A Whale of a Good Time:
Exploring Flexibility in the Recreation Demand Model

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ABSTRACT

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This research seeks to produce more robust, less biased estimates from the two-constraint recreation demand model by applying globally flexible estimation techniques to travel cost data for California whale watching trips. While locally flexible functional forms do improve upon previously used restrictive forms imposed for estimation of travel cost models, specification errors occur unless the chosen form happens to coincide with the true unknown underlying form. A globally flexible functional form can consistently approximate the true function and its derivatives for all points in the sample range. This paper seeks to reduce specification error and improve accuracy of estimates from the two-constraint recreation demand model by using a globally flexible functional form.

The empirical model is based on a construction by Chalfant (1987), which combines Deaton and Muellbauer's AIDS model with the Fourier flexible form of Gallant. The resulting functional form preserves the aggregation properties of the PIGLOG class of preferences while approximating the true function within an arbitrary degree of precision. A comparison of model estimation results shows that the locally flexible AIDS model results in specification error. Further research of an extension of the model, which combines travel cost data with contingent valuation responses to hypothetical population enhancements, is briefly discussed.

Introduction

Traditional demand analysis tools do not necessarily generalize to the case of recreation demand due to the lack of observable market and price signals associated with its consumption. The time involved in a recreation trip can influence consumption decisions concerning whether to undertake the activity, and also the level of participation in the activity. First suggested by Hotelling, and formalized by Clawson in 1959, was the notion that travel time and costs could be used to estimate recreation demand models. This method, based on the notions of revealed preference, became formalized as travel cost method (TCM) which, in its many variations, is widely used for recreation demand modeling and estimation.

A significant development in recreation demand modeling is the two-constraint framework in which choices are made under both a money and time constraint (Bockstael *et al*; McConnell; Larson; Larson and Shaikh; Smith). However, empirical specification of these models is complex and data sets can be limited in scope, so assumptions are often imposed to simplify estimation. This can result in empirical models that lack a consistent link to the theoretical model defining the decision-making process of the consumer. It has recently been shown that the presence of the time constraint in the two-constraint recreation demand model provides additional structure to relate time and money variables (Larson and Shaikh). These relationships can be used to improve empirical specification of the two-constraint model.

It is possible to maintain notions of consumer demand and preference theory through the theory of the two-constraint model. An empirical model, based on the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer, is constructed using restrictions posed by the theoretical model. We incorporate a Fourier expenditure function, which uses global approximations to improve consistency, to enhance the flexibility of this empirical model. The benefits of global flexibility over local flexibility are examined in the recreation demand case.

The Two-Constraint Model

The omission of time as a relevant cost in the decision-making process leads to incomplete prices and budgets. Cesario and Knetsch indicated that to avoid correlation between variables, it is advantageous to create "full" costs and "full" budgets by combining all travel costs and time costs. The theoretical restrictions of a two-constraint utility maximization problem can be used to identify the appropriate specification of the empirical demand functions.

The two-constraint model uses theoretical developments of Smith (1986) and Bockstael *et al*. (1987). The indirect utility function is:

(1) $$V(\mathbf{p},\mathbf{t},z,M,T) = \max_{\mathbf{x}} \; u(\mathbf{x},z) + \lambda(M - \mathbf{px}) + \mu(T - \mathbf{tx})$$

where $u(\boldsymbol{x},z)$ is a twice continuously differentiable utility function of **x**, a vector of consumption goods with money prices **p**, and time prices **t**, and non-priced quality z. Choices are made subject to a money budget constraint M = **px** and a leisure time budget constraint T = **tx**. We assume that both constraints bind, which implies non-satiation, and that all time must be spent in some activity. The Lagrange multipliers λ and μ represent the marginal utility of income and the marginal utility of leisure time, respectively. Therefore, the money value (opportunity cost) of time is defined as the ratio of Lagrange multipliers, $\rho = \mu/\lambda = \mathrm{V}_T/\mathrm{V}_M$.

From the comparative statics of the model, the Marshallian demands, can be recovered through two separate versions of Roy's Identity:

$$\mathrm{x}_i(\mathbf{p},\mathbf{t},\mathrm{z},\mathrm{M},\mathrm{T}) \equiv -\mathrm{V}_{p_i}/\mathrm{V}_M \equiv -\mathrm{V}_{t_i}/\mathrm{V}_T$$

Larson and Shaikh (1997) show that from these identities, relationships exist between demand coefficients for money price and time price, as well as, for money budgets and time budgets. These relationships will hold regardless of whether or not he individual is trading at the margin or has a fixed work week. In either case, a sufficient condition uses the marginal value of time ρ, to express the demand arguments as full prices, $p_i = (p_i + \rho * t_i)$ and full budgets, $(M + \rho * T)$. This logic is carried over to the empirical model to maintain consistency with the theoretical developments. By constructing full prices and budgets, the dual expenditure functions that result from the two-constraint problem can be reduced to one "full" expenditure function. Hereafter, all prices and budgets and the expenditure function are defined as "full".

Locally Flexible Forms

Model implications can be ambiguous if restrictive functional forms are used. Therefore, it is beneficial to choose an integrable and flexible functional form. An integrable form uses imposed demand theory restrictions to ensure that the indirect utility function is recoverable from the demand equations. A flexible form contains enough model parameters to provide a local approximation at particular values of the price-income ratios (Deaton and Muellbauer). While locally flexible forms have been used extensively for demand analysis, only recently have they been used to estimate recreation demand (e.g. Creel; Larson, Shaikh and Loomis.).

The Almost Ideal Demand System

One of the advantages of the AIDS model over more commonly used empirical models of recreation, is its aggregation properties which are consistent with the price-independent, generalized-logarithmic (PIGLOG) class of preferences. PIGLOG preferences permit exact aggregation over consumers so demand can be analyzed for a rational, representative consumer. Deaton and Muellbauer define the cost function as:

(2) $$\log c(u,\mathbf{p}) = (1-u)\log\{a(p)\} + u\log\{b(p)\}.$$

The AIDS model is defined as flexible since it contains enough parameters so that at a single point, the derivatives are equal to those of an arbitrary cost function. It is defined as:

(3) $$\log a(p) = a_0 + \sum_k a_k \log p_k + \tfrac{1}{2}\sum_k \sum_j \gamma^*_{jk} \log p_k \log p_j \text{, and}$$

$$\log b(p) = \log a(p) + \beta_0 \prod_k p_k^{\beta_k}.$$

The resulting Marshallian share is:

(4) $$s_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(M/P),$$

where log P = log a(p) and M is total expenditure. Elasticities in the linear approximate AIDS model are calculated as $\hat{\varepsilon}_{ii} = -1 + \hat{\gamma}_{ii}/\hat{s}_i - \hat{\beta}_i$, for own price, $\hat{\eta}_i = 1 + \hat{\beta}/\hat{s}_i$, for income, and $\hat{\varepsilon}_{iz} = \hat{\gamma}_{iz}/\hat{s}_i$, as the elasticity with respect to quality.

Limitations of Local Flexibility

While the AIDS model provides both flexibility and integrability, there is no reason to believe a specific form of utility function for individual or aggregate consumption. White (1980) found that the estimates of a local approximation generally do not correspond to the expansion of the underlying utility function at the expansion point, therefore resulting in biased estimates. Therefore, specification error results from the local approximation unless the parametric specification happens to coincide with the true unknown underlying function. Even with potential limitations, the AIDS model has many beneficial properties for consumer demand analysis and provides a simple framework for estimation of share equations.

Global Flexibility and the Fourier Flexible Form

Gallant (1981) defines a measure to be globally flexible if it satisfies the requirements of the *Sobolev norm*. Following Elbadawi, *et al.* (1983), as a compact notation for partial differentiation, let

$$D^{\psi} f(x) = \frac{\partial^{\psi}}{\partial x_1^{\psi} \partial x_2^{\psi_2} \ldots \partial x_k^{\psi_k}} f(x)$$

where ψ is a K x 1 vector of nonnegative integers and $|\psi| = \sum_{i=1}^{k} |\psi_i|$, is the order of the partial derivative, and the function f(x) is a K x 1 vector. When ψ is the zero vector, $D^{\psi}f(x) = f(x)$. The *Sobolev norm* of the function f(x) is defined as, $\|f(x)\|_{m,X} = \max_{|\psi|^* \leq m} \sup_{x \in X} |D^{\psi} f(x)|$, where *m* is a nonnegative finite integer and X is the domain of the function f(x). Sobolev flexibility then, is global, since the supremum is over X. The Sobolev norm of the difference between the true function and the approximating model H(***x***,*ϕ*), (where x is a vector of exogenous variables and ϕ is the parameter vector) tends almost surely to zero: $\|f^*(x) - H(x, \hat{\phi})\|_{m,X} \to 0,$ almost surely.

A Fourier series approximation, a linear combination of sine and cosine functions, possesses Sobolev-flexibility. Because it has the ability to exactly represent any true function, a flexible functional form using a Fourier series should avoid the restrictive nature and limitations of a locally flexible functional form (Chalfant). For exact representation of a function, a Fourier series may require an infinite number of expansion terms. However, since data sets are finite, exactness is not generally feasible, and it is appropriate to use a Fourier series to approximate a function to an arbitrary degree of precision.

The Fourier form of Gallant (1981, 1982, 1984), uses a leading quadratic term with a multivariate Fourier series expansion. Generally, it can be written as:

(5) $$H(x|\theta) = u_0 + \mathbf{b}'\mathbf{x} + \tfrac{1}{2}\mathbf{x}'\mathbf{C}\mathbf{x} + \sum_{\alpha=1}^{A} \{u_{0\alpha} + 2[u_\alpha \cos(\lambda \mathbf{k}_\alpha{}' \mathbf{x}) + v_\alpha \sin(\lambda \mathbf{k}_\alpha{}' \mathbf{x})],$$

where the $\mathbf{k}_\alpha$'s are N x 1 vectors of positive and negative integers, λ is a scaling factor and **x** is a vector of logged prices and income. C is an N x N matrix defined by $C = -\sum_{\alpha=1}^{A} \lambda^2 u_{o\alpha} k_\alpha k_\alpha'$ and the vector of parameters is θ. The benefit of using the second order polynomial is that one can test if the Fourier form reduces to a more simple, locally flexible form, such as the AIDS.

The Fourier flexible form has been used to improve specification bias on elasticities (Chalfant and Gallant) and welfare estimates (Creel; Chen and Randall; Creel and Loomis). Chalfant (1987) combined a Fourier cost function with an AIDS specification resulting in a globally flexible functional form, that included the aggregation properties of the AIDS model. Following Chalfant's model, a globally flexible model is constructed and specified in the context of the recreation model by using full prices and budgets as defined previously, and by treating the time conversion factor (based on the reported wage) as an endogenous parameter to be estimated.

The Empirical Model

The empirical model replaces log a(P) from equation (3), of the AIDS model with the Fourier cost function in (5). The resulting "full" expenditure function is:

(6) $$\begin{aligned} \log e(p,z,u) = {} & u_0 + \mathbf{b}'\mathbf{x} + \tfrac{1}{2}\mathbf{x}'\mathbf{C}\mathbf{x} + \sum_{\alpha=1}^{A} \left\{ u_{0\alpha} + 2[u_\alpha \cos(\lambda \mathbf{k}_\alpha{}' \mathbf{x}) + v_\alpha \sin(\lambda \mathbf{k}_\alpha{}' \mathbf{x})] \right\} \\ & + u\beta_0 \prod_k p_k^{\beta_k} \end{aligned}$$

The Marshallian share equation is of the form:

(7) $$s_i = b_i - \lambda \sum_{\alpha=1}^{A} \{u_{0\alpha} \lambda \mathbf{k}' \mathbf{x} + 2[u_\alpha \sin(\lambda \mathbf{k}' \mathbf{x}) + v_\alpha \cos(\lambda \mathbf{k}' \mathbf{x})]\} \mathbf{k} \quad + B_1 \ln(M/P).$$

Own price elasticity is defined as $\hat{\varepsilon}_{ii}^{GF} = (-\lambda^2 (\hat{\gamma}_{ii} + \hat{u}_p \cos(\lambda \ln p_i) - \hat{v}_p \sin(\lambda \ln p_i)) / \hat{s}_i - 1$, and elasticity with respect to quality as $\hat{\varepsilon}_{iz}^{GF} = (-\lambda^2 (\hat{\gamma}_{1z} + \hat{u}_z \cos(\lambda \ln z) - \hat{v}_p \sin(\lambda \ln z)) \big/ \hat{s}_i$. Income elasticity is calculated as in locally flexible model since the Fourier cost function does not affect the income term. The combined, globally flexible, model reduces to the locally flexible AIDS model if the $u_{0\alpha}$'s correspond to the γ_{ij}'s from the AIDS and that the parameters on the expansion terms, the u_α's and v_α's, are all equal to zero. By estimating the γ_{ij}'s, directly in the unrestricted share equation in (7), a simple F test can be used to test reduction of the globally flexible model to the locally flexible one (Piggott 1997).

California Whale Watching

The data used to illustrate the model are from on-site intercepts of whale-watchers at four sites in California during the winter of 1991-92. The survey collected information on trips taken so far that season, expected future trips, travel time, travel costs, and whether or not the trip was their primary destination. It also collected data on actual contributions to marine mammal groups, time spent reading, watching, or thinking about wildlife and whales, as well as purchases of whale-related merchandise. Respondents' were asked to rate the relative importance of viewing whales, knowing whales exist, existence of whales for future generations, etc. Demographic information including work status and job structure related variables, wage rates, and income was also collected

Four goods can be used to define the time and money share systems from the whale-watching data set: whale-watching trips (x_1); time donations to whale- and marine mammal-related organizations (x_2); time volunteered for such organizations (x_3); and a numeraire good for consumption of all other goods (x_4). Each good has an associated money and time price which are used to construct a full price with the time conversion factor to be estimated. In some cases, the money or time price of a good may be zero or one. The time price of a money donation is negligible and assumed to be zero. The time price of a time donation is taken to be one, although realistically it could be greater than one due to transaction costs from driving to the site, etc. The money cost of a time donation represents transaction costs of donating time. The survey does not provide information on this variable but it is suspected to be small, thus it is taken to be zero.

In addition to the time and money prices, it is expected that the individual's whale-watching success will influence both trips demand and, potentially, the willingness to make donations of time and money. The quality variable (z) is the individual's ex-ante expectation of whale sightings for the whale-watching trip when they were contacted. Money budget (M) is the household income before taxes, and the time budget is amount of non-working time in the number of weekend and paid vacation days.

Model Estimation

Using SAS Version 6.12, incomplete demand systems using the trips (s1) share equations from (4) and (7) were estimated as the restricted and unrestricted models, respectively. Intercept dummies were included to account for differences in whale watching sites. The x vector is comprised of logged full own price (lp1f), logged full prices for time donations (lp2f) and money donations (lp3f), and logged quality (lz). The k_α terms are defined such that only first order Fourier expansions on own price and quality are used.

McConnell and Strand (1981) defined the opportunity cost of time as a constant times average income. We construct full prices and budgets similarly by defining the marginal value of time as, $\rho = v * w_i$, where v is a parameter to be estimated, and w_i, is the individual's reported wage. The value of v is not restricted to be less than one since the wage rate is not necessarily the upper bound of the value of leisure time (Bockstael, *et al.;* Larson; Larson *et al.*).

Preliminary Results

Table 1 provides the estimated parameters and standard errors for both models. The value of v, which when multiplied by the reported wage, converts time to money units, is significant in both models. The value of v is .65 in the restricted model and .9 in the unrestricted, indicating that the wage is greater than the implied value of time. This finding is consistent with other empirical studies, which have treated wage as the upper bound of the value of time (Smith, *et al.*; McConnell and Strand). The value of time varies by individual wage rates.

Both models found own price significant, however, none of the cross price estimates (time and money donations) are significant in either model and are omitted from the reported results for brevity. The first site dummy variable in the locally flexible model is significant, indicating possible variation by site choice. Two of the Fourier expansion terms are significant in the globally flexible model. While the coefficient estimates on the expansion terms are not interpretable on their own, the significance suggests their necessity in correctly approximating the true function. Quality (z) is also a significant in the globally flexible model.

Table 2 provides elasticities at the mean and median predicted shares, as well as the range of values for both models. The signs and magnitudes are as expected given the nature of the data. There does appear to be more variation in elasticities in the globally flexible model, although it is difficult to compare since income and quality effects were not significant in the locally flexible model. Whale-watching trips are own-price inelastic in both models, but close to one in the locally flexible model. Trips appear to be income inelastic, and normal, although roughly 8% of calculated elasticities are negative and the coefficient estimate borders on insignificant. The elasticity of trips with respect to quality is positive and less than one implying an inelastic effect.

Testing the AIDS Specification

A main objective of this research is to test for possible misspecification from choosing a fully parametric specification. By setting the Fourier expansion terms coefficients, v_z, u_z, v_p, and u_p to zero, the globally flexible model reduces to the locally flexible AIDS model. The null hypothesis that the Fourier expansion terms are zero is rejected ($F_{4,277} = 19.945$). This implies that under the PIGLOG preference assumption, the correct specification of the empirical model requires the Fourier expansion terms. In this case, the AIDS model does not correctly approximate the true underlying model or its derivatives, thereby resulting in specification error.

Summary and Further Research

This research improves upon traditionally used estimation methods for recreation demand by using a flexible and integrable functional form to link the theoretical and empirical models. However, we do not know how well the chosen form approximates the true underlying function. The AIDS specification of the model is tested through estimation of a globally flexible model, which approximates the true unknown function to an arbitrary degree of precision. The AIDS model, under the maintained hypothesis of PIGLOG preferences, results in specification error implying that the locally flexible model does not coincide with the true function. Since results are preliminary, some further research is warranted.

The value of time to varies with wage rate. However it was treated as a constant fraction across the sample. Ultimately, the opportunity cost of time varies by individual. Since demand analysis generally involves the "representative consumer", defining this empirically has proven quite problematic and warrants future research.

Combining Travel Cost and Contingent Valuation Data

An extension to this research combines the travel cost (TC) data with contingent valuation (CV) responses, in time and money donations, to hypothetical increases in whale populations. TC data provides a demand function for the existing activity while CV information further explains recreationists' behavior through WTP estimates for changes in quality. Combining the two, therefore, can more completely identify preferences for differing quality levels since respondents refer to the same preference set to answer questions about observed and stated behavior (Cameron; Larson, Loomis and Chien).

From the full, combined model, expenditure function, Hicksian WTP equations for two hypothetical quality changes are derived in both money and time donations units. The resulting set of equations consists of the share equation, as given previously, and two sets of WTP equations, all of which are linked by parameters and the error structure of the underlying expenditure function. Initial results are consistent with our reported findings, which show significance of the Fourier terms in the unrestricted model. Preliminary estimation shows significance of parameters from the expenditure function, which appear in the WTP equations and not in the share equations. These parameters represent values unaffected by demand implying positive nonuse value associated with enhancing gray whale populations. Further results will be available shortly and presented at the meetings.

In conclusion, this research has explored the differences in global and local approximations to an unknown underlying function. The preliminary results from this research warrant caution in interpreting elasticity or welfare estimates resulting from parametric models.

Table 1: Estimation Results

(291 observations, standard errors in parentheses)

Variable	*Coefficient*	*Locally Flexible Estimate*	*Globally Flexible Estimate*
Intercept	α_1	-0.0003	0.002389
		(.000711)	(.001694)
Wage Fraction	K	0.659304***	0.90602**
		(.20679)	(.39173)
Site 1 Dummy	D1	4.00E-06**	9.53E-06
		(1.95E-06)	(2.89E-05)
Site 2 Dummy	D2	-1.49E-07	-2.8E-04***
		(3.47E-06)	(.000105)
Site 3 Dummy	D3	-4.72E-06	-2.9E-04***
		(4.62E-06)	(8.49E-05)
Own Price	γ_{11}	1.07E-05***	-1.04E-03***
		(1.49E-06)	(.000194)
Quality	γ_{1Z}	3.32E-07	-.12E-04**
		(3.42E-07)	(5.06E-05)
Income	$\beta 1$	4.13E-05	-2.82E-04
		(7.96E-05)	(.000184)
Quality Sine Expansion	u_z		5.98227E-06
			(6.89E-05)
Quality Cos Expansion	v_z		9.16E-05**
			(4.06E-05)
Own Price Sine Expansion	u_p		1.575E-05
			(8.8E-05)
Own Price Cos Expansion	v_p		-4.3E-04***
			(.000115)

*significant at 10%, **significant at 5%, ***significant at 1%.

Table 2: Calculated Elasticities

	Locally Flexible Model				*Globally Flexible Model*			
Elasticity	At Med. Share	At Mean Share	Min	Max	At Med. Share	At Mean Share	Min	Max
ε_{11}	-0.97827	-0.98127	-0.99418	-0.40231	-.53821	-.646358	-.89015	1.924619
ε_{1z}	0.000663	0.00058	0.000181	0.018481	.104688	.078308	.019401	.475676
η_1	1.083702	1.072142	1.022538	3.297588	.622253	.667567	-.6518	.909533

References

Bockstael, N. E., I.E. Strand and W. M. Hanemann. "Time and the Recreation Demand Model." *American Journal of Agricultural Economics* 69 (1987): 293-302.

Cameron, T.A. "Combining Contingent Valuation and Travel Cost Data for the Valuation of Nonmarket Goods." *Land Economics.* 68 (1992): 302-17.

Cesario, F. J. and J.K. Knetsch. "Time Bias in Recreation Benefits Estimates." *Water Resources Research* 6 (1970): 700-704.

Chalfant, J. A. "A Globally Flexible, Almost Ideal Demand System." *Journal of Business and Economics Statistics* 5 (1987): 233-242.

Chalfant, J.A. and A.R. Gallant. "Estimating Substitution Elasticities with the Fourier Cost Function: Some Monte Carlo Results." *Journal of Econometrics* 28 (1985): 205-220.

Chen, H.Z. and A. Randall. "Semi-nonparametric Estimation of Binary Response Models with an Application to Natural Resource Valuation." *Journal of Econometrics* 76 (1997): 323-340.

Clawson, M. "Methods of Measuring the Demand for and Value of Outdoor Recreation." Washington, DC: Resources for the Future. 1959.

Creel, M. "Welfare Estimation Using the Fourier Form: Simulation Evidence for the Recreation Demand Case." *Review of Economics and Statistics* 79 (1997): 88-94.

Creel, M. and J.B. Loomis. "Semi-nonparametric Distribution Free Dichotomous Choice Contingent Valuation." *Journal of Environmental Economics and Management* 32 (1997): 341-358.

Deaton, A. and J. J. Muellbauer. "An Almost Ideal Demand System." *American Economic Review* 70 (1980): 312-326.

Diewert, W.E. "Intertemporal Consumer Theory and the Demand for Durables." *Econometrica* 42 (1974): 497-516.

Elbadawi, I., A.R. Gallant, and G. Souza. "An Elasticity Can be Estimated Consistently without a priori Knowledge of Functional Form." *Econometrica* 51 (1983): 1731-1751.

Gallant, A.R. "On the Bias in Flexible Functional Forms and an Essentially Unbiased Form: The Fourier Flexible Form." *Journal of Econometrics* 15 (1981): 211-45.

———. "Unbiased Determination of Production Technologies." *Journal of Econometrics* 20 (1982): 283-323.

———. "The Fourier Flexible Form." *American Journal of Agricultural Economics* 66 (1984): 204-208.

Larson, D.M. "Joint Recreation Choices and Implied Values of Time." *Land Economics* 69 (1993): 270-286.

Larson, D.M., J.B. Loomis and Y. Chien. "Combining Behavioral and Conversational Approaches to Value Amenities: An Application to Gray Whale Population Enhancement. Contributed Paper. AAEA Annual Meeting. Orlando, FL 1993.

Larson, D.M. and S.L. Shaikh. "Empirical Specification Considerations for Two-Constraint Models of Recreation Demand." Contributed Paper. American Agricultural Economics Association Annual Meeting. Toronto, Canada. 1997.

Larson, D.M., S.L. Shaikh and J.B. Loomis. "A Two-constraint AIDS Model of Recreation Demand and the Value of Leisure Time." Contributed Paper. XXII International Conference of Agricultural Economists. Sacramento, CA 1997.

McConnell, K.E. "Some Problems in Estimating the Demand for Outdoor Recreation." *American Journal of Agricultural Economics* 57 (1975): 330-39.

McConnell, K.E. and I.E. Strand. "Measuring the Cost of Time in Recreation Demand Analysis: An Application to Sportfishing." *American Journal of Agricultural Economic*s 63 (1981): 153-156.

Piggott, N.E. "The Benefits and Costs of Generic Advertising of Agricultural Commodities." Ph.D. Dissertation. Dept. of Agricultural and Resource Economics, University of California at Davis. 1997.

Smith, T.P. "A Comparative Static Analysis of the Two-constraint Case." Appendix 4.1 in Benefit Analysis Using Indirect or Imputed Market Methods, Vol.2, N.E. Bockstael, W.M. Hanemann and I.E. Strand, eds. Washington, D.C.: Report to the Environmental Protection Agency, 1986.

Smith, V.K., W.H. Desvousges and M.P. McGivney. "The Opportunity Cost of Travel Time in Recreation Demand Models." *Land Economics* 59 (1983): 259-277.

White, H. "Using Least Squares to Approximate Unknown Regression Functions." *International Economic Review* 21 (1980): 149-70.