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Title: Application of Hurdle Negative Binomial Count Data Model to Demand for Black Bass Fishing in the Southeastern United States.

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Title: Application of Hurdle Negative Binomial Count Data Model to Demand for Black Bass Fishing in the Southeastern United States.

Abstract: This paper identifies factors that influence the demand for a black bass fishing trip taken in the Southeastern U.S. using a double hurdle negative binomial count data model. The probability of fishing for a black bass is estimated in the first stage and the trip frequency for fishing a black bass is estimated in the second stage given that the individual has a positive probability towards undertaking a black bass fishing trip in the Southeast. The applied approach allows the decomposition of the effects of factors responsible for the decision of taking a fishing trip and the number of trips.

Introduction

In 1996, more than 13 million American anglers fished for a black bass on 191 million days in freshwater sources excluding the Great Lakes. More importantly, the Southeast was leading all other classified regions in the trip participation rate (38 percent) for all water-body type fishing (1996 National Survey of Fishing, Hunting and Wildlife Associated Recreation). The observed sample shows that the individuals took an average of 13 black bass fishing trips spending $24 per trip in the state where they resided.

The main objective of this study is to identify the factors affecting black bass fishing trip demand in the southeastern U.S. using a hurdle negative binomial count data model. In addition, we also estimate black bass fishing trip demand elasticities based on count data model techniques. The focus on a single category of fish in this study reflects strong preference among anglers for it because of the reputation that each catch generates. The black bass category includes several species of ferocious predatory fish known to grow to a large size. Black bass fishing refers to only smallmouth and largemouth black bass and excludes white bass, spotted bass, striped bass, striped bass hybrids, and rock bass. The Southeast is classified as the primary bass fishing area.

The popularity of black bass fishing stresses the importance of topic. The majority of anglers fish for it in publicly accessible lakes and ponds. State parks administered by agencies charged with the management of natural resources are frequently visited by residents who fish for recreation. By developing a profile of avid black bass anglers, natural resource departments will gain knowledge of the most probable black bass anglers and their motives for fishing. The knowledge of price elasticity, the catch rate elasticity and income elasticity enables policymakers to design actions maximizing benefits to all parties involved, those who fish and those who service them.

Data

Data on fishing si not readily available. This study, focused on fishing for black bass required particularly detailed data. The 1996 National Survey of Fishing, Hunting and Wildlife Associated Recreation (NSFHWAR) data were used because they provide a large, specific information base. The survey was conducted among the U.S. residents in three waves with in-person and telephone screening of households. The interviews were conducted between April 1996 and January 1997. By following this procedure, the sample reduced recall bias for last trips. From 22,578 records in the national sample, we used the sample of 2179 records of the Southeast anglers after cases with the incomplete demographic information such as income, age, or marital status were discarded.

Methods

Only recently the use of count data models, where the dependent variable takes a non-negative integer value, has been well appreciated in applied studies (Creel, and Loomis, 1990; Hellerstein, 1991; Grogger and Carson, 1991; Englin and Shonkwiler,1995; Haab and McConnell, 1996; Gurmu and Trivedi, 1996; Shonkwiler and Shaw, 1996;Chankroborty and Keith, 2000).

The discrete non-negative nature of black bass trip frequency can be modeled by using the simple Poisson count model. However, this benchmark model has a restrictive assumption in which the conditional mean of each count dependent variable is equal to its corresponding conditional variance. The pervasive feature of empirical count data in most economic applications is the presence of overdispersion: the conditional variance usually exceeds the conditional mean. Overdispersion problem is mainly related to the heterogeneity and positive contagion in data (McCullagh and Nelder, 1989). In addition, another frequently encountered feature of empirical data in recreation is a higher relative frequency of zero observations when off-site survey is employed (Gurmu and Trivedi, 1996; Gurmu 1997; 1998). Overall, the standard Poisson model is not appropriate for the data with excess zeros and presence of overdispersion.

To account for both the unobserved heterogeneity and the excess of zeros in our model, we use the hurdle negative binomial model. This model distinguishes the decision to take a black bass trip, the participation decision, from the frequency of black bass fishing trips taken, the consumption decision. The participation decision and consumption decision are not constrained to be the same in the model. First, if an individual is a non-user, any value of the independent variables is irrelevant due to abstentions. Second, the individual could be a potential user, but may decide not become a user for some economically justified reasons. The latter is said to be a corner solution. We can, therefore, assume that a set of exogenous factors, which affects the individual's decision, for example, to go black bass fishing, is different from factors determining the number of eventually undertaken black bass fishing trips. However, in empirical applications, most researchers have ended up using the same set of economic and non-economic factors to explain both decision processes due to the lack of guidance based on the economic theory (Blaylock and Blisard, 1993; Jones, 1989a, 1989b; Yen, 1994). Two hurdles must be overcome before a trip is taken. That is:

$$\begin{aligned} P_1\left(y_i = 0|Z_i\right) &= f_1(0), & j = 0 \\ P_2\left(y_i = j|Z_i, X_i\right) &= f_2(y_i)\frac{\left[1 - f_1(0)\right]}{\left[1 - f_2(0)\right]} \\ &= f_2(y_i)\theta_i, & j > 0, \end{aligned} \tag{1}$$

where $\theta_i = [1\text{-}f_1(0)]/[1\text{-}f_2(0)]$. The model collapses to the compound count data models, standard Poisson or negative binomial model, only if $f_1(.) = f_2(.)$ (Cameron and Trivedi, 1998). The expected value and the corresponding variance are given by

$$\begin{aligned} E\left(y_i|Z_i, X_i, y_i > 0\right) &= \sum_{y_i=1}^{\infty} y_i f_2(y_i)\theta_i \\ V\left(y_i|Z_i, X_i, y_i > 0\right) &= \theta_i \sum_{y_i=1}^{\infty} y_i^2 f_2(y_i) - \theta_i^2\left[\sum_{y_i=1}^{\infty} y_i f_2(y_i)\right]^2. \end{aligned} \tag{2}$$

It is worth noting that over- or underdispersion is now defined at the individual level, not for the sample as a whole, and it depends on the value of the ratio, θ_i.

The likelihood function is

$$L = \prod_{y_i=0} f_1(0) \prod_{y_i>0} \left[1 - f_1(0)\right] \prod_{y_i>0} \left[\frac{f_2(y_i)}{\left[1 - f_2(0)\right]}\right] \tag{3}$$

and its corresponding log-likelihood is

$$Ln\,L = \sum_i 1(y_i = 0)\ln\left[P_1(y_i = 0|Z_i, X_i)\right] + \left(1 - 1(y_i = 0)\right)\ln\left[1 - P_1(y_i = 0|Z_i, X_i)\right] + \sum \left[\left(1 - 1(y_i = 0)\right)\ln\left[P(y_i = j|Z_i, X_i)\right]\right] \tag{4}$$

where L_1 can be regarded as a log-likelihood function for the binary (zero/positive) outcome, e.g., logit or probit model and L_2 as a log-likelihood function for a truncated-at-zero (positive number of black bass fishing trips). The first hurdle follows the decision in which an individual does or does not take a black bass fishing trip in the underlying binary probability distribution, logit or probit. The second hurdle truncates non-zero counts in the underlying negative binomial distribution. Thus, the maximum likelihood estimates of β_1 and β_2 can be obtained separately from L_1 and L_2. The Poisson models is obtained when the overdispersion parameter alpha, α_2, equals to the zero. For computational simplicity, we use α_1=1, which corresponds to the use of logit model at the first stage in the double-hurdle negative binomial count data model.

To obtain the change in the conditional mean given a change in explanatory variables is

$$\frac{\partial E(y_i|z_i, x_i)}{\partial x_i} = \left\{\frac{\partial \mathbf{Pr}(y_i > \mathbf{0})}{\partial x_i} . E(y_i|z_i, x_i; y_i > \mathbf{0})\right\} + \left\{\mathbf{Pr}(y_i > \mathbf{0}). \frac{E(y_i|z_i, x_i; y_i > \mathbf{0})}{\partial x_i}\right\} \tag{5}$$

where the first part is the change in the probability of taking a nonzero fishing trip weighted by the conditional expected mean value of black bass fish trips, and the second part is the change in the conditional mean of black bass fishing trips weighted by the probability of taking a black bass fishing trip.

We construct a discriminative test which is applied to the appropriateness of the two-stage modeling procedure (e.g., the compound negative binomial and its variant, the hurdle, models are the same) using the Likelihood Ratio test (LR) since the variables used in both stage are identical, $f_1(.) = f_2(.)$.

Results and Discussion

The decision to undertake a fishing trip was estimated using the logit technique (Table 2). The decision was influenced mostly by socio-economic and demographic characteristics rather than measures of successful fishing. Respondents who received more years of formal schooling were more likely to take a fishing trip than those with fewer years of schooling. This result had to be tested empirically because in case of recreational freshwater fishing the relationship is not obvious. According to this study results, people with various level of education undertake fishing trips suggesting that fishing was enjoyed by a wide segment of population. However, males were more likely to take a trip than female respondents. Stronger participation rates among men were consistently reported over time and this result supports previous figures. Within the cluster of states where black bass fishing is possible, white respondents were more likely to undertake a trip than representatives of other races. This general finding may not hold in some localities; for example, some state parks are frequented by substantial numbers of members of other races.

Although the high level of education increased the probability of undertaking a trip, the higher the income of respondents, the lower the chances of actual participation in fishing. Reports of leisure activities nationwide suggest that anglers can be found primarily in the middle income group and the participation rate declines for those with the income exceeding $75,000

(Statistical Abstract of the United States, 2001).

Two measures of successful fishing, the average number of caught fish and the average length of a caught fish were statistically insignificant. However, the cost per trip positively influenced the probability of decision to fish. The cost per trip is interpreted as the price of a fishing trip and it would be expected to be inversely related to the number of trips, but in this study it is, primarily, the reflection of the total expenditures spent on fishing trips in a year. Therefore, the average cost per trip, if high, suggests relatively large expenditures and few trips. Large total expenditures on fishing trips indicate a particularly high preference for this type of recreational activity, although, due to other factors, an individual was able to undertake only a relatively few trips. Therefore, the positive influence of the average expenditures on the decision to take a trip is plausible.

The trip frequency decision was estimated using the negative binomial equation. This choice of the estimation approach was indicated by the test on overdispersion. We test the compound negative binomial model against its variant, the hurdle negative count model, using Likelihood Ratio test (LR) due to the same set of the identical variables used in each model. The standard normal statistics were calculated. The value of $\chi^2 = 1366.17$ with one degree of freedom was obtained the null hypothesis that there is no difference between the standard negative binomial and its hurdle variant. The result shows that the splitting of negative binomial count model is preferred to its compound count model. Results confirm expectations regarding the influence of income, age, the cost of trip and two measures of successful fishing on the trip frequency. Individuals with high income were more likely to travel more often on a black bass fishing trip than those with less income. It is possible that the specific purpose of fishing for black bass is responsible for this outcome because the income effect on the number of fishing trips is not always clear. For example, general information about the participation in recreational fishing suggest that persons with very high income are less likely to fish.

The negative influence of age on the number of fishing trips was expected. Fishing is an outdoor activity and elements not always encourage spending long hours in a boat or on the bank of a lake or a pond. Older individuals may have health conditions or physical impairments limiting the frequency of fishing. The more expensive was a trip the less likely was a respondent to increase the number of trips. Increasing costs of a trip reduced the trip frequency, an expected result for a leisure activity.

Anglers are encouraged to take more trips if the trips are particularly rewarding. Anglers' satisfaction can be expected to be higher if they actually catch fish and the size of fish is large. Two measures of fruitful fishing had positive and significant influence on the number of fishing trips. The probability of increasing the trip frequency was higher if the average catch and the average length of fish was greater. These two measurers are specific to recreational fishing and their importance was confirmed in case for fishing for the black bass.

Two other demographic characteristics influenced the trip frequency. Married individuals were more likely to take a larger number of trips than unmarried. It is plausible that a variety of reasons is responsible for this statistically confirmed result, but all of them are related to the family lifestyle. Families may join the angler on a trip regardless whether they fish or not. Fishing trips can be a shared, regularly scheduled event that involves an extended family further encouraging frequent trips or it can be a form of socializing among selected individuals within the extended family.

Non-white respondents were more likely to undertake a larger number of fishing trips than white respondents. No a priori expectations were held regarding the frequency of black bass fishing trips and the race variable, but this study indicates that this form of recreational activity is particularly enjoyed by races other than white.

Table 3 shows individual effects of all variables in both equations separately and the combined effects. The partial effects in the trip frequency were larger than in the decision equation with the exception of the trip cost, therefore, the combined effects were primarily influenced by the partial effects calculated from the trip frequency equation. In case of partial effects associated with the trip cost, the average catch and the average fish length, the combined positive effect was due to the magnitude of the partial effect from the second stage equation. The opposite result was associated with the partial effects of age, gender and race variables, i.e., the combined effects were negative because the partial effects in the second equation were negative. The partial effects of income, marital status and education were of the same direction in both equations.

Using the combined effects, we calculated elasticities for three important variables. The income elasticity (-.8006) indicates that with increasing incomes, the number of black bass fishing trips can be expected to decline. Recreational freshwater fishing, although enjoyed by a wide segment of the population, may be less popular with individuals reporting very high income. Own price elasticity had a unitary value (1.0005) and was positive. The signs is consistent with the method of calculating the price, i.e., the cost per trip, which were total expenditures divided by the number of trips. High expenditures imply that a person was particularly enjoying the black bass fishing and this strong preference was reflected in heavy spending on this leisure activity. Once resources were committed to fishing, an individual benefitted by taking the larger number of trips possible; those who took infrequent trips were encouraged to take more or face an implicit loss of using the tackle and other equipment. Finally, most elastic response was to the average catch per trip. The calculated elasticity was 2.1776 suggesting that anglers were very likely to increase their participation in the black bass fishing if the average catch increased.

Implications

The popularity of the black bass fishing among anglers prompted the investigation of factors that influence the decision to take a fishing trip and the trip frequency. The demand for recreational black bass fishing is of regional importance. Black bass encompasses several kinds of bass indigenous to the ten state area considered in this study and is a highly prized fish.

Although this study confirmed that typical factors influenced the decision to take a fishing trip, the trip frequency was influenced by measures of reward from fishing, among others. Black bass includes the largemouth bass, a trophy fish pursued by anglers. It can weigh 22 pounds. Lakes and ponds that stock this fish can expect to be more often visited than other bodies of freshwater, if they are open to the public. Managing black bass species should be a priority for state operated parks because of the high demand for trips specifically aimed at catching this fish. A proper managing plan involves also other species of fish because bass is a predatory fish.

Catch limits may negatively affect trip frequency because the higher was the average number of fish caught the more likely was the higher number of trips reported by a respondent.

Currently, states regulate the minimum length of black bass and require that undersized fish be released. In some cases, the number of specific species are limited on a catch-per-day basis. Although the existing limits may seldom be exceeded, a periodic review resulting from stock management considerations may take into account the confirmed relationship between the average catch reported in the survey and the trip frequency. For example, a reduction of the allowable number of fish could lower the trip frequency and generate less revenue if fishing took place in a state park and required a fee entrance. State park revenues generate a large portion of operating revenues in some southeastern states.

The relationship of recreational fishing and trip numbers to the marital status of the respondent indicates the importance of this activity to families. Sites visited by anglers eager to fish for the black bass may consider expanding their facilities and encourage alternative activities for the non-fishing family members. Opportunities for expansion may be considered given the specific conditions of each site because adding picnic facilities or play grounds will change the number and the composition of visitors to a park and the surrounding area.

References

Blaylock, J. R. and W. N. Blisard. "Wine Consumption by US Men." *Applied Economics* 24 (1993) 645-651.

Cameron, A.C. and P. Trivedi. *Regression Analysis of Count Data*. Cambridge University Press, Cambridge 1998.

Chakraborty, K. and J. E. Keith. "Estimating the Recration Demand and Economic Value of Mountain Biking in Moab, Utah: An Application of Count Data Models." *Journal of Environmental Planning and Management* 43 (2000): 461-469.

Creel, M. D. and J. B. Loomis. "Theoretical and Empirical Advantages of Truncated Count Data Estimators for Analysis of Deer Hunting in California." *American Journal of Agricultural Economics* 72 (1990): 434-441.

Dean, C. and J. F. Lawless. "Tests for Detecting Overdispersion in Poisson Regression Models." *Journal of the American Statistical Association* 84 (1989): 467-472.

Englin, J. and J. S. Shonkwiler. "Estimating Social Welfare Using Count Data Models: An Application to Long-Run Recreation Demand Under Conditions of Endogenous Stratification and Truncation." *The Review of Economics and Statistics* Vol. 77 (1995) 104-112.

Greene, W. H. *Econometric Analysis, 3th* ed. New Jersey: Prentice Hall 1997.

____________. *LIMDEP Version 8.0 User's Manual*. Econometric Software, Inc. New York, 2002.

Grogger, J. T.and R. T. Carson. "Models for Truncated Counts." *Journal of Applied Econometrics* 6 (1991): 225-238.

Gurmu, S. "Tests for Detecting Overdispersion in the Positive Poisson Regression Model." *Journal of Business and Economic Statistics* 9 (1991): 215-222.

Gurmu, S. and P. Trivedi. "Overdispersion Tests for Truncated Poisson Regression Models." *Journal of Econometrics* 54 (1992): 347-370.

____________. "Excess Zeros in Count Models for Recreational Trips." *Journal of Business and Economic Statistics* 14 (1996): 469-477.

____________. "Semi-Parametric Estimation of Hurdle Regression Models with an Application to Medicaid Utilization." *Journal of Applied Econometrics* 12 (1997): 225-242.

____________. "Generalized Hurdle Count Data Regression Models." *Economics Letters* 58 (1998): 263-268.

Haab, T. C. and K. E. McConnell. "Count Data Models and the Problem of Zeros in Recreation Demand Analysis." *American Journal of Agricultural Economics* 78 (1996) 89-102.

Hellerstein, D. M. "Using Count Data Models in Travel Cost Analysis with Aggregate Data." *American Journal of Agricultural Economics* (1991) 861-867.

Jones, A. M. "A Systems Approach to the Demand for Alcohol and Tobacco." *Bulletin of Economic Research* 41 (1989a) 86-101.

____________. "A Double-Hurdle Model of Cigarette Consumption." *Journal of Applied Econometrics* 4 (1989b) 23-39.

____________. "The UK Demand for Cigarettes 1954-86, A Double-Hurdle Approach." *Journal of Health Economics* 8 (1989c) 133-141.

Maddala, G. S. *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge, MA: Cambridge University Press, 1999.

McCullagh, P. and J. A. Nelder. *Generalized Linear Models. Monographs on Statistics and Applied Probability* 37, Chapman & Hall, London, 1989.

Mullahy, J. "Specification and Testing in some Modified Count Models." *Journal of Econometrics* 33 (1986): 341-365.

Shonkwiler, J. S. and W. D. Shaw. "Hurdle Count-Data Models in Recreation Demand Analysis." *Journal of Agricultural and Resource Economics* 21 (1996): 210-219.

Statistical Abstract of the United States. U.S. Census Bureau 2001, U.S. Department of Commerce, 2001.

Winkelmann, R. and K. F. Zimmermann. "Count Data Models for Demographic Data." *Mathematical Population Studies* 4 (1993): 205-221.

____________. "Recent Developments in Count Data Modeling: Theory and Application." *Journal of Economic Surveys* 9 (1995): 1-24.

Vuong, Q. H. "Likelihood Ratio Tests for Model Selection and Non-Nested Hypotheses." *Econometrica* 57 (1989): 307-333.

Yen, S. T. "Cross-Section Estimation of US Demand for Alcoholic Beverage." *Applied Economics* 26 (1994): 381-392.

Table 1. Descriptive Statistics of Variables Used in the Empirical Model

Variable name	Units	Mean	Standard deviation
Bass fishing trips	Average number of black bass trips	2.2038	9.3859
Fishavg	Average cost per trip	3.9403	17.7536
Catch	Average number of caught fish per trip	.7270	1.0613
Fishinch	Average length of fish in inches	11.7246	2.2899
Income	Household income in $	4.6067	2.6127
Age	Years	.4554	.1447
Age^2	—	.2283	.1435
Married	1 if married, 0 otherwise	.6976	.4594
Gender	1 if male, 0 otherwise	.8109	.3917
Race	1 if white, 0 otherwise	.8756	.3301
School	Years	13.0831	2.8482

Note: Income variable is divided by 10,000; catch and age variables are divided by 100.

Table 2. Estimation Results of the First and Second Stage Model of Demand for Bass Fishing

Variable name	Binary Hurdle Equation		Count Model Equation	
	Coefficient	t-value	Coefficient	t-value
Constant	-10.0169	-5.11[a]	3.8113	5.21[a]
Fishavg	1.1050	8.13[a]	-.0029	-1.92[b]
Catch	-.3159	-1.56	2.5530	280.56
Fishinch	-.0061	-.18	.0664	8.00[a]
Income	-.1748	-1.96[a]	-.1121	-5.05[a]
Age	.9375	.14	-4.7841	-2.23[a]
Age^2	3.2575	.51	.7001	.33
Married	.0231	.05	.3116	2.86[a]
Gender	2.3674	3.37[a]	-.5612	-1.50
Race	1.4808	2.55[a]	-1.2056	-5.55[a]
School	.2084	3.29[a]	.0461	2.39[a]

[a] Significant at $\alpha = .05$.

[b] Significant at $\alpha = .10$.

Table 3. Partial and Combined Effects of Variables in the Decision and Frequency Equations

Variable name	Effects in Binary Hurdle Equation	Effects in Count Model Equation	Combined Effects
	- - - - - - - - - - - - - - - - - - - estimated effect[a]	- - - - - - - - - - - - - - - - - - -	
Constant	-5.1812	10.0761	4.8949
	(-1.78)	(4.65)	(1.86)
Fishavg	.5715	-.0077	.5638
	(1.68)	(-1.86)	(1.67)
Catch	-.1634	6.7493	6.5859
	(-1.14)	(23.67)	(27.86)
Fishinch	-.0032	.1756	.1724
	(-.18)	(7.15)	(5.52)
Income	-.0904	-.2963	-.3868
	(-1.28)	(-5.08)	(-4.05)
Age	.4849	-12.6477	-12.1628
	(.14)	(-2.21)	(-1.79)
Age^2	1.6850	1.8509	3.5359
	(.49)	(.74)	(.53)
Married	.0120	.8237	.8357
	(.05)	(.00)	(2.24)
Gender	1.2245	-1.4838	-.2593
	(1.72)	(.15)	(-.28)
Race	.7660	-3.1873	-2.4214
	(1.46)	(.00)	(-3.28)
School	.1078	.1218	.2296
	(1.54)	(.02)	(2.74)

[a] t-values in parentheses.