HOW TO HANDLE HIGH PROPORTION OF ZERO OBSERVATIONS IN THE CROSS-SECTION STUDIES: APPLICATION TO NONRESIDENTIAL WILDLIFE WATCHING EXPENDITURES

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Abstract

This study used data extracted from the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation to analyze individuals' trip related expenditures associated with nonresidential wildlife watching activities based on utility maximization framework in a double hurdle model. Empirical results of this study indicated that income, age, gender, education level, fishing or hunting, use of private or public lands, wildlife category (i.e., mammals) and ecosystem category (including oceans, lakes, wetlands, open fields and man-made environments) had significant effects on nonresidential wildlife watching expenditures. The results provide insight into determinants of nonresidential wildlife watching expenditures, which all observations can be used in the estimation for participation decision, but only positive observations that pass participation and consumption decisions simultaneously can be used in the estimation based on a censored and truncated sample, allowing for richer interpretation of consumer behavior.

1.0 Introduction

Wildlife-based recreation plays an increasingly important role in outdoor recreation in the United States. It is evident that wildlife watching has grown in popularity in the U.S. This increasing trend in wildlife watching also shows that public interest in wildlife watching activities (such as observing, photographing, or feeding wildlife) extends well beyond consumptive wildlife recreation activities (i.e., fishing and hunting) (U.S. Fish and Wildlife Service 1993, 1997, 2002).

According to the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 82 million U.S. residents 16 years old and older participated in wildlife-based recreation activities. More than 34 million Americans fished, 13 million Americans hunted, and 66 million Americans participated in observing, photographing, or feeding wildlife in 2001 (U.S. Fish and Wildlife Service 2002).

Among wildlife watching participants, about 22 million Americans took trips of at least 1 mile away from home to participate in these activities. More than 20 million participants observed wildlife, while 7 million fed birds and other wildlife, and 9 million photographed wildlife at least 1 mile away from home in 2001 (U.S. Fish and Wildlife Service 2002).

In addition to the popularity of participation in wildlife watching, expenditures on these activities are large enough to rival consumptive wildlife recreation activities. For example, total wildlife-based recreation expenditures were $70 billion in 2001, with $28.1 billion spent on trip-related costs, $64.5 billion spent on equipment, and $15.8 billion spent on other related items. Anglers spent a total of $35.6 billion, hunters spent a total of $20.6 billion, and wildlife watching participants spent a total of $38.4 billion in 2001 (U.S. Fish and Wildlife Service 2002).

According to the 1991, 1996, and 2001 National Surveys of Fishing, Hunting, and Wildlife-Associated Recreation, participation in wildlife watching decreased from 76.1 million in 1991 to 62.9 million in 1996, but it increased to 66.1 million from 1996 to 2001. Expenditures for trip-related costs and equipment increased by 21 percent from 1991 to 1996, and 10 percent from 1996 to 2001 (U.S. Fish and Wildlife Service 1993, 1997, 2002).

In spite of its growing popularity, wildlife watching has received only cursory attention in the literatures of natural resource economics and related fields. Most research conducted on wildlife watching has been on the participation aspects (Hay and McConnell 1979; Hay and McConnell 1984; Shaw and Mangun 1984; Rockel and Kealy 1991; Smith and Luzar 1995; Chi et al. 2000). There have been only a few studies on wildlife watching activities (Shaw and Mangun 1984) and fewer on valuation of wildlife watching sites (Clayton

and Mendelsohn 1993). In addition, there also have been only a few studies on wildlife watching and leisure expenditures (Thompson and Tinsley 1978; Dardis et al. 1981; Dardis et al. 1994; Chi and Luzar 1997; Chi and Luzar 1998; Chi and Luzar 1999).

However, wildlife managers are often faced not only with increasing participation in wildlife watching activities relative to consumptive wildlife recreation activities, but also with the problems of where and how to obtain revenues to support public policies for wildlife watching uses. In particular, expenditure analyses provide information about how different socio-economic groups allocate their resources toward this wildlife watching activity. In the absence of this information, it is assumed that no difference exists between wildlife watching and consumptive recreation participants in their demand for wildlife-based recreation. Also, recognition of sample and data related issues (censored, truncated samples) common to expenditure models could improve measurement reliability.

The purpose of this study is to analyze the socio-economic characteristics associated with individual consumption behavior of primary nonresidential wildlife watching expenditures. It may contribute to a better understanding of current and future individual consumption behavior on primary nonresidential wildlife watching activities, which is defined as any trip or outing that is taken at least one mile from home for the primary purpose of observing, photographing, or feeding wildlife.

2.0 Conceptual Model

An analysis of wildlife watching expenditures can benefits from the use of more appropriate economic analysis and measurement to comprehend the full value of this type of wildlife-based recreation activity within the framework of wildlife management. In particular, analyzing wildlife watching expenditures in the framework of an individual who must allocate a constrained budget to maximize utility improves our understanding of the tradeoffs made in this process.

A conceptual model of wildlife watching activities was developed by integrating three components: wildlife watching participants, wildlife resources, and wildlife habitats. This conceptual model demonstrates the context of the human-wildlife interaction and provides a framework that identifies utility maximization as the ultimate objective for the participants in wildlife watching in terms of their consumption decisions. Wildlife watching can be viewed as an intermediate interface between the wildlife watching participants and wildlife and its habitat. Wildlife watching participants can be treated as the demand sector and wildlife resources and habitats can be treated as the supply sector in the conceptual model. Without adequate wildlife resources and habitats, there would be far fewer or no participants in wildlife-based recreation activities.

Based on the consumer demand theory, the primary nonresidential wildlife watching expenditure equation evaluates the relationship between individuals' trip-related expenditures and his or her socio-economic characteristics and wildlife-attribute variables, which can be specified as:

Expenditure = f(High Income, Mid Income, Age, Male, Married, College, Minority, Cross-Over, Private Land, Public Land, Bird, Mammal, Ocean, Lake, Marsh, Forest, Brush, Open Field, Manmade, μ) (1)

where

Expenditure = Trip-related expenditures on nonresidential wildlife watching activities;
High Income = 1 if respondent's household income greater than $50,000; 0 otherwise;
Mid Income = 1 if respondent's household income between $30,000 and $50,000; 0 otherwise;
Age = Respondent's age (in year; 16 years old and older);
Male = Respondent's gender; 1 if male; 0 otherwise;
Married = Respondent's marital status; 1 if married; 0 otherwise;
College = Respondent's education level; 1 if at least attended college; 0 otherwise;
Minority = Respondent's ethnicity; 1 if minority; 0 otherwise;
Cross-Over = 1 if respondent fished or hunted; 0 otherwise;
Private Land = 1 if respondent visited any areas on private land at least a mile from home; 0 otherwise;
Public Land = 1 if respondent visited any areas on public land at least a mile from home; 0 otherwise;

Bird	= 1 if respondent observed, photographed, or fed birds at least a mile from home; 0 otherwise;
Mammal	= 1 if respondent observed, photographed, or fed mammals at least a mile from home; 0 otherwise;
Ocean	= 1 if respondent observed, photographed, or fed wildlife on an ocean side at least a mile from home; 0 otherwise;
Lake	= 1 if respondent observed, photographed, or fed wildlife on a lake or stream side at least a mile from home; 0 otherwise;
Marsh	= 1 if respondent observed, photographed, or fed wildlife on a marsh, wetland, or swamp at least a mile from home; 0 otherwise;
Forest	= 1 if respondent observed, photographed, or fed wildlife at a woodland at least a mile from home; 0 otherwise;
Brush	= 1 if respondent observed, photographed, or fed wildlife at a brush-covered area at least a mile from home; 0 otherwise;
Open Field	= 1 if respondent observed, photographed, or fed wildlife at an open field at least a mile from home; 0 otherwise;
Manmade	= 1 if respondent observed, photographed, or fed wildlife at a man-made area (golf course, cemetery, urban park, etc.) at least a mile from home; 0 otherwise;
μ	= Error term.

Trip-related expenditures on nonresidential wildlife watching activities include: (1) food, drink, and refreshments; (2) lodging of motels, cabins, lodges, campgrounds, etc.; (3) public transportation, including airplanes, trains, buses, and car rentals; (4) the round trip cost for transportation by private vehicle; (5) guide fees, pack trip or package fees; (6) public land use or access fees; (7) private land use or access fees (not including leases); (8) equipment rental as boats, camping equipment, etc.; (9) boat fuel; (10) other boat costs (such as launching, mooring, storing, maintenance, pump out fees, insurance); and (11) heating and cooking fuel (U.S. Fish and Wildlife Service 2002).

3.0 Econometric Model

According to consumer demand theory, wildlife watching participant attempts to maximize his/her utility from wildlife watching subject to his/her budget constraint. Thus, the maximization of the utility function for individual consumption behavior associated with wildlife watching can be stated as follows:

$$\begin{aligned} &\text{Maximize} && u = u(q, x, w) \\ &\text{Subject to} && pq = I \end{aligned} \qquad (2)$$

where $u(.)$ represents the utility function which is assumed to be continuous, increasing, and quasi-concave, q is a vector of market goods the individual purchased for wildlife watching, p is a vector of corresponding market prices for market goods, x denotes a vector of individuals' socio-economic characteristics, w denotes a vector of wildlife-attribute variables, and I is individuals' household income. The demand function can be derived from the analysis of utility maximization problem in terms of market prices, socio-economic characteristics, wildlife-attribute variables and monetary budget. In practice, prices are typically assumed constant with the cross-sectional data.

A better understanding of the nature of the data helps in selecting an appropriate econometric model for this research. In practice, the sample containing observations with reported zero expenditure present a unique problem with cross-sectional survey data. Using standard econometric techniques, the parameter estimates are biased and inconsistent (Maddala 1983; Judge et al. 1988; Greene 1997). For example, regression analysis based on nonzero observations of the dependent variable can lead to biased parameter estimates.

In general, researchers have often used the Tobit model to estimate demand relationships with limited dependent variables. However, the Tobit model is very restrictive in its parameterization, which implies that the probability of consumption and the level of consumption are determined by the same sets of variables and parameters. Hence, drawing inferences from the Tobit model would lead to erroneous conclusions, especially the sample containing a high proportion of zero observations in the cross-sectional survey data.

The double hurdle model, originally proposed by Cragg (1971), is established as a useful extension of the univariate Tobit model because it allows two separate stochastic processes for participation and consumption

(Cragg 1971; Jones 1989). According to the double hurdle model, individuals have to pass two separate hurdles before they are observed with a positive level of consumption. The double hurdle model may provide a better interpretation of consumer behavior, which takes into account the probability of consumption and the level of consumption. The double hurdle model can be written as, for $i = 1, \ldots, n$:

$$\begin{aligned} y_i = y_i^*, \quad & \text{if} \quad w_i = z_i'a + u_i = 1, \quad y_i^* = x_i'\beta + e_i > 0, \\ y_i = 0, \quad & \text{if} \quad w_i = z_i'a + u_i = 1, \quad y_i^* = x_i'\beta + e_i \le 0, \\ & \text{or} \quad w_i = z_i'a + u_i = 0, \quad y_i^* = x_i'\beta + e_i > 0, \\ & \text{or} \quad w_i = z_i'a + u_i = 0, \quad y_i^* = x_i'\beta + e_i \le 0 \end{aligned} \tag{3}$$

where w_i characterizes the decision of whether to participate in primary nonresidential wildlife watching activity; z_i is a vector of explanatory variables that influence participation; y_i is the individual observed expenditure, y_i^* is the corresponding desired expenditure, x_i is a vector of explanatory variables that influence expenditures; α and β are the vectors of unknown parameters for the participation and expenditures, respectively; and u_i and e_i are independently and normally distributed error terms with distribution $N(0, 1)$ and $N(0, \sigma^2)$, respectively. Meanwhile, $\Phi(.)$ and $\Phi(.)$ denote the standard normal density and distribution functions, respectively.

For the observations y_i's that are zero,

$$Prob\,(y_i = 0) = 1 - Prob\,(w_i > 0)\; Prob\,(y_i > 0) = 1 - \Phi(z_i'\sigma)\;\Phi(x_i'\beta/\sigma) \tag{4}$$

For the observations y_is that are greater than zero,

$$Prob\,(y_i > 0)\; f(y_i \mid y_i > 0) = \Phi(z_i'\sigma)\;(1/\sigma)\;\phi[(y_i - x_i'\beta)/\sigma] \tag{5}$$

Using 0 to denote zero observations and + denote positive observations, the likelihood function for the double hurdle model can be specified as:

$$L = \Pi_0[1 - \Phi(z_i'a)\;\Phi(x_i'\beta/\sigma)]\;\Pi_+\{\Phi(z_i'a)\;(1/\sigma)\;\phi[(y_i - x_i'\beta)/\sigma]\} \tag{6}$$

The maximum likelihood estimation technique can be used to estimate the unknown parameters for the primary nonresidential wildlife watching expenditure analysis (Cragg 1971; Blundell and Meghir 1987; Jones 1989; Jones 1992).

4.0 Data

Data used in this study were extracted from the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Fish and Wildlife Service 2002). The survey is conducted every five years by the U.S. Census Bureau for the U.S. Fish and Wildlife Service (USFWS) and gathers extensive information on fishing, hunting, and wildlife watching participation, expenditures, and socioeconomic characteristics of respondents.

This study uses the wildlife watching data set, which is one of the three data sets generated from the survey results by USFWS. The U.S. Census Bureau interviewed 80,000 households in the United States to determine participants in wildlife-related activities. From this initial phase, 15,300 wildlife watchers were selected for detailed interviews about their participation and expenditures in 2001.

5.0 Empirical Results

Descriptive statistics for all variables used in estimation are presented in Table 1. Average trip-related expenditure is $203 for the total sample, but average trip-related expenditure is $868 for the sample with positive expenditures. More than 76 percent of zero expenditure reported in the data used in this study. The double hurdle model for the primary nonresidential wildlife watching expenditure analysis was estimated by maximizing the logarithm of the likelihood function, equation (6), using the censored and truncated regression procedures in LIMDEP (Greene 1995).

In socio-economic data, there often exists a problem with multicollinearity between variables, resulting in estimates that are unstable and have high standard errors. In order to test which variables are collinear with other variables, collinearity diagnostic tests based on condition indexes were performed. The value of the largest condition index resulting from the principal component analysis performed was 14.84 in this analysis. As Belsley et al. (1980) suggested, the explanatory variables selected to

Table 1.—Descriptive Statistics for Variables in Nonresidential Wildlife Watching Expenditure Analysis

Variables	TotalSample (N=15300)		Sample of Expenditure>0 (N=3577)		Sample of Expenditure=0 (N=11723)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Expenditure	203.00	919.16	868.33	1742.59	------	------
Age	48.21	16.51	44.60	14.21	49.31	16.99
High Income	0.35		0.46		0.32	
Mid Income	0.23		0.26		0.22	
Male	0.47		0.50		0.46	
Married	0.70		0.72		0.70	
College	0.58		0.68		0.55	
Minority	0.10		0.08		0.11	
Cross-Over	0.10		0.15		0.08	
Private Land	0.11		0.43		0.03	
Public Land	0.21		0.85		0.02	
Bird	0.24		0.90		0.01	
Mammal	0.21		0.82		0.02	
Ocean	0.07		0.27		0.01	
Lake	0.18		0.70		0.02	
Marsh	0.12		0.48		0.01	
Forest	0.19		0.76		0.02	
Brush	0.16		0.65		0.02	
Open Field	0.16		0.65		0.02	
Manmade	0.08		0.31		0.01	

explain wildlife watching expenditure associated with nonresidential activities were not correlated in this case.

Empirical results of the double hurdle model for the primary nonresidential wildlife watching expenditure analysis are presented in Table 2. All observations can be used in the estimation for participation decision, but only positive observations which pass participation and consumption decisions simultaneously can be used in the estimation based on a censored and truncated sample.

The variables *High Income, Private Land, Public Land, Mammal, Ocean, Lake,* and *Open Field* are all positively and significantly related to nonresidential wildlife watching expenditures for both participation and consumption decisions.

Empirically, wildlife watching participants with high household income level have positive and significant effects on nonresidential wildlife watching participation and expenditures. It revealed that nonresidential wildlife watching is a normal good for which demand increases with high household income level. Use of public or private lands appeared to affect nonresidential wildlife watching participation and expenditures significantly, implying that demand increases with use of public or private lands.

As we expected, mammal has positive and significant impacts on nonresidential wildlife watching participation and expenditures, indicating that demand increases significantly with the presence of mammals, which is the primary purpose of wildlife watching activities. We

Table 2.—Empirical Results of Double Hurdle Model for Nonresidential Wildlife Watching Expenditure Analysis

Variable	Participation (N=15300)			Consumption (N=3577)		
	Parameter Estimate	Standard Error	T-Ratio	Parameter Estimate	Standard Error	T-Ratio
Constant	-1.8513	0.0741	-24.979*	-8142.60	468.33	-17.387*
High Income	0.1067	0.0465	2.296*	583.05	171.22	3.405*
Mid Income	0.0850	0.0489	1.738*	-283.83	194.98	-1.456
Age	-0.0023	0.0012	-1.927*	27.94	4.92	5.675*
Male	0.0148	0.0379	0.390	327.36	133.36	2.455*
Married	0.0476	0.0435	1.092	58.77	156.83	0.375
College	0.0082	0.0400	0.205	468.86	160.51	2.921*
Minority	0.0163	0.0635	0.257	-222.77	256.76	-0.868
Cross-Over	0.0450	0.0612	0.734	816.55	170.73	4.783*
Private Land	0.3674	0.0657	5.593*	1022.20	143.03	7.146*
Public Land	1.1532	0.0621	18.557*	1060.20	237.36	4.466*
Bird	0.9752	0.0624	15.620*	389.94	291.85	1.336
Mammal	0.8482	0.0604	14.047*	798.94	216.49	3.690*
Ocean	0.1254	0.0716	1.752*	2142.60	143.25	14.957*
Lake	0.2882	0.0602	4.785*	740.43	180.39	4.105*
Marsh	-0.0128	0.0644	-0.199	496.25	151.72	3.271*
Forest	0.1654	0.0700	2.364*	179.66	204.45	0.879
Brush	0.0985	0.0703	1.402	200.14	178.94	1.118
Open Field	0.2367	0.0661	3.582*	556.23	177.58	3.132*
Manmade	-0.0536	0.0709	-0.756	453.65	142.25	3.189*
σ	--------	--------	--------	2002.60	30.80	65.013*
Log-Likelihood		-1806.844			-28199.94	

* denotes statistical significance at the 5% level.

also found that the ecosystem categories such as oceans, lakes, and open fields to be positively and significantly related to nonresidential wildlife watching participation and expenditures, appearing that demand increases with oceans, lakes, and open fields.

Although having the positive sign, the variables *Male, College,* and *Cross-Over* are significant in the consumption decision but not significant in the participation decision, whereas the variables Bird and Forest are significant in the participation decision but not significant in the consumption decision. Empirically, wildlife watching participants are more likely to participate in nonresidential wildlife watching with the presence of birds, but insignificantly tend to consume more associated with bird watching. Similarly, wildlife watching participants are more likely to participate in forest environments, but insignificantly tend to consume more for nonresidential wildlife watching associated with forestlands.

On the other hand, we found that well-educated male individuals are insignificantly more likely to participate in, but tend to spend more when they consume for this particular wildlife-based recreation significantly. Meanwhile, sportsmen, i.e., anglers or hunters, are insignificantly more likely to participate in, but willing to spend more when they consume for this type of wildlife watching activities significantly.

The double hurdle estimates indicate that the explanatory variables might have different impacts on participation and consumption in sign or magnitude. There is no strong economic theoretical basis to suggest what explanatory variables should be in each hurdle or for predicting the signs of estimated coefficients in each hurdle (Jones, 1989).

The variables *Mid Income, Age, Marsh,* and *Manmade* all have different signs in the participation and consumption decisions. Even having different signs, the variable Age is significant for both participation and consumption decisions, the variable Mid Income is significant in the participation decision but not significant in the consumption decision, and the variables Marsh and Manmade are significant in the consumption decision but not significant in the participation decision.

Empirically, participants are less likely to participate with age, but tend to consume more related to nonresidential wildlife watching activities. Wildlife watching participants with middle household income level are more likely to participate in, but not willing to spend more for this type of wildlife-based recreation activities. We also found that participants are less to participate in marsh and manmade environments, but tend to consume more for nonresidential wildlife watching associated with marsh and manmade environments.

In summary, empirical results of the primary nonresidential wildlife watching expenditure analysis indicate that well-educated male sportsmen who are anglers or hunters with high household income and age level would observe, photograph, or feed mammals on oceans, lakes, marshes, open fields, or manmade environments, either in public or private lands at least one mile away from their home.

6.0 Conclusions

This study has provided an empirical analysis of individual consumption behavior for observing, photographing, and feeding wildlife more than one mile away from their home nationally using data extracted from the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. The primary nonresidential wildlife watching expenditure analysis in this case is a necessary step in understanding relationship between individual consumption behavior and his/her socioeconomic characteristics and the attributes of wildlife and its encounter.

Empirical results of this study indicated that income, age, gender, education level, fishing or hunting, use of private or public lands, wildlife category (i.e., mammals) and ecosystem category (including oceans, lakes, marshes, open fields and manmade environments) had significant effects on nonresidential wildlife watching expenditures. Wildlife watching is a form of nature-based tourism that draws our attention to the animal kingdom, which rely on environmental attributes to attract participants to an area, and use its wildlife resources and their habitats as the focal point of the activities. In order to continue high quality of wildlife watching experiences for the participants, a healthy environment for wildlife must be properly provided through well-defined planning and management strategies and decision-making processes.

To compare the Tobit model and the double hurdle model, all observations can be used in the estimation for the Tobit model based on a censored sample, but only positive observations that pass participation and consumption decisions simultaneously can be used in the estimation for the double hurdle model based on a censored and truncated sample. The results in this study provide insight into determinants of nonresidential wildlife watching expenditures, which also can be interpreted in terms of two stochastic processes, participation and consumption, allowing for richer interpretation of consumer behavior.

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