ESTIMATION OF DEMAND FUNCTIONS FOR WETLANDS - BASED RECREATION USING AN ALMOST IDEAL DEMAND SYSTEM

by

Sukumar Ajmera

Jack E. Houston

and

John C. Bergstrom

Sukumar Ajmera is a graduate research assistant, and Jack Houston and John Bergstrom are assistant professors in the Department of Agricultural Economics, The University of Georgia, Athens, GA 30602.

The analysis is based on data collected in a survey designed and implemented jointly by Dr. John R. Stoll of Texas A & M University and John C. Bergstrom of the University of Georgia. Support for the survey from the U.S. Army Corps of Engineers (USCOE) is gratefully acknowledged. Appreciation is expressed to John Titre, Jim Henderson, and Roger Hamilton of the Waterways Experiment Station, USCOE, for technical support and coordination. Assistance and advice on data collection from Mr. Richard Bush and Mr. Theodore Hokannen of the New Orleans District, USCOE, and comments on data collection and interpretation from Dr. David Moser of the Institute of Water Resources, USCOE, are also gratefully acknowledged.

Paper prepared for presentation at the 1989 meetings of the American Agricultural Economics Association, Baton Rouge, LA, August, 1989.

#6639

ESTIMATION OF DEMAND FUNCTIONS
FOR WETLANDS - BASED RECREATION
USING AN ALMOST IDEAL DEMAND SYSTEM

Abstract

The determinants of demand for waterfowl hunting, freshwater fishing, and saltwater fishing were examined using an Almost Ideal Demand System. Own-price elasticities indicate that demand for these activities are relatively price inelastic. Cross-price elasticities suggest that these activities are complements. Age and education levels significantly affect only waterfowl hunting. Finally, policy variable elasticities suggest that all three activities are sensitive to activity success in waterfowl hunting.

ESTIMATION OF DEMAND FUNCTIONS FOR WETLANDS - BASED RECREATION USING AN ALMOST IDEAL DEMAND SYSTEM

INTRODUCTION

Resource economists have become increasingly interested in measuring costs of alternative uses of natural resources since the passing of the Flood Control Act of 1936 (Seller et al. 1985). One method that has been widely used in measuring costs of alternative uses of natural resources is the travel cost method conceptualized by Hotelling in 1949. Over the years, the travel cost method has been applied hundreds of times and improved considerably (Walsh 1986; Ward and Loomis 1986). The objective of this paper is to identify factors that influence demand for recreational uses of the coastal wetlands using travel cost demand functions estimated within the framework of neoclassical economics.

OBJECTIVES OF THE STUDY

The three kinds of recreational uses the wetlands considered are freshwater fishing, saltwater fishing, and waterfowl hunting. A linear scaled version of an AIDS (Almost Ideal Demand System) model (Deaton and Muellbauer 1980a) is specified and estimated using survey data. An AIDS model is chosen over other models because it has been considered the most flexible of the currently available demand models, and it permits a wide range of tests on the structure of preferences (Teklu and Johnson).

Moreover, it does not require additivity of preferences (Eales and Unnevehr). The model is used to obtain estimates of price and expenditure elasticities. Saltwater fish catch, freshwater fish catch, and waterfowl hunting are treated as policy instrument variables, subject to public control and investment. The demographic and qualitative variables included in the system are age, education, and boat ownership.

Wetlands are considered a public good. Hence, the estimates are expected to have some welfare implications. Futhermore, the estimates will enable the identification of the personal characteristics of the respondents that significantly affect the respondents' choices for recreational uses of the wetlands. The demand responses of the policy variables would give a measure of substitution among the recreational uses of the wetlands and benefits, such as fish catch and waterfowl bag, accruing from such uses. Thus, appropriate policy measures can be taken by public authorities to develop the natural resources of the wetlands in a way that is most beneficial to the public.

EMPIRICAL MODEL

The AIDS (Deaton and Muellbauer 1980a) model is specified in a linear scaled version:

$$(1)\quad w_i = \alpha_i + \sum_j \gamma_{ij} \log p_i + ß_i \log (Y/P^x) + \theta_{1i} \log (Age) + \theta_{2i} (Boat) + \theta_{3i} \log (Educ) + \phi_{1i} \log (WFbaga) + \phi_{2i} \log (FFcata) + \phi_{3i} \log (SFcata)$$

where

P_i = contains Twhexp, Tffexp, and Tsfexp expenses for waterfowl hunting, fresh water fishing, and saltwater fishing,

P^x = $\Sigma w_k p_k$ is Stone's price index (Deaton and Muellbauer 1980b),

w_i = the average expenditure share of the ith type of recreational use,

Twhexp = trip expenditures on waterfowl hunting, used as a proxy for price of waterfowl hunting,

Tffexp = trip expenditures on freshwater fishing, used as a proxy for price of freshwater fishing,

Tsfexp = trip expenditures on saltwater fishing, used as a proxy for price of saltwater fishing,

Totexp (Y) = combined total expenditure on all kinds of recreational uses (freshwater fishing, saltwater fishing and waterfowl hunting),

Wfbaga = average number of waterfowl bagged per day when hunting on trips for the main purpose of waterfowl hunting,

Ffcata = average number of freshwater fish caught per day when fishing on trips for the main purpose of freshwater fishing,

Sfcata = average number of saltwater fish caught per day when fishing on trips for the main purpose of saltwater fishing, and

Boat = boat ownership (1 if boat owner, 0 otherwise),

Age = respondent's age,

Educ = respondent's educational level.

Consistency of (1) with consumer demand theory requires the following parameter restrictions:

ADDING UP: $\Sigma\alpha_i = 1$, $\Sigma\beta_i = 0$, $\Sigma\theta_{1i} = 0$, $\Sigma\theta_{2i} = 0$, $\Sigma\theta_{3i} = 0$

$\Sigma\phi_{1i} = 0$, $\Sigma\phi_{2i} = 0$, $\Sigma\phi_{3i} = 0$

SYMMETRY: $\gamma_{ij} = \gamma_{ji}$

HOMOGENEITY: $\Sigma\gamma_{ij} = 0$

The demand elasticities with repect to the independent variables in the model can be expressed as follows:

Own-price elasticities: $\epsilon_{ii} = (\gamma_{ii} - \beta_i w_i)/w_i - 1$

Cross-price elasticities: $\epsilon_{ij} = (\gamma_{ij} - \beta_i w_j)wj$

Expenditure elasticity: $\beta_i/w_i + 1$

Waterfowl hunting bag elasticity: $\epsilon_{d,WH} = (\theta_{1i} - \beta_i)/w_i$

Freshwater fishing catch elasticity: $\epsilon_{d,FF} = (\theta_{2i} - \beta_i)/w_i$

Saltwater fishing catch elasticity: $\epsilon_{d,SF} = (\theta_{3i} - \beta_i)/w_i$

Formulae for price and expenditure elasticities are given in Telku and Johnson (1988). The formula for calculating household size elasticity given in Telku and Johnson is used here for calculating elasticities with respect to policy instrument variables, bag and catch.

DATA SOURCES AND TRANSFORMS

Survey data used in the analysis were obtained from the Wetland Recreational Use Survey conducted in 1985-86 by the U.S. Army Corps of

Engineers Waterways Experiment Station, Vicksburg, Mississippi. In all, 1466 observations were used in the analysis. Total expenditure on all recreational activities (TOTEXP) was measured as the sum of the product of expenses on each individual recreational activity and the number of trips made for the respective activity. The qualitative variable for boat ownership (BOAT) was defined 1 if boat owner, 0 otherwise.

Implicit prices for recreational activities were measured as waterfowl hunting trip costs (TWHEXP), freshwater fishing trip costs (TFFEXP), and saltwater fishing trip costs (TSFEXP). Trips cost for all activities accounted for the costs of operating a medium-sized motor vehicle and the opportunity cost of time for a two-way trip. The implicit price, or trip costs, for each activity times the number of trips made for the activity was divided by the total expenditure on all activities to obtain expenditure shares for individual activities.

ECONOMETRIC ESTIMATION

The expenditure share equations constitute a multivariate, seemingly unrelated system of equations and were, therefore, estimated using Zellner's Seemingly Unrelated Regressions technique (Zellner, 1962). Since expenditure shares sum to unity, one of the equations is redundant. Hence, the saltwater fishing travel cost demand equation was deleted from the system, and its parameter estimates were derived from adding up, symmetry and homogeneity restrictions.

RESULTS

The parameter estimates of the share equations, constrained to satisfy homogeneity, symmetry, and adding up are presented in Table 1. T-values are reported in parentheses. Since the parameters of the saltwater share equation were derived from restrictions for homogeneity, symmetry and adding up, t-values for the parameters of that equation are not presented. The R-squares of the waterfowl hunting and freshwater fishing equations are .49 and .49.

The implicit own and cross prices of recreational uses (TWHEXP, TFFEXP, and TSFEXP) are statistically significant at the five percent level. Also, total expenditure is statistically significant in the waterfowl hunting and freshwater fishing equations. None of the demographic variables -- age, education and boat ownership -- are statistically significant in the freshwater fishing equation. Hence, it is difficult to surmise the impact that these variables have on the demand for freshwater fishing. Of the policy variables included in the system, waterfowl bag is not statistically significant at generally accepted levels in the freshwater fishing equation. The fact that the majority of the policy variables are statistically significant is consistent with economic theory and previous studies, which suggest that bag or catch should be an important determinant of the demand for hunting or fishing.

The implicit own and cross price elasticities are presented in Table 2. The own price elasticity of demand for waterfowl hunting is negative and close to one, suggesting that an additional increase in the cost of trips for waterfowl hunting results in a proportionate decrease in the number of trips for waterfowl hunting. A ten percent increase in the cost of trips for freshwater fishing would decrease the number of trips by 7.8 percent. Complementarity, though limited, between alternative recreation uses is suggested by negative cross price elasticities. The total expenditure elasticities are positive and close to one for all three recreation uses of the wetlands.

The hypothesized demographic shift variables exert a statistically significant impact only on the demand for waterfowl hunting. However, signs of these variables in the remaining equations provide some intuition as to their impact on freshwater fishing and saltwater fishing (Table 1). The estimates suggest that higher education contributes to an increase in the number of trips only for waterfowl hunting. Boat ownership has a positive effect only on the number of trips for freshwater fishing, and with age the number of trips increase only for saltwater fishing.

Policy elasticities give a measure of the impact that bag or catch success have on the number of trips for alternative recreation uses of wetlands (Table 3). These estimates are expected to be useful in enabling policymakers to better allocate resources for the development of one use versus that of another. A ten percent increase in waterfowl bag indicates a nearly five percent associated increase in the number of trips for waterfowl hunting. Equivalent ten percent increases in freshwater fish catch and saltwater fish catch success are accompanied by increases of nearly three percent and two percent, respectively, in the number of trips for these activities.

Cross price elasticities of demand with respect to policy variables suggest that waterfowl bag postively influences the number of trips for both freshwater fishing and saltwater fishing. On the other hand, a substantial decrease -- nearly four percent -- in the number of trips for waterfowl hunting would follow a ten percent increase in the freshwater and saltwater fishing catches. All three activities appear to be sensitive to activity success in waterfowl hunting, and appropriate policy measures such as increasing waterfowl population could lead to greater use of the wetland resources by recreationists.

Conclusions

This study incorporated socioeconomic and site quality factors in the AIDS model to determine their influence on respondents' decisions about recreational uses of the Louisiana Wetlands. Age, education level, and boat ownership are found to significantly affect the travel cost demand for waterfowl hunting. The policy instrument variables are statistically significant, and, hence, firm conclusions as to their impact on travel cost demands are possible. Waterfowl hunting is found to be an important recreation activity relative to other activities, as determined by the sensitivity of the quantity of hunting or fishing trips demanded to success measured in terms of bag or catch.

The own price elasticities suggest that the demand for each activity is relatively inelastic. In the recreation economics literature, alternative recreational activities such as hunting and fishing are often viewed as substitutes. The signs of cross price elasticities estimated in this study, however, suggest that waterfowl hunting, freshwater fishing and saltwater fishing, at least in the wetlands area, are complements.

The use of natural resources such as coastal wetlands for outdoor recreation is growing in the United States. Management of these resources requires greater knowledge of the determinants of outdoor recreation demand. In order to gain this knowledge, better data and improved modelling techniques are needed. Recreation demand systems, such as the AIDS model, provide a useful means for analyzing recreation demand determinants, as demonstrated in this paper.

Table 1. Parameter Estimates of Share Equations

Independent Variable	Expenditure Shares: Waterfowl Hunting Share	Freshwater Fishing Share	Saltwater Fishing Share
INTERCEPT	.2303 (2.802)	.6523 (5.26)	.1174
LTWHEXP	.2602 (32.76)	- .0077 (-10.72)	-.2525
LTFFEXP	- .0077 (-10.72)	.0413 (33.65)	-.0336
LTSFEXP	- .0185 (-23.56)	- .0336 (-30.07)	.0521
LBOAT	- .0154 (-.533)	.0682 (1.56)	-.0528
LAGE	- .0295 (-2.29)	- .0056 (-.29)	.0351
LWFBAGA	.0903 (4.365)	-.0335 (-1.03)	-.0568
LFFCATA	-.0319 (-2.052)	.0785 (3.35)	-.0466
LSFCATA	- .0337 (-2.60)	-.0972 (-4.98)	.1309
LEDUC	.0367 (2.27)	- .0251 (-1.03)	-.0116
LTOTEXP	.0198 (4.98)	- .0246 (-4.08)	.0048
R^2 (OLS)	0.49	0.49	
R^2 (System Weighted)	0.50		

Note: T-ratios for estimated coefficients in parentheses
Saltwater fishing share equation derived from restrictions for adding up, symmetry, and homogeneity.

Table 2. Estimated Price, Expenditure, and Demographic Variable Elasticities

Elasticity with Respect to Price of	Activity		
	Waterfowl Hunting	Freshwater Fishing	Saltwater Fishing
Waterfowl Hunting (TWHEXP)	- .95	-.02	-.03
Freshwater Fishing (TFFEXP)	-.10	-.78	-.06
Saltwater Fishing (TSFEXP)	- .23	- .07	-.88
Expenditure	1.15	.92	1.01

Notes: Parameters for saltwater fishing share equation are derived using restrictions.

Table 3. Estimated Policy Variable Elasticities.

	Activity		
Elasticity with Respect to	Waterfowl Hunting	Freshwater Fishing	Saltwater Fishing
WFBAGA	.54	.03	.11
FFCATA	-.40	.35	.10
SFCATA	-.41	.25	.22

Notes: Parameters for saltwater fishing share equation are derived using restrictions.

REFERENCES

Barten, A.P. "Maximum Likelihood Estimation of a Complete System of Demand Equations." European Economic Review, 1 Fall 1969: 7-73.

Deaton, A., and J. Muellbauer. "An Almost Ideal Demand System." American Economic Review. 70(1980a):312-26.

_____. Economics and Consumer Behavior. Cambridge, MA: Cambridge University Press, 1980b.

Eales, S.E., and L.J. Unnevehr. "Demand for Beef and Chicken Products: Separability and Structural Change." American Journal of Agricultural Economics. 70(Aug.1988):522-532.

Hotelling, H. "The Economics of Public Recreation." The Prewitt Report. National Park Service, Washington, D.C., 1949.

Seller, C., Stoll, J.R., and J.P. Chavas. "Validation of Empirical Measures of Welfare Change: A Comparison of Nonmarket Techniques." Land Economics. Vol. 61(May, 1985):156-174.

Stone, J.R.N. The Measurement of Consumer's Expenditure and Behavior in the U.K. 1920-30. Cambridge: Cambridge University Press (1953).

Teklu, T., and S.R. Johnson. "Demand Systems for Cross Section Data: An Application to Indonesia." Canadian Journal of Agricultural Economics. 36(1988): 83-101.

Walsh, R. G. Recreation Economic Decisions: Comparing Benefits and Costs. State College, PA: Venture Publishing Inc. (1986).

Ward, F. A. and J. B. Loomis. "Travel Cost Demand Model as an Environmental Policy Assessment Tool: A Review of Literature." Western Journal of Agricultural Economics. 11(1986):164-178.

Zellner, A. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." Journal of American Statistical Association. 57(1962):348-68.