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Title: Estimation of Wilderness Use Functions for California: An Analysis of Covariance Approach

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Alternative estimation techniques are presented and tested in this paper to account for differences among destinations. The results indicate that then dealing with a multi-area wilderness system assumptions with regard to the structure of the system must be explicitly stated and tested.

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ESTIMATION OF WILDERNESS USE FUNCTIONS FOR CALIFORNIA: AN ANALYSIS OF COVARIANCE APPROACH

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ABSTRACT

The Hotelling-Clawson procedure for estimating the demand for recreation resources assumes only one destination with no close substitutes. Knetsch in 1963 states,"One factor which is of particular importance in describing the demand for any single recreation area is the availability of close substitutes". The problem of estimating the demand for wilderness use in California is an example where the availability of close substitutes will influence both the estimation technique and the determinants accounting for wilderness use.

Alternative estimation techniques are presented and tested in this paper to account for differences among destinations. The results indicate that then dealing with a multi-area wilderness system assumptions with regard to the structure of the system must be explicitly state and tested.

ESTIMATION OF WILDERNESS USE FUNCTIONS FOR CALIFORNIA: AN ANALYSIS OF COVARIANCE APPROACH

Recently there have been a number of papers analyzing different aspects of wilderness use in the California wilderness system (McKillop, 1975; Rausser and Oliveira, 1976; and Wetzstein and Green, 1978). McKillop concentrated on determining the socio-economic factors that influence wilderness use. He developed a single-equation model and employed ordinary least squares to obtain estimates of the parameters. Rausser and Oliveira focused their attention on predicting daily fluctuations in wilderness and campground use. They employed an econometric model which combined cross-section and time series data, a Box Jenkins time series model, and a combination of the two techniques to obtain 7, 14, and 28 days forecasts for wilderness use. Wetzstein and Green were primarily interested in determining the effects of alternative opportunities on demand for a particular site's service. They employed principal components to derive an alternative opportunities variable and then estimated the substitution effects assuming that the existing wilderness system were to expand.

In this paper an analysis of covariance model is developed to account for differences in destinations as well as changes occurring over time in analyzing California wilderness use. The model was estimated with "permit" data collected by the Forest and National Park Service for 24 wilderness areas in California for the years 1972 through 1975. The empirical results indicate that substantial substitution effects would exist if new wilderness study areas were to be introduced into the present system. Furthermore, the various wilderness sites differ significantly from each other and little structional change has occurred from 1972 to 1975.

Section one of the paper specifies wilderness use models and discusses the explanatory variables employed in the models. The estimation results obtained from the various models are presented in section two.

The Models

An extension of the Hotelling-Clawson approach was chosen to represent the use functions for a specific area's services. Specifications similar to the ones developed below have been previously developed (Boyet and Tolley, 1966; Grubb and Goodwin, 1968; Johnston and Pankey, 1968; and Sinden, 1974). An attempt was made to select use functions that are generally employed in the literature to demonstrate the introduction of an alternative opportunities variable and to account for differences in destinations and changes through time. The postulated multiplicative use model is

$$v_{ijt} = A\, x_{1ij}^{\beta_1}\, x_{2i \cdot t}^{\beta_2}\, x_{3i \cdot t}^{\beta_3}\, x_{4ij}^{\beta_4}\, e^{u_{ijt}}, \quad \begin{matrix} (i = 1, \ldots, I) \\ (j = 1, \ldots, J) \\ (t = 1, \ldots, T) \end{matrix} \qquad (1)$$

where, v_{ijt} is the number of visitor days from origin "i" to area "j" in time "t" (one visitor day equals 12 visitor hours).

x_{1ij} is the distance between origin "i" to area "j" (measured in total highway miles between zones) and is a surrogate for price,[1/]

x_{2it} is the population of origin "i" in time "t" (in thousands),

x_{3it} is the median income of origin "i" in time "t" measured in dollars, and

x_{4ij} is a proxy to account for the alternative wilderness opportunities of a similar nature available to residents of different population origin zones.

The interpretation of the variables are straight forward except for the alternative opportunities variable, x_{4ij}. This variable attempts to account for the attractiveness and price of alternative areas. That is, it measures the substitution effect alternative areas exert on individual wilderness areas.[2/] Wilderness areas in California are not homogeneous; therefore, an attractiveness index needs to be developed to account for the heterogeneous nature of the areas. A principal component attractiveness index was applied to the wilderness area system taking into account the varying attractiveness among areas (see Wetzstein and Green, 1978). The following alternative opportunities variable incorporates both alternative areas' attractiveness and price:

$$\sum_{\substack{k=1 \\ k \neq j}}^{J} (A_{.k}/D_{ik}) \; / \; A_{.j}/D_{ij}).$$

This variable measures the alternative opportunities to the j^{th} area from origin "i". The numerator expresses the hypothesis that the more attractive an alternative wilderness area is, as measured by the principal components index, $A_{.k}$, the more competition it poses for the j^{th} area. This competitive factor is, however, relative to the area's distance from origin "i". The farther it is away from origin "i", the less of the competing factor it becomes, regardless of its attractive features. Thus, $A_{.K}$ is divided by distance with the result then summed over all of the alternative areas. A subset of alternative areas could have been chosen if it was felt that some of the areas were not viable alternatives for the given(j^{th}) area. The attractiveness and distance of alternative sites are relative to the given area, hence the numerator is divided by $A_{.j}/D_{ij}$ to account for this property.

The specification given in equation (1) assumes the same structure exists for each destination and no structural shifts over time. McKillup (1975) and Wetzstein and Green (1978) also assumed the same structure exists for each destination and thus pooled the data and estimated a regression equation by ordinary least squares. This procedure is valid only if the coefficients associated with the independent variables are constant over all the wilderness areas and time. That is, this type of specification does not account for differences in the structure of various destinations nor does it allow for structural changes over time. In many cases these restrictive assumptions with respect to the structural form are not valid.

An analysis of covariance model removes these restrictive assumptions by assuming each destination (cross-sectional unit) and each time period are characterized by their own special intercept. This modification is introduced into equation (1) by the use of binary variables. Thus, equation (1) modified to allow for different destination and time intercepts results in the following analysis of covariance model. 3/

$$V_{ijt} = A\, X_{1ij}^{\beta_1}\, X_{2i.t}^{\beta_2}\, X_{3i.t}^{\beta_3}\, X_{4ij}^{\beta_4} \exp(\gamma_2 Z_{.2} + \gamma_3 Z_{.3} + \cdots$$

$$+ \gamma_{22} Z_{.22} + \delta_2 T_{..2} + \delta_3 T_{..3} + \delta_4 T_{..4} + u_{ijt});$$

$(i = 1, \ldots, I)$

$(j = 1, \ldots, J)$

$(t = 1, \ldots, T)$

where $Z_{.j} = 1$ for destination "j"

$= 0$ otherwise

$T_{..t} = 1$ for time "t"

$= 0$ otherwise,

and v_{ijt}, X_{1ij}, $X_{2i.t}$, $X_{3i.t}$ and X_{4ij} are as defined previously.

Empirical Results

The analysis of covariance model presented in equation (2) was transformed by a logarithmic transformation and then estimated by ordinary least squares. Permit data collected by the Forest and National Park Service in 24 California wilderness areas for years 1972 through 1975 were employed in the estimation.

Socio-economic data population and median income were collected from the California Department of Finance and Franchise Tax Board respectively for all 58 origins (counties). Distance as a travel impedance measure was based on the hypothesis that most wilderness users travel on highways. Therefore, distance between origin-destination nodes were determined from roadmaps.[4/] The results of applying ordinary least-squares to the linearized equation (2) are:

$$\ln v_{ijt} = 4.46 - \underset{(8.11)}{0.73} \ln X_{1ij} + \underset{(49.26)}{0.94} \ln X_{2i.t} + \underset{(11.50)}{0.55} \ln X_{3i.t}$$

$$- \underset{(14.07)}{1.17} \ln X_{4ij} + \underset{(6.76)}{1.70} Z_{.2} - \underset{(4.22)}{1.2} Z_{.3} + \underset{(3.76)}{0.94} Z_{.4}$$

$$+ \underset{(6.11)}{1.62} Z_{.5} + \underset{(5.77)}{1.50} Z_{.6} + \underset{(2.18)}{0.53} Z_{.7} - \underset{(5.91)}{1.83} Z_{.8}$$

$$+ \underset{(1.52)}{0.39} Z_{.9} + \underset{(3.78)}{0.97} Z_{.10} - \underset{(3.76)}{1.00} Z_{.11} + \underset{(7.23)}{1.75} Z_{.12}$$

$$+ \underset{(4.85)}{1.15} Z_{.13} + \underset{(4.00)}{0.99} Z_{.14} - \underset{(1.82)}{0.48} Z_{.15} - \underset{(3.40)}{1.02} Z_{.16}$$

$$+ \underset{(4.84)}{1.22} Z_{.17} - \underset{(1.56)}{0.46} Z_{.18} + \underset{(2.73)}{.80} Z_{.19} - \underset{(0.29)}{0.10} Z_{.20}$$

$$+ \underset{(2.56)}{0.71} Z_{.21} + \underset{(0.31)}{0.12} Z_{.22} - \underset{(0.34)}{0.03} T_{..2} + \underset{(2.20)}{0.17} T_{..3}$$

$$+ \underset{(2.86)}{0.22} T_{..4},$$

where the values in parentheses represent t-ratios with 3007 degrees of freedom and $\bar{R}^2 = 0.65$.

The signs of the coefficients in every case are consistent with _a priori_ expectations. That is, the population and income coefficients are positive while the "price" and alternative opportunities coefficients are negative. Furthermore, the t-ratios indicate that all of the coefficients associated with the socio-economic explanatory variables are highly significant, 0.99 confidence interval. The t-ratios associated with the destination and destination dummy variables indicate that most of these coefficients are also highly significant, 0.99 confidence interval. The t-ratios corresponding to the time dummy variables are rather low, 0.34, 2.20, and 2.86.

F-ratios were calculated to test the assumption of structural shifts in the intercepts due to destination and/or time. The results indicated that the hypothesis of equal intercepts among destinations can be rejected at the 0.1 percent level of confidence. The hypothesis of equal intercepts among time, however, cannot be rejected even at the 25 percent level of confidence. Thus the F-ratios indicate that pooling the destinations is not valid; however, there does not appear to be a problem of structural changes over the observational interval.

Equation (2) assumes that the socio-eocnomic coefficients are constant over all the wilderness areas. One method of relaxing this restrictive assumption is to assume unique coefficients for all the wilderness areas. This method can be accomplished by estimating a separate regression for each destination with pooled data from the 58 origins over time.5/ Table 1 presents the results of estimating equation (1), by applying ordinary least-squares, for each wilderness separately.6/

In most cases, the signs of the coefficients are consistent with _a priori_ expectations. On a theoretical basis all the explanatory variables are related to the dependent variable and thus should remain in the model regardless of the sign on their associated coefficients. The t-ratios indicate that most of the coefficients are highly significant except when associated with a coefficient of the wrong sign. The overall goodness of fit, $\bar{R}^2$, ranges from a low of 0.253 for High Sierra wilderness area to a high of 0.842 for Yosemite.

The coefficients associated with the explanatory variables in Table 1

Table 1. Estimated Wilderness Use Functions

Destination	Constant	Price x_{1ij}	Population $x_{2i.t}$	Income $x_{31.t}$	Alternative Opportunities x_{4ij}	Degrees of Freedom	$\overline{R}^2$ [a]
Cucamonga	51.125	-0.405	-0.474	-5.193	-1.051	40	0.722
		(0.449)[b]	(2.248)	(2.695)	(1.182)		
Desolation	-0.037	-0.322	1.299	0.170	-2.250	201	0.778
		(1.085)	(19.453)	(0.252)	(8.552)		
Dome Land	9.546	2.458	0.224	0.352	-3.101	44	0.536
		(0.307)	(1.229)	(0.247)	(3.246)		
Hoover	-1.262	-1.330	1.169	1.733	-0.804	180	0.639
		(4.987)	(15.124)	(2.355)	(2.253)		
Marble Mountain	-4.057	-1.210	0.728	1.266	-0.636	176	0.526
		(3.009)	(8.595)	(1.661)	(2.166)		
Minarets	5.973	-1.531	1.268	-0.414	-5.207	179	0.679
		(5.740)	(17.502)	(0.548)	(0.975)		
Mokelumne	-17.227	-0.564	0.796	2.627	-1.781	144	0.647
		(1.554)	(9.255)	(3.520)	(4.817)		
San Gabriel	-1.491	-3.022	1.091	1.665	1.696	36	0.742
		(1.941)	(4.340)	0.941)	(1.117)		
San Gorgonio	19.125	-2.138	0.722	-1.011	-5.413	101	0.816
		(4.946)	(5.222)	(0.913)	(1.387)		
San Jacinto	2.451	-2.125	8.127	8.201	-5.395	83	0.733
		(4.143)	(4.808)	(0.567)	(1.267)		
San Rafael	12.235	-0.178	0.444	-0.569	-1.947	83	0.588
		(0.261)	(2.635)	(0.418)	(3.344)		

Continued

Table 1 continued

Destination	Constant	Price x_{1ij}	Population $x_{2i.t}$	Income $x_{3i.t}$	Alternative Opportunities x_{4ij}	Degrees of Freedom	$\bar{R}^2$
South Warner	-20.421	-1.443	0.550	3.322	-0.383	164	0.440
		(3.335)	(6.388)	(4.436)	(1.219)		
Thousand Lakes	-0.934	-1.049	0.561	0.675	-0.259	133	0.308
		(2.255)	(5.011)	(0.789)	(0.739)		
Ventana	-9.820	-0.238	0.839	1.264	-1.039	179	0.625
		(0.605)	(10.449)	(1.483)	(2.950)		
Yolla Bolly	1.679	-1.010	0.794	0.126	-1.983	126	0.494
		(0.181)	(7.690)	(0.158)	(4.068)		
Agua Tibia	7.523	-0.087	0.604	-0.631	-1.134	38	0.656
		(0.080)	(2.900)	(0.355)	(1.165)		
Emigrant Basin	-3.605	0.004	1.064	0.850	-2.850	177	0.738
		(0.012)	(16.688)	(1.231)	(7.536)		
High Sierra	28.424	0.489	0.388	-3.000	-1.239	42	0.253
		(0.568)	(2.369)	(2.012)	(0.864)		
Salmon-Trinity	1.752	-1.194	0.926	0.260	0.514	193	0.489
		(2.711)	(10.002)	(0.305)	(1.553)		
Yosemite	-2.128	-0.749	1.196	0.222	-1.327	213	0.842
		(4.236)	(27.001)	(0.441)	(6.002)		
Lassen and Caribou	-4.981	-1.835	0.8670	1.290	-0.204	133	0.519
		(3.811)	(8.369)	(1.364)	(0.493)		
John Muir and	1.365	-1.249	1.197	0.051	-0.463	213	0.837
Sequoia-Kings		(4.732)	(22.659)	(0.092)	(1.529)		

[a] $\bar{R}^2$ is the adjusted R^2 value

[b] The values in parenthesis represent t-ratios

vary significantly between destinations. F-ratios were calculated to test the assumption of structural shifts in the coefficients. The results indicated that the hypothesis of equal explanatory coefficients among destinations can be rejected at the 0.1 percent level of confidence.

Thus, when dealing with a multi-area wilderness system use models must not only include a variable accounting for alternative opportunites but assumptions with regard to the structure of the system must be explicitly stated and tested. The results of estimating equation (1) indicate that the wilderness areas within the California wilderness area system are unique with regard to their structure.

Conclusions

When multi-area analysis is required for estimating impacts of wilderness use care must be taken in not only the specification of an alternative opportunities explanatory variable but also with regard to the validity of the assumptions required for estimation. This paper presents a methodology which accounts for substitution effects of alternative recreational areas. In addition, the paper developed and estimated a wilderness use model that accounts for differences in destinations and structural changes over time. Significant differences existed among destinations, however, estimation of the analysis of coveriance model did not indicate structural changes over the time period under consideration.

FOOTNOTES

1/ Some authors express this variable in terms of travel costs while others leave it in terms of highway miles (Burt and Brewer, 1971 and Sinden, 1974). If it is assumed that travel costs between an origin and a site are proportional to the highway miles between the areas then the problem reduces to one involving units of measurement. Consequently, no difficulty exists, although one should bear in mind the units of measurements.

2/ The inclusion of measures of alternative recreational opportunities in a recreation area's demand function have been justified on heuristic grounds. Recently, however, there have been a couple of theoretical attempts to account for the substitution effects in outdoor recreational demand equations (see Burt and Brewer, 1971 and Cicchetti, et al, 1976).

3/ The disturbance term, u_{ijt}, is assumed to satisfy the classical normal linear regression model assumptions. Alternative stochastic specifications would assume u_{ijt} to be autoregressive or heteroskedastic. In addition, interaction terms between time and cross sectional units could be included.

4/ For a detailed listing of the data sources see Wetzstein and Green, 1977.

5/ Recently, Burt and Brewer (1971) and Cicchetti et al (1976) employed a simultaneous systems-equations approach to estimate the cross-price elasticities of various recreational areas which also does not require these restrictive assumptions.

6/ A number of destinations were aggregated due to the inability of separating their representative permit use. These adjacent destinations are Lassen and Caribou, John Muir and Sequoia-Kings.

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