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EFFECTS OF ENVIRONMENTAL CHANGE ON RECREATION USE AND VALUE:
AN APPLICATION TO OFFSHORE RIGS IN CALIFORNIA

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Effects of Environmental Change on Recreation Use and Value: An Application to Offshore Rigs in California.[1]

In an era of widespread concern over the effects of proposed alterations of the environment, practical methods of evaluating a change in a public good are essential. This paper describes a method of assessing the effect of environmental change on the use and value of a system of recreational sites.

The proposed alteration in question is the development of offshore oil and gas resources. Citizens in coastal areas fear that the effects of this environmental alteration - the construction of large oil and gas drilling and pumping rigs - may reduce the attractiveness of recreation in the areas where the offshore platforms can be seen. The result could be a loss of tourist spending through a decline in use and a reduction in the economic value of recreation in the affected area to recreationists. This possible decline in both recreationist consumer surplus and tourist spending needs to be quantified to measure the anticipated effects on use and value of the recreational sites adjacent to proposed oil and gas platforms. This possible alteration in the public good of coastal recreational sites is becoming a major controversy between the need for domestic oil and gas production, and the recreation based livelihood of California coastal communities.

The method employed here to measure the effect of the proposed alteration of the environment incorporates a trip distribution model to determine travel flows to a system of recreation areas, and the travel cost method (TCM) to determine the economic value of each recreation site as measured by consumer surplus. Applying a trip distribution model and travel cost method to a system of recreation sites follows the line of work by Clawson and Knetsch (1976) and Sutherland (1983).

The trip distribution model is used in conjunction with the TCM to overcome data problems.[2] To estimate demand curves using the TCM, data on the number of visitors to a site traveling from different origins is required. This data is often not available or is too costly to collect for a whole system of recreation sites. The trip distribution model is thus used to provide estimates of the number of visitors to a system of recreation sites from a set of origins, and these estimates are in turn used as inputs in the TCM to estimate site demand functions. By combining these approaches, a change in a site's consumer surplus value due to a change in the site's environment can be estimated. This research extends earlier work by the application of Tobit analysis to the travel cost method.

Results of an application of the methodology are reported after a review of the model components. In particular, the research measures the change in the demand and value of California beach recreation due to offshore oil and gas development. This research is part of a larger study determining the impacts of Outer Continental Shelf (OCS) development on the adjacent coastal recreation areas. The entire study concerns recreational boating and fishing as well as analysis of the effects of oil spills and construction activity.

Methodology

In the trip distribution model, a region is subdivided into mutually exclusive subareas called population centers which can be counties, townships, or census tracts. The model is used to estimate the number of visits taking place at M recreations sites originating from the N population centers. The model output is an M x N matrix of trip frequencies. The model assumes that the number of trips between an origin-destination pair depends on the characteristics of the population centers, the recreation sites, and their spatial separation. The model stated in the most general form is:

$$V_{ij} = g(A_j, T_i, f(d_{ij}))$$

where

V_{ij} = the number of visits to site j from population center i where = 1,...,N;

A_j = a measure of the attractiveness of recreation site j where j = 1,..., M;

T_i = the number of recreation trips originating from population center i;

$f(d_{ij})$ = a function of the distance from origin i to site j.

This trip distribution model has several desirable properties. First, the functional form of the distance function can reflect the negative and diminishing effect of distance on the choice of sites by recreationists. Second, the composite population origin variable,

T_i, can incorporate differences in participation rates based on the socioeconomic characteristics of recreationists at the origin. Third, the attractiveness measure, A_j, can incorporate characteristics of the recreation site which can change in response to a change in the recreation site's environment. An element critical to the evaluation of an environmental impact is determining the effect of a change in the environment on a site's attractiveness index. If attractiveness changes, the trip distribution model can be rerun to determine how recreationists are redistributed to alternative sites when a site's attractiveness index shifts either up or down.

The second component of this research is based on the travel cost method of estimating the demand for recreation sites. The TCM assumes that a recreationists travel expenses serve as a proxy for the price of the recreation site. By observing the participation rates for a site from a variety of distances, a demand relationship for the site is estimated. When the travel cost method was presented by Clawson (1959) and Clawson and Knetsch (1966), origins were defined as a series of concentric circles. In the approach used here, counties are the population centers rather than concentric circles.[3]

The first step in the travel cost method is to estimate site visitation as a function of travel cost and other explanatory variables. The second step is to derive the implied economic value of the site from the estimated visitation equation. In the first step, model specification and functional forms are issues which have attracted researcher's attention (e.g., Allen and Stevens, 1981; Burt and Brewer, 1971; Cesario and Knetsch, 1970; Sutherland, 1982; Smith, 1975; Ziemer, Musser, and Hill, 1980). Attention has also been directed to empirical methods of estimation (Bowes and Loomis, 1980; Stynes, Peterson, and Rosenthal, 1986).

An estimation problem overlooked by previous researchers is the censored sample property of the travel cost data. The dependent variable, visitation rate, only varies for those origin-destination pairs within some threshold distance of the recreation site. For other origin-destination pairs, the values of the dependent variable is zero whether the distance is 1 mile or 200 miles beyond the threshold. Under such circumstances, the sample is said to be censored because variance is not observed in the dependent variable over the entire range of origin distances. The censored regression model is defined:

$$
\begin{aligned}
y_i &= B' X_i + e_i && \text{if } y_i > \text{threshold} \\
y_i &= 0 && \text{otherwise}
\end{aligned}
$$

where B' is a vector of unknown parameters; X_i is a vector of known constants; and e_i is the residual which is independently and normally distributed with mean zero and common variance. The equation may be rewritten:

$$E(y_i | X_i, y_i > 0) = B'X_i + E(e_i | e_i > -B'X_i).$$

If ordinary least squares estimation techniques are used on a censored sample which includes the zero observations, the estimated parameters will be biased. If OLS is used on just the non-zero observations, the expectation of the error term is not zero, again causing the least squares estimate to be biased.

Estimation techniques have been developed for censored dependent variable samples (Tobin, 1958; Amemiya, 1973; Heckman, 1976). The research reported here uses a tobit estimation procedure to accommodate the censored sample property of the data generated by the trip distribution model. Tobit is based on the maximum likelihood principle to estimate the parameters. The likelihood function describes the probability of obtaining the sample served. The estimates are those values which maximize this function and are known to have the desirable properties of consistency and minimum variance among all consistent estimators.

Application

The trip distribution model used in this research is based on the 58 California counties as origins, and 49 coastal segments as destinations.[4] These coastal destinations encompass the entire California coastline. The specific model is:

$$V_{ij} = [(r_i \; P_i \; A_j) \; / \; f(d_{ij})] \; / \sum_j [A_j \; / f(d_{ij})]$$

where

r_i = the per capita rate of participation of county i;

P = the population of county i;

and the other variables are defined above.

The California Department of Parks and Recreation (CDPR) estimated two of the three critical elements of the trip distribution model: participation rates and distance decay functions. CDPR first estimated the effect of the socioeconomic characteristics of age, income, ethnicity, sex, occupation, and education on recreational participation based on a 1980 survey of California residents. A composite participation rate for each county, r_i, was then constructed based on the distribution of a county's socioeconomic characteristics.

The CDPR also used the 1980 survey to estimate distance decay functions for a variety of recreational activities. The estimated distance function for beach activities is:

$$f(d_{ij}) = .9064\ e^{-.1198\ (d_{ij}\ -\ 9)^2}\ ;$$

where

$f(d_{ij})$ = the distance decay function for a given activity;

d_{ij} = the distance in 20 minute intervals of travel time;

To develop the third element of the trip distribution model, the attractiveness measure, the factors affecting beach attendance were analyzed. Beach attendance is hypothesized to be a function of beach characteristics and a measure of a beach's locational attributes, referred to as the proximity variable. To determine the impacts of OCS development on beach use, attendance is also hypothesized to be a function of offshore oil and gas development.

Beach attendance data was available for 107 federal, state, county, and city maintained beaches along the California coast. Cross section data for ;the fiscal year 1979/80 was collected to correspond to the survey data used to determine participation rates.

The proximity variable reflects a beach's relative distance to population centers and substitute coastal segments. For a beach in coastal segment j, the value of the distance decay function to destination j from origin i relative to the distance decay function value from county i to every other coastal segment is used as an index of spatial closeness. This index is multiplied by the number of trips generated in county i and then summed over all counties to create the proximity variable. The proximity variable, x_j, is specified:

$$x_j = \sum_i r_i \; P_i \frac{f(d_{ij})}{\sum_j f(d_{ij})}$$

The value of the proximity variable for a coastal segment is directly proportional to the size and spatial closeness of county participation. Each beach in coastal segment j will have the same proximity value.

The measure of OCS development is the sum of the reciprocals of the distance from the beach to each platform for all platforms within 15 miles of the beach. This inverse function assures a diminishing visibility effect of OCS development with increases in distance. This measure of OCS development also captures both the number and closeness of the oil platforms. The specification of the oil variable, O_j, for beach j is:

$$O_j = \sum_k 1/n_{ik} \qquad \text{for } n_{jk} < 15$$

where n_{jk} is the distance from beach j to oil platform k, in nautical miles.

In calculating this variable, latitude and longitude readings were made for each beach and each oil platform. An algorithm was constructed to determine the distances from each beach to each visible platform. Fifteen miles is the cutoff distance because the upper decks on more distant rigs are not visible due to the earth's curvature. Line of sight was also confirmed using navigation charts. If a platform's potential visibility was blocked by coastline, it was not included in the summation. In addition, platforms that were backdropped by industrial development and therefore not readily distinguishable from a beach were also excluded.

The other beach characteristics included in the estimation are: the aesthetic quality of a beach, pedestrian accessibility, beach length, whether or not the beach is located in a metropolitan area or in Northern California, and distance to a major highway. The aesthetic index of each beach is the Granville Report rating for the coastal segment containing the beach (Granville Corporation, 1981). These landscape architect ratings are based on the variety, harmony, and distinctiveness of the land formation and shoreline. The pedestrian accessibility variable is a dummy variable indicating whether or not there is parking available adjacent to the beach. The beach length variable is measured by ocean-front footage. The metro variable is a dummy variable indicating whether or not the beach is located in a city with a population over 50,000. This variable is not correlated with the proximity variable because the metro variable is defined by the population of the adjacent city whereas the proximity variable is a function of the populations in every county in California. A dummy variable is also used to indicate whether or not a beach is north of Point Conception. The beaches located north of this point are influenced by the Alaskan current and the water temperature is as much as ten degrees fahrenheit colder than southern waters. The highway variable is calculated based on the distance to the nearest freeway exit or distance to the major coastal highway in Northern California.

A logarithmic functional form is used in the ordinary least squares estimation of factors affecting beach attendance. A log linear functional form is specified for several reasons. This functional form assures declining marginal effects of each independent variable. In addition, measuring attendance in natural logs reduces the range of the dependent variable. Annual beach attendance data varies from 14,000 to over 21 million among the 107 beaches. The double log functional form also implies the explanatory variables have a multiplicative effect on attendance.

Multiple regression results are reported in Table One. All the variables significantly affect attendance in the expected direction. Proximity, beach aesthetics, beach length, metropolitan location, and pedestrian accessibility all positively affect beach attendance. OCS development and distance to the freeway negatively affect attendance. This analysis indicates that an oil platform three miles offshore will reduce beach attendance by twelve percent.

Once the factors affecting beach attendance are estimated, each coastal segment's attractiveness index is calculated. The estimated beach attendance model is used to predict beach attendance for the California beaches without attendance data. Total estimated beach attendance for a coastal segment is determined by summing over the coastal segment's beaches. A coastal segment's attractiveness index is determined by dividing the total estimated attendance of the coastal segment by the value of the coastal segment's proximity variable.[5]

This attractiveness index is entered in the trip distribution model to generate the projected distribution of trips from each origin county to each coastal segment. The travel flows generated by the trip distribution model become the input for the TCM to estimate a coastal segment's demand function. Demand is assumed to be a function of the travel costs, which depend upon the marginal costs of operating a car, the number of passengers sharing expenses, and a measure of the cost of travel time. The marginal costs of operating

TABLE ONE

OLS Regression: Factors Affecting Beach Attendance

(dependent variable = log of attendance)

Variable	Estimated Coefficient	T Ratio
intercept	-9.3177	-3.60***
ln proximity	.6333	5.67***
ln aesthetic rating	1.0130	2.24**
ln beach feet	.5900	6.83***
ln distance to freeway	- .1477	-1.93*
OCS measure	- .3810	-1.83*
pedestrian accessibility	.4583	2.25**
metro location	1.2869	5.34***
north/south dummy	.3195	2.31**

Adjusted R square = .6054

107 Observations

* indicates significance at the 10% level, ** at the 5% level, and *** at the 1% level.

a car are determined to be \$.13 per mile in 1980 dollars, the average speed of travel to recreation sites is estimated at 40 mph, and the average number of passengers per vehicle entering recreation sites is 3.4. The opportunity cost of travel is assumed to be one third the 1980 minimum hourly wage. This value of time estimate is in keeping with previous research (Cesario, 1976; Menz and Wilton, 1983).[6]

Other variables that can affect the number of trips demanded include some measure of the price of substitutes. A virtue of the trip distribution model, however, is that each coastal segment is considered a substitute for every other coastal segment and the model distributes trips to all substitutes by weighing travel distances and relative attraction.

For each coastal segment, some origins did not generate visitors. Due to the censored sample nature of the data a tobit estimation procedure is used. The estimated demand equation specified in terms of per capita visitation rates is:

$$\frac{v_{ij}}{P_i} = b_0 + b_1 TC_{ij} + e \qquad \text{if } v_{ij} > 0$$

$$\frac{v_{ij}}{P_i} = 0 \qquad \text{otherwise}$$

The results of the estimation procedure for each of the 49 coastal segments confirm a priori expectations. The coefficient on travel cost is always negative and significant at the one percent level, varying from -.0002 to -.0389 with a mean value of -.01. The adjusted r square ranges from .37 to .87 with a mean value of .63.

The net economic value of coastal segment j to recreationists in county i is found by taking the definite integral of the estimated visitation equation between the current price and the price at which demand becomes zero. In this model the current price is interpreted as the cost of traveling to the specified coastal segment, and the maximum price is the price at which demand becomes zero. Total consumer surplus for coastal segment j is computed by summing the county consumer surpluses for site j. Confidence intervals for the estimated consumer surplus are also calculated. The variance of the consumer surplus estimate is determined using the reported variance-covariance matrix of each tobit estimation procedure.

The value of the consumer surplus for water dependent and water enhanced activities varies from $21,922 to $276 million over the 49 coastal segments, and per visitor consumer surplus varies from $8.04 to $21.88 with a mean value of $11.52. With 90% confidence intervals, the widest per visitor interval is plus or minus $9.13; the narrowest interval, plus or minus $1.35.

The economic value of a change in the environment due to offshore development can be determined by the difference in consumer surplus before and after the proposed environmental change. To estimate the change in consumer surplus, demand curves are first estimated for a base case and then reestimated from the new travel patterns with the OCS-related change in the environment. This change in travel patterns is estimated by the trip distribution model using new attractiveness indices reflecting the changed environment. Thus, all OCS-related changes must be translated into a change in the attractiveness index of the coastal segment. The economic effects of several potential OCS development plans were determined using the methodology outlined in this paper. The results are obviously specific to the proposed location of the offshore platforms. In a test case, the model determines that the economic effect of a proposed development of three offshore oil rigs in the Eastern Santa Barbara Channel reduces beach attendance from 4 to 16 percent among the five affected coastal segments with a 15 percent loss in consumer surplus, valued at $8 1/2 million.

Conclusion

The methodology outlined in this paper offers a practical approach to analyzing the economic consequences of environmental changes at one or more sites in a multi-site recreation system when household or contingent value surveys are not available. The approach can be used whenever an environmental change can be linked to attendance at a site. This link can be direct, as reported here with the statistical association found between OCS platforms and beach attendance, or the link can be indirect, as when the environmental change affects a site attribute that in turn is shown to influence attendance. This indirect link occurs, for example, when an oil spill or construction project precludes people from using portions of a beach. In that case, the explanatory variable, length of beach can be decreased to reflect the environmental change, and the economic effect can be determined using the approach reported here.

The application of tobit analysis to the travel cost method is critical. Earlier researchers have not acknowledged the censored sample property of the travel data and have not employed appropriate estimation techniques, leading to biased results. The tobit estimation technique is not restricted to the approach developed in this paper, but should be used in all applications of the travel cost method.

FOOTNOTES

1. This research was supported by the Mineral Management Service, United States Department of the Interior. The views and conclusions presented here are not necessarily those of the Mineral Management Service.

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2. The trip distribution model is used rather than a hedonic model because of data limitations. Observations on which recreation site individual recreationists frequented were not available. Aggregate data was available, however, on distance decay function and characteristics of recreationists.

3. Sutherland (1982) has demonstrated the explanatory power of the model is higher when population centers are treated as origin zones, rather than when population centers are aggregated into concentric origin zones.

4. Coastal segments rather than beaches are used as the unit of analysis because the distance function estimated by the California Department of Parks and Recreation is based on coastal segment destinations.

5. This calculation is possible due to the specification of the proximity variable and the trip distribution model. The proximity variable is a combination of the tripmaking and distance decay components of the trip distribution model. By rearranging terms, the attractiveness index of a coastal segment can be isolated.

6. Travel costs = $((40 * 2 * .13)/3.4 + 1.30)/3) * d_{ij} = 1.45\ d_{ij}$. Forty miles per hour is the assumed travel speed. The multiplication by two represents the round trip factor. The 13 cent marginal cost of operating a car was determined from data reported by the United States Department of Transportation. The 3.4 average vehicle passengers was obtained from California Parks and Recreation reports. One third the 1980 minimum wage is $1.30. The division by three converts 20 minute travel units into fractional hours.

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