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ABSTRACT

Opportunity time cost is usually a significant part of the price variable in the travel cost demand model (TCM). Thus, its accurate measurement is important to the estimation of demand and benefits evaluation for nonmarket goods. In this paper we evaluate a technique derived by Ward (1983) to find the value of time implicit in a travel cost model. Monetary costs and time are entered as separate arguments to explain trips per year and, under certain conditions, the ratio of the partial effect of time cost to the partial effect of monetary cost reveals the implicit value of time. The often-used technique of assuming an opportunity time cost on the basis of income is examined using the implicit time cost approach of McConnell and Strand.

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INTRODUCTION

Although opportunity time cost is conventionally assumed as some proportion of income (Water Resources Council), it is empirically measured in a paper by McConnell and Strand where opportunity time cost is inferred within the estimation of the TCM. McConnell and Strand (M-S) specify price in their model as the argument in the right hand side of equation 1,

$$r = f[c + (\alpha)(1-t)F'(w)] \qquad (1)$$

where r is trips per year, c is out-of-pocket costs per trip , α is travel time per trip and $(1-t)F'(w)$ is the after tax marginal income foregone per unit time. It is assumed in the M-S model, as in most orthodox TCM formulations, that any increase of travel cost, whether it is out-of-pocket spending or the money value of travel time expended, has an equal marginal effect on visits per year.[1] M-S replace marginal foregone income ($F'(w)$) with average income per hour and estimate (1) as a linear function. They conclude for their sample of sportfishermen in the Chesapeake Bay region in 1978 that opportunity time cost is 61.2 percent of hourly income. Thus M-S make the explicit assumption that opportunity time value rises proportionately with average income.

Measurement and statistical problems often beset the full price variable in empirical applications. First, as is the case for M-S, the marginal income specified by theory is usually replaced with a more easily observable measure consisting of average family income per unit time.[2] Unfortunately, marginal and average values of income are unlikely to be the same. Furthermore, all income measures are inaccurate indicators of opportunity time cost for several reasons. Only earned income should be used when measuring opportunity time cost thus opportunity cost may be overstated for the wealthy whose income may require little of their time. Conversely, students who are investing in education and have little market income will have their true opportunity time costs understated. For some visitors, travel is limited to vacation or weekend time and only moonlighting income (if any) is foregone. For these visitors income foregone may be overstated. For some visitors, market institutions force them to work far more than they desire in order to retain a job. For these visitors the earned income rate understates their true opportunity time cost. For example, Bockstael, Strand and Hanemann (1987) found a money/time tradeoff of $60/hour for individuals with fixed work hours and $17/hour with flexible work hours. For retired persons, the opportunity time cost may be an alternative recreation experience or other activities, such as social services, unrelated to their income level. In addition to these formidable measurement problems, out-of-pocket spending is often positively correlated with earning rates reducing the ability of multiple regression to separate the partial effects of the two components of price when income is used to proxy the opportunity time cost.

Ward suggests a modification of the M-S approach which avoids some of the measurement and statistical problems inherent in the M-S separation of monetary and opportunity time costs. Ward severs the tie of opportunity time cost to average income but retains the assumption that marginal effects of monetary and opportunity time costs are equal. Ward's theoretical relation for travel cost price is the right hand side of equation 2,

$$r = \beta_0 + \beta_1(F) = \beta_0 + \beta_1 c + \beta_1 y\alpha \qquad (2)$$

where r, c, and α are trips per year, out-of-pocket cost, and travel time per trip, as defined before. $F = c + y\alpha$ where y is the marginal opportunity cost of time per unit time. F then is the full cost of a trip including monetary cost and opportunity time cost. Ward suggests estimating the equation,

$$r = b_0 + b_1 c + b_2\alpha\ . \qquad (3)$$

The coefficient b_1 is $\delta r/\delta c$ which from equation (2) is β_1. The coefficient b_2 is $\delta r/\delta\alpha$ which from equation (2) is $\beta_1(\delta(y\alpha))/\delta\alpha$. Ward suggests using the ratio of the estimated coefficients b_2/b_1 as a measure of opportunity time cost. This coefficient ratio is equal to the ratio $\beta_1(\delta(y\alpha))/\delta\alpha\ /\ \delta r/\delta(c)$ and, given that y is a constant with respect to travel time, this can be written as $\beta_1 y/\beta_1 = y$. Thus Ward's methodology implicitly assumes that opportunity time cost (y) is independent of travel time (α).[3] With y fixed, the methodology assumes that marginal and average time opportunity costs are equal. This assumption is tested in the following section when opportunity time costs are allowed to vary across occupation/alternative activity groups and by trip length.

EMPIRICAL RESULTS

Table 2 shows an application of Ward's technique to estimate opportunity time cost for a sample of 200 visitors to Blue Mesa reservoir in 1986. Variables are defined in Table 1. The reservoir is located about 250 miles southwest of Denver, Colorado. It is the largest reservoir in the state. At maximum capacity it is 20 miles in length, has a shoreline of 96 miles and a surface area of 9,000 acres. Fishing is for primarily for rainbow trout, with some Kokanee salmon, brown trout and lake trout. Number of anglers has varied from a low of 74,000 in 1975 to 225,000 in 1986 (Johnson, 1989). A linear model, such as that suggested by Ward is used. The ratio of b_2/b_1 in this case is found to be -0.22885/(-0.012008) = 19.06. Thus the average opportunity time value is found to be $19 per hour. This estimate is comparable with the $17 reported in a study of southern California sport fishing (Bockstael, Strand, and Hanemann, 1987) in 1983 dollars. All of the participants in the southern California study were boat owners and similarly most of the Blue Mesa participants also fished from their own boats. Adjustment for inflation would move this estimate of opportunity time value even closer to that found in the California study. Although each of the coefficients which make up the ratio are highly significant, the determination of significance of the ratio is not simple since the coefficients are not independent. The problem is discussed in M-S.

Often the application of a conventional ordinary least squares model (OLS) to data collected from on-site visitors may result in bias toward zero of the estimated regression coefficients. This result occurs because the data are truncated at one trip (Maddala, 165-170). If the variables in the model are multinormally distributed the truncation bias can be defined. The vector of estimated regression coefficients b is related to the true coefficients as $b = \phi \beta$, where $\phi = \Theta/[1-(1-\Theta)\delta^2]$ and ϕ lies between zero and one. However, since the opportunity time cost estimator is the <u>ratio</u> of two regression coefficients in the TCM, the bias term (ϕ) cancels. Thus, OLS provides unbiased estimates of the opportunity time cost when non-visitors are excluded from the sample given that the assumption of a multinormal distribution is valid.

This methodology is very sensitive to variation in monetary travel costs and any error in these costs can create corresponding error in imputed opportunity time value. For example, if the monetary cost data are doubled, the estimated coefficient on monetary cost (b_1) is cut in half and thus the ratio of estimated coefficients b_2/b_1 (estimated opportunity time cost) is doubled. Errors in defining and measuring monetary costs thus are reflected directly in the estimate of opportunity time value. The monetary trip cost data used in this study were in response to two questions: What is your individual share of trip costs?, and What part of these trip costs are required? Thus the cost data are the visitors estimate of their share of required costs. As shown in Appendix Table 2, monetary costs vary from $1 to $2,500 for a trip. The variability of the costs data is seen more clearly by calculating monetary cost per mile, CPM. CPM varies from a low of 0.6 cents to a maximum of $5 per mile. The mean CPM is 30.4 cents and the standard deviation is 46.82. An experiment in which observations were removed from the data set if CPM was less than 25 cents or greater than $1.24 resulted in about a ten percent reduction in estimated opportunity time value, thus the inclusion of outliers does not initially appear to make a huge difference in the aggregate results. Since theoretical justification for removal of outliers is lacking, the data are first analyzed as reported in the personal interview surveys. Later it will be shown that cost outliers can have a serious effect on the estimates of opportunity time value in the Ward method and both cost and income outliers can effect estimates of opportunity time value in the M-S method.

Because of the poor fit found for the linear travel cost model the functional form for (3) is replaced with either a Box-Cox transformation or a power function (log-log) for purely statistical reasons. The Box-Cox technique is maximum likelihood under the assumption that the transformed variables are normally distributed and homoscedastic. Amemiya has criticized the use of pseudo MLE when errors are not truly normally distributed (Amemiya and Powell, 1981; Amemiya, 1985). Amemiya suggests an alternative procedure using non linear two stage least squares. Khazzoom (1989) shows that Amemiya's method is flawed since his estimator is not well defined when the untransformed dependent variables all exceed unity or are all fractions. White (1990) concludes that "for most cases Box-Cox is perfectly fine, and is maximum likelihood."

If only the dependent variable (trips) is transformed with the independent variables linear (except age which is cubic) Box-Cox comparisons reject linear (and other) functional forms in favor of a box transformation of the dependent variable for our data (see Appendix Table 1). If all variables are subject to Box-Cox transformation, excepting age and the monetary and time costs of the trip, then the log-log model is found superior. The results for both of these modifications of functional form are shown in Tables 3 and 4. The simple correlation of the Box-Cox transformation of the dependent variable, trips, with the logarithm of trips is 0.93435. Thus the Box-Cox transformation on the dependent variable (trips), which is $[(\text{trips}^{-0.68} - 1.0)/(-0.68)]$ is not markedly different from a logarithmic transformation.

Table 3 shows a version of the travel cost model where the dependent variable, trips, and many of the exogenous variables are transformed in logarithms. The estimate of average opportunity time cost value is b_2/b_1 = \$23.23/hour, higher than the \$19.06/ hour found in the linear travel cost model. Table 4 shows the travel cost model with the Box-Cox transformation on the dependent variable. In this case, the estimate of the average opportunity time cost value (b_2/b_1) rises to \$21.01/hour.

One of the remaining problems in the estimation of opportunity time value is the assumption that it is constant with respect to travel time. Allowing for variation in estimated value of opportunity time is first approached through the disaggregation of visitors into six groups according to their occupation/alternative activity. Significant differences between opportunity time value estimates across occupation/alternative activity classes may provide indications of effects of time constraints and income. The alternative activity categories are: (1) student or unemployed; (2) retired; (3) farmer or sales; (4) unskilled blue collar; (5) skilled blue collar and professional; (6) manager. Thus, opportunity time cost, but not monetary cost, is allowed to vary by occupation/alternative activity. The travel time variable is entered separately for these six categories. Sample size, estimated value of time, and average income for the six occupation/alternative activity categories are summarized in Table 5 . The linear functional form (regression not shown) as opposed to other functional forms tested (shown in Tables 3 and 4) results in very low levels of significance for 4 of the 6 opportunity time cost variables.

Table 5 shows the estimated opportunity time cost values disaggregated for the 6 occupation/alternative activity categories based on the linear, logarithmic transformed and Box-Cox transformed travel cost model. For the linear model, three of the opportunity time cost variables are significant at alpha = .05 or better. Categories 3 and 6 have a very low estimated time value and the coefficient in the numerator is not significantly different from zero. It is interesting that the groups containing unskilled blue collar (4) and students or unemployed (1) had higher estimates for the value of time than the average for all groups. It is perhaps not so surprising that retirees also had an above average value on time. The estimated time value does not appear to vary positively with average income. The square of the simple correlation of opportunity time cost and income shown in Table 5 is -0.63, -0.85 and -0.60 for the linear, log-log and Box-Cox models respectively. If only the 4 most significant coefficients are examined the correlation squared is still -0.25, -0.79 and -0.47. The unskilled blue collar, student or unemployed are relatively more willing than farm/sales, skilled/professional or managers to spend money rather than time for travel to the fishing site. This could result from the relatively fixed schedules of unskilled and students relative to farmer, skilled or professionals. Unskilled and students may be required to spend more time at work (study) than they would if not constrained by institutional requirements. Conversely, skilled blue collar, professionals and managers who visited the reservoir may value their time relatively less as compared to monetary travel costs because their positions allow them freedom to allocate their time as they desire.

The above outcomes are derived when the full sample of 200 visitors is studied. The outcomes are much different if a subset of visitors who could reach the site within a day were considered. The column labeled Box-Cox(b) in Table 5 contains opportunity time value estimates for these "local" visitors. In this group the opportunity time value estimates for most occupation/alternative activity categories have risen to approach those found for the unskilled blue collar group within the total sample. The tendency toward equality of time values at high levels might indicate that day trippers with fixed work schedules dominate among locals while those visiting from further away have more flexible schedules.[4]

The opportunity time cost values for the full sample found with the Box-Cox transformation and a logarithmic transformation of the dependent variable are also shown in Table 5. Four of the six categories are significantly different from zero with the Box Cox transformation. The Box-Cox transformation regression is similar to that found with the logarithmic transformation except that the coefficient values found for the weakly significant and non-significant categories (student, farm/sales, unskilled) are larger with larger t values. When the Box-Cox transformation is applied to day-trippers the coefficients are all significant, generally much higher, and the time value estimates are much more uniform across occupations. This result is consistent with visitors whose time constraints reduce their recreation time below that which they desire as might be expected for many day trippers.

Table 6 shows the effect of eliminating long distance travel from the sample. Round trip time is eliminated first above 6 hours and then maximum trip time is extended in 2 hour increments. Sample size is too small or variation of the travel time variable too small to obtain significance for the essential regression coefficients for maximum trip time less than 6 hours. Three ways to estimate time value are shown.

First shown are the estimates using the coefficient ratios suggested by Ward, second are the simple dollars per hour of average reported income, and third are the implied time values using income in the TCM as suggested by McConnell and Strand. The estimated opportunity time values show no relationship to trip hours between 6 and 20 hours. The eight observations between 22-30 hours contain a discontinuity in estimated time value which corresponds to the jump in monetary out-of-pocket costs shown in figure 1. After 30 hours the estimates appear similar to the range found between 6 and 22 hours. The reason for the high monetary costs between 22-30 hours is unknown. However, it is clear that the jump in monetary costs has resulted in small values for b_1 which leads to inflated opportunity costs estimated in that same travel time interval. The implicit assumption that time value (y) is independent of trip length in hours (α), required by the methodology of using the coefficient ratio to estimate time value, is supported by the results reported in Table 6.

Table 6 also allows a comparison of three measures of time value, Ward TCM method, reported income method, and M-S TCM method. Both TCM methods generally indicate higher time values than the reported income method. This result is consistent with persons who value time above their average wage. Some may receive overtime compensation to equate their marginal wage to their time value while others may be constrained by work rules such that they would prefer to substitute recreation time for work time. The M-S method results in estimates of time value that are closer to the reported average incomes. Unfortunately, for the full sample, the M-S method resulted in an extremely small estimate of time value as the estimated coefficient on (income x travel time) dropped sharply. Inclusion of a very high income person in this group strongly influenced the M-S estimate while the Ward method was unaffected. Both the Ward method and the M-S method were affected by the anomaly in out-of-pocket costs which occurred in the 22-30 hour range. A conclusion for researchers is that if the M-S method is used the data must be purged of anomalies in the income and monetary cost data and if the Ward method is used the data must be purged of anomalies in the monetary cost data.

The estimates of opportunity time value shown in Table 7 and plotted in Figure 2 provide further evidence on the relationship or lack thereof to average income. A simple regression of opportunity time value on hourly income yields Opportunity Time Value = 47.11 -1.73 M with an adjusted R^2 = 0.274. If the first observation is deleted (because it is based on a monetary cost coefficients of low significance) no relationship is detected between average income and estimated opportunity time value. As was the case with the occupation/alternative activity analysis this evidence also shows lack of support for using a proportion of average income as a proxy for opportunity time value.

CONCLUSIONS

Ward's modification of the McConnell-Strand technique for measuring opportunity time value was tested in a travel cost model of reservoir fishing in Colorado. The average time value was found to be very close to that found by Bockstael, Strand, and Haneman in California. Examination of the empirical vagaries in our data revealed that the method is sensitive to possible error of measurement of out-of-pocket spending.

Error in estimated opportunity time value is directly proportional to measurement error in out-of-pocket costs.

The implicit assumption of the method that opportunity time value is independent of total time on trip was tested and found valid for our sample. However, coefficient estimates tended to be more strongly significant and estimated time value was often higher if trips over 16 hours round trip were eliminated from the data set. Thirty nine of the 200 observations were eliminated by this deletion. An apparent anomaly in the out-of-pocket cost data (about 8 observations) between 22 and 30 hours travel time in which travel cost was abnormally high may account for this result. Separation of the opportunity time value estimates into six occupation/alternative activity classes revealed large variation of estimated time value within the data. It was concluded from inspection of this variation and correlations with average hourly income as an alternative measure of time value that the latter measure was inaccurate possibly because institutional time constraints prevented hourly earnings from representing marginal valuation of time. Some categories such as students, retirees and unemployed have no market valuation or a much understated value for their time.

A further test of income as a predictor of time value was conducted by a separation of the sample into 16 classes deleting successive upper bounds of round trip time. Time values were estimated based on Ward's method, average hourly earnings, and the McConnell and Strand approach. Excluding the 22-30 hour estimates, the M-S method values were slightly above the actual hourly income while the Ward method estimates were considerable higher. The use of Ward's modification of the M-S technique which severs the connection between opportunity time value estimates and income ranges from $21.61 to $52.07 while the M-S approach ranges from $4.76 to $32.79. For the full sample of 200, the Ward method estimate of time value was $21.61 and the M-S method estimate only $4.76. Based on the realism of the implied value of time, inclusion in the TCM of travel time per trip rather than travel time valued at average income nominally appeared superior as a method to adjust the TCM equation for the opportunity time cost component of travel cost. The methods were both very sensitive to anomalies in the data. The Ward method was sensitive to anomalies in reported out-of-pocket cost while the M-S method was sensitive to anomalies in both reported monetary cost and reported income.

Detailed separation of the data revealed information not supplied by the total sample. Deleting the 8 observations between 22-30 hours where monetary costs were abnormally high and the 6 observations above 50 hours where income was abnormally high resulted in plausible time value estimates by both methods. For any subsample tested, the Ward method resulted in time value estimates that were higher than the M-S method. The M-S method yielded time value estimates higher than average income except in the 0-6 and above 50 hour intervals where some abnormally high incomes were reported.

Table 1. Definition of Variables

c = answer to, What part of trip costs are required? times reported trip cost.

D1 = 0 unless student or unemployed then is round trip travel hours.

D2 = 0 unless retired then is round trip travel hours.

D3 = 0 unless farmer or sales then is round trip travel hours.

D4 = 0 unless unskilled blue collar then is round trip travel hours.

D5 = 0 unless skilled blue collar or professional then is round trip travel hours.

D6 = 0 unless manager then is round trip travel hours.

α = round trip travel hours.

X1 = expected fish catch.

X2 = expected fish length.

X3 = days fish all areas per year.

X4 = round trip travel hours to substitute site.

X5 = income.

X6 = age.

X7 = age squared.

X8 = age cubed.

r = visits to Blue Mesa.

rb = a box-cox transformation on visits.

if variable name starts with "l" then there is a logarithmic transformation.

Travel hours are based on reported distances.

Table 2. OLS Linear Travel Cost Model to Infer Opportunity Time Cost[1]

200 OBSERVATIONS DEPENDENT VARIABLE = r

R-SQUARE = 0.3363 R-SQUARE ADJUSTED = 0.3012

LOG OF THE LIKELIHOOD FUNCTION = -808.000

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 189 DF	PARTIAL CORR.
c	-0.12008E-01	0.53460E-02	-2.2462	-0.1612
α	-0.22885	0.87403E-01	-2.6184	-0.1871
X1	0.34236	0.26066	1.3134	0.0951
X2	0.34580	0.62315	0.55492	0.0403
X3	0.23565	0.38079E-01	6.1885	0.4105
X4	0.66579E-02	0.95485E-02	0.69728	0.0507
X5	0.58989E-03	0.44688E-01	0.13200E-01	0.0010
X6	-7.4310	2.1961	-3.3837	-0.2390
X7	0.14152	0.47405E-01	2.9853	0.2122
X8	-0.84630E-03	0.32541E-03	-2.6007	-0.1859
CONSTANT	115.81	32.706	3.5409	0.2494

Opportunity Time Value = $19.06

1/ The demand relation is linear but age enters as a cubic.

Table 3 OLS Partially Logarithmic Transformed Travel Cost Model

200 OBSERVATIONS DEPENDENT VARIABLE = lr

R-SQUARE = 0.3820 R-SQUARE ADJUSTED = 0.3493

LOG OF THE LIKELIHOOD FUNCTION = -262.547

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 189 DF	PARTIAL CORR.
c	-0.97126E-03	0.32669E-03	-2.9730	-0.2114
α	-0.22561E-01	0.56749E-02	-3.9756	-0.2778
lX1	0.32470	0.10889	2.9820	0.2120
lX2	0.60657	0.49581	1.2234	0.0886
lX3	0.32526	0.82310E-01	3.9517	0.2763
lX4	-0.40998E-01	0.56150E-01	-0.73016	-0.0530
lX5	-0.19258E-01	0.12526	-0.15374	-0.0112
X6	-0.49864	0.14721	-3.3871	-0.2392
X7	0.96986E-02	0.31397E-02	3.0890	0.2192
X8	-0.58875E-04	0.21354E-04	-2.7571	-0.1966
CONSTANT	6.1868	2.4362	2.5396	0.1817

Opportunity Time Value = $23.23

Table 4 OLS TCM Regression with Box-Cox Transformation of Dependent Variable

200 OBSERVATIONS DEPENDENT VARIABLE = rb

R-SQUARE = 0.3671 R-SQUARE ADJUSTED = 0.3337

LOG OF THE LIKELIHOOD FUNCTION = -94.1491

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 189 DF	PARTIAL CORR.
c	-0.57461E-03	0.15063E-03	-3.8147	-0.2674
α	-0.12071E-01	0.24627E-02	-4.9016	-0.3358
X1	0.22191E-01	0.73446E-02	3.0215	0.2147
X2	0.20972E-01	0.17558E-01	1.1944	0.0866
X3	0.28246E-02	0.10730E-02	2.6326	0.1881
X4	0.40125E-03	0.26904E-03	1.4914	0.1078
X5	0.13083E-02	0.12592E-02	1.0390	0.0754
X6	-0.20456	0.61880E-01	-3.3058	-0.2338
X7	0.39729E-02	0.13357E-02	2.9744	0.2115
X8	-0.23820E-04	0.91691E-05	-2.5978	-0.1857
CONSTANT	3.2844	0.92154	3.5641	0.2510

Opportunity Time Cost = $21.01

Table 5 Opportunity Time Value by Occupation/Alternative Activity: Estimated in Linear, Logarithmic or Box-Cox Transformation Travel Cost Models

Occupation Category	Sample Size	Time Value				Income	
		Linear	Logarithmic	Box-Cox(a)	Box-Cox(b)[2]	$ per year	$ per hour
1 student/unemployed	12	28.68[1]	38.73	29.80	58.16	17,167	8.58
2 retired	48	39.68	26.68	27.49	51.18	30,104	15.05
3 farm/sales	19	8.91[1]	7.06[1]	10.59[1]	42.62	43,684	21.84
4 unskilled	9	66.07[1]	44.38[1]	50.25	48.17	19,666	9.83
5 skilled/professional	97	23.87	22.87	20.68	42.51	41,711	20.86
6 manager	14	2.80[1]	10.78[1]	13.85[1]	45.58	63,214	31.61

1/ Coefficient is not significantly different from zero at alpha = 5% using a 2 tail t test.

2/ Box-Cox(b) limited to single day trips (round trip travel time limited to 16 hours) see appendix table 3.

SOURCE: Linear regression not shown, logarithmic and Box-Cox regressions shown in Appendix Tables 4 and 5.

Table 6 Estimated Opportunity Value of Time and Estimated Proportion of Hourly Income As Sample Is Restricted to Exclude Distant Origins (Dependent Variable is Box-Cox Transformation of Trips)

	Ward Method		*Actual Wages*		*M-S Method*
Round Trip Maximum Hours In Sample	Estimated Opportunity Time Value (b_2/b_1) (dollars/hour)	Sample Size	Average Income (dollars/hour)	Estimated Opportunity Time Value Coefficient on Income	Estimated Opportunity Value (dollars/hour)
0-6	21.28	59	16.03	0.6116	9.8
0-8	55.85	81	16.41	1.9985	32.79
0-10	43.92	114	18.07	1.0133	18.31
0-12	42.01	141	18.12	1.1929	21.62
0-14	45.51	157	18.27	1.3595	24.84
0-16	49.12	161	17.99	1.4934	26.87
0-18	42.01	165	17.91	1.4064	25.19
0-20	52.07	167	17.99	1.7400	31.3
0-22	98.85	170	18.00	3.0000	54.00
0-24	"	"	"	"	"
0-26	70.48	175	18.11	2.1993	39.83
0-28	70.73	176	18.06	2.1425	38.69
0-30	102.14	178	18.32	3.4931	63.99
0-40	36.14	187	18.56	1.0509	19.51
0-50	30.95	194	18.47	1.2023	22.21
all data	21.61	200	19.07	0.2495	4.76

Table 7 Opportunity Time Value Estimates When Data Are Ordered by Income

Avg. Income (dollars)	Avg. Income per Hour	Estimated Opportunity Time Value ($/hour)	Sample Size
20,826	10.41	39.55[1]	92
23,588	11.79	26.25	119
25,572	12.79	17.11	138
28,032	14.02	16.64	158
32,973	16.49	17.59	184
34,513	17.26	14.57	191
38,135	19.07	21.61	200

1/ The t value on monetary cost for this case is 1.65 which is not quite significant at the 10 percent level with a 2 tail test. All other coefficients used in constructing the table are significant at 5 percent or better.

Appendix Table 1 Box-Cox Functional Form Tests (t values are shown in parentheses)

	Linear	Double-Log	Semilog(a)[1]	Semilog(b)[1]	Reciprocal	Log Reciprocal	Reverse Reciprocal	Full[2] Box-Tidwell
lambda r (trips)	1	0	0	1	1	0	-1	free
lambda c	1	0	1	0	-1	-1	1	free
lambda z_1 X3	1	0	1	0	-1	-1	1	free
lambda z_2 X1	1	0	1	0	-1	-1	1	free
lambda z_3 (v2)[4]	1	0	1	0	-1	-1	1	free
lambda z_4 X6	1	0	1	0	-1	-1	1	free
lambda α (v1)[4]	1	0	1	0	-1	-1	1	free
b_0 constant	1.7027	1.8925	0.3397	28.2290	155.56	6.0671	0.2566	1.8925
	(0.41)	(2.80)	(1.22)	(2.45)	(1.81)	(0.81)	(2.70)	(2.80)
b_c c	-0.0099	-0.3448	-0.0011	-4.5214	-102.55	-4.9770	-0.0004	-0.3448
	(-1.93)	(-5.88)	(-3.10)	(-4.53)	(-16.13)	(-9.03)	(-3.14)	(-5.88)
b_1 X3	0.2360	0.3276	0.0111	6.4946	30.512	2.7890	0.0018	0.3276
	(8.32)	(5.59)	(5.81)	(6.50)	(2.47)	(2.61)	(2.76)	(5.59)
b_2 X1	0.3190	0.2712	0.0504	1.0233	4.9411	0.9318	0.0187	0.2712
	(1.39)	(3.37)	(3.06)	(0.75)	(1.29)	(2.80)	(3.32)	(3.37)
b_3 v2	0.0329	0.0112	0.0044	-0.3384	-4.4713	-0.2251	0.0016	0.0112
	(0.70)	(0.26)	(1.40)	(-0.46)	(-2.14)	(-1.24)	(1.51)	(0.26)
b_4 X6[3]	-0.0384	0.2427	0.0043	-0.4234	15.940	4.2056	0.0017	0.2427
	(-0.52)	(1.46)	(0.87)	(-0.15)	(0.18	(0.53)	(0.98)	(1.46)
b_α v1	-0.0130	-0.4082	-0.0014	-4.5752	-97.027	-7.8851	-0.0005	-0.4082
	(-2.99)	(-5.70)	(-4.78)	(-3.75)	(-5.71)	(-5.33)	(-4.92)	(-5.70)
Log Likelihood	-809.828	-385.478	-443.038	-779.528	-731.849	-415.750	-401.119	-385.478
R Squared Adj.	0.303	0.614	0.313	0.485	0.6804	0.4772	0.2653	0.614

1/ Semilog(a) has the log transformation on the left hand side variable while semilog(b) has the transform on the right hand side variables.

2/ The full Box-Tidwell model allows lambdas for both the dependent and all independent variables to be estimated and the results were identical with that when all lambdas were forced to zero. Thus the log linear model was superior.

3/ Experimentation based on previous studies revealed that age was not monotonic and a cubic in age was substituted in the regression used for the analysis.

4/ v1 is 1-way road miles from origin to fishing site, v2 is miles to substitute site. Travel time is assumed proportional to miles.

Appendix Table 2 Averages, Standard Deviations, Maximum and Minimum Values

Series	Mean	Std. Dev.	Variance	Minimum	Maximum
lr	0.86495	1.1468	1.3150	0.0	4.5951
lc	4.1692	1.3121	1.7216	0.0	7.8240
lα	2.1314	1.0766	1.1590	-2.3026	4.3820
lX1	1.7468	0.65999	0.43558	0.0	3.0910
lX2	2.5483	0.13984	0.19556E-01	1.9459	2.8332
lX3	3.2622	0.84356	0.71159	1.0986	4.5951
lX5	3.4465	0.65954	0.43500	1.0986	5.5215
c	145.74	258.03	66581.	1.0000	2500.0
α	13.409	13.892	192.98	0.10000	80.000
r	6.7351	16.921	286.30	1.0000	99.000
X1	6.9450	4.1591	17.298	1.0000	22.000
X2	12.905	1.7031	2.9005	7.0000	17.000
X3	35.795	27.546	758.76	3.0000	99.000
X5	38.135	26.357	694.70	3.0000	250.00
X6	48.745	14.489	209.94	20.000	77.000
X7	2585.0	1411.0	0.19911E+07	400.00	5929.0
X8	0.14612E+06	0.11121E+06	0.12368E+11	8000.0	0.45653E+06
D1	0.48300	3.8200	14.592	0.0	50.000
D2	3.3860	9.3083	86.644	0.0	70.000
D3	1.6255	7.2275	52.236	0.0	60.000
D4	0.36425	1.9540	3.8180	0.0	12.500
D5	6.4425	10.785	116.33	0.0	60.000
D6	1.1075	6.5242	42.565	0.0	80.000
rb	0.46323	0.48825	0.23839	0.0	1.4060

Appendix Table 3 OLS TCM Opportunity Time Value Estimation Excluding Overnight Travel With Opportunity Time Cost Disaggregated by Occupation

(data limited to 16 hours travel round trip)

161 OBSERVATIONS DEPENDENT VARIABLE = rb

R-SQUARE = 0.5417 R-SQUARE ADJUSTED = 0.4943

LOG OF THE LIKELIHOOD FUNCTION = -50.9130

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 145 DF	PARTIAL CORR.	TIME VALUE ($/HOUR)
c	-0.12170E-02	0.36074E-03	-3.3736	-0.2698	
αD1	-0.70778E-01	0.18220E-01	-3.8847	-0.3070	$58.16
αD2	-0.62288E-01	0.11798E-01	-5.2794	-0.4015	51.18
αD3	-0.51864E-01	0.12840E-01	-4.0394	-0.3180	42.62
αD4	-0.58619E-01	0.14760E-01	-3.9715	-0.3132	48.17
αD5	-0.51730E-01	0.89403E-02	-5.7861	-0.4331	42.51
αD6	-0.55475E-01	0.13826E-01	-4.0124	-0.3161	45.58
X1	0.28914E-01	0.76002E-02	3.8044	0.3013	
X2	0.26064E-01	0.18716E-01	1.3926	0.1149	
X3	0.40297E-02	0.11119E-02	3.6243	0.2882	
X4	0.95613E-03	0.11649E-02	0.82077	0.0680	
X5	0.32833E-03	0.13059E-02	0.25142	0.0209	
X6	-0.14673	0.60675E-01	-2.4183	-0.1969	
X7	0.28449E-02	0.13200E-02	2.1553	0.1762	
X8	-0.16954E-04	0.90846E-05	-1.8662	-0.1531	
CONSTANT	2.6293	0.90676	2.8997	0.2341	

Appendix Table 4 OLS Partially Logarithmic Transformed Travel Cost Model With Opportunity Time Cost Disaggregated by Occupation

200 OBSERVATIONS DEPENDENT VARIABLE = lr

R-SQUARE = 0.4169 R-SQUARE ADJUSTED = 0.3693

LOG OF THE LIKELIHOOD FUNCTION = -256.739

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 184 DF	PARTIAL CORR.
C	-0.12354E-02	0.37819E-03	-3.2665	-0.2341
αD1	-0.47853E-01	0.18357E-01	-2.6068	-0.1887
αD2	-0.32957E-01	0.93674E-02	-3.5183	-0.2511
αD3	-0.87271E-02	0.10135E-01	-0.86109	-0.0634
αD4	-0.54827E-01	0.35415E-01	-1.5481	-0.1134
αD5	-0.28251E-01	0.74180E-02	-3.8085	-0.2703
αD6	-0.13320E-01	0.11935E-01	-1.1160	-0.0820
lX1	0.34239	0.10872	3.1492	0.2261
lX2	0.62231	0.49645	1.2535	0.0920
lX3	0.37309	0.82255E-01	4.5358	0.3171
X4	0.11278E-02	0.75234E-03	1.4990	0.1098
lX5	-0.80809E-01	0.12649	-0.63883	-0.0470
X6	-0.46352	0.14693	-3.1547	-0.2265
X7	0.87227E-02	0.31361E-02	2.7814	0.2009
X8	-0.50568E-04	0.21346E-04	-2.3690	-0.1720
CONSTANT	5.6370	2.4027	2.3462	0.1704

Appendix Table 5 OLS Partially Box-Cox Transformed Travel Cost Model With Opportunity Time Cost Disaggregated by Occupation

200 OBSERVATIONS DEPENDENT VARIABLE = rb
R-SQUARE = 0.3861 R-SQUARE ADJUSTED = 0.3361
LOG OF THE LIKELIHOOD FUNCTION = -91.1052

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 184 DF	PARTIAL CORR.
c	-0.59482E-03	0.16672E-03	-3.5677	-0.2544
αD1	-0.20539E-01	0.80144E-02	-2.5628	-0.1856
αD2	-0.14003E-01	0.41173E-02	-3.4011	-0.2432
αD3	-0.55337E-02	0.44375E-02	-1.2470	-0.0915
αD4	-0.29936E-01	0.15319E-01	-1.9542	-0.1426
αD5	-0.13046E-01	0.32025E-02	-4.0738	-0.2876
αD6	-0.10836E-01	0.52575E-02	-2.0610	-0.1502
X1	0.22815E-01	0.73753E-02	3.0935	0.2223
X2	0.23696E-01	0.17825E-01	1.3294	0.0975
X3	0.29120E-02	0.10857E-02	2.6821	0.1940
X4	0.49846E-03	0.32783E-03	1.5205	0.1114
X5	0.64438E-03	0.13071E-02	0.49298	0.0363
X6	-0.19708	0.62222E-01	-3.1673	-0.2274
X7	0.37455E-02	0.13440E-02	2.7868	0.2012
X8	-0.21882E-04	0.92318E-05	-2.3703	-0.1721
CONSTANT	3.2139	0.92381	3.4790	0.2484

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Endnotes

1. The travel cost model methodology was established with the implicit assumption that travel has no utility or disutility. The omission from price of any measures of willingness to pay to avoid travel or conversely a willingness to pay to increase travel is apparent. If utility or disutility of travel is related to distance or travel time the required weak complementarity condition that trips have no value without visiting a site and a site has no value with out the trip is violated and the true travel costs are mistated (Bowes and Loomis, 1980).

2. A widely accepted methodology for revealing true marginal value of time within a survey has yet to be developed but it could involve a contingent valuation approach as used by Walsh, Sanders and McKean (1990).

3. This is our interpretation of the McConnell-Strand and Ward methodology and not necessarily the view of those authors.

4. The coefficients for this subset are all significant and generally all variables have higher significance levels than with the full sample.