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Benefit Transfer of Outdoor Recreation Demand Studies, 1968–1988

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The accumulation of studies on outdoor recreation demand creates an opportunity to apply the growing science of reviewing research for purposes of benefit transfer. The process involves developing an understanding of the variables that explain the observed difference in estimates. This paper illustrates how the results of previous studies could be adjusted to develop some tentative estimates of nonmarket values for future policy analysis. Also, the evaluation of some potentially important variables should help improve statistical analysis and the allocation of resources to new studies. The challenge is to build each subsequent work on the knowledge gained from previous ones. In this experimental phase, there is a need to examine additional variables that might conceivably be more important than those considered in the past.

INTRODUCTION

For the past quarter century, the unit-day value approach to water-based recreation benefit transfer relied on expert judgment to develop an approximation of the average willingness to pay for recreation activities. An estimate, adjusted for characteristics of the study site, was selected from a range of updated values approved by federal guidelines [*U.S. Water Resources Council*, 1964, 1973, 1979, 1983]. The exercise was controversial because water agencies lacked a scientific basis for adjustment. Typically, they relied on the concept of reasonable and proper levels for the purpose intended.

More recently, some agencies have begun to use past outdoor recreation demand studies to estimate unit-day values of new or expanded sites. The U.S. Department of Agriculture Forest Service, for example, periodically reviews demand studies applying the contingent valuation method (CVM), travel cost method (TCM) and related methods to provide an empirical basis for revision of unit-day values of major recreation activities in forest regions. The CVM relies on surveys of individual intentions to pay rather than forgo a recreation activity or resource. TCM is based on the observed number of trips to a recreation site in response to travel cost. The literature review by *Dwyer et al.* [1977] contributed, in part, to estimation of recreation values for the 1980 resource planning program (RPA) of the Forest Service. Subsequently, detailed summary statistics from past studies were prepared by *Sorg and Loomis* [1984] on behalf of the 1985 RPA. Our objective in the work reported here is to provide a range of benefit estimates for outdoor recreation activities as part of the 1990 RPA.

For this purpose, there is a need for research to develop an understanding of the variables that explain the observed difference in estimates. A potentially useful approach to the benefit transfer problem would be to pool the data from existing studies and apply multiple regression analysis. If the basic model specification is complete, that is, if it includes the relevant explanatory variables in the correct functional form, then it could explain the variation in benefits embodied in differences among the explanatory variables. The net benefit estimated for a site lacking data would then be predicted by inserting appropriate values of explanatory variables into the model fitted to data from other study sites.

Benefit transfer research draws on standard procedures developed by metaanalysis, the growing science of reviewing research [*Cooper*, 1984; *Light and Pillemer*, 1984]. The approach introduces precision into the analysis with respect to the specific purpose of the literature review; the selection of the studies for review; the similarity of the units of analysis and subject matter across studies; the distribution of study values; and the relationship of study values to research design, characteristics of participants, quality of the sites and management programs.

THE DATA BASE

A systematic search of the available literature was conducted in an effort to review as many empirical studies as possible prior to 1989. The selection process was designed to fairly represent all the research on the topic in the United States. Included were studies in journals, chapters in books, unpublished research reports, masters and doctoral theses, research reports from private organizations and government agencies, and conference papers. In a number of cases, the authors were contacted by phone to clarify a methodological question or to obtain the results of unpublished studies. The overall effect of the selection process was to provide sufficient studies to identify interesting trends and get a broad

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TABLE 1. Net Economic Values per Recreation Day Reported by TCM and CVM Demand Studies From 1968 to 1988, United States (Third Quarter 1987 Dollars)

Activity	Number of Estimates	Mean	Median	Standard Error of the Mean	95% Confidence Interval	Range
Total	287	\$33.95	\$27.02	\$ 1.67	\$30.68–37.22	\$3.91–219.65
Camping	18	19.50	18.92	2.03	15.52–23.48	8.26–34.89
Picnicking	7	17.33	12.82	5.08	7.37–27.29	7.05–46.69
Swimming	11	22.97	18.60	3.79	15.54–30.40	7.05–42.94
Sightseeing and off-road driving	6	20.29	19.72	3.73	12.98–27.60	10.33–31.84
Boating, Motorized	5	31.56	25.67	10.36	11.25–51.87	8.27–68.65
Boating, nonmotorized	11	48.68	25.36	15.85	17.61–79.75	10.26–183.36
Hiking	6	29.08	23.62	5.82	17.67–40.49	15.71–55.81
Winter sports	12	28.50	24.39	4.48	19.72–37.28	11.27–66.69
Resorts, cabins, and organized camps[a]	2	12.48	···	···	···	3.91–19.93
Big game hunting	56	45.47	37.87	3.47	38.67–52.27	19.81–142.40
Small game hunting	10	30.82	27.48	3.51	23.94–37.70	18.72–52.04
Migratory waterfowl hunting	17	35.64	25.27	5.87	24.13–47.15	16.58–102.88
Cold water fishing	39	30.62	28.49	3.24	24.27–36.97	10.07–118.12
Anadromous fishing[b]	9	54.01	46.24	11.01	32.43–75.59	16.85–127.26
Warm water fishing	23	23.55	22.50	2.46	18.73–28.87	8.13–59.42
Salt water fishing	17	72.49	53.35	14.05	44.95–100.03	18.69–219.65
Nonconsumptive fish and wildlife	14	22.20	20.49	2.30	17.69–26.71	5.27–38.06
Wilderness	15	24.58	19.26	6.10	12.62–36.54	8.72–106.26
Other recreation activities	9	18.82	16.06	3.65	11.67–25.97	6.81–43.39

[a]Resorts were 1.83% valued at \$19.93 per day; seasonal and year-around cabins were 3.06% valued at \$3.91 per day; and organized camps were 1.79% valued the same as camping.
[b]Anadromous fishing estimates included in cold water fishing. Estimated as roughly 5%.

flavor of the findings from both published and unpublished studies.

The literature review represents an update and evaluation of a previous review by *Sorg and Loomis* [1984]. Their 93 benefit estimates in studies completed from 1968 through 1982 are supplemented with 20 they missed plus 164 estimates in studies completed from 1983 through 1988. The 287 estimates of net economic value per day reported by 120 outdoor recreation demand studies from 1968 to 1988 are adjusted to third quarter 1987 dollars.

Table 1 illustrates the resulting summary statistics for 19 recreation activities. Mean value of the estimates is \$34 per day, with a 95% confidence interval of \$31–37 and a range of \$4–220. The median is \$27. The average benefit of activities ranges from \$12 to \$72 per day with the highest values reported for hunting, fishing, nonmotorized boating, hiking and winter sports. The problem is that Table 1 does not reveal what is causing the extreme range in values, whether variation in characteristics of users, quality of sites, or research methods.

The values reported represent consumer surplus calculated by the authors of each study from the demand functions they reported. The net economic values are equivalent to the dollar amount participants would be willing to pay over and above their current expenditures to ensure continued availability of the opportunity to use recreation resources. The review is limited to studies measuring the on-site recreation use benefits provided by a natural resource of given quality. Many of the studies also estimate the change in benefits with changes in the quality of the resource and interested readers are referred to the detailed descriptions of the original studies for estimates [*Walsh et al.*, 1988]. Also, the values reported here do not include the public benefits from preservation of resource quality such as option values of future use and existence values to the general population of users and nonusers [*Peterson and Sorg*, 1987; *Walsh*, 1986; *Sanders et al.*, 1990].

The standard unit of measurement is an activity day, defined as one person on-site for any part of a calendar day. When values are reported on any other basis than per activity day, they are adjusted to this common unit. For TCM demand functions, the appropriate unit of analysis often is number of trips, but most authors also report the results in terms of value per activity day. If not, values per trip are divided by the reported number of days per trip. Similarly, annual values are divided by the reported days of participation. Household group values are divided by the number of persons and days of participation per person. Where the value of recreation activities is reported for hypothetical quality changes, the base value for current site quality is used. There is a problem of defining recreation activity days at some sites, notably reservoirs with camping, swimming, boating and fishing on the same trip. In this case, the concept of recreation use is based on the standard procedure of the U.S. Census, whereby an activity is defined as primary use when it represents over 50% of total individual activity while at the site.

DESCRIPTION OF VARIABLES

The empirical model used to explain the variation in benefit estimates should be based primarily on applied microeconomic theory [*McKean and Walsh*, 1986; *U.S. Department of the Interior*, 1986]. In an ordinary demand function for a recreation site, the dependent variable to be explained is the quantity demanded. The list of independent

TABLE 2. Description of Variables in the Analysis

Name	Definition of Variable
Dependent variable	Consumer surplus estimated by each study, standardized to average values per activity day, adjusted to third quarter 1987 dollars.
Site quality	Qualitative variable: 1 if site was rated by each study as uniquely high quality; 0 If medium or low.
Forest Service administered	Qualitative variable: 1 if the study sites were Forest Service administered; 0 if otherwise.
Household survey	Qualitative variable: 1 if household survey of participants in an activity at public and private sites; 0 if otherwise (the omitted category is on-site survey).
Specialized activity	Continuous variable given as percent. Proportion of total recreation use of U.S. Forest Service resources in the activity category. Proxy of taste and preference for specialized versus generalized activities.
Inflationary adjustment	Qualitative variable: 1 if data were collected for each study prior to 1980; 0 if 1980–1988.
Sample coverage	Qualitative variable: 1 if only in-state residents were included in the sample of users; 0 if out-of-state residents were also included.
Method	Qualitative variable: 1 if CVM; 0 if TCM or other method.
Substitution	Qualitative variable: 1 if a substitute price term was included in the TCM demand specification; 0 if otherwise.
Travel time	Qualitative variable: 1 if travel time cost was omitted in the TCM demand specification; 0 if time was included.
Individual observation	Qualitative variable: 1 if TCM sample units were individual observations; 0 if otherwise.
Household production and hedonic price	Qualitative variable: 1 if household production or hedonic price TCM procedure; 0 if otherwise (the omitted category was the zonal group approach).
Open-ended question	Qualitative variable: 1 if noniterative open-ended question was asked in a CVM; 0 if otherwise.
Dichotomous choice question	Qualitative variable: 1 if dichotomous choice CVM question was used; 0 if otherwise (the omitted category was the interative question).
Socioeconomic characteristics	Proxy for socioeconomic characteristics of participants in the service area of the study site. The nine forest regions are qualitative variables. Alaska is the omitted region.
Recreation activity	The 19 national recreation use categories are potential qualitative variables for activities. Omitted categories include activities with limited representation in the studies, e.g., resorts, cabins, and organized camps.

variables that influence demand includes a proxy for direct cost or price and such factors as travel distance or the value of time, the price and availability of substitutes, consumer income, other socioeconomic variables such as age, quality or attractiveness of the site, population of the consuming group, individual taste or preference, and expectations or experience with respect to crowding. Other variables related to research method may include recreation activity; sample size and coverage; CVM, TCM, or other method; statistical model; econometric estimators; type of CVM question; and site administration. The possible effect of the specification of each of these variables should be carefully evaluated.

Table 2 defines the explanatory variables included in the equations. Most are conventional measures and require little added explanation. Nearly all of the variables are qualitative, indicating that a particular treatment is either present or absent. Of primary interest are three adjustments by *Sorg and Loomis* [1984] for omission of travel time, the use of individual observations, and in-state sample coverage discussed later in this paper. Other important determinants of demand are included to hold constant their effects and to estimate the partial effect of each of these variables and other possible candidates for adjustment in benefit estimates. The variable list is constrained by the availability of information, time, and budget for this study. As a result, some potentially important variables are omitted including differences among the studies with respect to the definition of direct travel cost per mile [*Duffield*, 1988], travel time cost per hour [*McCollum et al.*, 1988; *Walsh et al.*, 1990*b*], income and other specific socioeconomic variables, sample size [*Shaw*, 1988], functional form, and type of estimator used [*Smith and Kaoru*, 1990].

A quality variable is included to control for specific characteristics of sites that vary among recreation activities and expectations of individual participants. Sufficient information is available in the studies to apply a rough index of site quality in three categories, (uniquely low, ordinary, and uniquely high) based on a review of the physical and biological information provided. A site administration variable is included to test the hypothesis that Forest Service–administered site benefits are not significantly different from other public and private sites. A variable tests the effect of household surveys compared to on-site studies. A specialized activity variable tests the hypothesis that benefits are lower for general activities than for specialized activities. This may be interpreted as a proxy for taste and preference. The federal guidelines [*U.S. Water Resources Council*, 1983] differentiate between general recreation activities engaged in by a large number of persons and specialized recreation limited to fewer participants with unique preference patterns. The guidelines associate specialized recreation with higher unit-day values than general recreation.

An inflationary adjustment variable is intended to begin examining the question of whether recreation values increase at the same rate as changes in the purchasing power of the dollar. For comparison purposes, the reported values must be adjusted for inflation. However, this is equivalent to assuming constant real prices, which would not be consistent with increased crowding and relative scarcity of natural resources available for resource-based recreation activities [*President's Commission on Americans Outdoors*, 1987]. Moreover, the procedure assumes an equal proportional change in the reported values for any given year which tends to dampen (enlarge) the absolute dollar adjustment for studies reporting low (high) values. This is evident for surveys from 1968–1979 when the inflation rate was 6.9 percent, compared to 4.8 percent from 1980–1987. Finally, willingness to pay is, in part, a function of ability to pay which suggests that secular adjustments for per capita real income would be useful.

A method variable is included to test the hypothesis that intended willingness-to-pay estimates of the CVM are lower than behavior-based TCM. This would be consistent with the observation that TCM values the entire trip including the primary activity and secondary activities while the CVM usually values the primary activity alone. For example, TCM always values the entire time on-site per calendar day of a trip while CVM usually values only that part of the day that pertains to the primary activity, e.g., the 4 hours devoted to fishing each day.

Willingness to pay for a constant unit of recreation use of an existing site should be approximately the same since both methods yield similar though not identical demand curves. The TCM estimates an ordinary Marshallian demand curve while the CVM estimates a Hicksian compensated demand curve [*Cummings et al.*, 1986]. Both approaches specify that benefit is a function of the number of trips to a recreation site, which is separable in consumption and subject to a budget constraint. If the specification of quantity and other variables can be controlled, theory suggests that there should be little or no difference between values obtained by the two methods.

A variable indicating location of the study sites by forest regions is included as a proxy for socioeconomic characteristics of the user population. Since the regression model controls for site quality and substitutes, the other important effect of location is the distribution of income and other socioeconomic characteristics of the population in the relevant market for the study site. While extensive data on household demographics and equipment ownership are available for outdoor recreation activities from national and state samples, similar information is available only for a small fraction of the studies reviewed here. Thus, this important feature of variation in benefits would have to be ignored without an effective proxy variable.

STATISTICAL RESULTS

With the increased output of empirical studies in recent years, there are enough data to begin understanding the variables that explain the observed differences in benefit estimates. Table 3 includes three functions showing the statistical relationship of recreation benefits to some important explanatory variables. These are for the total sample of 287 benefit estimates, 156 TCM and related estimates, and 129 CVM. The number of observations is sufficient for statistically significant analysis. The R^2, adjusted for degrees of freedom, indicates that 36–44% of the total variation in the reported values is explained by the variables included in the functions. The overall equations are significant at the 0.01 level. The t statistics shown in parentheses beneath the coefficients indicate that about two-thirds of the variables (27 of 42) are significant at the 0.10 level or above. Omission of the coefficient for a variable (three dots) indicates that it is not statistically related to benefits.

The panel nature of the data renders the usual statistical tests of the model an approximation rather than a precise estimate. Although the residuals are close to normally distributed, heteroscedasticity is likely to be present in any study with parameters drawn from different data sets. Even though review of the correlation matrixes indicates mostly low levels, multicolinearity is likely to result from inclusion of more than one benefit estimate from some studies. The t statistics somewhat overestimate or underestimate variable significance based on a *Smith and Kaoru* [1990] comparison of ordinary least squares (OLS) estimates with the *Newey and West* [1987] variation of the *White* [1980] consistent covariance estimates of standard errors used in calculating t statistics.

Of primary interest here are the variables estimating the effect of the three adjustments in benefit by *Sorg and Loomis* [1984]; namely, for omission of travel time cost, use of the individual observation approach, and in-state samples at sites with out-of-state users. The increase in reported TCM values by 30% for omission of travel time cost seems to be about right. The statistically significant coefficient indicates that TCM benefits are about 34% less for the 30 studies omitting travel time cost, other variables in the equation held constant. (The −13.333 coefficient for travel time cost is 34% of TCM mean value of $39.) On the other hand, their decrease in reported benefits by 15% for use of the individual observation approach seems quite conservative. The significant coefficient indicates that benefits are 46% greater for the 52 TCM studies using individual observations. The increase of both TCM and CVM values by 15% for omission of out-of-state users appears to be about right for the total sample where the coefficient shows a 20% increase, although not statistically significant. The 15% adjustment seems conservative for TCM studies where the significant coefficient indicates the correct adjustment would be an increase of about 30%. Thus, while the three adjustments appear about right or to err on the low side, their overall effect is reasonably correct. The regression for the total sample (Table 3) indicates that when variations in site quality, recreation activity, region, method, etc. are held constant, no significant difference remains between the mean value of adjusted and unadjusted studies.

Another critical issue, of course, in the evaluation of the *Sorg and Loomis* [1984] adjustments is whether they are supported by applied microeconomic theory, accepted econometric procedures and the federal guidelines. Obviously, some adjustment for the omission of travel time is required; however, the precise level is not known and would vary for each study site. The statistical effect of the travel time cost variable could be improved if specified as a continuous variable in dollars per hour rather than as a

TABLE 3. OLS Regressions of Recreational Values on Several Important Explanatory Variables, United States, 1987

	Total		Travel Cost Method		Contingent Valuation Method	
Independent Variable	Mean	Coefficient	Mean	Coefficient	Mean	Coefficient
Site quality	0.129	33.568[a] (7.51)	0.154	39.171[a] (6.06)	0.101	25.082[a] (4.42)
Specialized activity	4.917	−0.574[a] (−2.23)	5.235	−0.679[a] (−1.83)	4.571	−0.147 (−0.519)
Forest Service administered	0.230	4.931 (0.98)	0.218	6.204 (0.84)	0.248	2.594 (0.42)
Household survey	0.596	9.891[a] (2.29)	0.571	6.933 (1.12)	0.636	13.539[a] (2.46)
Inflationary adjustment	0.564	−7.971[a] (−2.35)	0.436	−10.579[a] (−2.03)	0.721	−16.582[a] (−3.31)
Sample coverage	0.115	−6.892 (−1.33)	0.186	−11.759[a] (−1.77)	0.031	−7.464 (−0.86)
Method	0.449	−8.098[a] (−2.34)		···		···
Sorg-Loomis adjustments	0.578	−4.290 (−1.09)		···		···
Travel time cost		···	0.192	−13.333[a] (−1.90)		···
Substitution variable		···	0.647	−10.831[a] (−2.05)		···
Individual observation		···	0.333	17.950[a] (3.44)		···
Household production and hedonic price		···	0.083	9.499 (1.03)		···
Open-ended question		···		···	0.333	−3.659[a] (−0.76)
Dichotomous choice question		···		···	0.101	3.503 (0.62)
Southern region	0.094	−13.089[a] (−2.48)	0.122	−12.333[a] (−1.66)	0.062	−10.998[a] (−1.67)
Northwest region	0.052	−10.676 (−1.47)		···	0.039	−12.186 (−1.53)
Pacific southwest region	0.059	−10.683[a] (−1.66)		···		···
Intermountain region	0.171	−9.252[a] (−2.18)		···	0.155	−13.517[a] (−2.98)
Salt water and anadromous fishing	0.091	34.566[a] (6.20)	0.096	42.939[a] (5.10)	0.085	24.454[a] (4.02)
Big game hunting	0.199	21.817[a] (5.33)	0.186	23.037[a] (3.58)	0.209	16.664[a] (4.04)
Waterfowl hunting	0.063	11.325[a] (1.80)		···	0.093	7.042[a] (1.28)
Constant		33.579[a] (6.89)		33.769[a] (4.24)		28.543[a] (3.98)
Sample size		287		156		129
Adjusted R^2		0.36		0.39		0.44

Here, t ratios are shown in parentheses beneath coefficients. For description of variables, see Table 2.
[a]Coefficient is significant at the 0.10 level or greater.

qualitative variable indicating presence or absence of the adjustment [*Walsh et al.*, 1990*b*]. With respect to the adjustment for use of individual observations in TCM studies, some economists argue that values from zonal studies should be increased rather than decreasing values from individual observation studies because of the dampening effect of aggregation problems in the zonal approach [*McConnell and Bockstael*, 1984]. Finally, limitation of the sample to in-state residents originates in the institutional constraints of the researcher. The precise level of adjustment for sample truncation would vary with the distribution of the user population relative to each site.

The regression results indicate other prime candidates for adjustment not considered by the earlier work. Benefit estimates from TCM studies omitting an effective cross-price term for substitution could be decreased about 30% according to the regression results. If the behavior-based TCM becomes the accepted standard for benefit estimation, then the CVM estimates of intended willingness to pay would be increased by an average of 20–25%. The results suggest the benefit estimates from CVM studies using dichotomous choice questions may be closer to TCM benefit estimates, perhaps requiring about half as much adjustment. However, benefit estimates from CVM studies asking open-ended willingness-to-pay questions could be increased by 10–15% more based on the preliminary regression results considered here. These are but a few of the possible adjustments that should be considered in applying the *Sorg and Loomis* [1984] approach of making adjustments before presenting statistical summaries of the data in policy applications.

An important question in applying the data to policy decisions is whether the benefit estimates from other public and private recreation sites are applicable to Forest Service resources. The insignificant coefficient for study sites administered by the agency suggests that there may be no appreciable difference. Apparently, the benefit estimates from the literature review apply to valuation of the agency's recreation program. In theory, benefit estimates for a forest lacking data can be predicted by inserting appropriate values of explanatory variables into the regressions. Unfortunately, an insufficient number of studies have been completed to obtain more than a few estimates of value by this method.

Forecasting with an econometric equation requires knowledge of the values for the independent variables in the model. Thus a certain amount of information on a site may have to be collected prior to making a forecast. If the site is average in all respects, a forecast value of $39 per day is obtained by multiplying the mean values of the variables in the TCM equation by their regression coefficients and adding the results to the constant term. If it is determined that quality of the site ranks in the upper 15% of all sites, its mean value would be set at 1.0 and the calculation repeated to obtain a value of $72 per day. Other variables are expected to vary from site to site and be affected by location. The coefficients of only four of the nine forest regions are significant in the models fitted to the data from the study sites. It seems likely that the agency will need to rely on a combination of several approaches until a greater number of studies of most recreation activities have been completed [*McCollum et al.*, 1990; *Bergstrom and Cordell*, 1989].

Finally, these results should be considered tentative and subject to revision with more complete specification of the model. Sensitivity analysis omitting various combinations of variables from the final equations significantly changes the coefficients of those remaining (as in the works by *Allen et al.* [1981], *Atkinson and Crocker* [1987], and *Smith and Kaoru* [1990]). This suggests that leaving important variables out of the final equations may attribute too much of the variation in benefit estimates to the differences in method that are included. Nonetheless, the equations in Table 3 include many possibly important variables and provide a basis for evaluating some of them as serious candidates for new research. The task remains to discover how far these results can be generalized. The importance of continued research is illustrated by the conceptual and empirical difficulties associated with estimation and the potential importance of recreation benefit in the economic assessment of programs such as water-based recreation.

SUMMARY AND CONCLUSIONS

This paper addressed the problem of information transfer, that is, the possibility of adjusting past studies to estimate benefits for long-run policy analysis. The process involves developing an understanding of the variables that explain the observed differences in benefit estimates. As a first step, the contribution of this paper was to update and evaluate a previous literature review that adjusted reported values before presenting summary statistics. The travel time adjustment was supported by the regression results while the adjustments for sample truncation and use of the individual observation approach were somewhat lower than suggested by those results. Overall, these three adjustments were reasonably effective. There was no significant difference between the mean value of adjusted and unadjusted studies. The regression results indicated other candidates for adjustment including substitution, CVM method, site quality, administration, recreation activity, and regional location.

Much more research is needed to fully understand the problems of information transfer. The approach illustrated here appears to be sufficiently promising to indicate that it could be used to analyze other important problems. These include adjusting for variation in the treatment of monetary and time cost of travel, substitution, site quality, and the functional form used in TCM applications. CVM problems include adjusting for variations in the method of payment, functional form used to analyze dichotomous choice questions, and information on resource quality, uncertainty, and substitution possibilities. Newer methods of controlling for the effects of these and other sources of variation in the estimates give reason to believe that it may be possible to resolve many of the problems of nonmarket value research. It is particularly noteworthy that in both the TCM and CVM approaches, the link between consumer theory and statistical estimation may be improved via use of discrete choice and qualitative response models with maximum likelihood statistical techniques.

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