The Impacts of Demographic Variables on the Price and Income Coefficients of the Travel Cost Model

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Abstract

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Economic and sociological studies have obtained significant statistical results for determinants of participation in recreation. We develop a recreational demand function incorporating socio-psychological factors. Economic value estimates of Ohio's Lake Erie water-oriented recreation activities with and without socio-psychological factors are compared. Consumer's surplus is over-estimated when socio-psychological factors are excluded.

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The travel cost model (TCM) is one of the mainstream economic methods in defining the demand function of a non-market commodity such as recreation (Wilman 1987, Caulkins et.al., Kealy and Bishop, Bockstael et al., Wilman 1980). Meanwhile, sociological studies have been conducted on identifying covariates and factors/barriers of participation in outdoor recreation (Napier et al., Searle and Jackson, Romsa and Hoffman). Both economic and sociological studies have obtained significant statistical results in recognizing the determinants of participation of recreation activities.

In this paper, we propose to incorporate socio-psychological or demographic factors into the consumer's economic behavior based on prior work by Pollak and Wales (1981). Based on the TCM, we develop a socio-economic recreational demand function incorporating socio-psychological factors which we then test empirically. Economic value estimates of Ohio's Lake Erie water-oriented recreation activities with and without socio-psychological factors are compared, based on the estimated recreation demand function.

Socio-economic Recreational Demand

In this section we incorporate demographic variables into the TCM. Searle and Jackson found that work commitments and "no opportunity to participate near my home" presented two barriers to recreation participation. Romsa and Hoffman argued that "participation rate would be a function of the cost and the time required to participate -----".

(2) $Z = g\ (P, Y, \beta(D))$

where P denotes the price vector (P_X, P_Z) and β is the parameter vector $(\beta_X, \beta_Z, \beta_Y)$ and also a function of D.

We now use specifications developed by Pollak and Wales (1980,1981) to generate more explicit formulation of equation (2). Five general procedures for incorporating demographic variables into a demand system were developed by Pollak and Wales: demographic translating, demographic scaling, the "Gorman procedure", the "reverse Gorman procedure", and the "modified Prais-Houthakker procedure".

With demographic translating, the demographic variables, D are first specified into a linear function

(3) $t_i = T_i\ (d_1 \text{ --- } d_n) = \Sigma\alpha_{ij}d_j$

and then the demand function is translated into

(4) $Z = g\ (P, Y, \beta(D)) = T_Z(D) + h\ (P, Y)$

In this demand function, only the T_Z depends on the demographic variables, where T_Z is the intercept of the demand function. Demographic variables generate parallel shifts in the demand curve under the translating procedure.

The demographic scaling procedure introduces the demographic variables into the demand function by specifying a function

(5) $s_i = S_i\ (\ d_1, \text{ --- }, d_n\ ) = 1 + \Sigma\delta_{ij}d_j, \quad i = x, z$

Under the scaling procedure, the slope of the demand curve changes when incorporating the demographic variable. For each good i, X and Z in our model, there is a corresponding s_i, given D. The s_i's vary with "demographic translating" was applied. However, translating was evaluated as the weakest of the five procedures in Pollak and Wales (1981).

We hypothesize that the Gorman procedure or the reverse Gorman procedure are appropriate specifications of the recreation demand function. For simplicity, we use the Gorman specification which yields the intercept as a linear function of the demographic variables:

(9) $Z = g\ (P,Y,\beta(D)) = t_z + s_z\ h\ (P_x s_x,\ P_z s_z,\ Y)$

where $t_z = \sum \alpha_{zj} d_j$, $s_i = 1 + \sum \delta_{ij} d_j$, $i = x, z$, d_j's are the demographic variables(d_1=family size, d_2=age of primary income earner (PIE), d_3=education of PIE).

Substitution of the simplest travel cost linear demand function ($h(P,Y) = a + bP_z + cP_x + eY$) into equation (9) gives us the corresponding socioeconomic recreational demand function as:

$$Z = t_z + s_z\ h\ (P_x s_x,\ P_z s_z,\ Y)$$

$$= t_z + s_z\ (a + bP_z s_z + cP_x s_x + eY)$$

(10) $$= t_z + as_z + bs_z^2 P_z + cs_z s_x P_x + es_z Y$$

(11) $$= [T_z(d_1, ---, d_n) + aS_z(d_1, ---, d_n)] + [bS_z^2(d_1, ---, d_n)]P_z + [cS_{zx}(d_1, ---, d_n)]P_x + [eS_z(d_1, ---, d_n)]Y$$

(12) $$= f_0(d_1, ---, d_n) + f_z(d_1, ---, d_n)P_z + f_x(d_1, ---, d_n)P_x + f_y(d_1, ---, d_n)Y$$

(13) $$= \mathbf{f_0(D) + f_z(D)\ P_z + f_x(D)\ P_x + f_y(D)\ Y}$$

where $f_i(D)$ are the coefficients functions of P_z, P_x, and Y. If the

(14) $Z_i^* = X_i'\beta + U_i \quad i = 1, 2, \ldots, n$

(15) $= f_0(D) + f_x(D)P_x + f_y(D)Y + f_z(D)P_z + U_i$

$Z_i = Z_i^* \quad \text{if } Z_i^* > 0$

$= 0 \quad \text{otherwise}$

where Z_i, the number of trips made by the sample respondents equals zero for non-participants and equals Z_i^*, the number of trips actually made, for participants. The vector U_i is assumed to be independently and normally distributed, with mean zero and a common variance σ^2.

The variable P_z is measured as the cost to the individual, participants and non-participants, for traveling from home to Lake Erie. Price P_z is the round-trip vehicle cost calculated as:

(16) $P_z = DIST * (0.15 + 1.3/MPG)/GPSZ$

where DIST represents the weighted totl round trip miles from the individual's home to visited sites at Lake Erie, \$0.15 is the cost per mile of automobile ownership, maintenance, and oil, \$1.3 is the approximate price of gasoline per gallon in the year 1984, MPG is the miles travelled per gallon of gasoline reported by sample respondents, and GPSZ is the group size of the recreaional party reported by the participants. GPSZ is set equal to the sample mean for non-participants. Here we include only the monetary travel costs, and do not include on-site money expenditure or any cost for time.

Utilizing the Gorman specification, the functional form estimated is:

(17) $Z_i = a + bP_z + eY + \Sigma\beta_{1i}d_i + \Sigma\beta_{2i}d_iP_z + \Sigma\Sigma\beta_{3ij}d_id_jP_z + \Sigma\beta_{4i}d_iY$

standard normal variable $X_i'\beta/\sigma$, respectively. By maximizing the likelihood function, the estimates of the parameters of the socio-economic recreational demand function can be obtained.

When the complete model of equation (17) was estimated, no variables were statistically significant because of excessive multicolinearity. Equations (4)-(7) in Table 1 contain selected sets of demographic variables where most of the coefficients are statistically significant. Equation (3) contains only price and income; both coefficients are of expected signs and are significant. The log likelihood ratio of each equation with demographic variables as compared to equation (1) without any variables (LRT1) and equation (3) with price and income only (LRT2) are highly significant (Table 1).

Taking equation (6), as an illustration, the total effect to Z with respect to price, income, and family size are:

$$\partial Z/\partial P_Z = -0.357 - 0.487d_1 + 0.003d_2 - 0.008d_1d_2$$

$$\partial Z/\partial Y = 0.00004 - 0.00002d_3$$

$$\partial Z/\partial d_1 = 1.48 - 0.487P_Z + 0.008d_2P_Z$$

Family size and age interact significantly with price while education interacts significantly with income. Family size increases the magnitude of the price slope or elasticity while age decreases it. Education or schooling reduces the income effect.

In Table 2 we present the values of $\partial Z/\partial Y$ at the sample means of all variables. These calculated estimates of socio-economic demand function parameters are fairly close. Compared to equation 1 in Table 1, the magnitudes of all coefficients in the socio-economic demand are higher at the sample mean.

Table 2. Socio-economic demands estimates at mean demographic characteristics

Equation	$f_0(D)$	$f_Z(D)$	$f_y(D)$
4	1.968	-0.973	0.00007
5	1.649	-1.062	0.00014
6	1.654	-0.961	0.00014
7	2.004	-0.989	0.00011

Welfare estimates associated with the socio-economic recreation demand

Based on the estimated socio/economic recreation demand function and mean values of price, trips, and incomes, the average willingness to pay and the average consumer's surplus are presented in Table 3. The estimated willingness to pay ranges from $41.99 to $42.62, while the

Table 3. Average economic values.

Eq.	Willingness to pay ($/year/person)	Consumer surplus ($/year/person)
3	44.906	9.934
4	42.623	7.656
5	41.985	7.014
6	42.722	7.751
7	42.504	7.533

estimated WTP for equation 3, which does not incorporate socio/economic factors, is $44.91. Consumer's surplus is about $7 per person per year for the socio-economic recreation demand functions, while equation 3 implies much higher consumer surplus of $9.934. By multilying the population of 18 years old and over, which was about 7.8 million in 1984, aggregate consumer's surplus for socio-economic recreation demand gives estimates of approximately $54.6 million, while equation 3 gives $77.5

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