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Substitute Site Measures in a Varying Parameter Model with Application to Recreational Fishing

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Abstract *This paper employs a varying parameter travel cost model to determine the economic valuation of fishing trips and catch for a sample of Long Island anglers. Substitution measures in the model are characterized in terms of the number and the quality of proximate alternative sites. This treatment of substitution as a site rather than an individual characteristic helps to define a site's uniqueness and in addition provides a feasible means of capturing substitution effects when measures of substitution at an individual level are not available. Per trip consumer surplus and changes in consumer surplus due to catch changes are computed and distinguished by controls for the availability and quality of substitute sites. Consumer surplus and the valuation of changes in catch are found to be substantially lower when controlling for substitution effects which is in agreement with most previous studies.*

Keywords Site Substitution, Varying Parameter, Travel Cost Model, Recreational Fishery Valuation.

Introduction

Since the travel cost method (TCM) was first suggested by H. Hotelling (1949), it has been applied extensively in valuing a wide range of recreational benefits including marine activities. The basic TCM utilizes the diversity in recreationists' travel costs and frequencies to provide the essential information for estimating demand functions for recreational services. In recent years the TCM has been generalized to include a multi-site, multi-attributes framework where demand functions or a system of demand functions for several recreational sites are estimated. While empirical applications of travel cost models have achieved somewhat satisfactory results, many problems are typically encountered by research-

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ers. The difficulties usually involve the data applied to the TCM being less than ideal to handle the demands of the theory.

The purpose of this study is to explore the problems of site definition and substitution, and to apply a varying parameter TCM in order to determine consumer surplus and the marginal value of catch for individual recreational anglers from salt water sites on Long Island. The sensitivity of these estimates to the modelling of substitution availability is examined. A distinguishing feature of this study is the inclusion of alternative site substitution measures as site characteristics rather than individual characteristics. Although this concept has been utilized by some authors in zonal models of regional recreational demand, it has not been employed in individual demand studies (Sutherland, 1982; Loomis *et al.*, 1986). Our treatment provides a means of characterizing a site's uniqueness as well as a practical alternative in situations where data on individual substitution alternatives are either not available or ill conditioned.

Substitution Effects

Early travel cost studies neglected the "cross prices" of alternative sites in the demand equation. It is well recognized that the failure to include potential substitute and complement prices can lead to biased estimates of important demand parameters for the primary site and thus its economic value (Samples and Bishop, 1985; Rosenthal, 1987). The precise effect that omission of cross-price terms has on primary site valuation depends on 1) whether alternative sites are considered to be substitutes or complements by recreationists and 2) the direction of the simple correlation between own price and cross prices.

Caulkins *et al.* (1985) illustrate that the direction of correlation between own and cross price terms in the TCM is determined by the geographic location of the origin of recreationists. For example when a recreationist lives within a corridor between a primary and alternative site, then as travel cost (P) to the primary site increases, the cost to the alternative site will decrease. For these recreationists the correlation between the two travel costs is negative. If recreationists do not live within such a corridor, then as the travel costs to the primary site increase so do the costs to the alternative site. In this case the correlation between the two travel costs is positive. Recently authors have extended the discussion of substitution omission further to include both price and quality omission (Kling, 1989) alternative measures of substitution (Wilman and Perras, 1989), and intercept misspecification (McKean and Revier, 1990).

Although the inclusion of substitute availability is clearly important, it is difficult for applied researchers to insert substitute variables in the demand model. The difficulty stems from the fact that information from the perspective of the recreationist must be gathered on a wide range of recreation sites in addition to the site under study. Needed information includes distances from each traveler's origin to all substitute sites. The preparation of these data is time consuming and at best only approximates substitute availability since individual time costs to all potential alternative sites are rarely available. Often recreational surveys rely on respondents' judgements about alternatives without determining actual availability (Smith and Kaoru, 1990). Even when reliable data are available, they are sometimes ill conditioned due to multicollinearity among a variety of price measures including own as well as substitute prices (Rosenthal, 1987).

Varying Parameter TCM

In addition to site substitution effects, the importance of other site characteristics in the TCM has long been recognized. The difficulty in including many site characteristics in the conventional TCM is that they either do not change or changes cannot be observed within a site over a specified period of time. In order to account for variation in site characteristics within a multisite sample, Freeman (1979) and Smith and Desvousges (1986) suggest that the visitation functions be estimated in two steps. The first step involves the estimation of separate travel demands for each site using information on travel distance, frequency, and various individual characteristics. The parameters for each site are then related to site characteristics in a second stage estimation. Desvousges *et al.* (1983) used the two-step varying parameter TCM to estimate the effect of changes in water quality on the benefits of water-based recreation. In studies such as ours where there are limited observations for each site, Vaughan and Russell (1982) propose a one-step version of the varying parameter model which provides a basis for pooling individual data across sites.

For a two-step model, the first step is to estimate a separate demand curve for each of the sites in the sample. Suppose all site demand functions have a simple linear form with travel cost, P, as the sole determinant of quantity demanded:

$$Q_i = \beta_{0i} + \beta_{1i} P_i + e_i \tag{1}$$

where the parameters are estimated using data from individual trips to site i. In the second step, the sample regression coefficients (estimated in step one for each site) are regressed on the characteristics of the sites:

$$\begin{aligned} \beta_{0i} &= \gamma_0 + \gamma_1 Z_{1i} + \ldots + \gamma_k Z_{ki} + v_{0i} \\ \beta_{1i} &= \delta_0 + \delta_1 Z_{1i} + \ldots + \delta_k Z_{ki} + v_{1i} \end{aligned} \tag{2}$$

where

Q_i	= visits to site i by individuals;
P_i	= travel cost to site i by individuals;
β_{0i}, β_{1i}	= first step parameters which vary across sites (i);
$Z_{1i} \ldots Z_{ki}$	= site characteristic variables which vary across sites i;
$\gamma_0 \ldots \gamma_k, \delta_0 \ldots \delta_k$	= second step parameters which vary across sites; and
e_i, v_{0i}, v_{1i}	= random errors.

The second step integrates site characteristics (Z) into the conventional TCM by recognizing that step one parameters implicitly reflect site characteristics.

In order to derive the one-step version from the two-step varying parameter model we simply insert Eq. (2) into Eq. (1) to obtain,

$$\begin{aligned} Q_i = \gamma_0 &+ \gamma_1 Z_{1i} + \ldots + \gamma_k Z_{ki} + \delta_0 P_i \\ &+ \delta_1 Z_{1i} P_i + \ldots + \delta_k Z_{ki} P_i \\ &+ e_i + v_{0i} + v_{1i} P_i \, . \end{aligned} \tag{3}$$

From Eq. (3) we can see that the error $(e_i + v_{0i} + v_{1i}P_i)$ using a one-step approach is potentially heteroscedastic since it is dependent on P_i. In general, this will be the case whenever β_{1i} from Eq. (2) is a stochastic function of the site characteristics. If either β_{1i} is treated as non-stochastic and/or simply not a function of site characteristics (Z), the error in Eq. (3) may be assumed initially as homoscedastic. This issue affects whether Eq. (3) should be estimated by generalized least squares (GLS) or ordinary least squares (OLS) (see Vaughan and Russell, 1982).

In the varying parameter TCM substitution effects are usually treated as personal characteristics and thus included in step one. This is conceptually appropriate since substitution is theoretically determined by individual preferences for site characteristics and not the characteristics themselves. Unfortunately when substitution information is ill conditioned on individuals, such as when travel origin is unavailable, there is simply no basis for computing cross price information for inclusion in step one as a personal characteristic. In this situation the inclusion of alternative site availability in step two (*i.e.* as a site rather than an individual characteristic) provides an approximate characterization of substitution and a means of mitigating potential parameter bias. Site substitution information is likely to be readily available since site information does not require individual survey information.

An additional motivation for including substitute information as site characteristics involves the definition of a recreational site. In the case of sport fishing the site itself is a somewhat artificial construct reflecting usually a launch point where individual anglers can be conveniently intercepted. In this case it may be important to account for site characteristics as they relate to a set of other proximate artificial sites. Measures of site substitution such as a count of nearby sites, their proximity and their quality may thus reflect not only useful substitution controls in the regression but also a site's uniqueness. In this case site substitution measures which attempt to quantify the alternatives become a vehicle for parameterizing a site's uniqueness and thus relate to site definition as well as to cross-price substitution.

Substitution measured as a site versus an individual characteristic can be compared in the simple case of one alternative site j using Fig. 1. Let d_{kj} represent substitution as an individual characteristic, measured as the distance from each angler's origin to an alternative site j. Psub represents a measure of substitution as a site characteristic, computed as the distance from the primary site i (the site visited) to the nearest alternative j. Generally when most anglers live nearer to the primary site i rather than to the alternative site j (*e.g.*, origin points 1 and 2), the correlation between Psub and d_{kj} is positive. An increase (decrease) in Psub reflecting a change in alternative site j's location will be accompanied by an increase (decrease) in the individual angler's distance d_{kj} to the alternative site j. Hence, if sites i and j are substitutes for individuals, an increase (decrease) in Psub will increase (decrease) the fishing trips to the primary site i. More precisely, we can see from Fig. 1 that for any origin points to the left of the alternative site j, a marginal change in Psub will represent a change in d_{kj} in the same direction. However, in the case where most anglers live to the right of the alternative site j such as origin points 3 and 4, the correlation between Psub and d_{kj} is negative. In this case a marginal increase in Psub reflects a decrease in d_{kj}. Thus the interpretation of Psub in terms of individual substitution depends on the spatial orientation between a recreationist's origin, primary site and alternatives. In general the

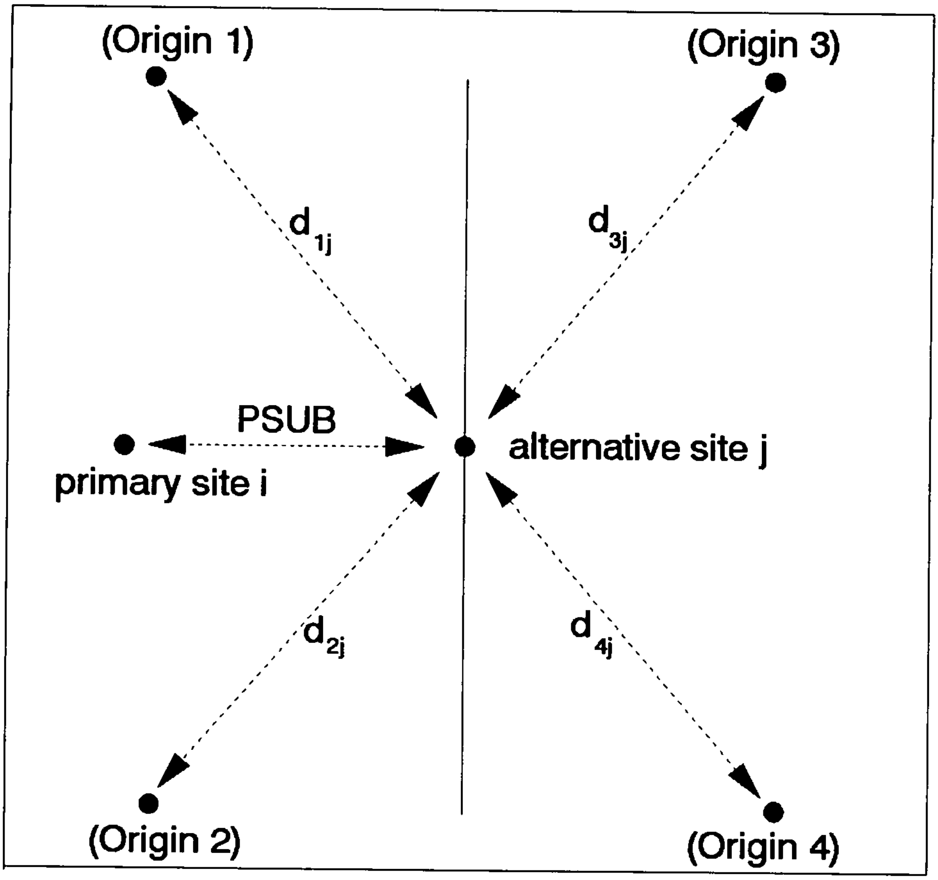

Figure 1. Relationship between site versus individual substitution measures.

coefficient of Psub will not allow one to distinguish between complementarity and substitutability in the usual individual sense but will nevertheless provide an important regression control.

Data

The data used for this study were drawn from the special Socioeconomic Survey conducted as a part of the Marine Recreational Fishery Statistics Survey (MRFSS) by the National Marine Fisheries Services (U.S. Department of Commerce, 1981).[1] Our analysis focuses on 20 Long Island, NY fishing sites where a significant number of observations are available to estimate the varying parameter model. Sites having less than ten observations were eliminated. Although the data used in this study reflect only the larger sites ($n \geqslant 10$), over 90 percent of the anglers surveyed in the Long Island area are represented. The total sample size for the 20 sites is 580 anglers. The survey provides the basic quantity and price

[1] The survey was conducted in two parts: 1) an intercept field survey of anglers and 2) a follow-up telephone survey in which socioeconomic information including income was sought. Since in the follow-up survey approximately one-half of the observations were lost, only the field survey is used in this study.

information needed to estimate a varying parameter TCM. Round trip distance from home for year round residents is used as a proxy for costs associated with fishing. Travel distance was monetized using $.13 per mile which reflects variable driving costs averaged over several vehicle types (U.S. Department of Transportation, 1984).

As a supplement to the limited information on individuals in the survey, additional variables were constructed to measure alternative site availability and quality. Site substitution like individual substitution can be measured in many ways including price and quantity dimensions as well as quality (Loomis, *et al.*, 1986 and Smith and Kaoru, 1990). In addition, substitution can be reflected in terms of single versus multiple alternatives. An additional advantage of treating substitution as a site rather than an individual characteristic is that the variety of alternative substitution measurements and dimensions can be handled more easily empirically since there are far fewer sites than individuals to keep track of. Table 1 categorizes our site substitution information matrix and defines the variables which are constructed from the geographical location of the survey sites and the catch rate for each of these sites.

Empirical Findings

The data allow the estimation of the one-step varying parameter model given in Eq. (3), with two individual characteristic variables, trip frequency (Q) and trip price (P), and several site characteristic variables Z. We estimate the following semilog model:

$$\begin{aligned} lnQ &= \gamma_0 + \gamma_1 Sub + \gamma_2 Catch + \gamma_3 Mode + \delta_0 P \\ &\quad + \delta_1 P\_Sub + \delta_2 P\_Catch + \delta_3 P\_Mode + e^* \end{aligned} \tag{4}$$

where Sub, Catch, and Mode reflect site characteristic variables Z. The variables are defined below except for the Sub vector whose variables are defined in Table 1.

Table 1
Substitution Variables

Alternative Availability Definition	Type of Measure		
	Quantity	Price	Quality
Single Alternative	*	PSUB	SUBCATCH
Multiple Alternatives	QSUB	PSUBAV	SUBCATCHAV

QSUB The number of alternative sites (i.e., within 10 miles).
PSUB Price of the nearest alternative site (travel cost monetized at $.13 per mile).
PSUBAV Price of alternative sites measured as the average distance to alternative sites monetized (total monetized distance of alternative sites within 10 miles divided by QSUB).
SUBCATCH Catch rate of the nearest alternative site.
SUBCATCHAV Average catch rate of alternative sites.
* Not a useful measure since there is always one single alternative.

lnQ	=	log of the number of visits (including the day of the intercept) in the past twelve months to a particular site;
P	=	the fishing trip price measured as the round-trip travel cost in 1984 dollars;
Sub	=	A vector of substitute variables defined in Table 1 (γ_1 is the corresponding parameter vector);
Catch	=	the mean of catch rate of all anglers for a given site (measured as the number of fish);
Mode	=	the mean for a site of a dummy variable constructed from the survey where 0 and 1 reflect shore and boat fishing modes respectively;
P_Sub	=	a vector of interaction terms between P and various site substitution measures defined in Table 1;
P_Catch	=	interaction between P and Catch;
P_Mode	=	interaction between P and Mode; and
e*	=	$e_i + v_{0i} + v_{1i}P_i$.

The semilog form was chosen as an appropriate empirical model after preliminary significance and goodness of fit testing of linear, double log, and semilog functional forms. Our finding that the semilog function performs well in recreational demand estimation is not unlike numerous other studies in the field (Ziemer, *et al.*, 1980; Smith, *et al.*, 1986). In order to determine whether P or Q should be treated as exogenous, exogeneity tests were performed using various individual characteristics from the survey as exogenous factors (see Hausman, 1978). In these tests Q does not pass as an exogenous variable whereas P does in the semilog specification.

An additional statistical consideration involves the potential limited nature of our dependent variable. If the range of trips is narrow and/or if most respondents to the survey report a single trip, then an alternative statistical model such as a Tobit estimator may be warranted. Table 2 shows some of the frequency distribution of trips as well as other summary statistics on our variables. Since most respondents indicate more than one trip per season, and the range is quite high, a Tobit estimator is deemed unnecessary.[2]

Various statistical tests were performed to determine the adequacy of our model structure. F tests for a standard covariance model provide the basis for determining to what extent site characteristics influence the first step parameters β_0 and β_1 defined in Eq. (1) (Kmenta, 1986). The null hypothesis that the parameters attached to the interaction terms in Eq. (4) are zero (*i.e.*, $\delta_1 = \delta_2 = \delta_3 = 0$) forms the basis for testing the effect of site characteristics on the slope β_1. On the basis of these F tests we were not able to reject the null hypothesis (.05 level), and thus the interaction terms can be eliminated from Eq. (4). These group F tests are reported in Table 3 for the site slope model as the F statistics for the site slope effects. The later range from 1.01 to 1.56. Although the site slope model is clearly

[2] Information on anglers who did not fish would be useful to include in the analysis in order to avoid potential selectivity biases caused by the omission of zero observations from the regression. Unfortunately, the intercept field survey data source does not provide non-user information. For extensive discussions of limited dependent variable considerations in general and applications to recreation demands see Maddala (1983) and Smith (1988) respectively.

Table 2
Summary Statistics (n = 580)

Variable	Mean	Std. Dev.	ln Q	P	Catch	Mode	Qsub	Psub	Psubav	Subcatch	Subcatchav
			Correlations								
Trips (Q)	15.59	30.9									
Log Trips (ln Q)	1.68	1.4	1.0								
Travel Cost (P)	8.17	9.3	−.18	1.0							
Catch	4.95	10.4	.12	.48	1.0						
Mode	.62	0.5	.09	.14	.33	1.0					
Qsub	5.12	4.3	.04	.65	.69	.21	1.0				
Psub	3.08	3.6	.08	−.29	−.33	−.12	−.43	1.0			
Psubav	5.29	2.9	.02	−.22	−.25	.04	−.30	.88	1.0		
Subcatch	4.06	4.4	.09	.49	.70	.28	.84	−.20	−.05	1.0	
Subcatchav	3.77	4.2	.06	.60	.70	.22	.88	−.13	−.03	.92	1.0

Frequencies

Trips (Q)	%	Distance (2-way miles)	%	Catch	%
(1)	25.6	(0)	0.9	(0)	39.5
(≤5)	53.7	(≤5)	23.4	(≤1)	47.8
(≤10)	70.9	(≤10)	44.5	(≤5)	73.8
(≤20)	82.3	(≤20)	58.3	(≤10)	87.9
(≤50)	93.7	(≤50)	79.0	(≤30)	97.2
(≤300)	100.0	(≤250)	100.0	(≤91)	100.0

rejected, we note that the coefficients of the additive variables change somewhat in the presence of the interactive variables of the site slope effect model. The effect of site characteristics on the intercept β_0 was tested by the F test for H_0: $\gamma_1 = \gamma_2 = \gamma_3 = 0$ after the interaction terms are dropped. On the basis of these F tests (referred to as F site intercept effects in Table 3), the null hypothesis is rejected. We conclude that the intercept β_0 of the travel cost model is influenced by site characteristics but that the slope is not. The final model is thus a simplified version of Eq. (4) (*i.e.*, without interaction effects),

$$1nQ = b_0 + b_1 P + b_2 Sub + b_3 Catch + b_4 Mode + e^{**} \tag{5}$$

where $e^{**} = e_i + v_{0i}$.[3] In order to test for the effects of substitution omission, a separate model without the site substitution term (b_2Sub) in Eq. (5) is also estimated.

In Table 3 are presented the parameter estimates for the hierarchy of models reflected in Eqs. (4) and (5). Model 1 represents Eq. (5) without substitution and is the simplest framework (*i.e.*, no site slope effects and no site substitution effects). Models 2 and 3 also represent Eq. (5). Model 2 reflects the inclusion of

[3] Since the interaction terms are insignificant heteroscedasticity is not structurally present in Eq. (5). As an empirical check on heteroscedasticity Park and Glejser tests were performed on the OLS residuals of Eqs. (4) and (5). Since the slopes in these test regressions were insignificant, our conclusion that there is no heteroscedasticity is corroborated, and GLS estimated is not necessary.

Table 3
Log of Travel Frequency Regressions Using a One-step Varying Parameter Model (absolute t-values in parenthesis, n = 580)

	Site Intercept Model			Site Slope Model		
Variable	1	2	3	4	5	6
Intercept	1.527	1.579	1.473	1.456	1.454	1.72
	(12.99)	(9.20)	(7.11)	(8.72)	(5.44)	(5.32)
Travel cost (P)	−.046	−.056	−.053	−.037	−.032	−.101
	(6.67)	(7.26)	(6.44)	(2.59)	(−1.25)	(2.21)
Catch	.081	.049	.053	.066	.030	.024
	(5.13)	(2.60)	(2.61)	(2.80)	(.97)	(.73)
Mode	.197	.411	.395	.426	.649	.585
	(1.23)	(2.52)	(2.41)	(1.83)	(2.79)	(2.30)
Qsub		.082	.112		.075	.052
		(3.85)	(2.99)		(2.43)	(.90)
Psub		1.364	1.542		1.31	1.434
		(5.00)	(5.23)		(3.26)	(3.27)
Psubav		−1.311	−1.366		−1.114	−1.356
		(4.06)	(4.09)		(2.40)	(2.85)
Subcatch			.041			.055
			(1.13)			(.86)
Subcatchav			−.076			−.050
			(1.57)			(.66)
P Interactions						
Catch				.001	.001	.003
				(1.05)	(.26)	(1.06)
Mode				−.028	−.020	−.021
				(1.39)	(.95)	(.91)
Qsub					.001	.013
					(.53)	(1.77)
Psub					.014	−.031
					(.27)	(.49)
Psubav					−.042	.009
					(.83)	(.17)
Subcatch						−.005
						(.88)
Subcatchav						−.005
						(.62)
R^2	.087	.135	.139	.090	.144	.155
F (equation)	18.24	14.9	11.49	11.35	8.69	6.9
F (site intercept effects)	36.36	87.61	62.87			
F (site slope effects)				1.01	1.21	1.56

alternative site quantity (Qsub) and alternative site price (Psub and Psubav). Model 3 adds alternative site quality measures (Subcatch and Subcatchav) to the estimation of Eq. (5). Models 4, 5, and 6 represent Eq. (4) and are the site slope interaction models associated with Models 1, 2, and 3.

With the rejection of the site slope models (4, 5, and 6) we focus on the site intercept models (1, 2, and 3) in Table 3. The individual characteristic travel cost (P) and the log of fishing trips (1nQ) are significantly inversely related. It is clear that site characteristics are also important. Adding site characteristics, average catch, and mode to individual travel cost (P) raises the R^2 from .032 (model not shown) to .087, and is associated with a highly significant F-statistic of 36.36. When we compare Model 1 with Models 2 and 3, it is apparent that site substitution is also quite important. In Model 2 site intercept effects have a highly significant F-statistic of 87.61, and raise the model's R^2 from .087 to .135. Adding site substitution quality variables (*i.e.*, Model 3) does not improve the model significantly.

The coefficients of the various site substitution measures are quite significant even though some fairly high correlations exist between these substitution measures (see Table 2 for correlations). The positive coefficients for Qsub and Psub indicate that higher frequency of visitations occurs to sites which have more alternatives nearby, but where the closest single alternative is farther away. The negative coefficient for Psubav indicates that lower frequency of visitations occurs to sites which have a more distant substitution set of alternatives (recall Table 1 for site substitution definitions). The signs of Qsub and Psubav indicate some site complementarity when substitution is measured in terms of multiple alternatives. The positive coefficient of Psub, on the other hand, indicates site substitution when alternatives are measured in terms of a single alternative. The coefficients of the site substitution variables do not tell us anything about individual substitution or complementarity effects since these depend on the exact location of the individual's residence which is unknown.

Per trip consumer surplus and the value of fishing success (measured as catch of a typical individual angler) can be readily computed from the regression estimates using Models 1, 2, and 3 in Table 3. The estimate of consumer surplus depends on the functional form of the demand equation (see Ziemer et al., 1980). For the semilog specification, ordinary consumer surplus per trip (OCS) is simply the absolute value of the reciprocal of the own price coefficient (from Eq. (5) per trip OCS is thus $1/|b_1|$). Recently Kling (1988) and Adamowicz, et al. (1989) have argued that not only is the reliability of demand coefficients important, but also that of consumer surplus which in general is a nonlinear transformation of demand parameters. Although reliability is not the sole criterion in choosing a functional form (see Smith, 1990), when empirical estimates are used for b_1, consumer surplus should reflect uncertainty in estimating the price parameter. Using an approximate minimum mean squared error criterion developed by Bockstael and Strand (1987), we measure OCS as

$$OCS = \frac{1}{|\hat{b}_1|}\left[1 + \left(\frac{1}{t_{\hat{b}_1}}\right)^2\right] \tag{6}$$

As discussed earlier, the omission of cross-price information can impact consumer surplus estimates since the regression coefficients will generally change.

Table 4
Per Trip Consumer Surplus and Catch Valuation (1984 $)

	Without Substitution	With Substitution	
	Model 1	Model 2	Model 3
OCS	$22.23	$18.20	$19.32
Value of Catch			
ΔOCS (ρ = .2)	$1.86	$0.91	$1.04
ΔOCS (ρ = 1)	$10.96	$4.99	$5.80

For Models 1, 2, and 3 in Table 3 we can see that omission of the substitution terms (Qsub, Psub, Psubav, Subcatch, and Subcatchav) results in a positive impact in the own price term (−.046 > −.056 and −.053). These changes are the net result of the signs of the substitution regression coefficients and the correlations between own price (*i.e.*, travel cost (P)) and the substitution terms. Table 2 shows these correlations. In this case per trip consumer surplus given by Eq. (6) will be overestimated by omission of the site substitution terms from the varying parameter TCM. Table 4 shows these overestimates for consumer surplus which range from $2.91 (22.23–$19.32) to $4.03 ($22.23–$18.20) depending on the controls for site substitution. Our findings agree with most previous studies in which positive biases in consumer surplus were found (see Rosenthal (1987) and Wilman and Pauls (1987)). Smith and Kaoru (1990) in their survey article using meta analysis find that studies which include substitution effects generate on average lower per trip consumer surplus values of between $11.42 and $23.80 (in 1967 $). Our differences using site substitution controls in the TCM framework generate differences somewhat smaller but of the same sign. Wilman and Perras (1989) in a follow-up study, however, find a negative bias from substitute price omission for one measure of substitute price in a semilog model. Our findings on the magnitude of estimates for per trip consumer surplus are somewhat lower than the $37.87 (expressed in 1984 dollars) found by Ziemer *et al.* (1980) for warm water fishing using a semilog model with no controls for substitute prices.

In order to compute the marginal value of fishing success (measured in terms of catch) we compute the change in ordinary consumer surplus (ΔOCS) resulting from an increase in catch. For a semilog model the minimum mean squared error estimator for a ρ fraction increase in the catch rate on a per trip basis is given as

$$\Delta OCS = \frac{1}{|\hat{b}_1|}\left[1 + \left(\frac{1}{t_{\hat{b}_1}}\right)^2\right][e^{\rho \hat{b}_2 \bar{c}} - 1] \tag{7}$$

where $\hat{b}_1$ and $\hat{b}_2$ represent the estimated price and catch coefficients from Eq. (5) and $\bar{c}$ is the mean value of catch rate (Huppert, 1989).[4] Table 4 gives ΔOCS for ρ = .2 and 1 (i.e., 20 percent and 100 percent increases respectively). Since the

[4] As noted by an anonymous referee, a complication arises if the own price coefficient were a function of site quality. (i.e., when Eq. (4) is the preferred model). In this case the shift in the demand curve due to a quality change would be non parallel and per trip ΔOCS would depend on the number of trips which is affected by site quality.

mean value of catch rate per trip in our sample is 4.95, 100ρ = 20 percent increase in catch approximates the marginal value of catching an extra fish for the typical angler. In comparison with other studies, our findings on the marginal value of fish catch lie within the broad spectrum of values found by other researchers (i.e., reexpressed in 1984 dollars): $0.87 found by Vaughan and Russell (1982), $11.67 found by Samples and Bishop (1985), $2.18 found by Agnello (1989), and $6.08 found by Johnson and Adams (1989).

The results in Table 4 show that the omission of site substitution in the TCM leads to quite different estimates for the marginal value of fishing success. In our sample these values are overestimated by substantial percentages. For example, when comparing Model 1 with Model 3 the ΔOCS is overestimated by 79 percent and 90 percent for ρ = .2 and 1 respectively. The differences are even larger when comparing Models 1 and 2. Thus controlling for alternative site availability and characteristics almost halves the value of fishing success for the typical angler.

Conclusions

Inclusion of alternative site availability and characteristics as a site rather than an individual characteristic variable in a varying parameter TCM appears to be a useful strategy for defining a site's uniqueness and controlling for substitution effects. Although our measures for the substitute site availability are certainly not all encompassing, their simplicity provides researchers with a convenient and practical way to deal with substitution effects. Recreational values obtained from travel cost models are apt to be severely misrepresented without controlling for alternative sites. For the sample of Long Island anglers analyzed, controlling for site substitution lowers the marginal value of catch and per trip consumer surplus.

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