costs of recreating because the visitors do not pay all the costs of developing and maintaining the site. Each policy may have significant differences for the investment requirements. For example, a non-exclusionary policy will probably result in a considerable need for expanding capacity compared with a policy that requires that recreationists pay the full cost of developing the facilities.

5) The cost-sharing rule among the federal government, the state, and/or local governments, and the recreationists. This issue is closely related to the previous consideration. The cost-sharing rule may affect considerably those who must cover the financial needs of the project in a cash flow basis. In particular, how adequate is the 50-50 cost-sharing basis of new capital expenditures between the federal government and local participation from the point of view of the state.

6) The relevance of substitution effects among sites. The project evaluation becomes more complicated if substitution effects are significant. The substitution effects may occur because of pricing policies or through changes in the characteristics of alternative and competing lakes (sites).

Objectives of the Study

The main objective of the research is to propose a more comprehensive planning procedure for recreational projects that can be useful to project managers in developing a Master Plan. The procedure will not only address the question on how much is the willingness to pay for recreational services but also to provide the optimal investment allocation and entrance fees for competing sites under alternative government policies. Specific objectives include:

1. To reestimate the demand for water-based recreation based on survey and secondary data available for five major Oklahoma lakes and project recreation demand for Lakes Fort Gibson and Tenkiller.
2. To estimate the unit costs of operating, maintaining, and expanding the water-based recreation facilities at Lakes Fort Gibson and Tenkiller.
3. To identify and estimate congestion costs at Lakes Fort Gibson and Tenkiller.
4. To incorporate diseconomies of size in the expansion of recreational facilities at Lake Tenkiller.
5. To evaluate alternative policy options for water-based recreation management at Lakes Fort Gibson and Tenkiller, with emphasis in pricing and budgetary policies, and in cost-sharing rules.

Application to Lakes Fort Gibson and Tenkiller

The following factors were considered in choosing Lakes Fort Gibson and Tenkiller for the application of the planning methodology:

1. Only lakes within the Arkansas Navigation System were considered since the survey carried out in 1975 focused in these recreation sites.
2. Fort Gibson and Tenkiller were chosen because the former is a local lake and the latter is a regional lake as defined by Schreiner, Willet, Badger and Antle. A previous study (Schreiner, Chantaworn, and Badger, 1987) applied the planning methodology to Fort Gibson and makes possible a comparison of their results with those obtained from the current study.
3. Lake Tenkiller has the largest market area among the lakes considered and thus provides the greatest potential for substitution among sites. Its market area reaches five states: Oklahoma, Arkansas, Missouri, Kansas, and Texas.

The following information is taken from the U.S. Army Corps of Engineers (1978a, 1978b).

Fort Gibson Dam is located on the Grand (Neosho) River at about five miles north of the town of Fort Gibson, Oklahoma, and about 12 miles northeast of Muskogee, Oklahoma. The Fort Gibson project was authorized for construction by the Flood Control Act of 1941. The project was placed in full operation for flood control and the generation of hydroelectrical power in 1953.

Tenkiller Ferry Lake is located on the Illinois River about 5 miles northeast of Gore, 22 miles southeast of Muskogee, Oklahoma and 40 miles northeast of Fort Smith, Arkansas. The lake is located in Cherokee and Sequoyah counties of Oklahoma. Tenkiller Ferry Dam and Lake was authorized by the Flood Control Act of 1938 and later modified in 1946 to provide hydroelectrical power. In 1946 this project was incorporated in the multiple-purpose plan for the Arkansas River.

Plan of Presentation

The elements of the planning model are presented in Chapter II. The main elements of a planning model are first identified and then conceptually interrelated. A literature review on welfare concepts, marginal benefit estimation, interest rate determination, and marginal cost estimation relevant to outdoor recreation is also presented in Chapter II.

Chapter III deals with the reestimation and projection of the demand and benefits for water-based recreation activities at five Oklahoma lakes in the McClellan-Kerr Arkansas River Navigation System. The main purpose of this chapter is to estimate the price substitution effects among the lakes.

The estimates and procedures for the cost components of the planning model are developed in Chapter IV.

The investment programming model and its results and validation for the base case are derived and reported in Chapter V.

An analysis of the 50-50 cost-sharing rule for new capital expenditures between the federal and local participation is discussed in Chapter VI.

Chapter VII evaluates pricing and budgetary policies for Lakes Fort Gibson and Tenkiller.

Chapter VIII presents a summary and conclusions of the study. Suggestions for further work as well as limitations of the study are pointed out.

Expected Results

The planning methodology should provide information useful to project managers in preparing their Master Plan and management decision concerning investment allocation and entrance fees. More specifically, the following results are made available:

1. Optimum timing and level of facility development for lakes likely to have substitution effects.
2. Total visitor days by time period and their associated benefits and costs.
3. Information on the effects of changing entrance fees.
4. Analysis of budget allocations across competing lakes.

CHAPTER II

ELEMENTS OF A RECREATIONAL PLANNING MODEL

The purpose of this chapter is to present and discuss the conceptual foundations that identify the elements of a planning model for recreational projects. The first section introduces the planning model. The following sections examine each of its elements.

A Conceptual Planning Model

The planning model assumes that the federal, state, and local governments share the same objective and therefore behave as if they were a single entity where the objective is to maximize social welfare from a national viewpoint. This assumption will be relaxed in Chapter VI.

The policy question to be addressed is the joint determination of the optimal investment path and entrance fees for Lakes Fort Gibson and Tenkiller such that social welfare is maximized.

Figure 1 presents the static demand and supply functions for the two lakes in a hypothetical case for expository purposes. In the upper left graph, the recreation market for lake 1 is depicted. The private supply (SP_1) includes the private costs of recreation such as travel and time costs. The social supply (SS_1) contains both the private costs and costs not paid by recreationists such as operation and maintenance (O&M) costs, investment costs, and negative externalities. A recreation capacity constraint (RC_0) has been placed between

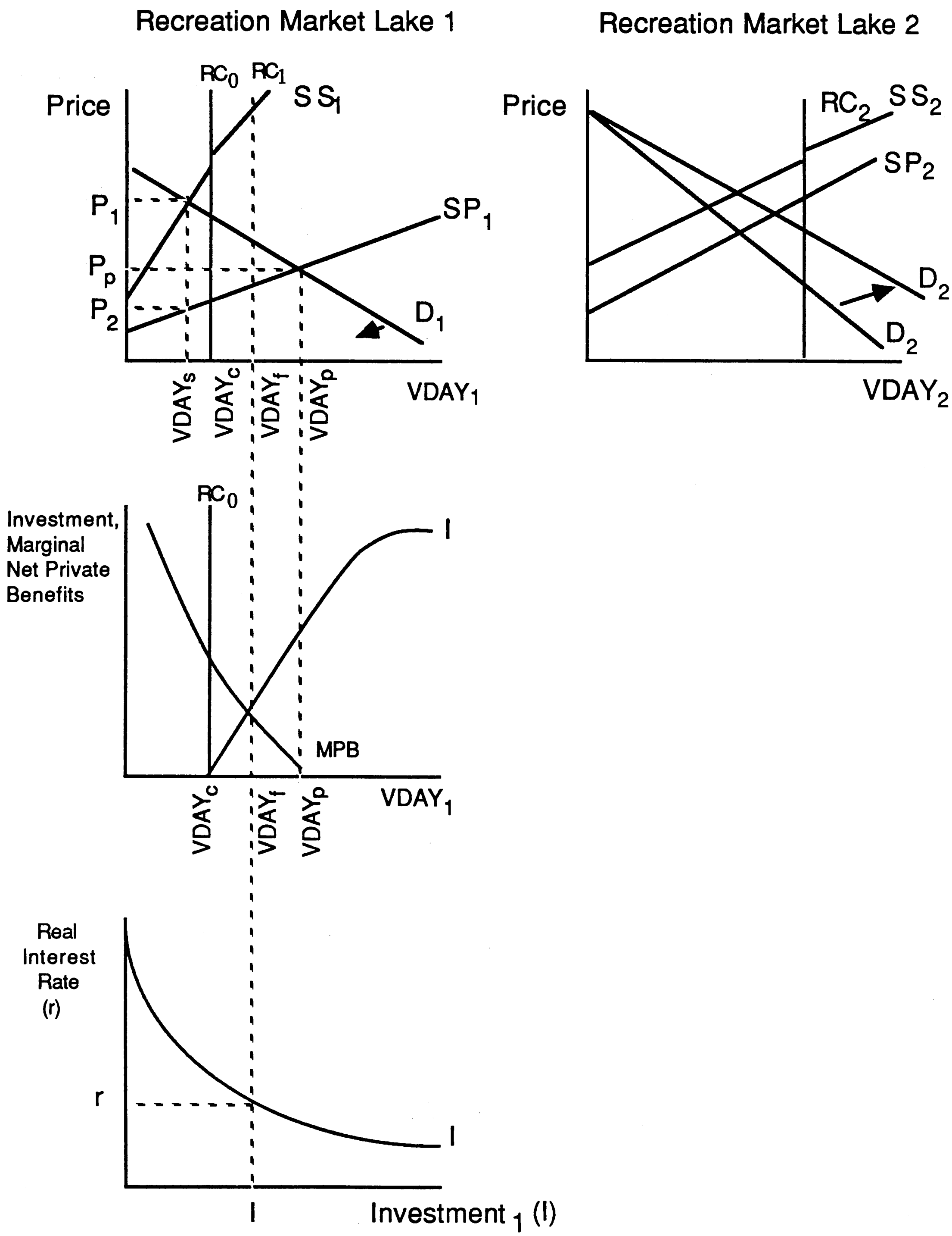

Figure 1. Optimal Recreation Investment Policy

the unconstrained private $VDAY_p$ (visitor days) and social $VDAY_s$ equilibrium. Note that the SS_1 has a discrete jump at the recreation capacity level $VDAY_c$.

The figure below the graph of the market for lake 1 shows investment and marginal private net benefit functions. The investment function is zero at levels of visitor days below the recreation capacity $VDAY_c$ and positive and increasing at a decreasing rate at levels above the recreation capacity. The marginal net private benefit function decreases at an increasing rate and goes to zero at equilibrium $VDAY_p$. The lower graph depicts the relationship between the investment function and the real interest rate. The demand for investment in recreation at lake 1 decreases as the real interest rate increases.

If the project manager does not set an entry fee for lake 1, then the equilibrium, assuming that investment is carried out instantaneously, will be given by $VDAY_f$. Note that the feasible set for equilibrium points such as $VDAY_f$ depends on factors such as the capacity constraint, the marginal net private benefit and costs, and the interest rate since it may limit the level of investment. To complicate things further, if the project manager decides to set entry fee at P_1 - P_2 to enforce the optimal social equilibrium $VDAY_s$, then the demand schedule may rotate multiplicatively if we consider price substitution effects due to the presence of the recreation market for lake 2. Hence, the solution cannot be easily determined *a priori* without using some kind of empirical technique. In Chapter V a multiperiod mathematical programming model is presented that incorporates the principal elements of the recreation market.

This framework suggests that the following constitute elements for a planning model, where data and/or further modelling are needed:

-- Estimates of the marginal productivity of investment for each lake. These estimates include the productivity of the lake characteristics - i.e., water quality, scenic beauty - as well as the recreational facilities that can be implemented.

-- Estimates of the marginal welfare benefits. Research in the outdoor recreation subdiscipline has focused mainly in this area. A discussion of the several ways of estimating these benefits with emphasis on the travel cost method (TCM) is presented below.

-- Estimates of the marginal cost of providing recreational services at each lake.

-- An estimate of the real interest rate.

-- Entrance fee policies.

-- Cost Sharing rules.

Social Welfare

A benchmark is needed for purposes of comparison with alternative specifications of policies in the water-based recreation market. This benchmark is usually defined as some measure of social welfare. The following welfare concepts are defined and discussed: Marshallian consumer surplus, compensating variation, equivalent variation, compensating surplus, and equivalent surplus.

The Marshallian consumer surplus is defined as the difference between the amount consumers are willing to pay and what they actually pay with a constant price per unit. The maximum willingness to pay for a good is measured by the demand curve. Unfortunately, the consumer surplus is not a good approximation of individual welfare since money income is held constant instead of the utility level. The use of consumer surplus is correct if the marginal utility of income is constant, which is unlikely to occur in real world applications.

Hicks (1943) defined four welfare measures to maintain utility constant at all points of the demand curve which are defined as follows for the case of a price decrease.

Compensating Variation (CV): the amount of compensation that must be taken from an individual to leave him at the same level of satisfaction as before the change.

Equivalent Variation (EV): the amount of compensation that must be given to an individual, in the absence of the change, to permit him to obtain the same level of satisfaction as before the change.

Compensating Surplus (CS): the amount of compensation that must be taken from an individual, leaving him just as well off as before the change if he were constrained to purchase at the new price the quantity of the good he would buy in absence of compensation.

Equivalent Surplus (ES): the amount of compensation that must be given to an individual, in the absence of the change, to make him as well off as he would be with the change if he were constrained to buy at the old price the quantity of the commodity he would actually buy with the new price in the absence of compensation.

The welfare measures differ mainly because the ES and the EV are not bounded by an individual's income constraint, whereas the CS and CV are. That is, they are based on different frames of reference.

The last two measures can be interpreted as measures of change of total welfare related with a quantity change (Just, Hueth, and Schmitz, 1982). These measures can be more relevant in some applications of environmental policies as opposed to welfare measures based on price variations (CV and EV) since these kind of resources are not exchanged in the private markets (Randall and Stoll, 1980).

For practical applications, it is worth noting that the ordinary consumer surplus is a good approximation of the compensated consumer surplus under certain general conditions as Willig (1976) has shown for the CV and EV cases and Randall and Stoll (1980) for the CS and ES cases. For example, if the price change for a good is small and the share of the budget spent on the good is also small, the change in disposable income is probably small so that ordinary consumer surplus is a good approximation of the Hicksian measures of welfare. However, it is important to be aware of the possible limitations of these approximations when dealing with quality changes instead of price changes (Hanemann, 1982). For example, Smith et. al. (1986b) report large differences in Marshallian and Hicksian measures of water quality change for twenty-two Army Corps of Engineers projects.

Although still not widely used, economists have developed several approaches to calculate Hicksian or "exact" measures of welfare using the same information required to estimate ordinary demand functions (Jorgenson and Lau, 1975; Hausman, 1981; Vartia, 1983).

Marginal Benefit Estimation: The Travel Cost Model

The objective of this section is to present the travel cost model and discuss the theoretical and empirical alternatives of considering substitution effects among lakes in order to estimate the marginal benefits of recreation. The marginal benefits per lake must be estimated since they are needed in the planning framework derived above. The travel cost model has been chosen because of data availability and also because it was previously used in the recreation demand estimation for Lakes Tenkiller and Fort Gibson. The travel cost model (TCM) is one of the three more common methods for valuing nonmarket goods such as outdoor recreation. The other approaches are the contingent ranking approach and the contingent valuation approach. See Smith and Desvousges (1986) and Mitchell and Carson (1988) for a presentation of the latter methods.

The TCM is an indirect approach for measuring households valuation of outdoor recreation. It is indirect in the sense that it uses data on marketed inputs needed for the provision of the final flow of service. The following theoretical outline of the TCM follows Smith and Desvousges (1986) and Rosenthal (1985, 1987), which in turn have followed Freeman (1979), Mäler (1974), and Randall (1984).

The theoretical justification of the TCM can be obtained from the expenditure function approach. The expenditure function is defined as indicating the least amount of money an individual would need to achieve a particular level of utility at given prices (Varian, 1984). In this case,

$$E = E(P_j, Y_j, U_o) \tag{2.1}$$

where E(.) is the expenditure function, Y_j is the recreational experience at lake j, P_j is the price of the recreational experience at lake j, and U_o is the given level of utility.

Taking the partial derivatives of (2.1) with respect to Y_1 and Y_2 gives as results the Hicksian compensated demand functions for the recreation activities on lakes Y_1 and Y_2.

Randall (1984) identifies three sets of valuation techniques that can be used within the expenditure function approach. These are the weak complementarity, perfect substitution, and hedonic prices techniques. The TCM is based on the weak complementarity technique. This procedure has its foundation in the weak complementary assumption (Mäler, 1974). Weak complementary between a marketed good Z_j and nonmarketed good Y_j is defined as

$$\frac{\partial U(Z_1 Z_2,\ldots,0,\ldots Z_m, Y_1 Y_2,\ldots,0,\ldots Y_n)}{\partial Y_j} = 0 \tag{2.2}$$

This assumption implies that when consumption of the market good Z_j is zero, then the individual utility does not show any variation derived from changes in the nonmarket good Y_j. Hence, this assumption enables the estimation of the demand for final service flow such as outdoor recreation at lakes from the observed behavior on the market of its inputs such as travel costs and the opportunity cost of time.

The weak complementary assumption implies that the TCM cannot take into account the nonuse values (Krutilla, 1967). One of the components of nonuse values is the recognition that the welfare of some individuals could increase just by being aware of the existence of an environmental benefit without necessarily expecting to visit it in the future. Therefore, enhancing the utility of an individual may not require observable acts of use of the resources involved.

The theoretical foundations of the TCM is shown by Bowes and Loomis (1980). Let Y_j^* represent removal of the recreation facilities at the jth lake. Therefore, the welfare loss as measured by the compensating variation criteria of removing Y_j is given by:

$$CS(Y_j) = E(P,Y_j^*) - E(P,Y_j) \tag{2.3}$$

Likewise, the welfare loss associated with increasing the entrance fee and travel costs to P^* such that the quantity demanded is driven to zero is

$$CS(T) = E(P^*,Y_j) - E(P,Y_j) \tag{2.4}$$

where T stands for the travel activity carried out by households and CS stands for consumer surplus.

Since the weak complementarity assumption implies that

$$E(P^*,Y_j^*) - E(P^*,Y_j) = 0 \tag{2.5}$$

The following relation is obtained from (2.3), (2.4), and (2.5)

$$CS(Y_j) = CS(T) - [E(P^*,Y_j^*) - E(P,Y_j^*)] \tag{2.6}$$

The last term of (2.6) is the consumer surplus derived from nonexistent recreational facilities, which can be assumed to be zero. Hence, $CS(Y_j)$ = CS(T), which proves the theoretical soundness of the TCM. Note that if the last term of (2.6) is zero, then this relationship coupled with (2.5) implies that the weak complementarity assumption holds from Y_j to Z_j as well as from Z_j to Y_j. That is, the consumer surplus measure for the elimination of either good is always equal.

Some researchers (Smith and Krutilla, 1982) have argued that the weak complementarity assumption is not required for the TCM. They focus on the supply side of outdoor recreation by stating that, for example, it is possible to derive the benefits of nonmarketed goods from the technical relationships between marketed and nonmarketed goods. That is, the availability of a nonmarketed good is associated with a marketed good, so it is not necessary to appeal to preference structures to specify the linkage between them.

One of the limitations of the expenditure function approach applied to the TCM is that, as Mäler (1974) has stated, the integrability conditions of the estimated demand functions may not be satisfied, violating an assumption of the expenditure function method. Most of the common functional forms used in empirical estimation such as the linear, quadratic, or common log transformations do not satisfy these conditions.

The TCM can be framed using a household production function approach (Becker, 1965). This approach can be described in a variety of ways such as in McConnell (1985), Deyak and Smith (1978), Bockstael and McConnell (1981, 1983). The basic idea is that households are both producers and consumers of services. They buy marketed goods to be combined with their own resources such as time to produce final flow services such that households' utility is enhanced. The TCM is a special case of the household production function (HPF) approach, where the households produce a recreation service flow. An advantage of using the HPF is that it provides a theoretical basis to include substitution effects among sites. Moreover, this property allows the incorporation of the characteristics of the sites on the recreation demand estimates. This feature could be quite useful for considering the linkages between investment – which changes the sites characteristics – and the demand for outdoor recreation. The HPF approach consists of two steps. In the first step, households minimize their costs of each possible set of final service flows after considering combinations of market goods and time to produce those service flows. That is, a set of shadow prices of producing each final service flow is determined. In the second step, households maximize their utility subject to income and time constraints by selecting the mix of final service flows.

Mäler (1985) claims that in using HPF theory it is not possible to estimate the demand for marginal willingness to pay for environmental products. Some *a priori* assumptions on the HPF are needed. In particular, as Pollak and Wachter (1975) have shown, the production function has to exhibit constant returns to scale and no joint production. In the HPF, these conditions are generally not met. It is necessary to assume either that quality per trip is exogenous or to use instead factor demands (Bocksteal and McConnell, 1983). Moreover, they showed that the HPF technique does not yield any new empirically testable hypothesis. However, as Smith and Desvousges (1986) assert, the HPF does not change the final form of the demand function, but it does help to understand the important assumptions that underlie the function which yields valuable qualitative insights.

The appropriate treatment of substitution effects in outdoor recreation has generated considerable literature but still substantial debate remains on incorporating these effects in estimation procedures (Rosenthal, 1987). The following approaches have been developed which follow the classification in Rosenthal (1985), Mendelsohn and Brown (1983), and Smith and Desvousges (1986) but with some modifications: own price only TCM; quality enhanced own price only TCM; classical travel cost models; incorporation of an index of relative attractiveness of other recreation sites; and discrete choice TCM.

Own Price Only TCM

The own price only TCM has been the most widely applied method. It is generally justified in estimating benefits from sites that are rather unique. However, when applied to sites that are common, substitution effects may become more important. Public agencies are becoming aware of the potential bias of not considering substitution effects in measuring benefits as in the case reported by Rosenthal (1985) where the U.S. Forest Service Planning Office lowered the values reported by published research by as much as fifty percent before using them. In own price only TCM the dependent variable is usually some measure of quantity of visits and the independent variables include, in addition to the cost of travel and time in reaching the site, such factors as income and population but do not include substitute sites.

The effect of omitting substitute prices can affect the parameter estimates in two ways: (1) econometric specification bias and (2) failure to identify a perfect substitute site. The effect of left-out variables in econometric estimation is well known (Theil, 1956; Griliches, 1957). The amount of bias on the included variable depends on the true sign of the left out variable and on the sign of the correlation between the included variable and the left-out variable. If we expect that the sign of the left-out variable and its correlation with the included variable to be the same, then the included variable has positive bias. Since it is expected that the prices between lakes are positively correlated and that the sign of the omitted substitution lake to be positive, then the own price only TCM may exhibit positive bias in its estimation. The extent of the bias depends on the particular case study.

The failure to identify a perfect substitute site on the estimation benefits could overstate the consumer surplus if the price of a trip to a perfect substitute price is less than the price that drives quantity demanded to zero. That is, the demand becomes perfectly elastic at the price level of the perfect substitute price. Rosenthal (1987) found that the without substitute model gives values for the consumer surplus per trip that are significantly higher than the other two methods he considered. He also concludes that no general statement can be made since the amount of the difference depends on the site being studied.

Quality Enhanced Own Price Only TCM

This approach assumes a specific form for a function that incorporates site attributes in the recreationists' utility function. Therefore, site selection is assumed to respond to utility-maximizing selections of these attributes (Smith and Desvousges, 1986). The functional form allows all parameters of the utility function to be recovered from the estimated equations. The advantage of this approach is that if the model is specified with an indirect utility function, then it is possible to derive demand as functions of the implicit prices, site attributes, and income. Unfortunately, this approach requires a substantial number of observations at each site and a substantial number of sites. Smith and Desvousges (1986) propose the use of the simple repackaging hypothesis introduced by Fisher and Shell (1968) to lower the data requirements in empirical applications. This hypothesis implies that if the contributions of each characteristic to the productivity of the site can be restricted to a specific form defined as the repackaging hypothesis, then the measurement of the sites characteristics as determinant of site demand will provide an explanation for the substitution. Therefore, after adjusting for their attributes, all sites are perfect substitutes for each other.

These restrictions allow the representation of the services of a different recreation site by a single scale or index.

Following Smith and Desvousges (1986), the definition for the scaled index is

$$V^s = J(a_j) * V_j \tag{2.23}$$

where V^s stands for scaled services, V_j stands for specific site's services and $J(a_j)$ is an augmentation function that has as arguments a vector a_j that represents the characteristics of the site. The augmentation function describes how sites would substitute for each other in the production of a final service flow. The Smith and Desvousges model also assumes that only one site will be selected. Therefore, the households' cost function will be a function of the site's attributes, which justifies the use of the augmentation function as an index for correcting the travel costs and opportunity cost of time. Moreover, it guarantees that changes in site characteristics affects the observed changes in the demands for recreation sites. This feature justifies the specification of an econometric procedure based on use of a two-stage varying parameters model, where visits are regressed first on the travel and time costs and other demand shifters – with the exception of implicit prices of substitute sites – and then in the second step each of the estimated parameters is regressed on the site's characteristics. Substitute prices can be dropped from the specification since these effects are taken into account by using the index.

Classical Travel Cost Models

Classical TCM includes substitution measures in the demand curve. Numerous applications have been carried out within this framework. The paper by Burt and Brewer (1971) is a classic work representing these models.

Their model can be formulated as

$$V_{ij} = a_j + b_j P_{ij} + \sum_k b_k P_{ik} + c_j Y_i + e_{ij} \qquad (2.7)$$

where:

V_{ij} = visits per household from origin i to site j;

P_{ij} = price of traveling from origin i to site j;

P_{ik} = price of traveling from origin i to substitute site k;

a, b, c = parameters to be estimated.

By taking into account the cross-price effects, equation (2.7) overcomes the econometric bias of the own price only TCM. Burt and Brewer (1971) introduced a simplifying assumption, namely, that perfect substitution holds among lakes within a given class of site. This simplification implies that for a given class of site, individuals will always visit the one with the minimum travel cost. This assumption allowed them to set an upper bound of integration for the computation of the net benefits and also to diminish the number of cross-price terms that need to be considered.

TCM with Indexes of Relative Attractiveness

This approach incorporates an index of relative attractiveness and availability of other recreation sites into the site's demand equation (Knetsh et. al., 1976; Talhem, 1978).

This approach has intuitive appeal since it can capture a negative relationship between visits to site i and the attractiveness of other sites as reflected by the index. Moreover, the changes on quality can be represented by the index (Rosenthal, 1985). However, this method is considered by Smith and Desvousges as the least desirable since the index is arbitrarily constructed. That is, the definition of the index implies a knowledge of the substitution relationships which presupposes the same information it tries to derive. Rosenthal (1985) shows by using the Burt and Brewer (1971) framework that this approach is pointless if the objective is to estimate the value of an existing recreation site since higher quality sites can be expected to have larger estimated parameters in the econometric demand equation. That is, separate price terms avoid the need to construct an index since the effects of both price and quality on substitution are already embodied in those price terms. On the other hand, if the objective is to determine the effect of changing quality on benefits at an existing site then the use of an index is a valid method to valuing quality, but still an inferior method since its definition remains arbitrary.

<u>Discrete Choice Travel Cost Models</u>

Discrete choice recreational demand models have recently been developed that incorporate substitution effects influencing recreationists' choices of where and how often to recreate (Caulkins et. al., 1986; Morey (1981); Hanemann (1982); Rosenthal (1985 and 1987). These models are both multi-site and multi-attribute TCM. The model is based on the assumption that households make two separate decisions leading to visitation at a lake. The first choice is whether or not an individual will undertake a recreational activity on a particular day given that the individual is among the lake recreation user population. The second choice is which site to visit given that the choice of visiting a lake has been made. Therefore, as Small and Rosen (1981) have shown, it is possible to represent a demand function as the product of two separate functions.

Caulkins et. al. (1986) use the laws of conditional probability to represent demand as follows

$$P_g\, n_i = P_i|_g * P_g|_r \tag{2.8}$$

where $P_g\, n_i$ is the joint probability of choosing to take a trip to a lake and choosing lake i from the choice set; $P_i|_g$ is the conditional probability of choosing lake i from the choice set given that one has decided to take a trip to a lake; and $P_g|_r$ is the probability of choosing lake recreation on a particular day given that one participates in lake recreation.

A variation on these models is to specify a gravity model to determine the level and distribution of trips across sites (Sutherland, 1982a, b; Rosenthal, 1985 and 1987). Following Rosenthal (1987), the number of trips from the origin to a recreation site is represented as

$$T_{ij} = T_i * P_{ij} \tag{2.9}$$

where T_{ij} is the number of trips from origin i to recreation site j; T_i is the total number of recreation trips from origin i; and P_{ij} is the probability that a trip from origin i will have j as its destination. That is, the gravity model consists of a trip generation function (T_i) and a trip distribution function (P_{ij}). Rosenthal estimated the trip distribution function with a multinomial logit model whereas the trip generation function was estimated using log-linear regression and maximum likelihood logistic regression.

Some of the advantages of using this approach include (1) perfect substitution assumption need not be made; (2) several problems associated with zero observations are handled such as nonnormality of errors, heteroskedasticity, and taking the logarithm of zero; and (3) it can be related within a choice theoretic framework.

Chapter III presents a discrete choice TCM with a gravity model for the estimation of recreational experiences at the major lakes in Oklahoma.

So far we have outlined the different approaches to estimating the recreation demand functions . It remains to discuss the other components outlined in the conceptual introduction, namely, the interest rate and the marginal costs of outdoor recreation facilities at each lake.

Interest Rate Determination in Public Sector Investment

This topic is still a controversial one among economists. The following approaches have dealt with the theoretical determination of the interest rate: the social time preference rate; the opportunity cost of displaced private investment; and the before tax rate of return on corporate investments (Young and Haveman, 1985).

In 1968, the Water Resources Council stated that the formula to compute the discount rate on federal water resources investment was to be based on the yield rate for long-term government bonds. Although this yield has approximated the real opportunity cost of displaced private spending, its conceptual foundation does not appeal to economists since it is based on the nominal cost to government of borrowing (Young and Haveman, 1985). The government borrowing rate is appropriate only when there is a complete segmentation of capital markets, so that no government funds are withdrawn from private investment projects with higher rates of return.

An important issue is whether to use a social interest rate different from the private interest rate. If the capital market is perfectly competitive, then the government should use the market rate of interest as its discount rate in evaluating public investment programs. However, some of the arguments put forward against using this criteria are that the private sector is more risk averse than the public sector; the existence of a corporation income tax that distorts the free market interest rate; the market rate of interest may not take into account society's concern for consumption by future generations; and, finally, the market interest rates change considerably with the business cycle and it does not seem proper to make investment decisions based on rates which fluctuate according with macroeconomic conditions.

Just, Hueth, and Schmitz (1982) contrast the decision on the appropriate interest rate to the determination of income distribution. In the latter, one compares income distribution among groups within the same generation, whereas in the former one compares income accruing to different generations. Hence, the appropriate social interest rate ultimately is a value judgement similar to the appropriate income distribution. They report that real rates of social discount used in the literature fall in the range between zero and four percent; whereas nominal rates vary from eight to sixteen percent.

Marginal Cost of Outdoor Recreation

Outdoor recreation has been considered as a mixed or public good by several authors. Some of the recreational activities carried out at the lakes under study are nonrival such as the enjoyment of scenic beauty. That is, consumption of scenic beauty by an individual does not reduce the amount available for another recreationist. On the other hand, some activities such as camping may become rival if the facilities become congested. Another characteristic of recreation supply is that the marginal costs are shared by the operator and the recreationists with private recreationist costs a nonnegligible part of total costs.

Since the lakes under study are managed by the U.S. Army Corps of Engineers, it is possible to design a rationing system by turning the consumption of recreational services exclusionary through charging appropriate entrance fees or through setting quantitative quotas on visitor days at each lake. However, the implicit policy has been to offer nonexclusionary recreational services (Harrington, 1987) by charging nominal entrance fees and by not setting any kind of quota. Therefore, the attendance at each lake is rationed only by private costs of recreation and externalities such as congestion costs.

Harrington (1987) discusses the aggregate recreation supply with emphasis on travel and congestion costs. He shows that in a spatial model with many communities and many recreation sites an equilibrium is obtained in which the attendance from each community is determined by the sum of congestion and travel costs. For any given community this sum, which turns out to be the price of recreating for that community, is the same for all sites. Otherwise, the community is priced out from a given site. He noted that there is no single price but a different price for each location in space.

Another issue is whether the marginal cost function is upward sloping. In the short run, where site inputs are held constant, marginal social cost is increasing since private costs vary positively with distance and congestion costs are an increasing function of the number of participants. In the long run, there may be some special cases that exhibit constant or decreasing costs (Harrington, 1987). However, these are unlikely to occur for recreation at Oklahoma Lakes since in the long run there is at least one input that remains fixed, which is the amount of available land at a recreation site. Estimates of the long run marginal costs for Tenkiller Lake are presented in Chapter IV and show that investment costs are increasing.

CHAPTER III

DEMAND AND BENEFIT ESTIMATION

The objective of this chapter is to reestimate the demand for water-based recreation activities at five Oklahoma lakes in the McClellan-Kerr Arkansas River Navigation System. The purpose is to incorporate substitution effects among the lakes for use in the investment planning model presented in Chapter 5. Schreiner et. al. (1985) previously estimated demand using the own price travel cost method (TCM) which does not include substitution effects. The principle policy variables considered in this study—entrance fees and investment allocation for lakes Ft. Gibson and Tenkiller—make it necessary to develop a procedure that incorporates substitution effects across recreational sites. These substitution effects come about through cross-price elasticity effects and through changes in the recreation facilities provided that affect quality of the recreational experience.

The Demand Model

The procedure chosen for demand estimation is a regional gravity model that incorporates a Discrete Choice TCM in the trip distribution function (Sutherland, 1982a and 1982b; Cesario and Knetsh, 1976; Rosenthal, 1985 and 1987). The total visitor-days from county i to lake j is modeled as the product of two separate terms:

$$T_{i,j} = T_i * P_{i,j}$$

where $T_{i,j}$ is total visitor days from county i to lake j; $T_i = \sum_j T_{i,j}$; and $P_{i,j}$ is the probability that county i attends lake j.

The term T_i is modeled using a trip generation function whereas the term $P_{i,j}$ represents a trip distribution function. The theoretical justification for separating the demands of a good into the product of two separate functions is found in Small and Rosen (1981). The product of these functions is the expected demand. The term $P_{i,j}$ is estimated using the multinomial logit model proposed by McFadden (1973, 1976). The multinomial logit model is defined as

$$P_{i,j} = \frac{exp[f(B,X_{i,j})]}{\sum_k exp[f(B,X_{i,k})]} \qquad \begin{array}{c} i = 1,..,N \\ k = j = 1,..,J \end{array} \qquad (3.1)$$

where *exp* is the natural number e and f is a function of a parameter vector B and regressors X. Observe that the predicted probabilities always lie between zero and one.

The term T_i is estimated as the product of two functions,

$$T_i = [\sum_j T_{i,j} \mid T_i > 0] * [P_i > 0] \qquad (3.2)$$

The first function of (3.2) determines the level of visitor days generated at county i given that the county registered positive visitor-days. The second function is the probability that county i was sampled at any of the lakes in the survey.

Equation (3.1) is estimated using weighted least squares, where f is specified as a linear function. Let j and m be alternative lakes, then from (3.1)

$$\frac{P_{i,j}}{P_{i,m}} = \frac{exp[(B'X_{i,j})]}{exp[(B'X_{i,m})]}$$

and taking logs to both sides results in

$$\ln \frac{P_{i,j}}{P_{i,m}} = B' (X_{i,j} - X_{i,m}) + \epsilon_i \qquad (3.3)$$

where ϵ_i is the error term. Equation (3.3) is readily amenable for estimation using weighted least squares. Note that the dependent variable is the logarithm of the probability of choosing alternative j over m. Therefore, it is no longer required that the predicted values of the dependent variable lie between zero and one but can lie on the entire real line.

An important property of the multinomial logit model (MNL) as shown by McFadden (1973) is that the model can be derived from utility maximization. The MNL is derived from utility maximization if and only if the error term in the stochastic individual utilities are independent and their distribution is given by a Type I extreme value distribution. This distribution is also known as the log Weibull distribution.

Another important feature of the MNL is the independence of irrelevant alternatives property (IIA). This means that the probability of j being chosen over m is independent from the availability or attributes of alternatives other than j and m. An implication of the IIA property is that the cross-elasticity of the probability of response m with respect to variable $X_{i,j}$ is the same for all $m \neq j$. The IIA property constitutes both an advantage and a disadvantage. The advantage is that the parameter vector B is constant for all alternatives making the model useful in predicting the demand for a new recreational site. The disadvantage is that the property is not plausible if the alternatives are similar since it is likely that the probabilities between alternatives j and m will change with the introduction of a similar alternative. Using the Domencich and McFadden (1975) example, if the alternatives for a model of transportation consist of car, red bus, and blue bus, instead of car, bus, and train, then the IIA property is an unreasonable assumption since the utility level for using a red bus is highly correlated with the utility level of riding in a blue bus. Hence, the probability of j being chosen over m depends on alternatives other than j and m.

Notice also that regressors common to all alternatives should be dropped from (3.3). Even the constant term should be dropped from the specification, but Amemiya (1981) suggests keeping the constant term since the fit is generally better. This specification implies that the utilities depend on the lake characteristics, which is in line with the hedonic demand models discussed by Lancaster (1966).

For a detailed discussion of the theoretical properties of the multinomial logit model see McFadden (1973, 1976, 1982) and Domencich and McFadden (1975).

The observed probabilities are estimated from grouped data, assuming that each of the error terms of the individual observations in a group is independent and follows a multinomial probability distribution which approximates a normal distribution in large samples. Since the error term in equation (3.3) is heteroscedastic (Theil, 1970; Pyndick and Rubinfeld, 1981) the data are weighted by

$$[1/V(i,j)]^{.5}$$

where V(i,j) is the variance of the error term given by

$$V(i,j) = \frac{n_i}{r_{i,j} * (n_i - r_{i,j})}$$

where n_i is the total visitor days originated from county i and $r_{i,j}$ is the total visitor days from county i to lake j.

The predicted values need to be renormalized into probabilities. The restriction that the sum of the probabilities must equal one is used to compute the predicted probabilities. An alternative way to compute the predicted probabilities is by substituting the estimated parameter vector B in (3.1).

The weighted least squares method of estimating the multinomial model results in consistent estimators. But if the sample is large and the selection probabilities are distributed very unevenly among the different alternatives, maximum likelihood yields better estimators than least squares using grouped data. Accessibility of the appropriate software for maximum likelihood estimation limited the author to that of estimation by weighted least squares for the multinomial logit model in equation (3.1).

The first function of equation (3.2) is estimated using weighted loglinear regression to correct for heteroscedasticity. The predicted values of the total visitor days are corrected for the bias present in the constant term (Goldberger, 1968, Kennedy, 1983). This bias results in overprediction of the dependent variable, which may be sizable in simulation studies that predict outside the range of the data set. The procedure presented by Kennedy is used to correct for bias and results in the following estimator

$$T_i^* = T_i \; exp[.5\,\hat{\sigma}^2 - .5V(i)]$$

where T_i is the predicted value from the loglinear regression, T_i^* is the corrected value, $\hat{\sigma}^2$ is the estimated variance of the regression, and V(i) is the estimate of the variance of the predicted value. V(i) is given by

$$V(i) = \hat{\sigma}^2 X_0' (X'X)^{-1} X_0$$

where X_0 is the specific value of X corresponding to the T_i to be forecast, and $(X'X)^{-1}$ is the estimated variance-covariance matrix.

The second function of (3.2) is estimated using a binomial logit specification, where the dependent variable takes the value of one if the county is observed and zero otherwise. The maximum likelihood method is used to obtain estimators of the binomial logit function. The algorithm used to compute the estimates is the Newton-Raphson method.

One important property of the demand function proposed is that it meets the integrability conditions which must hold in the specification of the mathematical programming model presented in Chapter 5 (Hotelling, 1938; Silberberg, 1978). Failure to meet this condition will result in an ambiguous welfare ranking of the multisites alternatives when many prices are assumed to change simultaneously. The necessary and sufficient conditions needed to fulfill the integrability condition is that the Slutzky cross price slopes must be the same. Neuberger (1971) showed that the integrability condition implies that the income elasticities of demand for all sites are equal for each observation. He also showed that this condition holds for the logit function. Hence, the primal-dual linear programming approach for dealing with the integrability condition which endogeneizes price changes (Yaron, Plessner, and Heady, 1969; Duloy and Norton, 1975; Willet, 1983) presented in Chapter 5 results in a meaningful social welfare since the demand equations meet the integrability conditions.

Data

Data on visitor days were obtained from the survey carried out by Oklahoma State University in 1975 at the McClellan-Kerr Arkansas River Navigation System (Badger, Schreiner, Presley, 1977). The Oklahoma lakes in the survey were Eufaula, Ft. Gibson, Keystone, Oolagah, and Tenkiller.

The purpose of the research is to analyze the investment path and price policies for a local lake (Fort Gibson) and a regional lake (Tenkiller), as defined by Schreiner et. al. (1985). Counties comprising the market area for Tenkiller are used as observations. Because the market area for Ft. Gibson is a subset of the market area for Tenkiller, no additional observations are needed in estimating the cross-price effects. An assumption imposed with the current data set is that all individuals aggregated within a county observation have the same utility function. Table I presents the observed visitor days by county and lake.

Data on lake characteristics were obtained from each lake's Master Plan prepared by the U.S. Army Corps of Engineers. These data are presented in Table II and include miles of shoreline, number of campsites, number of public-use areas, water surface area, and land area. Data on characteristics of water quality such as dissolved oxygen, which have been identified as important variables in other studies (Smith, Desvousges, and Fischer, 1986), were not available for the Oklahoma lakes.

Data on income per capita by county for 1975 were obtained from the U.S. Department of Commerce, Bureau of Economic Analysis (1981). Data on population by county were obtained from the Oklahoma Employment Security Commission (1976). Data on travel costs were derived from Schreiner et. al. (1985). The maximum observed travel cost for a given lake was assumed for those counties with missing data. Unfortunately, the time costs data were highly correlated with travel costs and thus were excluded. Appendixes A, B, and C display the data used in the estimation procedure.

Results

The final form of equation (3.3) is

$$\ln \frac{P_j}{P_m} = B_1 + B_2\,[\ln CS_j - \ln CS_m] + B_3[\ln TC_j - \ln TC_m] + \epsilon_i \qquad (3.4)$$

where CS is number of campsites and TC are travel costs to a given lake. The subscript i for county (observation) has been dropped for convenience.

The logarithmic specification of the independent variables gives a better fit to the equation compared with the data untransformed which confirms previous

TABLE I

OBSERVED VISITOR DAYS BY LAKE AND COUNTY FROM SAMPLE SURVEY, 1975

County	State	LAKE Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller	Total
Adair	OK		4			20	24
Cherokee	OK					69	69
Cleveland	OK	32	20			39	91
Craig	OK		40				40
Creek	OK	4	65	204	15	266	554
Delaware	OK					8	8
Garvin	OK	20					20
Haskell	OK	23					23
Hughes	OK	20				28	48
Latimer	OK	19					19
LeFlore	OK	24				25	49
Lincoln	OK	6	20	56			82
Logan	OK	24				56	80
McIntosh	OK	282	15				297
Mayes	OK		8		21	10	39
Muskogee	OK	28	234			57	319
Noble	OK			8		6	14
Nowata	OK				5		5
Okfuskee	OK	77					77
Oklahoma	OK	863	68	80	61	761	1,833
Okmulgee	OK	200	6		14	54	274
Osage	OK		25	4	42	16	87
Pawnee	OK			10			10
Payne	OK		6	103		16	125
Pittsburg	OK	307				3	310
Pontotoc	OK	54					54
Pottowatomie	OK	315				87	402
Rogers	OK	6	131	2	80		219
Seminole	OK	15		6		44	65
Sequoyah	OK					135	135
Tulsa	OK	80	1,099	771	364	645	2,959
Wagoner	OK		35	10		30	75
Washington	OK		18	5	92	35	150
Benton	AR					16	16
Crawford	AR					66	66
Sebastian	AR	9				183	192
Washington	AR					48	48
TOTAL		2,408	1,794	1,259	694	2,723	8,878

SOURCE: Badger, Daniel D., Dean F. Schreiner, and Ronald W. Presley. Analysis of Expenditures for Outdoor Recreation at the McClellan-Kerr Arkansas River Navigation System. U.S. Army Corps of Engineers Contract Report 77-4, 1977.

TABLE II

LAKE CHARACTERISTICS DATA

Lake	Shoreline (Miles)	Number of Campsites	Number of Public Use Areas	Water Surface Area (Acres)	Land Area for Fish & Wildlife Management (Acres)	Visitor Days Per Campsite May-Aug 1975 (1,000)	Number of Public Use Areas with Boat Ramps	Ratio of Campsites to Land Area
Eufaula	600	652	23	102,500	56,401	4.37	21	0.012
Ft. Gibson	225	559	22	19,900	44,654	4.645	18	0.013
Keystone	330	394	24	24,500	21,377	4.865	19	0.018
Oolagah	209	252	12	29,500	18,160	3.423	11	0.014
Tenkiller	130	891	18	12,650	13,607	3.992	18	0.065

SOURCE: U.S. Army Corps of Engineers, Tulsa District "Lake Data."

Oklahoma Water Resources Board."Oklahoma's Water Atlas", Publication No. 76, 1976.

Schreiner, D. F., D. A. Willet, D. D. Badger and L. G. Antle. Recreation Benefits Measured by Travel Cost Method for McClellan-Kerr Arkansas River Navigation System and Application to Other Selected Corps Lakes, U.S. Army Corps of Engineers Contract Report 85-C-1, 1985.

findings (Amemiya, 1981). It means that individuals react less proportionally to a given stimulus, i.e., twice as far is not twice as bad.

The empirical result of equation (3.4) is

$$\ln \frac{P_j}{P_m} = \underset{(6.88)}{.788} + \underset{(4.171)}{.919} [\ln CS_j - \ln CS_m] - \underset{(-14.733)}{1.217} [\ln TC_j - \ln TC_m] \tag{3.5}$$

where the numbers in parenthesis are t values and the number of observations is 148.

The Pseudo R^2 (Maddala, 1983) is .631. The Likelihood Ratio Test (Mendenfall, Sheaffer, Wackerly, 1981) is 184.55, which implies that the null hypothesis (i.e., the slope parameters are zero) is rejected at the one percent significance level.

Furthermore, the individual estimates are significant at the 1 percent probability level. The expected signs are obtained for the slope parameters. An increase of one unit in the difference of the logarithms of campsites between j over m increases the logarithm of the probability of favoring alternative j by .919. Likewise, an increase of one unit in the difference of the logarithms of travel costs between j and m decreases the logarithm of the probability of favoring alternative j by 1.217.

The campsite variable is interpreted as a proxy variable for quality of recreation. The addition of lake characteristics other than campsites did not improve the estimates and resulted in a loss of statistical efficiency. Although investment in campsites improves the quality of the lake by providing facilities, it is likely that the U.S. Army Corps of Engineers invest in those sites where quality perceived by recreationists is the highest.

Observe that the price and campsite coefficients are the same for all lakes. That is, the quality effect has been factored out from the price effect. Some alternative methodologies result in estimates for the price coefficient that include differences in quality among alternatives.

Equation (3.5) allows the estimation of the predicted probabilities for the unobserved counties. Tables III and IV present the observed and predicted probabilities that county i attends lake j. For the purposes of computing the dependent variable in equation (3.5), the zero observed probabilities were adjusted arbitrarily to .01 preserving the restriction that the sum of the observed probabilities equals one.

The loglinear regression part of equation (3.2) is estimated with the following specification

$$T_i = A[POP_i]^{B5} [D_i]^{B6} * e_i \tag{3.6}$$

where POP_i is the population in thousands for county i, D_i is the value of the denominator obtained in (3.5), and e_i is an independent normally distributed error term. Taking logarithms to both sides results in

$$\ln T_i = \ln A + B_5 \ln POP_i + B_6 \ln D_i + \ln e_i \tag{3.7}$$

The D_i variable was identified as important in previous studies since it measures the supply of visitor days (Rosenthal, 1985; Cesario and Knetsch, 1976; Ewing, 1980). It is hypothesized that the relationship between D_i and T_i is positive since the more facilities located at a lake, the greater is the expected number of trips to the lake. Ewing (1980) points out reasons why an increase in the number, attractiveness, or accessibility of destinations will result in some increase in the number of trips generated. He asserts that increased trips are likely because (1) the existence of more facilities increases the probability that knowledge about these facilities will be diffused more widely in the population; (2) crowding at facilities can be reduced by an increase in the supply of facilities, which in turn may have a positive feedback on the perceived attractiveness of the sites; and (3) increased attractiveness of the sites may

TABLE III

OBSERVED PROBABILITIES THAT COUNTY I ATTENDS LAKE J (1)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller
Adair	OK	0.000	0.167	0.000	0.000	0.833
Cherokee	OK	0.000	0.000	0.000	0.000	1.000
Cleveland	OK	0.352	0.220	0.000	0.000	0.429
Craig	OK	0.000	1.000	0.000	0.000	0.000
Creek	OK	0.007	0.117	0.368	0.027	0.480
Delaware	OK	0.000	0.000	0.000	0.000	1.000
Garvin	OK	1.000	0.000	0.000	0.000	0.000
Haskell	OK	1.000	0.000	0.000	0.000	0.000
Hughes	OK	0.417	0.000	0.000	0.000	0.583
Latimer	OK	1.000	0.000	0.000	0.000	0.000
LeFlore	OK	0.490	0.000	0.000	0.000	0.510
Lincoln	OK	0.073	0.244	0.683	0.000	0.000
Logan	OK	0.300	0.000	0.000	0.000	0.700
McIntosh	OK	0.949	0.051	0.000	0.000	0.000
Mayes	OK	0.000	0.205	0.000	0.538	0.256
Muskogee	OK	0.088	0.734	0.000	0.000	0.179
Noble	OK	0.000	0.000	0.571	0.000	0.429
Nowata	OK	0.000	0.000	0.000	1.000	0.000
Okfuskee	OK	1.000	0.000	0.000	0.000	0.000
Oklahoma	OK	0.471	0.037	0.044	0.033	0.415
Okmulgee	OK	0.730	0.022	0.000	0.051	0.197
Osage	OK	0.000	0.287	0.046	0.483	0.184
Pawnee	OK	0.000	0.000	1.000	0.000	0.000
Payne	OK	0.000	0.048	0.824	0.000	0.128
Pittsburg	OK	0.990	0.000	0.000	0.000	0.010
Pontotoc	OK	1.000	0.000	0.000	0.000	0.000
Pottowatomie	OK	0.784	0.000	0.000	0.000	0.216
Rogers	OK	0.027	0.598	0.009	0.365	0.000
Seminole	OK	0.231	0.000	0.092	0.000	0.677
Sequoyah	OK	0.000	0.000	0.000	0.000	1.000
Tulsa	OK	0.027	0.371	0.261	0.123	0.218
Wagoner	OK	0.000	0.467	0.133	0.000	0.400
Washington	OK	0.000	0.120	0.033	0.613	0.233
Benton	AR	0.000	0.000	0.000	0.000	1.000
Crawford	AR	0.000	0.000	0.000	0.000	1.000
Sebastian	AR	0.047	0.000	0.000	0.000	0.953
Washington	AR	0.000	0.000	0.000	0.000	1.000

(1) Observed probabilities are estimated as:

$$P_{ij} = \frac{r_{ij}}{n_i}$$

where r_{ij} is the sampled number of visitor days from county i to lake j, n_i is the total number of visitor days sampled from county i, and P_{ij} is the observed probability that county i attends lake j.

TABLE IV

PREDICTED PROBABILITIES THAT COUNTY I ATTENDS LAKE J (1)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller
Adair	OK	0.223	0.042	0.015	0.026	0.693
Atoka	OK	0.511	0.056	0.039	0.065	0.329
Bryan	OK	0.454	0.075	0.052	0.086	0.334
Cherokee	OK	0.180	0.651	0.011	0.018	0.141
Choctaw	OK	0.421	0.077	0.053	0.089	0.360
Cleveland	OK	0.178	0.269	0.061	0.102	0.389
Coal	OK	0.491	0.058	0.040	0.067	0.343
Craig	OK	0.152	0.516	0.073	0.031	0.228
Creek	OK	0.015	0.109	0.417	0.081	0.377
Delaware	OK	0.466	0.078	0.054	0.090	0.312
Garvin	OK	0.128	0.129	0.089	0.148	0.507
Haskell	OK	0.319	0.167	0.016	0.027	0.471
Hughes	OK	0.374	0.046	0.032	0.053	0.496
Johnston	OK	0.445	0.079	0.054	0.091	0.331
Latimer	OK	0.368	0.045	0.031	0.051	0.505
LeFlore	OK	0.216	0.033	0.023	0.038	0.689
Lincoln	OK	0.023	0.100	0.735	0.025	0.117
Logan	OK	0.162	0.040	0.116	0.047	0.635
McClain	OK	0.398	0.088	0.061	0.102	0.351
McCurtain	OK	0.356	0.091	0.063	0.105	0.384
McIntosh	OK	0.908	0.028	0.007	0.004	0.053
Mayes	OK	0.282	0.062	0.109	0.383	0.164
Murray	OK	0.386	0.090	0.062	0.104	0.358
Muskogee	OK	0.111	0.412	0.060	0.022	0.397
Noble	OK	0.414	0.116	0.217	0.134	0.119
Nowata	OK	0.276	0.051	0.176	0.153	0.343
Okfuskee	OK	0.547	0.028	0.135	0.032	0.259
Oklahoma	OK	0.300	0.166	0.160	0.074	0.301
Okmulgee	OK	0.206	0.088	0.155	0.086	0.463
Osage	OK	0.250	0.332	0.062	0.131	0.225
Ottawa	OK	0.313	0.068	0.047	0.079	0.493
Pawnee	OK	0.366	0.067	0.130	0.078	0.359
Payne	OK	0.251	0.064	0.502	0.074	0.108
Pittsburg	OK	0.859	0.036	0.025	0.042	0.038
Pontotoc	OK	0.688	0.039	0.027	0.046	0.199
Pottowatomie	OK	0.415	0.063	0.181	0.073	0.268
Pushmataha	OK	0.450	0.065	0.045	0.076	0.364
Rogers	OK	0.055	0.239	0.025	0.326	0.356
Seminole	OK	0.259	0.067	0.093	0.077	0.504
Sequoyah	OK	0.284	0.112	0.011	0.018	0.575
Tulsa	OK	0.115	0.218	0.389	0.097	0.182
Wagoner	OK	0.384	0.184	0.036	0.029	0.367
Washington	OK	0.318	0.154	0.070	0.162	0.297
Benton	AR	0.314	0.077	0.053	0.089	0.466
Boone	AR	0.114	0.131	0.090	0.151	0.513
Carroll	AR	0.294	0.094	0.065	0.109	0.438
Conway	AR	0.099	0.114	0.079	0.132	0.576
Crawford	AR	0.378	0.036	0.025	0.041	0.520

TABLE IV (CONTINUED)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller
Franklin	AR	0.388	0.060	0.041	0.069	0.441
Garland	AR	0.113	0.129	0.089	0.149	0.520
Howard	AR	0.318	0.116	0.080	0.134	0.353
Johnson	AR	0.375	0.071	0.049	0.081	0.424
Logan	AR	0.387	0.059	0.041	0.068	0.445
Madison	AR	0.292	0.071	0.049	0.082	0.506
Marion	AR	0.132	0.152	0.104	0.175	0.437
Montgomery	AR	0.265	0.064	0.044	0.074	0.554
Newton	AR	0.307	0.108	0.074	0.124	0.386
Perry	AR	0.104	0.120	0.082	0.138	0.556
Pike	AR	0.306	0.110	0.076	0.127	0.381
Polk	AR	0.360	0.083	0.057	0.096	0.404
Pope	AR	0.359	0.084	0.058	0.097	0.403
Scott	AR	0.383	0.066	0.045	0.076	0.429
Searcy	AR	0.130	0.149	0.103	0.172	0.446
Sebastian	AR	0.205	0.055	0.038	0.064	0.638
Sevier	AR	0.330	0.105	0.073	0.122	0.370
Washington	AR	0.233	0.045	0.031	0.052	0.639
Yell	AR	0.322	0.091	0.063	0.105	0.418
Chautauqua	KS	0.090	0.104	0.266	0.120	0.420
Cherokee	KS	0.093	0.107	0.073	0.123	0.604
Crawford	KS	0.105	0.120	0.083	0.139	0.554
Labette	KS	0.325	0.080	0.055	0.093	0.447
Montgomery	KS	0.113	0.129	0.089	0.149	0.520
Neosho	KS	0.111	0.128	0.088	0.148	0.525
Barry	MO	0.286	0.084	0.058	0.097	0.476
Barton	MO	0.111	0.128	0.088	0.148	0.525
Jasper	MO	0.102	0.117	0.081	0.136	0.564
Lawrence	MO	0.112	0.128	0.088	0.148	0.524
McDonald	MO	0.305	0.067	0.046	0.078	0.503
Newton	MO	0.328	0.074	0.051	0.086	0.460
Stone	MO	0.108	0.124	0.085	0.143	0.540
Taney	MO	0.124	0.143	0.098	0.165	0.469
Lamar	TX	0.391	0.092	0.063	0.106	0.348
Red River	TX	0.363	0.107	0.073	0.123	0.334

(1) Predicted probabilities are estimated as:

$$P_{ij} = \frac{exp\,(\hat{B}_1 + \hat{B}_2\,CS_j + \hat{B}_3\,TC_{ij})}{\sum_{k=1}^{5} exp\,(\hat{B}_1 + \hat{B}_2\,CS_k + \hat{B}_3\,TC_{ik})}$$

where CS_k is the number of campsites at lake k, TC_{ik} are the travel costs from county i to lake k, $\hat{B} = (\hat{B}_1, \hat{B}_2, \hat{B}_3) = (.788, .919, -1.217)$ is the estimated parameter vector, and Pij are the predicted probabilities that county i attends lake k.

induce substitution away from other leisure activities into outdoor recreational activities.

The empirical results obtained are

$$\ln T_i = -16.263 + 1.213 \ln POP_i + .9231 \ln D_i \qquad (3.8)$$
$$\qquad (-7.00) \quad (8.55) \qquad\qquad (5.037)$$

where again the numbers in parenthesis are t values.

The number of observations is 37 and other statistics are the following:

Adjusted $R^2 = .704$ $\qquad F_{2,34} = 43.9$

Variance-Covariance Matrix:

	Intercept	lnPOP	lnD
Intercept	5.3949	-.24138	-.33199
lnPOP		.020129	.003783
lnD			.033762

The variance-covariance matrix is reported since it must be known to correct for the prediction bias described above. The F test is statistically significant at the one percent probability level. The individual parameters are also significant at the one percent level.

The county population elasticity is positive and greater than one. Taking into account the effect of the other two functions given in equations (3.1) and (3.2) does not change this basic result as reported below. The author has not found a convincing justification for the appropriate magnitude of the population parameter. For example, Cesario and Knestch (1976) in a model similar to the one presented above, found population elasticities of 1.012 and 1.123 corresponding to two different methods for measuring generalized travel costs. On the other hand, Flegg (1976) found population elasticities between .334 and .80 according to the type of visitor. Both argued that their estimates fall within their expectations without providing much elaboration.

The results of (3.8) also agree with Cesario and Knestch in that the income per capita variable is not as significant as population in explaining total visitor days emanating from each origin. The income per capita variable was not statistically significant and its inclusion resulted in a negative coefficient. Hence, it was decided to drop it from equation (3.8). Duffield (1984) reported that unlike many other studies, the income variable was significantly correlated with the visitor day rate but he also obtained a negative relationship. He explained this result by the fact that the wealthiest individuals lived farther from the recreation site, so that income was correlated with distance. Similarly, Flegg (1976) found income to be significant only for casual visitors, but with a negative .956 coefficient. He concluded that low income casual visitors tend to visit more frequently than those with higher incomes.

The final specification of the logit part of equation (3.2) is

$$P_i = \frac{1}{1 + exp\,(B_7 + B_8STA_i + B_9\ln Y_i + B_{10}\ln POP_i + B_{11}\ln D_i)} \tag{3.9}$$

where STA is a dummy qualitative variable, with one if the county is located in the state of Oklahoma and zero otherwise, Y is income per capita, and the other variables defined as before. The empirical estimates of equation (3.9) are the following:

	B_7	B_8	B_9	B_{10}	B_{11}
Estimate	-116.4	4.41	7.516	1.404	4.637
t value	(-3.22)	(3.23)	(2.076)	(1.584)	(3.133)
Significance Level	.001	.001	.037	.113	.002

The Pseudo R^2 is .758. The only variable not significant is population but it was decided to keep it in the specification. The state variable is highly significant. It agrees with results found by Sutherland (1982a) although he suggested that this variable may turn out to be significant because of sampling errors in the surveys conducted in his study. However, it may be reasonable to expect a significant positive sign. In-state residents probably have more information available about the state's recreational facilities through local news, friends, and promotional efforts of the local office of the U.S. Army Corps of Engineers. Moreover, availability of rental cabins and cars might be restricted or bear a higher rate for out-of-state visitors. Table V presents the actual and predicted probabilities that one or more visits from county i were sampled at any of the lakes.

The predicted sample visitor days by county are presented in Table VI. Except for a few counties, the predicted visitor days follow a similar pattern with respect to the observed data. Note that the specification of equation (3.2) smooths the predicted visitor days by county. Counties that showed up in the sample will generally have lower predicted visitor days while counties with zero observed visitor days will show positive values for visitor days. The dependent variable of the logistic part of (3.2) is a function of the sampling rate used in the survey. If a higher sampling rate is used, the predicted probability of sampling a county will be closer to one, and that county's observation will be taken into account in the loglinear part of (3.2). If a lower sampling rate is used, then the predicted probability of unobserved counties will be closer to zero, but this downward effect will be compensated by the upward bias in the loglinear part of (3.2).

TABLE V

PROBABILITY THAT ONE OR MORE VISITS FROM A COUNTY WERE SAMPLED AT ANY OF THE LAKES (1)

County	State	Observed Probability (1)	Predicted Probability (2)
Adair	OK	1	0.975
Atoka	OK	0	0.182
Bryan	OK	0	0.814
Cherokee	OK	1	0.999
Choctaw	OK	0	0.119
Cleveland	OK	1	0.984
Coal	OK	0	0.215
Craig	OK	1	0.999
Creek	OK	1	1.000
Delaware	OK	1	0.206
Garvin	OK	1	0.488
Haskell	OK	1	0.989
Hughes	OK	1	0.894
Johnston	OK	0	0.100
Latimer	OK	1	0.723
LeFlore	OK	1	0.985
Lincoln	OK	1	0.999
Logan	OK	1	0.981
McClain	OK	1	0.613
McCurtain	OK	0	0.226
McIntosh	OK	1	1.000
Mayes	OK	1	0.999
Murray	OK	0	0.325
Muskogee	OK	1	1.000
Noble	OK	1	0.320
Nowata	OK	1	0.931
Okfuskee	OK	1	0.973

TABLE V (CONTINUED)

County	State	Observed Probability (1)	Predicted Probability (2)
Oklahoma	OK	1	1.000
Okmulgee	OK	1	0.997
Osage	OK	1	0.972
Ottawa	OK	0	0.953
Pawnee	OK	1	0.824
Payne	OK	1	0.969
Pittsburg	OK	1	0.994
Pontotoc	OK	1	0.996
Pottowatomie	OK	1	0.985
Pushmataha	OK	0	0.080
Rogers	OK	1	0.998
Seminole	OK	1	0.910
Sequoyah	OK	1	0.999
Tulsa	OK	1	1.000
Wagoner	OK	1	0.998
Washington	OK	1	1.000
Benton	AR	1	0.575
Boone	AR	0	0.011
Carroll	AR	0	0.018
Conway	AR	0	0.007
Crawford	AR	1	0.717
Franklin	AR	0	0.062
Garland	AR	0	0.090
Howard	AR	0	0.009
Johnston	AR	0	0.035
Logan	AR	0	0.130
Madison	AR	0	0.016

TABLE V (CONTINUED)

County	State	Observed Probability (1)	Predicted Probability (2)
Marion	AR	0	0.000
Montgomery	AR	0	0.012
Newton	AR	0	0.000
Perry	AR	0	0.000
Pike	AR	0	0.001
Polk	AR	0	0.017
Pope	AR	0	0.109
Scott	AR	0	0.011
Searcy	AR	0	0.000
Sebastian	AR	1	0.742
Sevier	AR	0.	0.007
Washington	AR	1	0.933
Yell	AR	0	0.014
Chautauqua	KS	0	0.003
Cherokee	KS	0	0.017
Crawford	KS	0	0.056
Labette	KS	0	0.089
Montgomery	KS	0	0.093
Neosho	KS	0	0.029
Barry	MO	0	0.042
Barton	MO	0	0.001
Jasper	MO	0	0.134
Lawrence	MO	0	0.007
McDonald	MO	0	0.003
Newton	MO	0	0.073
Stone	MO	0	0.002

TABLE V (CONTINUED)

County	State	Observed Probability (1)	Predicted Probability (2)
Taney	MO	0	0.005
Lamar	TX	0	0.088
Red River	TX	0	0.003

(1) Observed probability is one if the county was sampled, zero otherwise.

(2) Predicted probabilities computed as:

$$P_{ij} = \frac{1}{1 + exp\,(\hat{B}_7 + \hat{B}_8\,STA_i + \hat{B}_9 \ln Y_i + \hat{B}_{10} \ln POP_i + \hat{B}_{11} \ln D_i)}$$

where

STA_i = 1 if county is located in Oklahoma, zero otherwise.
Y_i = is per capita income for county i.
POP_i = is population at county i.
D_i = is the value of the denominator of the trip distribution function for county i.
$\hat{B}$ = $(\hat{B}_7, \hat{B}_8, \hat{B}_9, \hat{B}_{10}, \hat{B}_{11})$ = (-116.4, 4.41, 7.516, 1.404, 4.637) is the estimated parameter vector.

TABLE VI

PREDICTED SAMPLE VISITOR DAYS BY LAKE AND COUNTY (1)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller	Total
Adair	OK	12.68	2.41	0.87	1.45	39.35	56.76
Atoka	OK	1.49	0.16	0.11	0.19	0.96	2.91
Bryan	OK	12.44	2.05	1.41	2.37	9.15	27.41
Cherokee	OK	25.24	91.28	1.47	2.47	19.81	140.27
Choctaw	OK	1.01	0.19	0.13	0.21	0.87	2.41
Cleveland	OK	25.08	37.94	8.62	14.43	54.79	140.87
Coal	OK	0.69	0.08	0.06	0.09	0.48	1.40
Craig	OK	6.20	21.03	2.97	1.26	9.30	40.75
Creek	OK	4.16	30.35	116.15	22.66	104.96	278.28
Delaware	OK	2.13	0.36	0.41	0.25	1.42	4.57
Garvin	OK	1.21	1.22	0.84	1.41	4.81	9.49
Haskell	OK	9.14	4.79	0.47	0.78	13.50	28.68
Hughes	OK	8.08	0.99	0.69	1.15	10.73	21.64
Johnston	OK	0.38	0.07	0.05	0.08	0.28	0.85
Latimer	OK	4.24	0.51	0.35	0.59	5.82	11.51
LeFlore	OK	21.65	3.33	2.30	3.85	69.04	100.17
Lincoln	OK	1.85	8.19	60.37	2.07	9.61	82.09
Logan	OK	8.04	2.01	5.77	2.32	31.63	49.78
McClain	OK	4.23	0.93	0.64	1.08	3.73	10.61
McCurtain	OK	3.23	0.83	0.57	0.96	3.49	9.08
McIntosh	OK	218.48	6.82	1.66	0.89	12.85	240.70
Mayes	OK	23.57	5.17	9.13	32.03	13.72	83.62
Murray	OK	1.11	0.26	0.18	0.30	1.03	2.88
Muskogee	OK	35.68	132.76	19.25	6.99	127.93	322.60
Noble	OK	0.89	0.25	0.47	0.29	0.26	2.15
Nowata	OK	3.81	0.71	2.43	2.11	4.72	13.77
Okfuskee	OK	15.37	0.77	3.79	0.89	7.29	28.12
Oklahoma	OK	408.83	255.97	217.69	100.73	410.40	1,363.62
Okmulgee	OK	20.93	8.98	15.77	8.78	47.03	101.48
Osage	OK	14.28	19.00	3.56	7.47	12.88	57.19
Ottawa	OK	12.68	2.78	1.91	3.21	20.00	40.58
Pawnee	OK	4.48	0.83	1.59	0.95	4.39	12.25
Payne	OK	22.16	5.68	44.27	6.56	9.56	88.23
Pittsburg	OK	87.25	3.69	2.54	4.26	3.85	101.58
Pontotoc	OK	47.18	2.71	1.87	3.12	13.66	68.53
Pottowatomie	OK	33.52	5.11	14.64	5.90	21.62	80.80
Pushmataha	OK	0.43	0.06	0.04	0.07	0.35	0.96
Rogers	OK	5.11	22.26	2.29	30.35	33.19	93.20
Seminole	OK	8.78	2.27	3.16	2.62	17.11	33.93
Sequoyah	OK	39.63	15.68	1.53	2.56	80.37	139.78
Tulsa	OK	268.25	509.42	910.04	227.25	425.18	2,340.13
Wagoner	OK	40.59	19.47	3.79	3.04	38.81	105.70
Washington	OK	22.93	11.13	5.02	11.67	21.41	72.15
Benton	AR	14.73	3.61	2.49	4.17	21.84	46.84
Boone	AR	0.02	0.02	0.02	0.03	0.09	0.17
Carroll	AR	0.06	0.02	0.01	0.02	0.09	0.22
Conway	AR	0.01	0.01	0.01	0.01	0.05	0.09
Crawford	AR	20.17	1.90	1.31	2.19	27.74	53.32
Franklin	AR	0.39	0.06	0.04	0.07	0.44	1.00
Garland	AR	0.54	0.62	0.42	0.71	2.48	4.77
Howard	AR	0.03	0.01	0.01	0.01	0.03	0.08
Johnson	AR	0.23	0.04	0.03	0.05	0.26	0.61
Logan	AR	1.28	0.20	0.13	0.23	1.47	3.31
Madison	AR	0.05	0.01	0.01	0.01	0.08	0.16
Marion	AR	0.00	0.00	0.00	0.00	0.00	0.00

TABLE VI (CONTINUED)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller	Total
Montgomery	AR	0.02	0.01	0.00	0.01	0.04	0.08
Newton	AR	0.00	0.00	0.00	0.00	0.00	0.00
Perry	AR	0.00	0.00	0.00	0.00	0.00	0.00
Pike	AR	0.00	0.00	0.00	0.00	0.00	0.01
Polk	AR	0.09	0.02	0.01	0.02	0.10	0.24
Pope	AR	1.50	0.35	0.24	0.40	1.68	4.17
Scott	AR	0.04	0.01	0.00	0.01	0.05	0.11
Searcy	AR	0.00	0.00	0.00	0.00	0.00	0.00
Sebastian	AR	35.42	9.60	6.61	11.08	110.40	173.11
Sevier	AR	0.02	0.01	0.00	0.01	0.02	0.06
Washington	AR	43.71	8.45	5.82	9.76	119.82	187.56
Yell	AR	0.07	0.02	0.01	0.02	0.09	0.21
Chautauqua	KS	0.00	0.00	0.00	0.00	0.00	0.01
Cherokee	KS	0.03	0.03	0.02	0.04	0.18	0.29
Crawford	KS	0.18	0.20	0.14	0.24	0.94	1.69
Labette	KS	0.80	0.20	0.14	0.23	1.10	2.46
Montgomery	KS	0.32	0.37	0.25	0.42	1.47	2.82
Neosho	KS	0.04	0.05	0.03	0.05	0.19	0.36
Barry	MO	0.27	0.08	0.05	0.09	0.44	0.93
Barton	MO	0.00	0.00	0.00	0.00	0.01	0.01
Jasper	MO	1.12	1.29	0.89	1.49	6.19	10.99
Lawrence	MO	0.01	0.02	0.01	0.02	0.07	0.13
McDonald	MO	0.02	0.00	0.00	0.00	0.03	0.05
Newton	MO	1.13	0.26	0.18	0.29	1.58	3.43
Stone	MO	0.00	0.00	0.00	0.00	0.01	0.01
Taney	MO	0.01	0.01	0.00	0.01	0.02	0.05
Lamar	TX	1.39	0.33	0.22	0.38	1.24	3.56
Red River	TX	0.01	0.00	0.00	0.00	0.01	0.04
Total		1,612.80	1,238.28	1,489.84	553.92	2,021.58	6,916.43

(1) Predicted sample visitor days are computed as:

$$T_{ij} = \left[A[POP_i]^{\hat{B}_5}[D_i]^{\hat{B}_6} \right] \left[\frac{1}{1 + exp\,(\hat{B}_7 + \hat{B}_8 STA_i + \hat{B}_9 \ln Y_i + \hat{B}_{10} \ln POP_i + \hat{B}_{11} \ln D_i)} \right] X$$

$$\left[\frac{exp\,(\hat{B}_1 + \hat{B}_2\, CS_j + \hat{B}_3\, TC_{ij})}{\sum_{k=1}^{5} exp\,(\hat{B}_1 + \hat{B}_2\, CS_k + \hat{B}_3\, TC_{ik})} \right] \left[exp\,[\,.5\,\hat{\sigma}^2 - .5v(i)\,] \right]$$

where

POP_i	=	population at county i
D_i	=	denominator of trip distribution function for county i
STA_i	=	1 if county i is located in Oklahoma, zero otherwise
Y_i	=	per capita income for county i
CS_k	=	number of campsites at lake k
TC_{ik}	=	travel costs from county i to lake k
$\hat{\sigma}^2$	=	estimated variance of the trip generation function
$v(i)$	=	estimated variance of the predicted value of the trip generation function
$\hat{B}$	=	estimated parameter vector.

Tables VII to IX present the population and income arc elasticities by county; the price arc elasticity matrix for Ft. Gibson Lake; and the price arc elasticity for Tenkiller Lake. The arc elasticities were obtained by raising the value of the independent variable by one percent and recording the effect in the predicted quantity of visitor days. Notice that with the above procedure, individual estimates of the elasticities were determined. The aggregate population elasticity is 1.23 but counties that were not sampled have greater elasticities because the probability of showing up in the sample increases proportionally more with respect to those counties that already are close to one. Furthermore, counties with greater populations (i.e., Oklahoma and Tulsa) have the lowest elasticities, reflecting perhaps the existence of greater urban recreational opportunities.

The aggregate income elasticity is 0.21. Individual elasticities display more variation, with a range from close to zero to more than seven. Again, those counties that were close to one in the probability of being sampled have the lower elasticities. Burt and Brewer (1971) reported income elasticities that varied from .14 to .71. Sinden (1974) found the income elasticity was not significant except for fishing, which was .64. Recall that the income variable enters only in the logit function of (3.2) while population changes both the level and the probability of the county being sampled. The income elasticities are constant across lakes (not shown) confirming the integrability condition discussed above.

The price elasticity matrix for Lake Ft. Gibson shows the effect on visitor day attendance from county i to lake j caused by a one percent increase in the price of attending Lake Ft. Gibson. An aggregate elasticity by county is also presented which measures the percentage change in total visitor days supplied by county i when the price for attending Ft. Gibson is changed by one percent.

TABLE VII

POPULATION AND INCOME ARC ELASTICITIES BY COUNTY

County	State	Population Elasticity (1)	Income Elasticity (2)
Adair	OK	2.534	0.178
Atoka	OK	4.848	6.263
Bryan	OK	1.481	1.359
Cherokee	OK	1.215	0.004
Choctaw	OK	2.481	6.781
Cleveland	OK	1.216	0.115
Coal	OK	2.364	5.993
Craig	OK	1.230	0.007
Creek	OK	1.201	0.000
Delaware	OK	2.354	6.070
Garvin	OK	1.946	3.830
Haskell	OK	1.251	0.081
Hughes	OK	1.379	0.768
Johnston	OK	2.522	6.937
Latimer	OK	1.629	2.040
LeFlore	OK	1.231	0.106
Lincoln	OK	1.220	0.004
Logan	OK	1.247	0.136
McClain	OK	1.775	2.869
McCurtain	OK	2.312	5.905
McIntosh	OK	1.222	0.000
Mayes	OK	1.217	0.009
Murray	OK	2.197	5.116
Muskogee	OK	1.198	0.000
Noble	OK	2.206	5.156
Nowata	OK	1.334	0.499
Okfuskee	OK	1.272	0.197
Oklahoma	OK	1.158	0.000
Okmulgee	OK	1.215	0.021
Osage	OK	1.254	0.200
Ottawa	OK	1.283	0.341
Pawnee	OK	1.482	1.285
Payne	OK	1.248	0.223
Pittsburg	OK	1.218	0.045
Pontotoc	OK	1.220	0.026
Pottowatomie	OK	1.228	0.110
Pushmataha	OK	2.547	7.099
Rogers	OK	1.214	0.016
Seminole	OK	1.345	0.650
Sequoyah	OK	1.215	0.005
Tulsa	OK	1.160	0.000
Wagoner	OK	1.217	0.018
Washington	OK	1.210	0.001
Benton	AR	1.804	3.157
Boone	AR	2.634	7.677
Carroll	AR	2.632	7.614
Conway	AR	2.644	7.708
Crawford	AR	1.613	2.079
Franklin	AR	2.570	7.253
Garland	AR	2.499	7.017

TABLE VII (CONTINUED)

County	State	Population Elasticity (1)	Income Elasticity (2)
Howard	AR	2.647	7.687
Johnston	AR	2.605	7.474
Logan	AR	2.464	6.692
Madison	AR	2.642	7.636
Marion	AR	2.668	7.764
Montgomery	AR	2.655	7.664
Newton	AR	2.674	7.766
Perry	AR	2.674	7.763
Pike	AR	2.666	7.758
Polk	AR	2.632	7.624
Pope	AR	2.484	6.866
Scott	AR	2.650	7.672
Searcy	AR	2.671	7.766
Sebastian	AR	1.554	1.896
Sevier	AR	2.652	7.710
Washington	AR	1.290	0.487
Yell	AR	2.635	7.649
Chautauqua	KS	2.677	7.741
Cherokee	KS	2.626	7.627
Crawford	KS	2.559	7.300
Labette	KS	2.518	7.027
Montgomery	KS	2.504	6.991
Neosho	KS	2.612	7.522
Barry	MO	2.589	7.420
Barton	MO	2.663	7.754
Jasper	MO	2.429	6.654
Lawrence	MO	2.636	7.711
McDonald	MO	2.651	7.741
Newton	MO	2.533	7.162
Stone	MO	2.659	7.752
Taney	MO	2.649	7.728
Lamar	TX	2.511	7.032
Red River	TX	2.653	7.738
Aggregate		1.234	0.209

(1) Population Elasticities are estimated as

$$\frac{POP_i}{VDAY_i} \cdot \frac{\Delta VDAY}{\Delta POP_i}$$

(2) Income elasticities are estimated as:

$$\frac{Y_i}{VDAY_i} \cdot \frac{\Delta VDAY}{\Delta POP_i}$$

TABLE VIII

PRICE ARC ELASTICITY MATRIX FOR FT. GIBSON LAKE (1)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller	Aggregate
Adair	OK	-0.001	-1.205	-0.001	-0.001	-0.001	-0.052
Atoka	OK	-0.253	-1.454	-0.253	-0.253	-0.253	-0.321
Bryan	OK	-0.073	-1.276	-0.073	-0.073	-0.073	-0.163
Cherokee	OK	0.080	-1.125	0.080	0.080	0.080	-0.704
Choctaw	OK	-0.373	-1.573	-0.373	-0.373	-0.373	-0.466
Cleveland	OK	-0.008	-1.212	-0.008	-0.008	-0.008	-0.332
Coal	OK	-0.251	-1.452	-0.251	-0.251	-0.251	-0.321
Craig	OK	0.049	-1.156	0.049	0.049	0.049	-0.573
Creek	OK	0.013	-1.191	0.013	0.013	0.013	-0.118
Delaware	OK	-0.343	-1.542	-0.343	-0.343	-0.343	-0.437
Garvin	OK	-0.363	-1.562	-0.363	-0.363	-0.363	-0.517
Haskell	OK	0.007	-1.197	0.007	0.007	0.007	-0.194
Hughes	OK	-0.024	-1.227	-0.024	-0.024	-0.024	-0.079
Johnston	OK	-0.391	-1.590	-0.391	-0.391	-0.391	-0.486
Latimer	OK	-0.066	-1.269	-0.066	-0.066	-0.066	-0.119
LeFlore	OK	0.000	-1.203	0.000	0.000	0.000	-0.040
Lincoln	OK	0.011	-1.193	0.011	0.011	0.011	-0.109
Logan	OK	-0.001	-1.205	-0.001	-0.001	-0.001	-0.050
McClain	OK	-0.186	-1.387	-0.186	-0.186	-0.186	-0.291
McCurtain	OK	-0.389	-1.589	-0.389	-0.389	-0.389	-0.499
McIntosh	OK	0.005	-1.999	0.005	0.005	0.005	-0.029
Mayes	OK	0.006	-1.198	0.006	0.006	0.006	-0.069
Murray	OK	-0.336	-1.535	-0.336	-0.336	-0.336	-0.444
Muskogee	OK	0.050	-1.155	0.050	0.050	0.050	-0.446
Noble	OK	-0.435	-1.634	-0.435	-0.435	-0.435	-0.574
Nowata	OK	-0.016	-1.220	-0.016	-0.016	-0.016	-0.078
Okfuskee	OK	-0.002	-1.205	-0.002	-0.002	-0.002	-0.035
Oklahoma	OK	0.013	-1.191	0.013	0.013	0.013	-0.186
Okmulgee	OK	0.007	-1.197	0.007	0.007	0.007	-0.099
Osage	OK	-0.026	-1.230	-0.026	-0.026	-0.026	-0.426
Ottawa	OK	-0.014	-1.217	-0.014	-0.014	-0.014	-0.096
Pawnee	OK	-0.062	-1.265	-0.062	-0.062	-0.062	-0.143
Payne	OK	-0.007	-1.210	-0.007	-0.007	-0.007	-0.084
Pittsburg	OK	0.002	-1.202	0.002	0.002	0.002	-0.042
Pontotoc	OK	0.003	-1.201	0.003	0.003	0.003	-0.045
Pottowatomie	OK	-0.001	-1.205	-0.001	-0.001	-0.001	-0.077
Pushmataha	OK	-0.332	-1.532	-0.332	-0.332	-0.332	-0.410
Rogers	OK	0.019	-1.185	0.019	0.019	0.019	-0.268
Seminole	OK	-0.029	-1.233	-0.029	-0.029	-0.029	-0.110
Sequoyah	OK	0.013	-1.191	0.013	0.013	0.013	-0.122
Tulsa	OK	0.026	-1.179	0.026	0.026	0.026	-0.237
Wagoner	OK	0.017	-1.187	0.017	0.017	0.017	-0.205
Washington	OK	0.011	-1.193	0.011	0.011	0.011	-0.174
Benton	AR	-0.178	-1.380	-0.178	-0.178	-0.178	-0.271
Boone	AR	-0.717	-1.913	-0.717	-0.717	-0.717	-0.874
Carroll	AR	-0.511	-1.709	-0.511	-0.511	-0.511	-0.624
Conway	AR	-0.627	-1.823	-0.627	-0.627	-0.627	-0.763
Crawford	AR	-0.053	-1.256	-0.053	-0.053	-0.053	-0.096
Franklin	AR	-0.309	-1.510	-0.309	-0.309	-0.309	-0.381
Garland	AR	-0.649	-1.846	-0.649	-0.649	-0.649	-0.804
Howard	AR	-0.635	-1.831	-0.635	-0.635	-0.635	-0.773
Johnson	AR	-0.375	-1.575	-0.375	-0.375	-0.375	-0.460
Logan	AR	-0.282	-1.483	-0.282	-0.282	-0.282	-0.353
Madison	AR	-0.386	-1.585	-0.386	-0.386	-0.386	-0.471

TABLE VIII (CONTINUED)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller	Aggregate
Marion	AR	-0.839	-2.033	-0.839	-0.839	-0.839	-1.020
Montgomery	AR	-0.348	-1.548	-0.348	-0.348	-0.348	-0.424
Newton	AR	-0.596	-1.793	-0.596	-0.596	-0.596	-0.725
Perry	AR	-0.662	-1.858	-0.622	-0.622	-0.662	-0.805
Pike	AR	-0.607	-1.803	-0.607	-0.607	-0.607	-0.738
Polk	AR	-0.450	-1.648	-0.450	-0.450	-0.450	-0.549
Pope	AR	-0.412	-1.611	-0.412	-0.412	-0.412	-0.513
Scott	AR	-0.359	-1.559	-0.359	-0.359	-0.359	-0.438
Searcy	AR	-0.825	-2.019	-0.825	-0.825	-0.825	-1.003
Sebastian	AR	-0.076	-1.279	-0.076	-0.076	-0.076	-0.142
Sevier	AR	-0.578	-1.775	-0.578	-0.578	-0.578	-0.704
Washington	AR	-0.013	-1.217	-0.013	-0.013	-0.013	-0.067
Yell	AR	-0.497	-1.695	-0.497	-0.497	-0.497	-0.607
Chautauqua	KS	-0.572	-1.769	-0.572	-0.572	-0.572	-0.696
Cherokee	KS	-0.579	-1.779	-0.579	-0.579	-0.579	-0.706
Crawford	KS	-0.627	-1.823	-0.627	-0.627	-0.627	-0.771
Labette	KS	-0.403	-1.602	-0.403	-0.403	-0.403	-0.499
Montgomery	KS	-0.648	-1.844	-0.648	-0.648	-0.648	-0.802
Neosho	KS	-0.686	-1.882	-0.686	-0.686	-0.686	-0.839
Barry	MO	-0.443	-1.642	-0.433	-0.433	-0.433	-0.544
Barton	MO	-0.706	-1.901	-0.706	-0.706	-0.706	-0.859
Jasper	MO	-0.561	-1.758	-0.561	-0.561	-0.561	-0.702
Lawrence	MO	-0.704	-1.900	-0.704	-0.704	-0.704	-0.858
McDonald	MO	-0.371	-1.570	-0.371	-0.371	-0.371	-0.451
Newton	MO	-0.380	-1.579	-0.380	-0.380	-0.380	-0.469
Stone	MO	-0.684	-1.879	-0.684	-0.684	-0.684	-0.832
Taney	MO	-0.787	-1.981	-0.787	-0.787	-0.787	-0.957
Lamar	TX	-0.460	-1.659	-0.460	-0.460	-0.460	-0.570
Red River	TX	-0.587	-1.783	-0.587	-0.587	-0.587	-0.714

Price arc elasticities for county i are estimated as:

$$E_{ij} = \frac{TC_{ij}}{VDAY_{ik}} \frac{\Delta VDAY_{ik}}{\Delta TC_{ij}} \quad \text{for all } k=1,\ldots 5$$

The aggregate price elasticities are estimated as:

$$E^{A}_{ij} = \frac{TC_{i}}{VDAY_{i}} \frac{\Delta VDAY_{i}}{\Delta TC_{j}}$$

TABLE IX

PRICE ARC ELASTICITY MATRIX FOR TENKILLER LAKE (1)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller	Aggregate
Adair	OK	-0.022	-0.022	-0.022	-0.022	-1.226	-0.857
Atoka	OK	-1.473	-1.473	-1.473	-1.473	-2.660	-1.864
Bryan	OK	-0.329	-0.329	-0.329	-0.329	-1.529	-0.729
Cherokee	OK	0.017	0.017	0.017	0.017	-1.187	-0.153
Choctaw	OK	-1.741	-1.741	-1.741	-1.741	-2.924	-2.167
Cleveland	OK	-0.012	-0.012	-0.012	-0.012	-1.215	-0.480
Coal	OK	-1.476	-1.476	-1.476	-1.476	-2.662	-1.883
Craig	OK	0.022	0.022	0.022	0.022	-1.183	-0.253
Creek	OK	0.047	0.047	0.047	0.047	-1.158	-0.408
Delaware	OK	-1.359	-1.359	-1.359	-1.359	-2.546	-1.729
Garvin	OK	-1.432	-1.432	-1.432	-1.432	-2.619	-2.033
Haskell	OK	-0.019	-0.019	-0.019	-0.019	-1.185	-0.548
Hughes	OK	-0.258	-0.258	-0.258	-0.258	-1.459	-0.853
Johnston	OK	-1.637	-1.637	-1.637	-1.637	-2.822	-2.030
Latimer	OK	-0.750	-0.750	-0.750	-0.750	-1.945	-1.354
LeFlore	OK	0.008	0.008	0.008	0.008	-1.196	-0.822
Lincoln	OK	0.013	0.013	0.013	0.013	-1.192	-0.128
Logan	OK	-0.014	-0.014	-0.014	-0.014	-1.218	-0.779
McClain	OK	-0.744	-0.744	-0.744	-0.744	-1.939	-1.164
McCurtain	OK	-1.632	-1.632	-1.632	-1.632	-2.816	-2.087
McIntosh	OK	0.010	0.010	0.010	0.010	-1.194	-0.054
Mayes	OK	0.015	0.015	0.015	0.015	-1.189	-0.182
Murray	OK	-1.330	-1.330	-1.330	-1.330	-2.518	-1.755
Muskogee	OK	0.048	0.048	0.048	0.048	-1.156	-0.430
Noble	OK	-0.447	-0.447	-0.447	-0.447	-1.646	-0.590
Nowata	OK	-0.109	-0.109	-0.109	-0.109	-1.311	-0.521
Okfuskee	OK	-0.015	-0.015	-0.015	-0.015	-1.218	-0.327
Oklahoma	OK	0.024	0.024	0.024	0.024	-1.180	-0.327
Okmulgee	OK	0.037	0.037	0.037	0.037	-1.168	-0.521
Osage	OK	-0.018	-0.018	-0.018	-0.018	-1.222	-0.289
Ottawa	OK	-0.099	-0.099	0.099	-0.099	-1.302	-0.692
Pawnee	OK	-0.333	-0.333	-0.333	-0.333	-1.533	-0.764
Payne	OK	-0.011	-0.011	-0.011	-0.011	-1.215	-0.142
Pittsburg	OK	0.002	0.002	0.002	0.002	-1.202	-0.043
Pontotoc	OK	0.013	-0.013	0.013	0.013	-1.191	-0.227
Pottowatomie	OK	-0.004	-0.004	-0.004	-0.004	-1.208	-0.326
Pushmataha	OK	-1.837	-1.837	-1.837	-1.837	-3.018	-2.267
Rogers	OK	0.029	0.029	0.029	0.029	-1.176	-0.400
Seminole	OK	-0.223	-0.233	-0.233	-0.223	-1.424	-0.828
Sequoyah	OK	0.069	0.069	0.069	0.069	-1.136	-0.623
Tulsa	OK	0.021	0.021	0.021	0.021	-1.183	-0.197
Wagoner	OK	0.034	0.034	0.034	0.034	-1.170	-0.408
Washington	OK	0.022	0.022	0.022	0.022	-1.182	-0.336
Benton	AR	-1.082	-1.082	-1.802	-1.082	-2.273	-1.637
Boone	AR	-2.784	-2.784	-2.784	-2.784	-3.954	-3.384
Carroll	AR	-2.357	-2.357	-2.357	-2.357	-3.533	-2.872
Conway	AR	-3.130	-3.130	-3.130	-3.130	-4.296	-3.802
Crawford	AR	-0.781	-0.781	-0.781	-0.781	-1.976	-1.403
Franklin	AR	-2.265	-2.265	-2.265	-2.265	-3.442	-2.785
Garland	AR	-2.596	-2.596	-2.596	-2.596	-3.769	-3.206
Howard	AR	-1.923	-1.923	-1.923	-1.923	-3.103	-2.339
Johnson	AR	-2.239	-2.239	-2.239	-2.239	-3.416	-2.738
Logan	AR	-2.210	-2.210	-2.210	-2.210	-3.298	-2.645
Madison	AR	-2.722	-2.722	-2.722	-2.722	-3.893	-3.314

TABLE IX (CONTINUED)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller	Aggregate
Marion	AR	-2.403	-2.403	-2.403	-2.403	-3.578	-2.916
Montgomery	AR	-2.985	-2.985	-2.985	-2.985	-4.153	-3.632
Newton	AR	-2.123	-2.123	-2.123	-2.123	-3.302	-2.578
Perry	AR	-3.044	-3.044	-3.044	-3.044	-4.211	-3.692
Pike	AR	-2.094	-2.094	-2.094	-2.094	-3.273	-2.544
Polk	AR	-2.178	-2.178	-2.178	-2.178	-3.356	-2.654
Pope	AR	-1.968	-1.968	-1.968	-1.968	-3.148	-2.443
Scott	AR	-2.323	-2.323	-2.323	-2.323	-3.499	-2.828
Searcy	AR	-2.455	-2.455	-2.455	-2.455	-3.630	-2.979
Sebastian	AR	-0.880	-0.880	-0.880	-0.880	-2.073	-1.641
Sevier	AR	-2.021	-2.021	-2.021	-2.021	-3.201	-2.458
Washington	AR	-0.189	-0.189	-0.189	-0.189	-1.391	-0.957
Yell	AR	-2.258	-2.258	-2.258	-2.258	-3.435	-2.750
Chautauqua	KS	-2.302	-2.302	-2.302	-2.302	-3.478	-2.796
Cherokee	KS	-3.248	-3.248	-3.248	-3.248	-4.413	-3.952
Crawford	KS	-2.864	-2.864	-2.864	-2.864	-4.034	-3.512
Labette	KS	-2.230	-2.230	-2.230	-2.230	-3.407	-2.756
Montgomery	KS	-2.589	-2.589	-2.589	-2.589	-3.762	-3.199
Neosho	KS	-2.798	-2.798	-2.798	-2.798	-3.968	-3.412
Barry	MO	-2.495	-2.495	-2.495	-2.495	-3.669	-3.053
Barton	MO	-2.877	-2.877	-2.877	-2.877	-4.046	-3.491
Jasper	MO	-2.675	-2.675	-2.675	-2.675	-3.847	-3.336
Lawrence	MO	-2.851	-2.851	-2.851	-2.851	-4.020	-3.463
McDonald	MO	-2.738	-2.738	-2.738	-2.738	-3.909	-3.327
Newton	MO	-2.335	-2.335	-2.335	-2.335	-3.511	-2.877
Stone	MO	-2.956	-2.956	-2.956	-2.956	-4.124	-3.587
Taney	MO	-2.567	-2.567	-2.567	-2.567	-3.740	-3.117
Lamar	TX	-1.744	-1.744	-1.744	-1.744	-2.927	-2.156
Red River	TX	-1.829	-1.829	-1.829	-1.829	-3.011	-2.224

Price arc elasticities for county i are estimated as:

$$E_{ij} = \frac{TC_{ij}}{VDAY_{ik}} \frac{\Delta VDAY_{ik}}{\Delta TC_{ij}} \quad \text{for all } k=1,\ldots 5$$

The aggregate price elasticities are estimated as:

$$E^{A}_{ij} = \frac{TC_{j}}{VDAY_{i}} \frac{\Delta VDAY_{i}}{\Delta TC_{j}}$$

The aggregate elasticity by county is less than one in absolute value except for a few cases. The aggregate price elasticities and the elasticities by lake exhibit the expected signs. That is, a price increase at Lake Fort Gibson reduces the level of attendance for all counties because it is less attractive to visit the sites. The reduction in attractiveness is captured through the variable D_i. A price increase at Lake Fort Gibson also induces substitution away from itself. Note that some counties have positive cross price elasticities. In these cases the reduction in total visitor days emanating from those counties is less severe because of an increase in visitation rates at other lakes.

Oklahoma and Tulsa counties are among those showing positive cross price elasticities. Observe that the cross price elasticities are the same for each county confirming the theoretical restriction of the MNL model. Similar results are obtained in the price elasticity matrix for Lake Tenkiller, although the aggregate price elasticities by county display more variation.

Benefit Estimation

The demand functions derived above are obtained by changing the price of recreating at a given lake and recording its effect on visitor days demanded. Hence, a series of solution points are found that lie on the demand curves. The Willig (1976) conditions are assumed to hold and thus to approximate compensated consumer surplus through the integration of the area below the ordinary demand curve.

The demand functions cannot be directly integrated. Numerical integration (Rosenthal, 1987) and polynomial fitting (Sutherland, 1982a) were disregarded in computing the benefits measured under the demand curves. The grid linearization technique formulated by Duloy and Norton (1975), which will be applied later in the mathematical programming formulation, requires an even spacing of the segments on the quantity axis and a function convex to the origin. These conditions cannot be satisfied with the techniques indicated above.

A simple exponential function is regressed instead on each of the price-quantity solution points. For each demand schedule, ten points are derived, where the highest price is the maximum observed and the lowest price is the minimum observed. Note that the price range is equal for all counties. Although this method introduces errors in the demand specification, the fit is nearly perfect for all counties. The exponential function used is

$$p_i = a\ q_i^{b} \qquad \text{for } i = 1,\ldots,83 \tag{3.10}$$

where p_i and q_i are price and quantity demanded by county i, and a and b are parameters to be estimated. The benefits for the first segment of the demand curves is determined by the procedure outlined in Schreiner, Chantaworn, and Badger (1987) where the upper bound for integration is determined by the intersection of the price axis with the line tangent to the demand curve at the maximum observed price. The benefits for the rest of the segments are found by solving the definite integral of (3.10). For further details on the grid linearization technique see Duloy and Norton (1975) and Schreiner, Chantaworn, and Badger (1987).

Demand Projection

The demand functions will shift through time according to new values of the independent variables. The demand functions are projected for each time period of the planning horizon by updating income per capita and population per county. The growth rate of per capita income is assumed to be the same for all counties. The annual rate of growth in per capita income of 1.91 estimated by Schreiner, Chantaworn, and Badger (1987) from time series data is used in the projections. Population projections by county from year 1975 to 2000 are taken from the U.S. Bureau of Census (1979).

Notice that the arc elasticities presented above will change through time. That is, as income and population increases, the probability of observing a county will eventually increase at a decreasing rate reaching an upperbound of one. Hence, equation (3.10) needs to be estimated for every time period, county, and lake which results in 830 distinct demand equations.

Limitations

More efficient estimates can be obtained by using a hierarchical response model (i.e., nested multinomial logit). Since the D_i variable estimated in (3.5) is used in (3.8) and (3.9), the estimated standard errors must be corrected for the use of variables constructed using previous estimates (Amemiya, 1978 and McFadden, 1981). The hierarchical response model was not pursued since the demand estimated above has a simple structure so it is likely that the loss in efficiency is small. Moreover, the main concern is in obtaining plausible results for the predicted values for later use in the mathematical programming model.

Maximum likelihood estimation of equation (3.1) should yield better estimators because, although the sample is relatively large, there still are many zero observations in the number of visitor days.

Lack of data on additional recreational sites visited by the recreationists and on time costs precluded a better estimation.

The IIA hypothesis has not been formally tested (Hausman and McFadden, 1984). It is expected to hold in this application because the distance to the recreational sites from a given county show large variations, contributing to widening of the dissimilarities among alternative lakes due to quality differences. Recent applications of the travel cost method using a MNL specification have been applied to model recreational demand (Caulkins, Bishop, and Bouwes, 1986; Rosenthal, 1987).

Caulkins, Bishop, and Bouwes (1986) point out that the assumption of each day trip representing a decision independent of past or planned future visits is not very plausible. They suggest a Markov chain model may be more appropriate. In the context of qualitative response models, these models can be extended to the analysis of discrete panel data which refers to a time series of observations on discrete responses of a cross section of recreationists by treating each possible response history as a discrete alternative (McFadden, 1982).

In summary, the demand procedure outlined above has several advantages. It handles substitution effects avoiding some statistical problems such as multicollinearity and zero cells observations; provides individual elasticity estimates; fulfills the integrability condition; and separates the price from the quality effect.

CHAPTER IV

RECREATION COST ESTIMATION FOR LAKES FORT GIBSON AND TENKILLER

The objective of this chapter is to estimate the cost components for recreation services at Lakes Fort Gibson and Tenkiller. In Chapter II the following cost components were identified as relevant for an investment planning model: private travel costs of recreation, costs of operating and maintaining recreation services, costs of expanding recreation capacity, and potential externalities such as congestion. The estimates for these costs are presented below. The existence of congestion costs at these lakes is tested following the hedonic travel cost model procedure.

Private Costs of Recreation

The primary private costs of recreation are the travel costs from the recreationists' origin to the lakes as well as the opportunity costs of time. Unfortunately, time costs are not included in this study because data were not available in the original survey from the recreationists on a county basis. Travel costs are derived from Schreiner et. al. (1985), and Schreiner, Chantaworn, and Badger (1987). For those counties that were sampled, travel costs are computed from the following equations:

$CVD_{ck} = (CT_{ck})/AVD_{ck}$

and

$CT_{ck} = (2)\,(0.069)D_{ck}$

where

CVD_{ck} = travel cost per visitor day ($) for the sample of recreationists interviewed at lake k from county c.

CT_{ck} = travel cost per trip ($) for those recreating at lake k from county c.

AVD_{ck} = average number of visitor days per trip for the sample of recreationists interviewed at lake k from county c, and

D_{ck} = distance in miles from county seat c to the dam site of lake k.

The 0.069 number is the per mile cost ($) of operating an automobile in 1975 according with the Department of Transportation.

For those counties that were not sampled, travel costs were computed from

$CVD_{ck} = CT_c/AVD_k$

where

AVD_k = average number of visitor days per trip for the sample of recreationists interviewed at lake k.

For those counties outside the market area of Fort Gibson Lake but within Tenkiller's, the maximum observed travel cost to Fort Gibson Lake is considered as the relevant travel cost.

Operation and Maintenance (O&M) Costs

Operation and maintenance costs were taken from the 1978 Master Plan for Lakes Fort Gibson and Tenkiller. These Master Plans were prepared by the U.S. Army Corps of Engineers. An implicit price deflator was used to bring the

O&M costs back to the 1975 base period. The O&M costs per visitor day were about $0.088 and $0.12 for Tenkiller and Fort Gibson, respectively.

Capacity Costs

Refurbishing

Refurbishing costs are taken from estimates prepared by Schreiner, Chantaworn, and Badger (1987) who used data provided by the Corps of Engineers. Previous experience has shown that refurbishing is carried out every 15 years at an approximate cost of $836.24 per campsite at 1975 prices. The visitor days per campsite ratio in 1975 was 7,352 and 5,865 for Fort Gibson and Tenkiller, respectively. These ratios were computed from the reported total visitor days and number of campsites at both lakes (Schreiner, Willet, Badger, and Antle, 1985). Refurbishing costs per visitor day in 1975 prices result in $0.11 and $0.143 for Fort Gibson and Tenkiller, respectively.

New Investment

Schreiner, Chantaworn, and Badger (1987) estimated the investment cost per visitor day capacity at $1.33 for Fort Gibson Lake. Assuming a 25 year life for new facilities, and a 3 percent real interest rate (see discussion Chapter 2) the amortized cost per visitor day is $0.0763.

The 1978 Master Plan for Lake Tenkiller provides detailed data by public use area on the number and costs of new facilities. That is, investment at the lake is carried out by identifying suitable public use areas for further development. Since the public areas are not homogeneous, the investment costs vary across area. Hence, it is possible to estimate a cost curve of investment for Lake Tenkiller which resulted in diseconomies of size as shown below.

Public use areas require a large number of inputs to be fully developed such as campsites, boat ramps, roads, restrooms, and electric outlets. To obtain costs of investment in terms of visitor days it is necessary to construct an index which makes alternative public use area investment costs comparable. The number of new campsites is chosen as the representative input across public use areas. The Army Corps of Engineers determined that 506 new campsites were needed to meet the Master Plan projected visitor days. The Master Plan also indicates the need for relocating 373 campsites to new public use areas.

The U.S. Army Corps adjusted the total visitation reported at Tenkiller in the 1978 Master Plan since the project traffic counters included individuals that visit residential and commercial sites but are not related to project visitation. Hence, the Master Plan projected 2,850,000 visitor days for 1983. The investment requirements specified by the 1978 Master Plan were thus estimated using an incremental visitor days projection of about 650,000. However, to remain consistent with the procedures carried out in the 1975 survey (Badger, Schreiner, and Presley, 1977) and with the cost computations for Fort Gibson (Schreiner, Badger, and Chantaworn, 1987), the Master Plan's incremental visitor days projection is scaled back up to the earlier reported data by multiplying the visitor days per campsite in 1975 (5,865) times the proposed new campsites (506), which results in a projected increase of 2,967,690 visitor days.

The 1975 recreation capacity at Tenkiller Lake is assumed to be equal to the number of visitor days that attended the lake in 1975 as reported by the U.S. Army Corps of Engineers (1978b). Therefore, the recreation capacity results in 5,226,300 annual visitor days (VDAY).

Table X shows the investment costs for Tenkiller Lake by public use area. The first column shows the cost of developing each public use area. This cost has been adjusted by deducting the relocation costs of campsites and picnic tables and common costs such as boat ramps, fee collection stations, and trailer dump stations. Common costs are those incurred in facilities that serve recreationists in a broader area than the single public use area. Total 1978 costs by public use area are adjusted to 1975 using a price deflator. The deflated common costs, and the engineering and administrative costs have been added back to each public use area according to their contribution to total planned visitor days. The projected incremental visitor days column is computed by multiplying planned campsites by the visitor days per campsite ratio of 5,865. Total 1975 costs are then converted into average cost per visitor day, which is computed as accumulated total cost divided by accumulated visitor days. The information contained in the total accumulated costs and accumulated visitor days is used to estimate a long run average cost curve as presented below.

Estimation of a cost curve for incremental investment at Lake Tenkiller is carried out following Intriligator (1978). For a detailed discussion on econometric estimation of cost curves see Johnston 1960, Scherer 1977, and Walters 1963 and 1968.

A common functional form of a total cost curve is the cubic:

$$TIC = a_0 + a_1VDAY + a_2VDAY^2 + a_3VDAY^3 \tag{4.1}$$

where TIC is the total investment cost ($) and VDAY is the total visitor days in millions. In the long run, a_0, which is fixed cost, vanishes. The cost curve usually estimated is the average cost curve since it alleviates heteroskedasticity problems. Hence, the estimated average cost curve is

$$AIC = a_1 + a_2VDAY + a_3VDAY^2 \tag{4.2}$$

TABLE X

INCREMENTAL INVESTMENT COSTS PER VISITOR DAY FOR LAKE TENKILLER (US$)

Public Use Area	Total Costs 1978	Relocation Costs	Common Costs	Adjusted Investment Costs 1978	Total Accumulated costs in 1975 Prices	New Campsites	Projected Incremental Visitor Days	Accumulated Incremental Visitor Days	Average Cost in 1975 Prices	Predicted Marginal Cost in 1975 Prices	Amortized Predicted Marginal Cost in 1975 Prices
Horseshoe Bend	120,000	0	0	120,000	144,669	30	175,950	175,950	0.8222	0.9837	0.0565
DamSite	276,000	68,040	0	207,960	364,370	31	181,815	357,765	1.0185	1.0999	0.0632
Dry Creek	366,300	70,560	59,920	235,820	601,460	27	158,355	516,120	1.1653	1.2011	0.0690
Cookson Bend	530,200	59,440	0	470,760	1,116,269	82	480,930	997,050	1.1196	1.5085	0.0866
Standing Rock Landing	286,000	85,680	0	200,320	1,351,742	46	269,790	1,266,840	1.0670	1.6809	0.0965
Chicken Creek Point	749,700	6,520	4,480	738,700	2,019,696	34	199,410	1,466,250	1.3775	1.8084	0.1039
Pettit Bay	536,600	16,080	0	520,520	2,509,634	37	217,005	1,683,255	1.4909	1.9471	0.1118
Carters Landing	386,800	23,000	9,520	354,280	2,842,828	25	146,625	1,829,880	1.5536	2.0408	0.1172
Sisemore Landing	586,200	2,000	9,520	574,680	3,370,669	32	187,680	2,017,560	1.6707	2.1607	0.1241
StrayHorn Landing	424,500	4,000	56,000	364,500	3,771,505	65	381,225	2,398,785	1.5723	2.4044	0.1381
Snake Creek Cove	855,700	6,000	9,520	840,180	4,533,184	40	234,600	2,633,385	1.7214	2.5543	0.1467
Elk Creek Landing	612,000	4,000	0	608,000	5,125,822	57	334,305	2,967,690	1.7272	2.7680	0.1590
Total	5,730,000	313,320	148,960	5,267,720		506	2,967,690				

Common Costs:

Engineering and Administrative	745,000
Public Use Area Common Costs	148,960
Total Common Costs	893,960

SOURCE: Computed from U.S. Army Corps of Engineers, Oklahoma. Tenkiller Ferry Lake Illinois River, Oklahoma. DM No. 1c Master Plan (updated) Tulsa District, 1978b.

where AIC is the average investment cost. The quadratic term in (4.2) was found not statistically significant for investment costs at Lake Tenkiller. A linear average cost curve provided the best fit. The empirical result is:

$$AIC = .871 + .3195\,VDAY$$
$$(12.96) \quad (8.338)$$

Adjusted R^2 = 86.2 and $F_{1,10}$ = 69.5. The "t" values are reported in parenthesis.

The total investment cost curve is given by

$$TIC = .871VDAY + .3195VDAY^2 \tag{4.3}$$

Equations similar to (4.2) have been estimated for a number of industries and it has been found that the long-run average cost curves are L-shaped. That is, the diseconomies of size portion of the cost curve does not appear in industrial empirical applications. On the other hand, for Tenkiller's case, the results found above suggest that expansion of new capacity at this lake is facing diseconomies of size. This result is expected since it is not possible for the U.S. Army Corps of Engineers to replicate the minimum average cost public use area whereas firms are generally capable of replicating the minimum average cost plant.

The marginal cost curve is given by

$$MIC = .871 + .639\,VDAY$$

The predicted marginal costs and the amortized predicted marginal costs in 1975 prices are reported in the last two columns of Table X.

Congestion Costs

In Chapter II it was concluded that it is possible for equilibrium between demand and supply in outdoor recreational services to be brought about by changes in the level of congestion since the government has historically provided recreational facilities in a nonexclusionary basis. Hence, it is necessary to investigate the relevance of congestion costs at Lakes Fort Gibson and Tenkiller.

A unit of measurement for congestion and its price is required for testing the above relationship. The measurement of congestion varies with the nature of the facility. For example, McConnell and Sutinen (1984) refer to the following measures of congestion for different types of recreation activities: density on the slope and waiting time for skiers, number of encounters with other visitors per day in wilderness recreation, and number of bathers per acre of beach.

Several approaches have been developed to measure the price of congestion. The most widely used approach is the contingent valuation technique in which recreation participants are asked directly how much they would be willing to pay for less crowded facilities. One of the advantages of the contingent valuation approach is that the effect of congestion can be isolated from other factors. On the other hand, it can be subject to biases since this method is based on hypothetical situations.

A second approach is simulation, which has been applied to wilderness recreation by Smith and Krutilla (1976). The cost of congestion can be derived by relating level of inputs at a recreational site with stochastic levels of congestion due to queues or crowded facilities.

A third approach is the indirect valuation of congestion by using data on observed behavior. Three methods have been developed for the latter approach, the household production function approach (Deyak and Smith, 1978), the own quality-own price model (Smith and Desvousges, 1986; Smith, Desvousges, and Fischer, 1986; Vaughn and Russell, 1982), and the hedonic travel cost method (Brown and Mendelsohn, 1984; Mendelsohn, 1984). The main advantage of the indirect methods is that valuation is determined by what individuals actually do rather than on what they might do under hypothetical situations. However, it is difficult to isolate the effects of congestion by using the indirect methods.

The hedonic travel cost method (HTCM) is applied to determine the price of congested facilities. For the current study it was not possible to implement the contingent valuation method since the survey conducted in 1975 (Badger, Schreiner, and Presley, 1977) did not include questions regarding willingness to pay for reduced levels of congestion. The Deyak and Smith (1978) household production function approach imposes theoretical restrictions based on reduced form equations where the dependent variables are quantity and price of recreation service flows. This approach requires data at the individual level which were not readily available from the earlier survey. Likewise, as mentioned in Chapter II, the own quality-own price technique requires extensive data based on a large sample of sites.

The HTCM has several appealing aspects. By treating heterogeneous sites as if each were a bundle of characteristics, the site price, derived indirectly from observing the willingness to pay through travel costs, can be decomposed into a set of implicit prices for each characteristic. Hence, it is possible to consider congestion as one of the site's characteristics and determine its implicit price. Moreover, this approach may be more relevant for policymakers since the resource manager controls some of the characteristics of the sites which can help them to allocate resources more efficiently (Brown and Mendelsohn, 1984). Finally, the data needed to apply the HTCM is less demanding.

The theoretical foundations of the HTCM is presented in Brown and Mendelsohn. The procedure to estimate the implicit prices involves two steps.

First, distance and travel time are regressed on the characteristics of the sites. Then the hour and distance prices need to be combined in an appropriate index to derive the actual prices that each individual faces. For example, the following regressions can be estimated:

$$T(Z) = a_o + \sum_i a_i Z_i \tag{4.4}$$

$$C(Z) = b_o + \sum_i b_i Z_i \tag{4.5}$$

where T(Z) is the miles traveled to each site, C(Z) is the number of travel hours needed to reach each site, and the Z_i are levels of the site characteristics. Brown and Mendelsohn show that the marginal hedonic price of characteristic Z_i is given by:

$$P_i (Z_i) = \beta \frac{\partial T}{\partial Z_i} + \alpha\gamma \frac{\partial C}{\partial Z_i} \tag{4.6}$$

where β is the cost per mile traveled, γ is the marginal wage rate, and α is the fraction of the marginal wage rate considered as opportunity cost by the recreationist. Note that a linear hedonic price function has been adopted which implies that these prices are constant. An endogenous marginal price specification leads to problems of identification and selectivity bias (Mendelsohn, 1984).

As mentioned above, data on travel hours needed to reach each site were not available for this study. Hence, only equation (4.4) is estimated. Data for all Oklahoma lakes in the McClellan-Kerr River Navigation System were used in the estimation procedure. Information about lake characteristics were presented in Table II. The density measure of peak month-visitor days per campsite is used to represent the level of congestion. As noted by Brown and Mendelsohn, only observed distance traveled from county i to lake j is included because we are trying to identify the best possible frontier in characteristic space.

The empirical results showed that congestion as modelled with peak month-visitor days per campsite was not a statistically significant characteristic in explaining willingness to travel to the lakes. The congestion coefficient was found not significant in all specifications tried, even being positive in most of the cases.

The final form chosen was

$$DIST_{i,j} = a_1\ SHOR_j + a_2 CAMPSITE_j + \in_{i,j}$$

where $DIST_{i,j}$ is the distance from county i to lake j, $SHOR_j$ is the number of shoreline miles at lake j, and $CAMPSITE_j$ is the number of campsites at lake j, and $\in_{i,j}$ is an error term.

The empirical results for this equation are

$$DIST_{i,j} = \underset{(2.897)}{.0785}\ SHOR_j + \underset{(8.241)}{.12}\ CAMPSITE_j$$

with the following statistics

Number of Observations=105 $F_{(1,103)} = 11.86$ Log Likelihood Test =11.437

The equation is significant at the 1 percent probability level as are the individual coefficients with reported "t" statistics shown in parenthesis. The intercept term was not significant and the fit was better without the intercept term so it was dropped from the final specification.

The results regarding the irrelevance of congestion for cases such as the one presented agrees with previous findings. For example, Deyak and Smith (1978) found that congestion is important for the decision to participate in remote camping. However, it is not likely to affect decisions concerning developed camping. Furthermore, they found that congestion was important in determining the decision to participate but not the level once the decision had been made. Brown and Mendelsohn (1984) concluded that congestion does not seem to be a consistent factor for steelhead fishermen when choosing sites. Congestion appears to be more important in other contexts such as wilderness recreation, skiing, and beach attendance (McConnell and Sutinen, 1984).

Since the Army Corps of Engineers plans the expansion of the sites' facilities according to the needs of a typical peak day, then it is also reasonable to expect that facilities provided are sufficient to cover demand for recreation most of the time. As reported below, the willingness to pay for additional campsites is slightly higher than the actual costs.

Given 1975 travel costs of \$0.069 per mile and using equation (4.6) without the travel time costs, the implicit price per campsite (willingness to pay) is computed as:

$$P_{CS} = 2(\$0.069)\ (.12) = \$0.01656$$

where P_{CS} is the implicit per visitor day campsite cost. The implicit price is compared to actual costs calculated as the following:

Cost per Campsite in 1978 (1)	\$1,700
Cost per Campsite in 1975 prices	\$1,422
Visitor Days per Campsite Tenkiller Lake	5,865
Visitor Days per Campsite Fort Gibson Lake	7,352
Cost per Campsite per VDAY Tenkiller Lake	\$0.242
Cost per Campsite per VDAY Fort Gibson Lake	\$0.193
VDAY/Distance Tenkiller Lake (2)	19.188
VDAY/Distance Fort Gibson Lake (2)	14.899
Cost of Campsite/Distance for Tenkiller Lake	\$0.01263
Cost of Campsite/Distance for Fort Gibson Lake	\$0.01298

(1) Taken from U.S. Army Corps of Engineers (1978b)
(2) Taken from Badger, Schreiner, and Presley (1977)

The results obtained from the HTCM suggest that the price of the characteristic "campsites" is $0.01656 as revealed by recreationists behavior, which is probably not statistically different from the actual cost of a campsite at each of the lakes as shown above.

It is worth mentioning some limitations of the HTCM. Brown and Mendelsohn caution against the use of the HTCM for valuing nonmarginal changes of the characteristics since they found sizeable valuation errors in their application. Smith and Kaoru (1985) indicate that results obtained using the HTCM are not robust to the assumptions and procedures adopted, especially with regard to the handling of negative attribute prices and how the quantity of site characteristics are defined. Particular limitations to the application carried out above include lack of data about visitations on a weekly or daily basis, and the somewhat arbitrary definition of the variable accounting for congestion.

Summary

In summary, it is important to point out one of the concluding comments by Harrington (1987), who states that the most important gap in our knowledge about recreation supply is the cost of congestion. He argues that no theory exists that is directly useful in determining how recreation users are quantitatively affected by crowding conditions. Further analysis in this study is limited to private travel costs of recreation, costs of operating and maintaining recreation services, and costs of expanding recreation capacity for the Lakes of Fort Gibson and Tenkiller as estimated in this chapter.

CHAPTER V

INVESTMENT MODEL FORMULATION

The objective of this chapter is to present the mathematical programming model that yields the optimum investment path for Lakes Fort Gibson and Tenkiller such that the net present value of social benefits is maximized.

Model Formulation

The mathematical programming model is outlined in this section. A nonlinear version is first presented that incorporates endogenous prices as well as investment levels for both lakes. Next, a linear version is presented where prices are set exogenously to the model. The linear model is the final version applied in this study.

Assumptions

1. The present value of net social benefits is maximized. Ordinary demand curves approximate closely the compensated demand curves. The government is able to enforce the optimal solution.
2. Recreation demand in year t is a function of price in that year and no other period.
3. Demand segments enter as linear approximations and are scaled by a predicted observation-to-sample ratio of 2,863.9.

4. Five-year decision time units are assumed and model results are representative of the initial year of the decision time unit.
5. All costs and benefits are assumed to occur as a lump sum for the representative initial year of the decision time unit.
6. There are no economies of size in O&M and refurbishing costs. Likewise, there are no economies of size in investment costs for Fort Gibson Lake but diseconomies of size in investment costs are considered for Tenkiller Lake.
7. Travel costs are constant per visitor day within a county but change across counties.
8. An annual real discount rate of three percent is used and assumed constant over the planning period.
9. All values are expressed in 1975 dollars.
10. The planning period is 25 years and is assumed to be the life of new investments before refurbishing needs to take place.
11. There are no budget constraints.
12. Existing recreation capacity at the lakes devalues following a straight line depreciation rule.
13. The difference between the discounted terminal value for the natural resource and capital stocks and its initial value is assumed to be negligible. Therefore, these terms are dropped from the model equations.

The Model Equations

The model is a variant of Schreiner, Chantaworn, and Badger (1987), Willet (1983), and Norton and Scandizzo (1981). The notation of the Schreiner et. al. is used in what follows. The equations of the model are:

$$\text{Max } 5 \Bigg[\underbrace{\sum_{t=1}^{5} \sum_{k=1}^{2} \sum_{c=1}^{83} \sum_{s=1}^{11} \alpha_t B_{tkcs} X_{tkcs}}_{\text{Gross Benefits}} - \underbrace{\sum_{t=1}^{5} \sum_{k=1}^{2} \sum_{c=1}^{83} \alpha_t a_{kc} Q_{tkc}}_{\text{Travel Costs}}$$

$$- \underbrace{\sum_{t=1}^{5} \sum_{k=1}^{2} \sum_{c=1}^{83} \alpha_t b_k Q_{tkc}}_{\text{O\&M Cost}} - \underbrace{\sum_{j=1}^{5} \sum_{k=1}^{2} \beta_r d_k R_{jk} \sum_{t=j}^{5} \alpha_t}_{\text{Refurbishing Cost}} - \underbrace{\sum_{j=1}^{5} \beta_s e\, S_{j11} \sum_{t=j}^{5} \alpha_t}_{\substack{\text{New Inv. Cost} \\ \text{Ft. Gibson Lake}}}$$

$$- \underbrace{\sum_{j=1}^{5} \sum_{i=1}^{12} \beta_s f_i S_{j2i} \sum_{t=j}^{5} \alpha_t}_{\substack{\text{New Investment Cost} \\ \text{Tenkiller Lake}}} - \underbrace{\sum_{t=1}^{5} \sum_{k=1}^{2} \alpha_t g_k \left(\frac{\sum_{c=1}^{83} Q_{tkc}}{CS_{tk}} \right)}_{\text{Congestion Cost}} \Bigg] \tag{5.1}$$

subject to

1. Recreation Demand and Supply Equilibrium.

$$- \sum_{c=1}^{83} Q_{tkc} + \sum_{c=1}^{83} \sum_{s=1}^{11} \varnothing_{tkcs} X_{tkcs} \leq 0 \quad \text{for all } t, k \tag{5.2}$$

2. Recreation Capacity.

$$\sum_{c=1}^{83} Q_{tkc} - \sum_{j=1}^{t} \theta^{r}_{t-j+1} R_{jk} - \sum_{j=1}^{t} \sum_{i=1}^{12} \theta^{s}_{t-j+1} S_{jki} \leq V_{tk} \quad \text{for all } t, k \tag{5.3}$$

3. Maximum Refurbishing.

$$\sum_{j=1}^{t} R_{jk} < V_k - V_{tk} \quad \text{for all } t, k \tag{5.4}$$

4. Tenkiller Investment Constraints

$$\sum_{j=1}^{5} S_{jki} \leq w_i \text{ for } i=1,\ldots 11 \tag{5.5}$$

5. Number of Campsites

$$CS_{tk} - \sum_{j=1}^{t} \mu_r \theta^r_{t-j+1} R_{jk} - \sum_{j=1}^{t} \sum_{i=1}^{12} \mu_s \theta^s_{t-j+1} S_{jki} \leq CS_{ok} \text{ for all } t, k \tag{5.6}$$

6. Convex Combination Constraint

$$\sum_{s}^{11} X_{tkcs} - H \sum_{\substack{m=1 \\ m \neq k}}^{2} \left(\frac{E_{kmc}}{P_{t-1,m}}\right) P_{tm} \leq H - H \sum_{\substack{m=1 \\ m \neq k}}^{2} E_{kmc} \text{ for all } t, k, c \tag{5.7}$$

7. Demand Functions

$$\frac{1}{Q_{t-1,kc}} \sum_{s}^{11} \varnothing_{tkcs} X_{tkcs} - H \sum_{m=1}^{2} \left(\frac{E_{kmc}}{P_{t-1,m}}\right) P_{tm} = H - H \sum_{m=1}^{2} E_{kmc}$$

for all t, k, c (5.8)

<u>Definition of Variables</u>

X_{tkcs} = demand segment s for county c, lake k, and decision time unit t.

Q_{tkc} = quantity of recreation visitor days for county c, lake k, and decision time unit t.

R_{jk} = refurbishing activity in visitor day capacity for lake k and decision time unit j.

S_{jki} = new investment activity segment i in visitor day capacity in decision time unit j for lake k; k=1 refers to Fort Gibson Lake and k=2 refers to Tenkiller Lake. Note that Fort Gibson Lake has only one segment.

CS_{tk} = campsite activity in number of campsites for lake k and decision time unit t.

P_{tk} = total price per visitor day for lake k and decision time unit t.

Definition of Parameters

α_t = average annual discount rate using a 3 percent interest rate for decision time unit t.

β_r = capital recovery factor for 15 years at 3 percent interest rate.

β_s = capital recovery factor for 25 years at 3 percent interest rate.

θ_t^s = adjustment factor due to depreciation in decision unit t. $\theta_t^s = 1$, depreciation rate is .20 per time period.

θ_t^r = adjustment factor due to depreciation in decision unit t. $\theta_t^r = 1$, depreciation rate is .33 per time period.

$\varnothing_{tkcs}$ = quantity demanded at segment s for lake k, county c, in decision time unit t.

μ_r = campsites-refurbishing ratio.

μ_s = campsites-new investment ratio.

B_{tkcs} = benefit for demand segment s for county c, lake k, in decision time unit t.

w_i = maximum investment at Lake Tenkiller for segment i.

a_{kc} = travel cost per visitor day from county c to lake k.

b_k = O&M cost per visitor day at lake k.

d_k = cost of refurbishing per visitor day capacity for lake k.

e = investment cost per visitor day of new capacity for Fort Gibson Lake.

f_i = investment cost per visitor day of new capacity for segment i for Tenkiller Lake.

g_k = congestion cost per visitor day/campsites for lake k.

V_{tk} = visitor day capacity in time period t for lake k assuming no refurbishing of the 1975 capacity for market area.

V_k = visitor day capacity in 1975 for lake's k market area.

CS_{ok} = number of campsites in 1975 for lake k.

E_{kmc} = cross price elasticity between lakes k and m for county c.

H = population-to-predicted sample visitor day scale factor which is equal to 2,863.9. This factor was computed as the sum of total visitor days attending both lakes in 1975 divided by the sum of the total predicted sample visitor days for both lakes.

t=j = decision time unit, and equals 1, 2, 3, 4, 5

k=m = lake, and equals 1, 2

c = county, and equals 1, 2,...,83

s = demand and benefit segments, and equals 1,2,...,11

i = investment segment and equals 1,2,...,12 for Tenkiller Lake and 1 for Fort Gibson Lake.

Remarks About the Model

a) Note that although the demand and benefit functions have been linearized following the procedure by Duloy and Norton (1975), the model still has nonlinear variables. Equation (5.1) specifies the congestion variable as the division of two endogenous variables in time t. Likewise, equations (5.6) and (5.7) present some terms which are a division of an endogenous variable in period t by another endogenous variable in period t-1.

Change-of-variable transformation method was attempted to linearize the model but it remained basically nonlinear. Among nonlinear general purpose methods, Manne (1985b) distinguishes those that depend upon gradients such as Newton methods, and those that do not. Newton methods cannot easily be applied to models involving linear activity analysis and/or weak inequalities. Fixed-point algorithms overcome the difficulties of the Newton method but are much slower (Manne, 1985b). See Manne (1985a) for a detailed discussion of solution methods for solving economic equilibrium problems. The application of nonlinear general purpose methods suitable for the above model were dismissed because of the sheer size of the model and software availability to the author.

The suggestion made by Norton and Scandizzo (1981) of solving the model recursively by updating the lagged endogenous variables was not followed since while it is appropriate for comparative statics, it is not a suitable method for solving a dynamic optimization model.

It was decided to specify the model without endogenous price substitution effects. In Chapter VII exogenous price substitution effects are built into the model. From the above discussion, it follows that equation (5.8) is no longer required and equation (5.7) can be rewritten as follows:

$$\sum_{s=1}^{11} X_{tkcs} \leq H$$

b) The congestion variable in equation (5.1) is dropped since congestion costs are zero as shown in Chapter 4. Thus, equation (5.6) is also dropped from the model specification since it is no longer needed.

c) The model consists of 4,670 columns and 1,691 rows. For computational considerations out-of-state counties were aggregated into states. This simplification results in 43 Oklahoma counties and 4 additional observations that account for Arkansas, Kansas, Missouri and Texas. The travel costs for these states are computed as:

$$TC_{sk} = \frac{\sum_{c} (TC_{ck})(VDAY_{ck})}{\sum_{c} VDAY_{ck}}$$

where TC_{sk} is the travel cost from state s to lake k, TC_{ck} is the travel cost from out-of-state county c to lake k, and VDAY is the predicted visitor days from out-of-state county c to lake k.

A dummy travel zone is also included that represents the demand for recreation at Lakes Fort Gibson and Tenkiller that are located outside their market areas. The demands for this dummy travel zone are 14 and 15 percent of total visitor days at Lakes Fort Gibson and Tenkiller respectively as defined by Schreiner, Willet, Badger, and Antle (1985). The travel costs for the dummy travel zone are computed using the same formula used to compute the state's travel costs. The model is set up in several LOTUS 1-2-3 spreadsheets. The data are converted from WK1 format into MPS format using the ToMPS program (Li, Ray, Stoecker, 1988). The model is solved using IBM's MPSX program.

Model Validation

The investment programming model presented in the previous section is specified with arbitrarily large absolute values in the objective function corresponding to the capacity activities. Hence, these activities are prevented from appearing in the optimal solution thus making it possible to validate the model for the base period. Let this scenario be named the "Without Capacity Activities" (WCA) scenario.

The programming model solution resulted in 4,110,000 and 5,226,000 total optimal visitor days in 1975 for Lakes Fort Gibson and Tenkiller respectively, which perfectly coincides with the observed visitor days at both lakes.

Table XI presents the predicted visitor days at Lakes Fort Gibson and Tenkiller first using the demand model and then utilizing the programming model. The programming optimal visitor days by each county is validated against the predicted visitor days obtained from the demand model presented in Chapter III.

The predicted visitor days for the demand model are computed from the multiplication of the predicted sample visitor days reported in Table VI for lake k times the market area share of lake k times the population-predicted-visitor days ratio for lake k. The predicted dummy travel zone is computed as the difference between total observed visitor days and total market area. The results from the programming model are reasonably close to the ones obtained from the demand model with the exception of some counties that show low visitor days for lake Tenkiller.

Table XII presents the results of some simulation error statistics applied to the visitor days reported in Table XI (Pindyck and Rubinfeld, 1981). The mean absolute error (MAE) and the root mean square error (RMSE) can be evaluated only by comparing them with the average size of the visitor days variable. The root mean square percent error (RMSPE) and the mean absolute percent error (MAPE) normalize the error between 0 and 100. Theil's inequality coefficient (U) always falls between zero and one. If U is close to zero, then the prediction errors will be smaller. The predicted visitor days are validated reasonable well by the programming model, being closer for Fort Gibson than for Tenkiller.

TABLE XI

VALIDATION OF THE MATHEMATICAL PROGRAMMING MODEL

Visitor Days Predicted by the Demand Model and by the Programming Model
(Visitor Days)

		Demand Model		Programming Model	
County	State	Fort Gibson	Tenkiller	Fort Gibson	Tenkiller
Adair	OK	6,885	86,469	3,630	61,449
Atoka	OK	468	2,102	434	103
Bryan	OK	5,849	20,103	6,063	32,309
Cherokee	OK	260,542	43,521	190,272	48,998
Choctaw	OK	529	1,905	496	105
Cleveland	OK	108,306	120,400	176,592	158,660
Coal	OK	233	1,058	222	51
Craig	OK	60,032	20,442	54,258	24,716
Creek	OK	86,628	230,639	69,021	208,563
Delaware	OK	1,022	3,128	1,023	331
Garvin	OK	3,484	10,564	3,931	887
Haskell	OK	13,675	29,662	9,842	29,912
Hughes	OK	2,839	23,569	2,892	14,418
Johnston	OK	191	617	176	45
Latimer	OK	1,464	12,779	1,483	8,910
LeFlore	OK	9,517	151,699	9,680	133,089
Lincoln	OK	23,385	21,115	25,722	22,927
Logan	OK	5,748	69,510	5,852	52,287
McClain	OK	2,664	8,192	2,800	580
MCurtain	OK	2,367	7,659	2,455	10,068
McIntosh	OK	19,477	28,235	20,422	25,728
Mayes	OK	14,760	30,141	7,011	30,737
Murray	OK	742	2,267	789	246
Muskogee	OK	378,950	281,106	303,236	265,248
Noble	OK	710	562	793	783
Nowata	OK	2,023	10,375	2,236	10,109
Okfuskee	OK	2,209	16,024	2,242	17,971
Oklahoma	OK	645,012	901,792	508,572	1,089,488
Okmulgee	OK	25,620	103,341	48,148	111,736
Osage	OK	54,233	28,311	43,231	38,265
Ottawa	OK	7,928	43,953	8,119	37,844
Pawnee	OK	2,358	9,653	2,432	12,904
Payne	OK	16,224	21,001	16,591	16,593

TABLE XI (CONTINUED)

County	State	Demand Model Fort Gibson	Demand Model Tenkiller	Programming Model Fort Gibson	Programming Model Tenkiller
Pittsburg	OK	10,521	8,455	10,710	10,755
Pontotoc	OK	7,727	30,009	7,868	34,387
Pottowatomie	OK	14,587	47,510	14,900	64,973
Pushmataha	OK	179	766	153	27
Rogers	OK	63,527	72,936	47,509	75,446
Seminole	OK	6,474	37,593	6,645	33,652
Sequoyah	OK	44,766	176,594	32,176	145,710
Tulsa	OK	1,454,106	934,255	1,544,266	883,245
Wagoner	OK	55,585	85,286	37,930	86,987
Washington	OK	31,759	47,039	57,558	51,710
Arkansas		71,225	630,156	68,757	689,574
Kansas		2,410	8,517	2,362	227
Missouri		4,722	18,338	4,627	358
Texas		941	2,751	877	223
Total Market Area		3,534,600	4,442,100	3,367,004	4,543,244
Outside Market Area		575,400	783,900	742,996	682,756
Total		4,110,000	5,226,000	4,110,000	5,226,000
Mean Market Area		75,204	94,513	71,638	96,665

TABLE XII

SIMULATION ERROR STATISTICS

	Fort Gibson	Tenkiller
Mean Absolute Error (MAE)	15,863	15,383
Mean Absolute Percent Error (MAPE)	15.55	37.28
Root Mean Square Error (RMSE)	38,899	34,616
Root Mean Square Percent Error (RMSPE)	2.54	5.09
Theil Inequality Coefficient (U)	0.063	0.069

1) Mean absolute error:

$$MAE = \frac{1}{T} \sum_{t=1}^{T} | Y_t^s - Y_t^a | ; \quad Y_t^s = \text{simulated value for observation t,}$$

$$Y_t^a = \text{actual value for observation t}$$

2) Mean absolute percent error:

$$MAPE = \frac{1}{T} \sum_{t=1}^{T} \frac{|Y_t^s - Y_t^a|}{Y_t^a} \times 100$$

3) Root mean square error:

$$RMSE = \sqrt{\frac{1}{T} \sum_{t=1}^{T} (Y_t^s - Y_t^a)^2}$$

4) Root mean square percent error:

$$RMSPE = \sqrt{\frac{1}{T} \sum_{t=1}^{T} \left(\frac{Y_t^s - Y_t^a}{Y_t^a} \right)^2} \times 100$$

TABLE XII (CONTINUED)

5) Theil Inequality Coefficient:

$$U = \frac{\sqrt{\frac{1}{T} \sum_{t=1}^{T} (Y_t^s - Y_t^a)^2}}{\sqrt{\frac{1}{T} \sum_{t=1}^{T} (Y_t^s)^2} + \sqrt{\frac{1}{T} \sum_{t=1}^{T} (Y_t^a)^2}}$$

Results

Let the model presented in the Model Equations Section be called the Full Cost Model (FCM). The principal results of this model are presented in Table XIII. The results of this model are compared with the Without Capacity Activities (WCA) scenario. This comparison allows us to follow the "with" and "without" principle in project evaluation (Squire and van der Tak, 1975; Gittinger, 1982) to determine the contribution of investment to social benefits. The results of the WCA scenario are presented in Table XIV.

The total annual visitor days for Lake Fort Gibson declines in the FCM since all marginal costs are paid in full by recreationists. Only in the last period the visitor days are greater than the observed in 1975. Visitor days for lake Tenkiller show a milder reduction in the third period and surpasses the base visitor days by the fourth period. Maximum refurbishing is carried out in all periods except for Fort Gibson's second period. New investment activities are higher in the latter periods to meet the increased demand for recreation. The cost structure shows that travel costs are the most important cost component followed by O&M costs. The investment budget for the entire planning period reaches about 10 million dollars for lake Tenkiller whereas it is just below 2.5 million for lake Fort Gibson. The present value of net social benefits is $212.7 million and the benefit cost ratio is 2.41.

The WCA scenario resulted in a present value of net social benefits of $189.3 million. Hence, there is an incremental $23.4 million of net social benefits due to the inclusion of capacity activities. It is indeed worthwhile to conduct these activities in lakes Fort Gibson and Tenkiller. The visitor days projection under this scenario show that the capacity constraint is binding for all time periods and for both lakes. Visitor days need to adjust to the straight line

TABLE XIII

RESULTS OF THE RECREATION INVESTMENT PROGRAMMING MODEL BY DECISION TIME UNIT, FULL COST MODEL

		Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Visitor Days (annual)		VDAY					
Fort Gibson			2,918,974	3,179,396	3,728,874	3,771,831	4,114,917
Tenkiller			5,226,000	5,254,702	5,104,973	5,668,148	6,797,723
Additions to Capacity		VDAY					
Fort Gibson	Refurbishing		0	661,311	822,000	822,000	822,000
	New Capacity		0	0	0	537,395	1,219,002
	Total		0	661,311	822,000	1,359,395	2,041,002
Tenkiller	Refurbishing		0	1,045,200	1,045,200	1,045,200	1,045,200
	New Capacity		0	28,702	204,412	1,306,599	2,482,217
	Total		0	1,073,902	1,249,612	2,351,799	3,527,917
Gross Benefits (annual)		$1,000	16,338	17,762	19,058	21,074	24,095
Costs (annual)		$1,000					
Travel Costs			6,063	6,376	6,841	7,393	8,574
O&M Costs			812	846	899	954	1,095
Refurbishing			0	14.96	16.18	16.18	16.18
New Investment			0	0.13	8.31	108.99	318.65
TOTAL			6,875	7,238	7,764	8,472	10,003
Net Benefits (annual)		$1,000	9,463	10,524	11,294	12,602	14,092
Net Benefits Per Visitor Day in 1975 Prices			1.16	1.25	1.28	1.33	1.29
Investment Budget in 1975 Prices							
Fort Gibson	Refurbishing		0	72,744	90,420	90,420	90,420
	New Capacity		0	0	0	714,735	1,621,272
Tenkiller	Refurbishing		0	149,464	149,464	149,464	149,464
	New Capacity		0	28,234	207,723	2,724,665	6,344,997
TOTAL			0	250,442	447,606	3,679,284	8,206,154
Present Value of Marginal Net Social Benefits		$1,000	212,690				
Marginal Social B/C			2.41				

TABLE XIV

RESULTS OF THE RECREATION INVESTMENT PROGRAMMING MODEL BY DECISION TIME UNIT, WITHOUT CAPACITY ACTIVITIES SCENARIO

		Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Visitor Days (annual)		VDAY					
Fort Gibson			4,110,000	3,288,000	2,466,000	1,644,000	822,000
Tenkiller			5,226,000	4,180,800	3,135,600	2,090,400	1,045,200
Additions to Capacity		VDAY					
Fort Gibson	Refurbishing		0	0	0	0	0
	New Capacity		0	0	0	0	0
	Total		0	0	0	0	0
Tenkiller	Refurbishing		0	0	0	0	0
	New Capacity		0	0	0	0	0
	Total		0	0	0	0	0
Gross Benefits (annual)		$1,000	17,192	16,825	14,967	12,858	8,719
Costs (annual)		$1,000					
Travel Costs			6,829	5,923	4,388	3,187	1,442
O&M Costs			955	764	573	382	191
Refurbishing			0	0	0	0	0
New Investment			0	0	0	0	0
TOTAL			7,784	6,687	4,961	3,569	1,633
Net Benefits (annual)		$1,000	9,408	10,138	10,006	9,289	7,086
Net Benefits Per Visitor Day in 1975 Prices			1.01	1.36	1.79	2.49	3.79
Investment Budget in1975 Prices							
Fort Gibson	Refurbishing		0	0	0	0	0
	New Capacity		0	0	0	0	0
Tenkiller	Refurbishing		0	0	0	0	0
	New Capacity		0	0	0	0	0
TOTAL			0	0	0	0	0
Present Value of Marginal Net Social Benefits		$1,000	189,355				
Marginal Social B/C			3.10				

decay of existing capacity. Notice the upward trend of net benefits per visitor day due to the rationing provoked by the binding capacity constraints. The programming model is forced to select visitor days with higher willingness to pay. For the same reason, the benefit cost ratio increases to 3.10.

CHAPTER VI

ANALYSIS OF THE INVESTMENT COST-SHARING RULE

Introduction

The Federal Water Project Recreation Act of 1965 (U.S. Statutes at Large, 1965) encourages state and local participation by a 50-50 cost-sharing basis of new capital expenditures. The purpose of this chapter is to determine if that rule is appropriate for recreational activities at lakes Fort Gibson and Tenkiller. That is, if the maximization of welfare accrued to the state of Oklahoma under the 50-50 cost sharing rule gives significantly different results for the optimal visitor days and investment plans obtained from maximizing national social welfare.

Since the market area includes out-of-state counties, then part of the benefits obtained from investing in lakes Fort Gibson and Tenkiller are attained by out-of-state individuals. Therefore, since these water projects are partly financed by the state and local governments, they may prefer to discount some of the out-of-state benefits. On the other hand, state and local governments have more leverage in terms of revenue potential if they invest in projects that bring about more federal monies into the state.

The validity of including benefits from the out-of-state individuals who stimulate Oklahoma's economy by spending some of their budget in outdoor recreation is examined below.

Policy Model

Marshall (1970) derives what he defined as the Association Rule which refers to the cost sharing rule where the costs are shared in the same proportion as benefits at the margin. Following Marshall (1970), the following relationships are defined:

$B = B(q)$

$C = C(q)$

$B = B_L + B_F$

$C = C_L + C_F$

$k = dB_L/dB$

$n = dC_L/dC$

where B stands for total benefits accruing to society, C stands for total costs to society, k is the proportion of B accruing to the local agents at the margin, n is the proportion of C paid by the local agents at the margin, and the subscripts L and F represents local and nonlocal agents. The net social benefits are maximized when

$$dB/dq = dC/dq$$

However, the net local benefits are maximized when

$$dB_L/dq = dC_L/dq$$

From the latter relationship we can derive

$$k * dB/dq = n * dC/dq$$

Therefore, only when $n = k$ will the scale desired by the local agents be equal to the socially efficient scale. If $k > n$, then the local decision makers will invest more relative to the social optimum and if $k < n$, then they will invest less than the social optimum level. The Association Rule implies that $k = n$.

Note that according to the Federal Water Project Recreation Act of 1965 the federal agencies bear up to 50 percent of separable costs and 100 percent of the joint costs. For operation and maintenance costs the federal agencies bear none of the separable costs but all joint costs.

The empirical issue is how to separate the local benefits from the total benefits. It is necessary to define first the market area of each lake without violating the assumptions of the TCM. In most applications, the market area has been defined somewhat arbitrarily as the area served by the lake such that some proportion of the visitor day rate originated from the area. Smith and Kopp (1980) propose a test developed by Brown, Durbin, and Evans (1975) to examine the hypothesis that an increase in distance from the site produces an increase in the likelihood of an origin zone's observed visitor rate resulting from behavior inconsistent with the conventional travel cost model. The test is based on the fact that estimated residuals from a constant coefficient model will exhibit nonrandom error terms when applied to observations inconsistent with its behavioral assumptions. The residuals are computed recursively with the introduction of each new observation and then they are standardized using an orthogonal transformation. One of the advantages of this approach is that it does not require prior specification as to which of the distance zones is inconsistent with the TCM assumptions.

Once the market area for each lake has been delineated then the disaggregation between local and federal benefits follow the established political demarcation.

It is important to point out the distinction between indirect benefits and indirect effects for calculating the marginal benefits of recreation to the local agents. Indirect effects originate from backward and forwards linkages with industries related to the provision of outdoor recreation which are usually computed as changes in value added using an input-output model. Although it is well known in the literature that indirect effects should not be counted as benefits to a project since they are pecuniary impacts that represent income distribution rather than allocative effects, these effects are still counted as benefits in some water project analysis (Stabler, Van Kooten, and Meyer, 1988). On the other hand, indirect benefits are defined as the increase in welfare in related but distorted markets. That is, if there is a difference between marginal benefits and marginal costs in a related market then the difference times the increase in output in that market due to the project should be included as indirect benefits of the project.

Stabler, Van Kooten, and Meyer (1988) examine indirect effects and indirect benefits from the point of view of a province or state. They argue that an important exception to not considering indirect effects as benefits is when impacts of the project go beyond the project's region. Regional indirect benefits may occur in large part through transfers from other regions. In particular, indirect benefits arise from spending funds raised outside the region. If the federal funding has a specific purpose then the full amount of the transfer should be used as a basis for calculating indirect benefits. In this case, an increase in value added of related industries constitutes the basis for calculating the secondary benefits since a large share of the loss of output linked with a decrease in private spending will probably take place outside the region. On the other hand, if the federal funding has a general purpose nature it would be necessary to compare the difference in indirect benefits due to the project with the benefits derived from the best alternative use of the funds in the region in order to identify the net gain, if any, that could be attributed to the external funding of the project (Stabler et. al.).

Procedure

Let the mathematical programming model presented in Chapter V be called the Full Cost Model (FCM). The FCM includes both Oklahoma and out-of-state counties. The cost components are paid their full price. On the other hand, let the welfare accruing only in Oklahoma be called the Oklahoma Welfare Model (OWM). The OWM includes only Oklahoma counties within Lake Tenkiller market area as defined by Schreiner, Willet, Badger and Antle, 1985. The refurbishing and investment costs are specified at 50 percent of the full price. It is assumed that the dummy travel zone "Outside Market Area" is not located in Oklahoma.

The mathematical programming model is solved under the above specifications.

Results

Table XV presents the principle results obtained with the two models. The FCM results in higher visitor days for both lakes and for each time period than the Oklahoma Welfare Model. These findings suggest that the state of Oklahoma share's in recreational water projects should be less than 50 percent if it is desired to service the optimal national social welfare visitor days. Figure 2 depicts the situation for lake Tenkiller in period 5. The aggregated demand (DF) for the FCM is located to the right of the demand (DO) for the OWM since it has more quantity demanded at a given level of price. Likewise, the aggregate supply (SO_o) for the OWM is located to the right of the supply (SF) for the FCM since it faces lower capacity costs. The optimal visitor days are about 5,420,000 and 6,798,000 for the OWM and the FCM respectively. The OWM supply schedule shifts to the right up to SO_1 to service the national optimal visitor days.

TABLE XV

COMPARISON OF RECREATION FACILITY DEVELOPMENT RESULTS BETWEEN FULL COST MODEL AND OKLAHOMA WELFARE MODEL

		Lake Fort Gibson		Lake Tenkiller		Total		Full Demand - 50% Cost Sharing Rule		
Variable	Unit	Full Cost Model	Oklahoma Welfare Model	Full Cost Model	Oklahoma Welfare Model	Full Cost Model	Oklahoma Welfare Model	Ft. Gibson	Tenkiller	Total
Visitor Days	Annual									
1975-1980		2,918,974	2,099,183	5,226,000	4,355,872	8,144,974	6,455,055	2,918,974	5,226,000	8,144,974
1980-1985		3,179,396	2,349,939	5,254,702	4,800,082	8,434,098	7,150,021	3,179,396	5,477,137	8,656,533
1985-1990		3,728,874	2,491,212	5,104,973	4,877,600	8,833,847	7,368,812	3,728,874	5,343,492	9,072,366
1990-1995		3,771,831	2,803,051	5,668,148	4,981,505	9,439,979	7,784,556	4,055,269	5,857,227	9,909,496
1995-2000		4,114,917	3,140,152	6,797,723	5,419,405	10,912,640	8,559,557	4,527,514	6,969,822	11,497,336
Capacity Costs	1975$	2,036,824	1,273,356	9,188,717	4,859,961	11,225,541	6,133,317	3,303,363	10,105,536	13,408,899
Present Value of Marginal Gross Benefits	1975$					363,534,605	292,096,910			367,345,845
Present Value of Marginal Total Costs	1975$					150,842,830	121,023,595			153,001,210
Present Value of Marginal Net Social Benefits	1975$					212,691,775	171,073,315			214,344,635
Marginal Social B/C						2.41	2.41			2.40

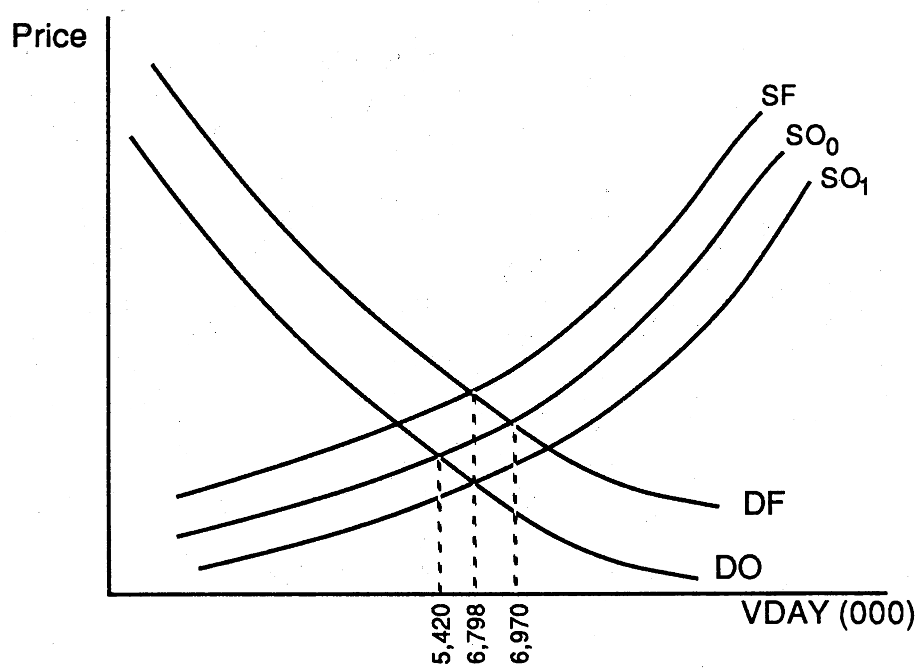

Figure 2. Optimal Visitor Days for Lake Tenkiller Period 5 Under the Oklahoma Welfare Model and the Full Cost Model

As discussed above, to induce the national optimal visitor days the cost sharing rule should be lowered in favor of the state of Oklahoma. Note that the difference between optimal visitor days under both models constitutes an upper bound since it is assumed that the dummy travel zone is not located in Oklahoma. That is, the dummy travel zone may include visitor days belonging to Oklahoma, which comes from counties outside lake Tenkiller market area but within Oklahoma.

The results also show that it is worthwhile to engage in recreational activities since the present value of marginal net social benefits is positive. The social benefit-cost ratios are almost the same under the two models and well over one.

Because it is not practical to limit out-of-state visitors or to change the 50-50 cost sharing rule, the most likely scenario is that the lakes will serve demand DF and that the cost sharing rule will persist. This scenario is denominated Full Demand 50 Percent Cost Sharing Rule Model (FDCM). The last columns in Table XV show that the results from the FDCM are equal or slightly higher than those obtained in the FCM, especially in Fort Gibson's case since most of the time the recreation capacity constraint is not binding. Moreover, since capacity costs are a small fraction of total costs, the shift to the right of the supply curve when capacity costs are reduced to 50 percent is rather small.

CHAPTER VII

PRICING AND BUDGETARY POLICIES FOR LAKES FORT GIBSON AND TENKILLER

So far it has been assumed that the government is able to enforce somehow the optimal social solution provided by the mathematical programming model. In this chapter alternative policies to enforce the optimal social solution are analyzed with emphasis in pricing and budgetary policies. Quantitative restrictions in the visitor day rate are not considered since they are unlikely to be applied by either the federal or local governments.

Pricing Policies at Lakes Fort Gibson and Tenkiller

Wilman (1988) has recently analyzed pricing policies for outdoor recreation. She concludes that marginal cost pricing is an appropriate pricing rule when economic efficiency is the objective and if marginal cost prices cover costs. Otherwise, it is necessary to supplement marginal cost prices with other methods of raising funds or replace this rule entirely by second-best prices such as Ramsey prices. It is apparent from the results presented in Chapter IV that marginal cost pricing covers costs at lakes Tenkiller and Fort Gibson because marginal costs are equal or greater than average costs for all cost components.

<u>Assumptions</u>

1) The objective of the pricing policy is to achieve economic efficiency.

2) Let the ordered triplet (x, y, z) represent the cost sharing rule in percent among the federal government (x), the state and local governments (y), and the recreationists (z). The federal government share refers only to new investment and refurbishing costs; whereas y and z accounts not only for investment and refurbishing costs but also for O&M costs. For example, the cost sharing rule (50,75,25) means that the federal government shares 50 percent of investment and refurbishing costs, the state and local governments pay 75 percent of the O&M costs and 75 percent of 50 percent of the investment and refurbishing costs, and the recreationists pay 25 percent of O&M costs and 25 percent of 50 percent of the investment and refurbishing costs.

3) Throughout this chapter, the federal government share is set at 50 percent of investment and refurbishing costs according with the guidelines of the Water Recreation Act of 1965 (U.S. Statutes at Large, 1965).

4) The entrance fees are set for the entire season since the programming model has an annual specification. The entrance fees are announced *ex ante* to cover all remaining marginal costs if any following the specified cost sharing rule. Note that because of the model's annual specification and the difficulty in determining when the capacity constraint is binding, the entrance fees include investment and refurbishing costs although these activities may not be carried out. The implication of this assumption is discussed below.

5) Cross price substitution effects between lakes Fort Gibson and Tenkiller are included. These price substitution effects are computed exogenously altering the convex combination constraint given in equation (5.7).

The new prices are found by adding the recreationists' share of the social costs by visitor day to their private travel costs. Equation (5.7) can be rewritten as

$$\sum_{s}^{11} X_{tkcs} < H \left[1 - \sum_{\substack{m=1 \\ m \neq k}}^{2} E_{kmc} + \sum_{\substack{m=1 \\ m \neq k}}^{2} \left(\frac{E_{kmc}}{P_{t-1,m}}\right) P_{tm} \right]$$

to reflect that the substitution effects are exogenous so that only the right hand side changes when the price at lake m changes.

6) Policies at lakes other than Fort Gibson and Tenkiller are assumed constant.

7) The proceeds from the entrance fees are appropriated by the state and local governments.

8) Federal funds for investment and refurbishing costs are never binding.

9) The marginal costs of investment at lake Tenkiller is assumed constant and equal to the average cost of investment as reported in Table X ($1.7272 per visitor day capacity).

<u>Price Policy Specification</u>

Three cost sharing rules are analyzed:

1) Recreationists pay the full O&M costs and 50 percent of investment and refurbishing costs (50,0,100);

2) The state and local governments pay the full O&M costs and 50 percent of investment and refurbishing costs (50,100,0); and

3) The state and local governments share equally with the recreationists the O&M, investment, and refurbishing costs (50,50,50).

The objective function of the programming model given in equation (5.1) is modified by introducing cost share parameters that vary according with the cost sharing rule.

Results

Table XVI presents the principal results obtained from the three pricing policy specifications. The entry fees and costs are in 1975 dollars discounted to the base year.

The entry fees for the (50,0,100) cost sharing rule in the first period are 0.2827 and 0.2997 per visitor day for Lakes Fort Gibson and Tenkiller, respectively. In terms of entry fees per trip, the corresponding results are $4.21 and $5.75 per trip in 1975 dollars.

The attendance at both lakes show an increasing trend across pricing policies. As expected, the visitor days are the lowest under the (50,0,100) scenario and the highest under the (50,100,0) scenario for both lakes and all time periods.

Total discounted capacity costs vary from $346,000 to $1,333,807 across the different cost sharing rules. Thus, total capacity costs are quite sensitive to the cost-sharing rule being used.

The O&M costs are considerably higher than the capacity costs. Therefore, the contribution of the federal government to the recreational activities is small with respect to social costs, and of course much smaller with respect to total costs.

The recreationist cost share and the state cost share are computed applying the respective cost sharing rule to the capacity and O&M costs.

TABLE XVI

COMPARISON OF RECREATION FACILITY DEVELOPMENT RESULTS UNDER THREE PRICING POLICIES

Policy (1)		Cost Sharing Rule (50,0,100)			Cost Sharing Rule (50,100,0)			Cost Sharing Rule (50,50,50)		
Variable	Unit	Ft. Gibson	Tenkiller	Total	Ft. Gibson	Tenkiller	Total	Ft. Gibson	Tenkiller	Total
Discounted Entry Fees	1975$/VDAY									
1975-1980		0.2827	0.2997					0.1414	0.1499	
1980-1985		0.2399	0.2441					0.1200	0.1221	
1985-1990		0.2030	0.1962					0.1013	0.0981	
1990-1995		0.1712	0.1548					0.0834	0.0774	
1995-2000		0.1437	0.1192					0.0718	0.0596	
Visitor Days	Annual									
1975-1980		2,785,211	5,226,000	8,011,211	5,012,494	6,863,482	11,875,976	3,715,118	5,707,251	9,422,369
1980-1985		3,053,031	5,325,726	8,378,757	5,417,491	8,302,677	13,720,168	4,046,708	6,309,040	10,355,748
1985-1990		3,547,188	5,307,858	8,855,046	6,123,666	8,131,230	14,254,896	4,482,818	7,016,488	11,499,306
1990-1995		3,882,720	6,393,094	10,275,814	6,714,621	8,884,400	15,599,021	4,974,744	8,241,057	13,215,801
1995-2000		4,370,392	7,167,403	11,537,795	7,264,630	9,900,240	17,164,870	5,457,625	9,074,056	14,531,681
Discounted Capacity Costs	1975$									
1975-1980		0	0	0	131,042	308,796	439,838	0	90,754	90,754
1980-1985		8,856	31,398	40,255	73,280	263,073	336,353	10,620	114,559	125,179
1985-1990		7,349	45,861	53,210	102,006	94,664	196,670	55,265	136,403	191,668
1990-1995		38,269	118,498	156,767	81,783	135,880	217,663	57,911	150,727	208,638
1995-2000		29,863	66,188	96,051	30,430	112,851	143,281	37,368	81,882	119,250
Total		84,338	261,945	346,283	418,541	915,266	1,333,807	161,164	574,326	735,490

TABLE XVI (CONTINUED)

Policy (1) Variable	Unit	Cost Sharing Rule (50,0,100) Ft. Gibson	Tenkiller	Total	Cost Sharing Rule (50,100,0) Ft. Gibson	Tenkiller	Total	Cost Sharing Rule (50,50,50) Ft. Gibson	Tenkiller	Total
Discounted O&M Costs	1975$									
1975-1980		334,226	461,889	796,115	601,499	610,081	1,211,580	445,814	504,422	950,236
1980-1985		316,029	406,033	722,062	560,782	636,613	1,197,395	418,887	481,005	899,892
1985-1990		316,732	349,070	665,802	546,787	537,805	1,084,592	400,274	461,437	861,711
1990-1995		298,827	362,394	661,221	516,779	506,493	1,023,271	382,871	467,147	850,019
1995-2000		290,376	350,743	641,119	482,674	487,245	969,919	362,613	444,050	806,663
Federal Cost Share	1975$									
1975-1980		0	0	0	65,521	154,398	219,919	0	45,377	45,377
1980-1985		4,428	15,699	20,127	36,640	131,537	168,177	5,310	57,279	62,589
1985-1990		3,674	22,931	26,605	51,003	47,332	98,335	27,632	68,202	95,834
1990-1995		19,135	59,249	78,384	40,891	67,940	108,831	28,955	75,363	104,319
1995-2000		14,932	33,094	48,025	15,215	56,426	71,641	18,684	40,941	59,625
Recreationists Cost Share	1975$									
1975-1980		334,226	461,889	796,115				222,907	274,900	497,807
1980-1985		320,457	421,732	742,190				212,098	269,142	481,241
1985-1990		320,406	372,001	692,407				213,953	264,819	478,773
1990-1995		317,962	421,643	739,605				205,913	271,255	477,169
1995-2000		305,307	383,837	689,144				190,648	242,496	433,144

TABLE XVI (CONTINUED)

Policy (1)		Cost Sharing Rule (50,0,100)			Cost Sharing Rule (50,100,0)			Cost Sharing Rule (50,50,50)		
Variable	Unit	Ft. Gibson	Tenkiller	Total	Ft. Gibson	Tenkiller	Total	Ft. Gibson	Tenkiller	Total
State Cost Share	1975$									
1975-1980					667,020	764,479	1,431,500	222,907	274,900	497,807
1980-1985					597,422	768,150	1,365,572	212,098	269,142	481,241
1985-1990					597,790	585,137	1,182,927	213,953	264,819	478,773
1990-1995					557,670	574,433	1,132,103	205,913	271,255	477,169
1995-2000					497,889	543,671	1,041,560	190,648	232,496	433,144
Surplus	1975$									
1975-1980		453,217	1,104,479	1,557,696				302,266	580,406	882,672
1980-1985		407,616	862,802	1,270,418				273,357	501,009	774,365
1985-1990		395,999	646,444	1,042,443				240,174	423,477	663,651
1990-1995		327,482	508,970	836,452				208,891	366,742	575,633
1995-2000		307,765	437,123	744,887				201,466	298,127	499,593

(1) The cost-sharing rule (X,Y,Z) means that the federal government contributes with X percent of capacity costs, the state contributes with Y percent of O&M costs and Y percent of X percent of capacity costs, and the recreationists contribute with Z percent of O&M costs and Z percent of X percent of capacity costs.

Of course, if the economic efficiency objective is followed, the (50,0,100) pricing rule is the most appropriate rule because the deadweight losses are eliminated. However, entrance fees include capacity costs that are charged to all recreationists even if it turns out that these activities are not implemented and that only visitor days beyond the recreation capacity constraint should be charged the marginal capacity costs. For this reason, the entry fee policy produces a surplus that is reported in the last rows of Table XVI. Even with the (50,50,50) cost-sharing rule, there is a surplus.

The existence of a surplus from the (50,0,100) rule can be seen in Figure 3. The entrance fee policy is to charge all marginal social costs to each recreationist, which result in entrance fee P_2 - P_0. Assumption number four states that it is infeasible to charge P_1 - P_0 to recreationists that attend the lake before the recreation capacity constraint (RC) has been reached and then charge the full cost to recreationists that attend the lake after the recreation capacity is binding.

The social supply SS_{ok} excludes the costs paid by the federal government. Once the entrance fees have been set, the demand curve rotates to D_e due to price substitution effects. For the case drawn, the mathematical programming model finds optimal visitor days $VDAY_e$. Notice that $VDAY_e$ for the case drawn is less than RC, so it is not even necessary to implement capacity activities. Thus, the marked area represents the surplus resulting from the (50,0,100) cost sharing rule.

Therefore, a more favorable cost sharing rule for the recreationists is needed to be consistent with the marginal cost pricing rule. The discontinuity in the social supply function makes it difficult to implement marginal cost pricing, which suggests that the price policy has to compromise the efficiency criteria. Lower entry fees than the ones implied under the (50,50,50) cost rule will make

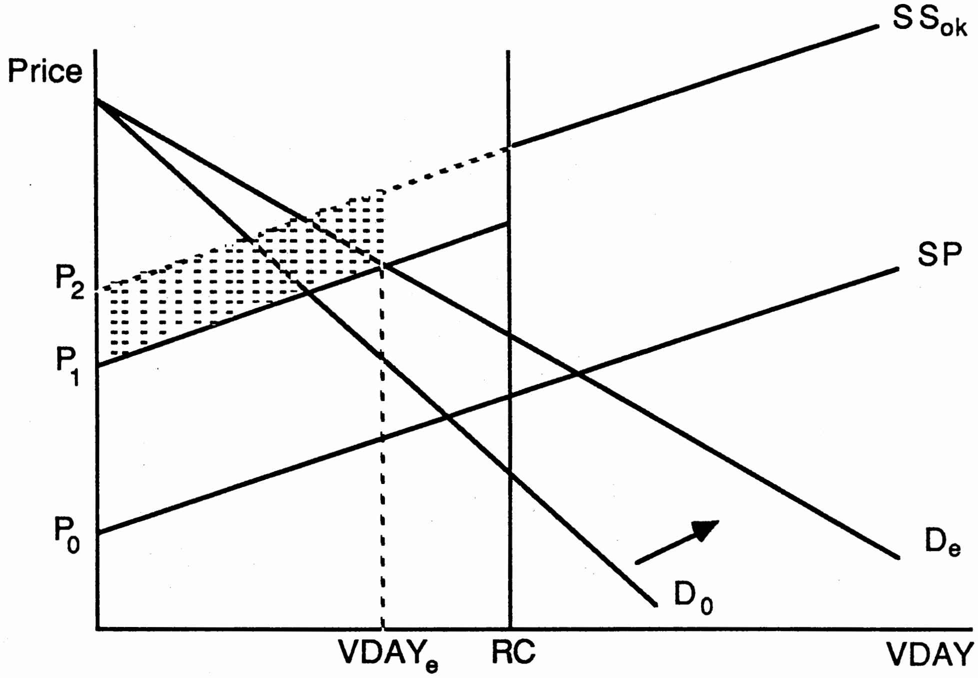

Figure 3. Effects of the Pricing Policy Under the (50,0,100) Cost-Sharing Rule

them closer to the actual or so called nominal entry fees. It appears that nominal entry fees are not significantly out of line with marginal cost pricing given that assumption number four is "realistic." For example, if only O&M costs are charged to recreationists, the entry fees for the first period are about $0.12 and $0.088 per visitor day for Lakes Fort Gibson and Tenkiller, respectively. Even though these entry fees were still higher than actual fees for 1975 (Presley, 1975), they represent about $0.259 and $0.189 per visitor day in 1988 dollars, which are close to current entry fees at the newer Oklahoma lakes.

Budgetary Policies for Lakes Fort Gibson and Tenkiller

In this section an alternative way of rationing visitor days other than pricing policies is explored: the state budget. The activities that entail costs in the programming model need to be specified also in a cash flow basis to determine if the financial requirements meet the available budget.

Assumptions

In addition to the assumptions stated previously, the following statements are assumed:

1) The federal government and the recreationists budget share are determined on a cost basis as in the previous section, whereas the state and local governments match the difference between budget needs and funds collected from the federal governments and the recreationists.

2) It is not possible to borrow or to lend funds across time periods.

3) Price policy is not feasible. The state and local governments can limit attendance only by providing lower financial resources to O&M and capacity activities.

4) Demand for recreational experiences adjusts to lower expenditures on O&M and capacity activities.

Budgetary Policy Specification

The objective of this section is to determine if there exists a budgetary policy that gives a solution close to the social welfare maximizing visitor days and investment plans from the point of view of the state of Oklahoma when pricing policy is not feasible to implement because of non-economic reasons.

Mumy and Hanke (1975) studied the implications for benefit-cost analysis when public facilities are underpriced or have a zero price. Their analysis was based on the rationing assumption in which each of the demanded consumption units at a given price has an equal probability of being satisfied. Porter (1977) examined the same issue but assumed that the rationing devices for underpriced facilities are queues and congestion. It appears that, in the past, the policy for recreational activities at lakes such as Fort Gibson and Tenkiller have been non-exclusionary (Harrington, 1987). That is, rather than rationing attendance, capacity activities have been implemented to accommodate the increased demand even though recreationists were not paying the social costs of the recreational experience.

Weitzman (1974) developed a criterion based on a loss function to determine the comparative advantage of using prices versus quantities as planning devices. He argues that no matter how one type of planning instrument is fixed, there is always a corresponding way to set the other such that it achieves the same results given the usual convexities assumptions. He concludes that quantity policies are better if the marginal cost function is flat and the benefit function is sharply curved. In particular, if the cost curves are piecewise linear cost functions with limited number of kinks the quantity policies tend to have relative advantage. On the other hand, pricing policies are superior if the marginal cost is highly curved and the benefit function is linear. He also asserts that conventional economic theory has tended to focus on smoothly differentiable production functions neglecting somewhat the activity analysis approach with its limited number of alternative production processes, resulting in many theoretical results that are based on the convexity property.

Let the budget policy be denominated Exclusionary Budget Policy (EBP). The EBP is defined as the time path of state budget allocations to Lakes Fort Gibson and Tenkiller such that the optimal social welfare plan is reached given that price policy is not feasible.

The mathematical programming model is specified similarly to the (50,100,0) cost-sharing rule presented in the previous section but with budget constraints by lake and time period. The approximated budget constraints are determined by computing the cash flow requirements from the results obtained from the (50,0,100) cost-sharing rule.

Results

Table XVII presents the main results of the EBP, which are compared with the (50,0,100) cost-sharing rule. The two first variables refer to the two policies being compared: entry fees versus budget allocation.

The optimal visitor days obtained from the EBP are fairly close to the ones obtained with the use of pricing policy. The same conclusion stands regarding refurbishing and new capacity activities.

The budget constraints are binding for both lakes and for all time periods. The budget policy has been successful in preventing the high attendance rates

TABLE XVII

COMPARISON OF RECREATION FACILITY DEVELOPMENTS UNDER COST SHARING RULE (50,100,0) AND EXCLUSIONARY BUDGET POLICY

Policy (1)		Cost Sharing Rule (50,0,100)			Exclusionary Budget Policy		
Variable	Unit	Ft. Gibson	Tenkiller	Total	Ft. Gibson	Tenkiller	Total
Discounted Entry Fees	1975$/VDAY						
1975-1980		0.2827	0.2997				
1980-1985		0.2399	0.2441				
1985-1990		0.2030	0.1962				
1990-1995		0.1712	0.1548				
1995-2000		0.1437	0.1192				
State Budget Allocation	1975$						
1975-1980					335,000	462,000	797,000
1980-1985					390,000	635,000	1,025,000
1985-1990					475,000	850,000	1,325,000
1990-1995					1,005,000	2,270,000	3,275,000
1995-2000					1,450,000	2,700,000	4,150,000
Visitor Days (annual)	VDAY						
1975-1980		2,785,211	5,226,000	8,011,211	2,791,667	5,197,505	7,989,172
1980-1985		3,053,031	5,325,726	8,378,757	3,048,161	5,326,511	8,374,672
1985-1990		3,547,188	5,307,858	8,855,046	3,581,583	4,677,481	8,259,064
1990-1995		3,882,720	6,393,094	10,275,814	3,900,275	6,767,910	10,668,185
1995-2000		4,370,392	7,167,403	11,537,795	4,379,726	7,516,526	11,896,252

TABLE XVII (CONTINUED)

Policy (1) Variable	Unit	Cost Sharing Rule (50,0,100) Ft. Gibson	Tenkiller	Total	Exclusionary Budget Policy Ft. Gibson	Tenkiller	Total
Additions to Capacity	VDAY						
- Refurbishing							
1975-1980		0	0	0	0	0	0
1980-1985		388,782	1,045,200	1,433,982	440,375	1,045,200	1,485,575
1985-1990		822,000	1,045,200	1,867,200	822,000	1,045,200	1,867,200
1990-1995		822,000	1,045,200	1,867,200	822,000	1,045,200	1,867,200
1995-2000		822,000	1,045,200	1,867,200	822,000	1,045,200	1,867,200
- New Capacity							
1975-1980		0	0	0	0	0	0
1980-1985		0	99,726	99,726	0	100,511	100,511
1985-1990		0	350,476	350,476	0	416,272	416,272
1990-1995		739,126	1,872,077	2,611,203	739,484	1,845,388	2,584,872
1995-2000		1,313,091	2,283,965	3,597,056	1,322,140	2,266,250	3,588,390
Total		4,906,999	8,787,044	13,694,043	4,967,999	8,809,221	13,777,220
Budget for Capacity Costs	1975$						
1975-1980		0	0	0	0	0	0
1980-1985		42,766	321,710	364,476	48,441	323,066	371,507
1985-1990		90,420	754,806	845,226	90,420	868,449	958,869
1990-1995		1,073,458	3,382,915	4,456,373	1,073,934	3,336,818	4,410,751
1995-2000		1,836,831	4,094,328	5,931,159	1,848,866	4,063,731	5,912,597
Total		3,043,475	8,553,759	11,597,234	3,061,661	8,592,063	11,653,724

TABLE XVII (CONTINUED)

Policy (1)		Cost Sharing Rule (50,0,100)			Exclusionary Budget Policy		
Variable	Unit	Ft. Gibson	Tenkiller	Total	Ft. Gibson	Tenkiller	Total
Budget for O&M Costs	1975$						
1975-1980		334,226	461,889	796,115	335,000	461,996	796,996
1980-1985		366,364	470,703	837,067	365,779	473,463	839,242
1985-1990		425,663	469,124	894,787	429,790	415,772	845,562
1990-1995		465,927	565,040	1,030,967	468,033	601,586	1,069,619
1995-2000		524,447	633,476	1,157,923	525,567	668,129	1,193,696
Federal Budget Share	1975$						
1975-1980		0	0	0	0	0	0
1980-1985		1,228	9,238	10,466	1,391	9,277	10,667
1985-1990		2,596	21,673	24,270	2,596	24,937	27,533
1990-1995		30,823	97,137	127,960	30,837	95,813	126,650
1995-2000		52,743	117,564	170,307	53,088	116,686	169,774
Recreationists Budget Share	1975$						
1975-1980		334,226	461,889	796,115			
1980-1985		367,592	479,941	847,533			
1985-1990		428,259	490,797	919,057			
1990-1995		496,750	662,177	1,158,927			
1995-2000		577,190	751,040	1,328,230			
Present Value of Marginal Net Benefits	$1,000			211,640			232,615

(1) The cost-sharing rule (X,Y,Z) means that the federal government contributes with X percent of capacity costs, the state contributes with Y percent of O&M costs and Y percent of X percent of capacity costs, and the recreationists contribute with Z percent of O&M costs and Z percent of X percent of capacity costs.

reached when recreationists do not pay any of the social costs as was shown in Table XVI under the (50,100,0) cost-sharing rule. However, the state and local governments need to commit greater financial resources since they must run an economic deficit and also cover the cash flow deficit because the federal government makes payments according with the cost incurred within a given period which are much smaller than the corresponding required budget.

The principal limitation of using the state's budget as a rationing device is that high willingness-to-pay recreationists may be excluded from the market. For example, the first groups that are served by the lake may be the low willingness-to-pay consumers, who may use up the services provided by the state and local governments in detriment of the high willingness-to-pay consumers that decide not to attend the site.

CHAPTER VIII

SUMMARY, CONCLUSIONS, POLICY GUIDELINES, AND STUDY LIMITATIONS

Summary

The principal objective of this study was to determine the optimal allocation of investment funds among competing lakes for water-based recreation activities under alternative government policies. The government policies analyzed were entry fees, state and/or local budget allocations between lakes, and alternative cost-sharing rules among the federal, state and local governments, and recreationists. The effects of these policies were studied using models that are consistent with economic choice theory. That is, the government in setting its policies recognizes that recreationists behave as if they were optimizing their own welfare.

A conceptual planning model was first presented that allows the identification of the elements that constitute a recreational planning model. The main elements are: the marginal benefits and costs of outdoor recreation, the marginal productivities of each site, the interest rate, and the budget constraints, if any, for maintaining and expanding the sites' capacities. A literature review was presented on each of these elements.

Marginal benefits were estimated using McFadden's discrete choice multinomial logit model to specify a trip distribution function coupled with a regional gravity model including a trip generation function. The procedure followed has several advantages. It handles substitution effects avoiding statistical problems such as multicollinearity and zero cells observations; provides individual elasticity estimates; fulfills the integrability conditions; and separates the price from the quality effect by explicitly considering the site's characteristics as quality variables. The procedure is carried out for five Oklahoma lakes using data from a 1975 survey conducted by the Department of Agricultural Economics at Oklahoma State University.

Marginal costs were estimated for the cost components of the recreational social supply function, namely travel costs, operation and maintenance costs, capacity costs, and congestion costs. Emphasis was given in estimating economies of size for investment in Public Use Areas at Lake Tenkiller and in determining the existence of congestion costs at the surveyed Oklahoma lakes. A long-run average cost curve for investment was estimated for Lake Tenkiller that shows the presence of diseconomies of size in investment. Congestion was modeled as if it were an additional characteristic of the sites. Thus, the hedonic travel cost model procedure was applied to determine the relevance of congestion at the five Oklahoma lakes.

The planning methodology was empirically applied to two competing lakes. Lakes Fort Gibson and Tenkiller were selected as the case study. Marginal benefits and costs for recreationists attending Lakes Fort Gibson and Tenkiller were projected from 1975 to the year 2000. A spatial intertemporal mathematical programming model was specified that solves for the optimal levels of visitor days, investment, and operation and maintenance activities such that the present value of social welfare is maximized.

The 50-50 cost-sharing basis of new capital expenditures between the federal government and/or state and local participation as stated in the Federal Water Project Recreation Act of 1965 was analyzed from the point of view of the state of Oklahoma. The mathematical programming model was solved including only Oklahoma counties within the sites' market area and by specifying capital costs at 50 percent of the full price.

Policies rationing attendance at the lakes were needed since marginal social costs are higher than marginal private costs in the recreation markets at both lakes. Alternative government policies to enforce the optimal solution were analyzed with emphasis in pricing and budgetary policies to achieve economic efficiency. Cross price substitution effects between the lakes were introduced into the mathematical programming model.

Conclusions

1. It is worthwhile to implement capacity activities at Lakes Fort Gibson and Tenkiller. The present value of marginal social net benefits due to the incorporation of capacity activities over the planning period 1975-2000 increases by about $23.5 million in 1975 prices.

2. County population, per capita income, travel costs, entry fees, in-state and out-of-state location of recreationists, and lake characteristics such as number of campsites are important variables explaining the level and distribution of visitor days to Oklahoma lakes. Congestion costs appear not to be a relevant variable for recreation activities at Oklahoma lakes.

3. Investment activities at Lake Tenkiller show increasing diseconomies of size.

4. The state of Oklahoma share in recreational water projects at Lakes Fort Gibson and Tenkiller should be less than the 50 percent suggested by the Federal Water Project Recreation Act of 1965 if it is desired to service the optimal national welfare visitor days.

5. The so-called nominal entry fees appear to be a good rule of thumb given the difficulty of implementing marginal cost prices due to discontinuities in the social supply curve.

6. The state and/or local budgets can be used as policy instruments to ration attendance at both lakes when price policy is not feasible.

Policy Guidelines

1. If the objective of the planning model is to enhance economic efficiency, a policy instrument is needed to ration attendance for recreational activities at Oklahoma lakes because social costs are higher than private costs. If entry fees set at marginal cost prices are difficult to implement because of non-economic reasons and discontinuities in the social supply function, a second best policy can be implemented by using a combination of nominal entry fees and budget allocation. For example, the entry fees may cover O&M costs and the state would cover the remaining 50 percent of capacity costs. The planning methodology used in this study can be used to investigate the effects of such second best policies.

2. Further research on the appropriate cost share between the federal government and state and/or local participation is needed to determine the convenience of the current 50-50 cost-sharing rule.

Limitations

1. The results of this study are limited by the accuracy of the data, software availability, and assumptions used. More specifically, better estimates for unobserved travel costs and sites destinations; and maximum likelihood

estimation of the trip distribution function should yield better estimates of the demand and benefit functions.

2. Alternative assumptions about the recreation capacity measure at both lakes and its decay through time were not explored.

3. Alternative methods of estimating congestion costs other than the hedonic travel cost method were not carried out due to data limitations.

4. A nonlinear mathematical programming algorithm may be more appropriate if it is desired to solve endogenously for the optimal path of the entry fees.

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APPENDICES

APPENDIX A

DISTANCE MATRIX FROM COUNTIES WITHIN LAKE TENKILLER MARKET AREA TO OKLAHOMA LAKES (1)

TABLE XVIII

DISTANCE MATRIX FROM COUNTIES WITHIN LAKE TENKILLER MARKET AREA TO OKLAHOMA LAKES (1)
(Miles)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller
Adair	OK	75	46			33
Atoka	OK	82				126
Bryan	OK	114				157
Cherokee	OK	66	13			31
Choctaw	OK	124				151
Cleveland	OK	133	158			162
Coal	OK	87				125
Craig	OK	120	69	76		92
Creek	OK	99	56	16	45	84
Delaware	OK	116				72
Garvin	OK	148				174
Haskell	OK	20	57			46
Hughes	OK	79				111
Johnston	OK	121				165
Latimer	OK	37				73
LeFlore	OK	57				58
Lincoln	OK	129	107	47		135
Logan	OK	170		73		163
McClain	OK	145				172
McCurtain	OK	167				165
McIntosh	OK	20	49	92		53
Mayes	OK	77	42	58	27	67
Murray	OK	152				173
Muskogee	OK	36	13	67		26
Noble	OK	176		72		164
Nowata	OK	126		63	22	113
Okfuskee	OK	73		47		85
Oklahoma	OK	141	153	95	146	157
Okmulgee	OK	66	53	49	60	58
Osage	OK	138	107	52	53	134
Ottawa	OK	144				106
Pawnee	OK	125	118	44		136
Payne	OK	164		48		146
Pittsburg	OK	42				81
Pontotoc	OK	114				142
Pottowatomie	OK	106		73		124
Pushmataha	OK	103				131
Rogers	OK	93	54	41	10	81
Seminole	OK	109		69		117
Sequoyah	OK	47	57			22
Tulsa	OK	86	54	14	32	82
Wagoner	OK	53	19	56		46
Washington	OK	122	78	64	42	126

TABLE XVIII (CONTINUED)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller
Benton	AR	158				102
Boone	AR					175
Carroll	AR	197				152
Conway	AR					142
Crawford	AR	72				68
Franklin	AR	108				104
Garland	AR					171
Howard	AR	219				215
Johnson	AR	127				123
Logan	AR	107				102
Madison	AR	157				107
Marion	AR					225
Montgomery	AR	156				91
Newton	AR	212				188
Perry	AR					152
Pike	AR	216				193
Polk	AR	150				146
Pope	AR	152				148
Scott	AR	118				115
Searcy	AR					218
Sebastian	AR	68				43
Sevier	AR	196				191
Washington	AR	130				76
Yell	AR	178				154
Chautauqua	KS			80		170
Cherokee	KS					129
Crawford	KS					153
Labette	KS	159				131
Montgomery	KS					171
Neosho	KS					168
Barry	MO	183				129
Barton	MO					168
Jasper	MO					148
Lawrence	MO					169
McDonald	MO	145				103
Newton	MO	148				120
Stone	MO					160
Taney	MO					202
Lamar	TX	152				179
Red River	TX	183				210

(1) Distance outside the market areas for each lake were not reported by the source.

SOURCE: Schreiner, D. F., D. A. Willet, D. D. Badger, and L. G. Antle. Recreation Benefits Measured by Travel Cost Method for McClellan-Kerr Arkansas River Navigation System and Application to Other Selected Corps Lakes, U.S. Army Corps of Engineers Contract Report 85-C-1, 1985.

APPENDIX B

OBSERVED TRAVEL COSTS FROM COUNTIES WITHIN LAKE TENKILLER MARKET AREA TO OKLAHOMA LAKES

TABLE XIX

OBSERVED TRAVEL COSTS FROM COUNTIES WITHIN LAKE TENKILLER MARKET AREA TO OKLAHOMA LAKES ($/VDAY)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller
Adair	OK	0.456	1.587	0.000	0.000	0.228
Atoka	OK	0.499	0.000	0.000	0.000	0.906
Bryan	OK	0.693	0.000	0.000	0.000	1.129
Cherokee	OK	0.401	0.124	0.000	0.000	0.620
Choctaw	OK	0.754	0.000	0.000	0.000	1.086
Cleveland	OK	1.721	1.090	0.000	0.000	1.146
Coal	OK	0.529	0.000	0.000	0.000	0.899
Craig	OK	0.730	0.238	0.914	0.000	0.662
Creek	OK	3.416	0.594	0.152	0.414	0.305
Delaware	OK	0.705	0.000	0.000	0.000	1.242
Garvin	OK	3.064	0.000	0.000	0.000	1.251
Haskell	OK	0.360	0.545	0.000	0.000	0.331
Hughes	OK	0.545	0.000	0.000	0.000	0.547
Johnston	OK	0.736	0.000	0.000	0.000	1.187
Latimer	OK	0.537	0.000	0.000	0.000	0.525
LeFlore	OK	0.656	0.000	0.000	0.000	0.320
Lincoln	OK	2.967	0.778	0.116	0.000	0.971
Logan	OK	0.978	0.000	0.878	0.000	0.402
McClain	OK	2.001	0.000	0.000	0.000	0.000
McCurtain	OK	1.015	0.000	0.000	0.000	0.000
McIntosh	OK	0.029	0.451	1.106	0.000	0.000
Mayes	OK	0.468	1.449	0.697	0.177	0.925
Murray	OK	0.924	0.000	0.000	0.000	1.244
Muskogee	OK	0.710	0.215	0.805	0.000	0.315
Noble	OK	1.070	0.000	1.242	0.00	3.772
Nowata	OK	0.766	0.000	0.757	0.607	0.813
Okfuskee	OK	0.262	0.000	0.565	0.000	0.611
Oklahoma	OK	0.857	1.242	0.983	1.321	1.082
Okmulgee	OK	0.683	1.219	0.589	0.680	0.445
Osage	OK	0.839	0.591	1.794	0.697	1.156
Ottawa	OK	0.875	0.000	0.000	0.000	0.762
Pawnee	OK	0.760	0.000	1.214	0.000	0.978
Payne	OK	0.997	2.714	0.386	0.000	2.519
Pittsburg	OK	0.227	0.000	0.000	0.000	3.726
Pontotoc	OK	0.291	0.000	0.000	0.000	1.021
Pottowatomie	OK	0.650	0.000	0.878	0.000	1.180
Pushmataha	OK	0.626	0.000	0.000	0.000	0.942
Rogers	OK	2.139	0.569	2.829	0.242	0.583
Seminole	OK	1.003	0.000	1.587	0.000	0.734
Sequoyah	OK	0.286	0.545	0.000	0.000	0.202
Tulsa	OK	0.890	0.468	0.223	0.497	0.772
Wagoner	OK	0.322	0.524	1.546	0.000	0.423
Washington	OK	0.742	1.196	1.766	0.630	0.994

TABLE XIX (CONTINUED)

County	State	Eufaula	Ft. Gibson	Keystone	Oologah	Tenkiller
Benton	AR	0.961	0.000	0.000	0.000	0.880
Boone	AR	0.000	0.000	0.000	0.000	1.259
Carroll	AR	1.198	0.000	0.000	0.000	1.093
Conway	AR	0.000	0.000	0.000	0.000	1.021
Crawford	AR	0.438	0.000	0.000	0.000	0.427
Franklin	AR	0.657	0.000	0.000	0.000	0.748
Garland	AR	0.000	0.000	0.000	0.000	1.230
Howard	AR	1.331	0.000	0.000	0.000	1.546
Johnson	AR	0.772	0.000	0.000	0.000	0.885
Logan	AR	0.650	0.000	0.000	0.000	0.734
Madison	AR	0.954	0.000	0.000	0.000	0.770
Marion	AR	0.000	0.000	0.000	0.000	1.618
Montgomery	AR	0.948	0.000	0.000	0.000	0.654
Newton	AR	1.289	0.000	0.000	0.000	1.352
Perry	AR	0.000	0.000	0.000	0.000	1.093
Pike	AR	1.313	0.000	0.000	0.000	1.388
Polk	AR	0.912	0.000	0.000	0.000	1.050
Pope	AR	0.924	0.000	0.000	0.000	1.064
Scott	AR	0.717	0.000	0.000	0.000	0.827
Searcy	AR	0.000	0.000	0.000	0.000	1.568
Sebastian	AR	1.043	0.000	0.000	0.000	0.519
Sevier	AR	1.192	0.000	0.000	0.000	1.374
Washington	AR	0.790	0.000	0.000	0.000	0.437
Yell	AR	1.082	0.000	0.000	0.000	1.108
Chautauqua	KS	0.000	0.000	0.962	0.000	1.223
Cherokee	KS	0.000	0.000	0.000	0.000	0.928
Crawford	KS	0.000	0.000	0.000	0.000	1.100
Labette	KS	0.967	0.000	0.000	0.000	0.942
Montgomery	KS	0.000	0.000	0.000	0.000	1.230
Neosho	KS	0.000	0.000	0.000	0.000	1.208
Barry	MO	1.113	0.000	0.000	0.000	0.928
Barton	MO	0.000	0.000	0.000	0.000	1.208
Jasper	MO	0.000	0.000	0.000	0.000	1.064
Lawrence	MO	0.000	0.000	0.000	0.000	1.215
McDonald	MO	0.882	0.000	0.000	0.000	0.741
Newton	MO	0.900	0.000	0.000	0.000	0.863
Stone	MO	0.000	0.000	0.000	0.000	1.151
Taney	MO	0.000	0.000	0.000	0.000	1.453
Lamar	TX	0.924	0.000	0.000	0.000	1.287
Red River	TX	1.113	0.000	0.000	0.000	1.510

SOURCE: Badger, Daniel D., Dean F. Schreiner, and Ronald W. Presley. Analysis of Expenditures for Outdoor Recreation at the McClellan-Kerr Arkansas River Navigation System. U.S. Army Corps of Engineers Contract Report 77-4, 1977.

APPENDIX C

TOTAL INCOME, PER CAPITA INCOME, POPULATION,

AND POPULATION PROJECTION FOR THE

YEAR 2000 BY COUNTIES

TABLE XX

TOTAL INCOME, PER CAPITA INCOME, POPULATION, AND POPULATION PROJECTION FOR THE YEAR 2000 BY COUNTIES

County	State	Total 1975 Income ($1,000)	1975 Per Capita Income ($)	Year 1975 Population (1,000)	Year 2000 Projected Population (1)
Adair	OK	45,671	2,674	17,080	22,900
Atoka	OK	30,790	2,551	12,070	13,700
Bryan	OK	106,664	3,867	27,583	34,300
Cherokee	OK	86,530	3,240	26,707	42,200
Choctaw	OK	49,607	2,666	18,607	17,000
Cleveland	OK	499,599	4,762	104,914	232,700
Coal	OK	18,324	3,049	6,010	5,500
Craig	OK	69,645	4,378	14,699	13,400
Creek	OK	223,496	4,343	51,461	92,900
Delaware	OK	58,841	2,894	20,332	36,500
Garvin	OK	119,337	4,432	26,926	28,900
Haskell	OK	34,813	3,417	10,188	12,900
Hughes	OK	51,062	3,527	14,477	15,700
Johnston	OK	28,074	2,998	9,364	12,500
Latimer	OK	31,885	3,165	10,074	11,400
LeFlore	OK	117,537	3,198	36,753	52,400
Lincoln	OK	92,574	4,128	22,426	41,200
Logan	OK	90,780	3,774	24,054	39,400
McClain	OK	73,353	4,038	18,166	33,800
McCurtain	OK	107,585	2,887	37,265	41,700
McIntosh	OK	45,244	3,331	13,583	20,900
Mayes	OK	119,417	4,255	28,065	44,500
Murray	OK	41,597	3,857	10,785	14,500
Muskogee	OK	300,379	4,830	62,190	68,500
Noble	OK	47,163	4,512	10,453	13,100
Nowata	OK	45,162	4,267	10,584	12,600
Okfuskee	OK	37,024	3,256	11,371	14,400
Oklahoma	OK	3,430,262	6,238	549,898	696,800
Okmulgee	OK	146,926	3,985	36,870	45,200
Osage	OK	129,617	3,941	32,889	55,200
Ottawa	OK	136,984	4,386	31,232	37,700
Pawnee	OK	55,029	4,210	13,071	23,000
Payne	OK	224,386	4,019	55,831	75,800
Pittsburg	OK	147,429	3,739	39,430	47,600
Pontotoc	OK	134,775	4,443	30,334	36,700
Pottowatomie	OK	225,053	4,458	50,483	84,500
Pushmataha	OK	26,988	2,527	10,680	14,100
Rogers	OK	155,817	4,316	36,102	79,000
Seminole	OK	111,020	4,040	27,480	43,700
Sequoyah	OK	87,931	3,202	27,461	42,000
Tulsa	OK	2,944,762	6,939	424,378	606,500
Wagoner	OK	107,522	3,521	30,537	76,700
Washington	OK	323,779	7,748	41,789	54,900

TABLE XX (CONTINUED)

County	State	Total 1975 Income ($1,000)	1975 Per Capita Income ($)	Year 1975 Population (1,000)	Year 2000 Projected Population (1)
Benton	AR	308,690	5,270	58,575	
Boone	AR	104,708	4,586	22,832	
Carroll	AR	62,175	4,398	14,137	
Conway	AR	74,198	4,160	17,836	
Crawford	AR	120,634	4,036	29,889	
Franklin	AR	51,348	4,004	12,824	
Garland	AR	312,655	5,069	61,680	
Howard	AR	60,732	4,638	13,094	
Johnson	AR	60,633	3,961	15,307	
Logan	AR	75,783	4,140	18,305	
Madison	AR	38,727	3,853	10,051	
Marion	AR	33,784	3,589	9,413	
Montgomery	AR	24,476	3,794	6,451	
Newton	AR	16,341	2,457	6,651	
Perry	AR	23,549	3,440	6,846	
Pike	AR	33,349	3,509	9,504	
Polk	AR	58,672	3,995	14,686	
Pope	AR	150,394	4,470	33,645	
Scott	AR	32,593	3,589	9,081	
Searcy	AR	21,509	2,638	8,154	
Sebastian	AR	461,207	4,232	108,981	
Sevier	AR	52,213	4,219	12,376	
Washington	AR	396,337	4,844	81,820	
Yell	AR	66,360	4,053	16,373	
Chautauqua	KS	20,920	4,502	4,647	
Cherokee	KS	92,646	4,338	21,357	
Crawford	KS	183,172	4,986	36,737	
Labette	KS	111,028	4,470	24,838	
Montgomery	KS	216,050	5,552	38,914	
Neosho	KS	99,077	5,387	18,392	
Barry	MO	91,613	4,228	21,668	
Barton	MO	43,578	3,975	10,963	
Jasper	MO	395,174	4,809	82,174	
Lawrence	MO	112,947	4,096	27,575	
McDonald	MO	42,348	2,760	15,343	
Newton	MO	139,978	3,856	36,301	
Stone	MO	48,809	3,860	12,645	
Taney	MO	78,209	4,546	17,204	
Lamar	TX	167,985	4,484	37,463	
Red River	TX	54,593	3,757	14,531	

(1) Out-of-state counties estimates computed using their state population projected growth rate.

SOURCES: U.S. Bureau of Census. Current Population Reports, Series P-25, No. 796, Illustrative Projections of State Populations by Age, Race, and Sex: 1975 to 2000, U.S. Government Printing Office, Washington, 1979.

U.S. Department of Commerce. Bureau of Economic Analysis. Local Area Personal Income 1974-1979, Vol. 7, U.S. Government Printing Office, Washington, 1981.

VITA

Geoffrey M. Cannock

Candidate for the Degree of

Doctor of Philosophy

Thesis: ANALYSIS OF WATER-BASED RECREATION MARKETS FOR TWO COMPETING LAKES IN THE MCCLELLAN-KERR ARKANSAS RIVER NAVIGATION SYSTEM UNDER ALTERNATIVE GOVERNMENT POLICIES

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Lima, Peru, August 2, 1958, the son of Richard M. Cannock and Hortensia Torero.

Education: Graduated from Santa María High School, Lima, Peru in 1975; received Bachelor of Science Degree in Economics from Pacifico University, Lima, Peru in 1984; received the Master of Arts Degree in Economics from Pacifico University, Lima, Peru in 1984; received the Master of Science Degree in Agricultural Economics from Oklahoma State University in July, 1986; and completed requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 1988.

Professional Experience: Assistant Manager, APOYO, Lima, Peru, 1979; Assistant Manager, PROTESA, Lima, Peru, 1980; Associate Researcher, Andean Pact, Lima, Peru, 1981-1984; Researcher, Pacifico University, Lima, Peru, 1984-1985; Consultant, United Nations Industrial Development Organization, Lima, Peru, 1984-1985; and Graduate Research Assistant, Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma, 1988.