Truncated-at-Zero Count Data Models with Partial Observability: An Application to the Freshwater Fishing Demand in the Southeastern U.S.

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Abstract: We extend the double-hurdle count data model to account for a joint decision in the first stage in which the individual jointly makes a decision about a participation in fishing and a site (region) selection decision. Contrary to the conventional the double-hurdle count data model, our model discriminates between the effects of non-participant and potential participants (e.g., potential participants are those who participated in fishing but may or may not take a trip to a specific site, the Southeastern U.S.) on the probability of taking a fishing trip.

Introduction

Studies on the determinants of recreational demand have frequently used count data models. Count data models are attractive because the dependent variable is a non-negative integer, mutually exclusive and collectively exhaustive. However, it is common to observe that the frequency of participation in recreational activities is inversely related to the number of participants. For example, fewer individuals undertake an increasingly larger number of leisure trips to state parks. A greater number of zero counts in cells corresponding to large trip numbers implies that few individuals frequently undertake a trip. The number of zero counts in some empirical cases exceeds the number that would be expected in applications of the count data models such as the conventional Poisson or its variation, the negative binomial. Conventional count data models fail to account for two different data-generating mechanisms for the zero and strictly positive counts (Mullahy, 1986; Winkelmann, and Zimmermann, 1995; Gurmu and Trivedi, 1996). The process producing zero counts is different from the process producing positive counts due to economic or non-economic factors.

The double-hurdle count data models, which originated from the Cragg double-hurdle continuous model, are then particularly useful to handle the frequently observed "excess" or "too

few" zeros along with positive data counts. The Cragg model is separated into two distinct phases. In the first phase the count moves from zero to some discrete event-count distribution (e.g., probit or logit), while second phase generates the observed count (e.g., Poisson or the negative binomial).

Besides the distinction of the data generating process responsible for zero and positive observations, it is important to note that an individual makes a simultaneous decision (not a sequential decision) about the participation in fishing and a site (region) selection decision. Thus, the trips to the particular site are observed only when the individual makes a joint decision.

This paper presents an application of two consistent utility theoretic count data models, which account for the joint decision of choice and frequency. The application is illustrated by fishing trips taken to the southeastern United States. In particular, the joint decision accounts for an individual's decision to undertake a fishing trip and the choice of its destination. In doing so, we distinguish those individuals who did not participate in fishing at all in a given time period from those who are potential fishermen. Both groups are precluded from participating in fishing in the Southeast by the income, prices or non-economic reasons.

The proposed approach differs from the conventional double-hurdle model which implies the sequential decision making by an individual. Although the double-hurdle approach may be suitable for modeling of some aspects of participation in recreational activities, this study distinguishes between non-participants. Some do not fish because fishing is not of interest to them, while others would fish if barriers to fishing were eliminated.

The distinction between two groups of non-participants calls for an alternative estimation technique. The joint decision is modeled as a standard choice equation reflecting a decision to

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fish and the decision about the destination implying fishing in freshwater in the Southeast. This formulation technique has an intuitive appeal because it matches a plausible feature of individual behavior, a joint two-stage decision process in our analysis. In the first stage, the individual jointly decides on whether or not to take a fishing trip and selects its destination. In the second stage, the individual decides the number of fishing trips to the particular site in question given that a decision favoring a trip was made. This complex pattern is captured by combining a bivariate model governing the outcome of the joint decision process and a truncated-at-zero count model for strictly positive integers reflecting the number of trips. In principle, the hurdle is set at-zero count in the second stage, conditional on a positive joint decision about taking a fishing trip and its southeastern site.

Data

The 1996 National Survey of Fishing, Hunting and Wildlife Associated Recreation (NSFHWAR) data are used in the study. The survey was conducted in three waves with in-person and telephone screening of households. The first interview wave began in April, the second wave in September and the last wave held in January 1997. By following this procedure, the sample aims to eliminate recall bias for the most recent trips.

From 22,578 records in the national sample, we used all 2281 records of the Southeast anglers. Cases with the incomplete demographic information such as income, age, or marital status were deleted from the sample. Descriptive statistics of variables included in the empirical investigation are presented in Table 1.

Methods

When an individual maximizes his utility subject to the budget constraint, the resulting

conditional travel cost demand for fishing trips is:

$$Q_i = f(P, T, M) \tag{1}$$

where Q_i is fishing trips to the Southeastern U.S., P is a vector of prices for the trip, T is the total time (the number of days) required to consume the trip, and M is the total household income.

We impose the assumption that an individual preallocates his work and pure leisure times prior to deciding among consumer goods (Bockstael et al., 1987; Larson, 1993a; 1993b; Shaw and Feather, 1999). In doing so, wage rates do not measure the value of time within the context of exogenous trip-time phenomena and thus the individual has to maximize his utility subject to two separate constraints: time and income.

It is worth noting that the frequencies of the trips taken to the Southeast region will be observed only when the individual jointly decides about fishing trips and the site. The individual may also decide to take a trip but out-of-region or travel both with in and out-of-region. Assuming the independence between the choice decisions in the first stage, the model is equivalent to the sequential decision making process: the individual first decides whether or not to undertake a fishing trip, and subsequently decides which site to visit. Eventually, the model may further collapse into a conventional double-hurdle count model, where the first stage decision is the individual's choice to take a fishing trip within or outside the region. However, this model will not distinguish those who did not participate in fishing at all from those who are potential users (e.g., those who participated in fishing at an alternative site). Thus, one major gain of introducing the joint is that it allows to discriminate non-participants from potential participants on the basis of the underlying probability distribution model.

Formally, let y_{2i} be the number of trips an individual takes, and denote by $P(y_{2i}|x)$ the probability of observing an individual with $y_{2i} = j$ trips, conditional on a set of covariates x. The essence of the hurdle model is to decompose the number of trips taken into two random components: 'y_{1i}, $y_{2i} > 0$', and '$y_{2i} | y_{1i}$, $y_{2i} > 0$'. The conditional probability mass function can then be written as:

$$P(y_{2i}|x) = \begin{cases} P(y_{1i} = 1, y_{2i} = 0) & for\ y_{2i} = 0 \\ P(y_{1i} = 0) & for\ y_{2i} = null \\ P(y_{1i} = 1, y_{2i} = 1) P(y_{2i}|y_{1i}, y_{2i} > 0, x) & for\ y_{2i} = 1,2,3,... \end{cases}$$ (2)

where $P(y_{1i}=1, y_{2i}=0)$ is the probability of taking a trip outside in the region, $P(y_{1i}=0)$ is the probability of not taking a fishing trip at all and $P(y_{2i}| y_{1i}, y_{2i} > 0, x)$ is the probability of observing $y_{2i} = j$ trips, given y_{1i}, $y_{2i} > 0$, and x. Recognizing that y_{2i} is observed only if $y_{1i} =1$, there is no observations of the subsequent behavior of non-participants in or outside the region. The mean number of taken trips conditional on the vector of covariates, x is:

$$E(y_{2i}|x) = P(y_{1i} = 1, y_{2i} = 1) E(y_{2i}|y_{1i}, y_{2i} > 0, x).$$ (3)

To implement the count data models, the sample of n observations is partitioned, so that the first N_1 observations have both positive probability of taking a fishing trip and wish at least one trip in the Southeast, N_2 observations have positive probability of taking a fishing trip but to out-of-region, and the last $(n-N_1-N_2)$ observations do not include fishing trips at all. The likelihood of the N_1 users is

$$L_i(\delta_1, \delta_2, \delta_3) = P(y_{1i} = 1, y_{2i} = 1|x) P(y_{2i}|y_{1i}, y_{2i} > 0, x),\ i = 1,...,N_1$$ (4)

The likelihood of the N_2 individuals who participated in fishing, but did not take any trips in the

Southeast is

$$L_2(\delta_1, \delta_2) = P(y_{1i} = 1, y_{2i} = 0), \qquad i = N_1 + 1, \ldots, N_2 \tag{5}$$

The likelihood of the last $(n-N_1-N_2)$ individuals who did not take fishing trips at all is

$$L_3(\delta_1) = P(y_{1i} = 0), \qquad\qquad i = N_2 + 1, \ldots, n \tag{6}$$

The likelihood of the entire sample is therefore

$$L = \prod_{i=1}^{N} P(y_{1i} = 1, y_{2i} = 1) P(y_{2i}|y_{1i}, y_{2i} > 0, x) \prod_{i=N_1+1}^{N} P(y_{1i} = 1, y_{2i} = 0) \\ \prod_{i=N_2+2}^{N} P(y_{1i} = 0) \tag{7}$$

The above likelihood estimation is simple, because it factors into two multiplicative

terms

$$L_1(\delta_1, \delta_2; x) = \prod_{i=1}^{N} P(y_{1i} = 1, y_{2i} = 1) \prod_{i=N_1+1}^{N} P(y_{1i} = 1, y_{2i} = 0) \\ \prod_{i=N_2+1}^{N} P(y_{1i} = 0) \tag{8}$$

$$L_2(\delta_3; x) \quad = \prod_{i=1}^{N} P(y_{2i}|y_{1i}, y_{2i} > 0, x)$$

The model was decomposed into two stages in which parameter estimates at the first and

the second stages are not constrained to be the same. The first likelihood depends exclusively on

parameter in the underlying bivariate probit model: 'y_{1i}, $y_{2i} > 0$' and the second likelihood

depends exclusively on parameters in the underlying count data models truncated at-zero: 'y_{2i} |

y_{1i}, $y_{2i} > 0$'.

The log-likelihood of L_1 is then

$$Ln\ L_1\left(\delta_1,\delta_2,\rho\right) = \sum\nolimits_{y_1=1,y_2=1} \ln F\left(\delta_1'x_{i1},\delta_2'x_{i2};\rho\right)$$
$$+ \sum\nolimits_{y_1=1,y_2=0} \ln\left[\varphi\left(\delta_1'x_{i1}\right) - F\left(\delta_1'x_{i1},\delta_2'x_{i2};\rho\right)\right] \qquad (9)$$
$$+ \sum\nolimits_{y_1=0} \ln\left[1 - \varphi\left(\delta_1'x_{i1}\right)\right]$$

where F(.) and φ are the bivariate standard normal cumulative distribution function and

univariate standard normal cumulative distribution function, respectively. More importantly, the

joint decision implies a potential correlation between two outcomes, and thus rho, ρ, corrects for

the potential sample selection bias that could be incurred in the separate estimation of the

probability of taking a trip to a site in the Southeast. In addition, this procedure is more efficient

than the procedure consisting of two separate probability equations. The log-likelihood for the

count data will depend on the model chosen.

An interesting and distinctive feature of hurdle models is that the probability of observing

a zero is assumed to be independent of the mean number of trips. Thus, the mean number of trips

can vary, while the probability of an individual reporting no trips at all remains constant. This is

interesting because there is evidence from the recreational demand studies that the average

number of trips per individual varies due to economic or site quality preferences, but the

percentage of individuals not undertaking any trips at all remains high (Gurmu and Trivedi,

1996; Cameron and Trivedi, 1998). In addition, the model also delineates the effects of non and

potential participants in the first stage.

We construct two discriminative tests, one is applied to test the appropriateness of two-

stage modeling procedure and the other is applied to discriminate between models (the truncated-

at-zero Poisson versus the truncated-at-zero negative binomial model). Testing the hurdle count

model against its compound model will allow us to make statements whether any excess zeroes are due to the splitting mechanism or are a consequence of the unobserved heterogeneity. Hurdle negative binomial model reduces to the hurdle Poisson model when the parameter alpha, α, equals to zero.

Results

The first stage involves the joint decision of choosing to fish and selecting the destination of the fishing trip. We estimated a bivariate probit model with partial observability because the trip frequency is reported only for individuals who decide to take a fishing trip and the visited destination. In other words, we observe the final outcome, the trip frequency, of two decisions made jointly. The model consists of two equations in this study: one depicting the decision to undertake a fishing trip, the other equation refers to the selection of a destination located within the southeastern United States. Table 2 shows the estimation results. The statistically significant rho, ρ, indicates that unexplained factors to take more fishing trips are actually associated with the higher frequency of taking trips with in the Southeast. Thus, many respondents, who choose to go on a fishing trip, were destined to a freshwater location in the region because of economic reasons. This result supports the appropriateness of using the bivariate probit model.

The decision to go on a fishing trip included variables describing respondents' income, education, and demographic characteristics. The specification implies the essential role of income in choosing a recreational fishing trip. The second equation refers to the trip's destination and the included variables emphasize the relevance of the total expenditures allocated to fishing trips and the specific purpose of such trips, the fishing for bass. The coefficient of the income variable is marginally insignificant, but has the expected sign. The higher the income of a

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respondent, the more likely was he to choose a fishing trip. Fishing in this study is considered a recreational activity and income permits to engage in this form of recreation. Among all other variables, only gender was strongly significant suggesting that men were much more likely than women to decide to go fishing. The number of men participating in freshwater fishing was more than twice the number of women (Statistical Abstract of the United States, 2001) and this difference was confirmed by our results.

In the destination choice equation three variables were confirmed to be relevant. The total expenditure on fishing increased the probability of choosing the regional destination. This is consistent with expectations that fishing is a hobby that a person wants to enjoy often. It is easier to go fishing more often if the visited spot is not too distant implying the choice of a lake or a pond in the region.

The special interest in fishing for bass increased the probability of choosing a location in the southeastern United States. This result was expected because of the natural range of the species and efforts to improve the stock of bass in freshwater bodies throughout the region. Finally, gender also proved to influence the location choice. Men were more likely to fish within the region than outside as compared to women. The education variable did not have significant influence on the joint decision. A plausible explanation is that more educated and, thus, possibly wealthier individuals face a higher opportunity costs of time and abstain from this form of recreation.

In the second stage, we include quality variables beside the variables describing the demographic and socio-economic characteristics of an angler. The quality variables are the angler's own travel cost, the total days spent fishing, and a dummy variable indicating whether

the individual fished for black bass in the region. The equation was estimated using both the

Poisson and the negative binomial process (Table 2). To test compound count models against the

hurdle count models, we use the non-nested Vuong t-test because we do not have the identical

set of variables in each model. The standard normal statistics were calculated. The value of 24.78

was obtained for the null hypothesis that the standard Poisson and its hurdle Poisson variant are

the same. The value of 32.69 was calculated the null hypothesis that there is no difference

between the standard negative binomial and its hurdle variant. These results show that the

splitting of count models are preferred to compound count models. Results obtained using the

Poisson approach show all variables as statistically significant with the exception of the

coefficient of educational attainment. However, the test for overdispersion as well as the

Likelihood Ratio (LR) test ($\chi^2 = 2213.24$ with one degree of freedom) indicate that the

assumption of the Poisson distribution truncated at-zero does not fit the sample. Therefore, we

report the results from the truncated-at-zero negative binomial model.

  All three quality variables are statistically significant (Table 2) and have the expected

signs. The number of undertaken fishing trips decreased as the travel cost increased. This inverse

relationship allows to predict the behavior in response to changes in travel costs useful from the

standpoint of policy development and projecting fluctuations in demand for complementary

goods and services. The more days were spent fishing, the larger was the number of trips

reported by respondents. This direct relationship was anticipated, but it is not a one-to-one

relationship. Many undertake short fishing trips that fit their work schedules on weekdays, while

reserving weekends for full day trips. It takes several short trips to report a whole day spent on

fishing. Also, a single fishing trip can stretch over two or three days. In 1999, more than half a

million days were spent on freshwater fishing, while 420,010 trips were reported (Statistical Abstract of the United States, 2001).

Black bass fishing is a region-specific event. This kind of fish requires a particular range of water temperatures that are present in lakes throughout the Southeast, but not in the extreme southern portion of the region. Also, freshwater bodies in northern states do not suit bass. Black bass is a prized trophy fish and bass-fishing tournaments are popular among anglers. Estimation results indicate that if an angler expressed special interest in bass fishing, he was more likely to undertake a larger number of fishing trips than an individual not particularly interested in fishing bass. Its size attracts anglers, who may return to lakes and ponds where this fish in known to be present in relatively large numbers, taking many trips to the same location.

Demographic variables including age, age-squared and gender are statistically significant (Table 2). The number of fishing trips were likely to increase as the age of respondent increased, but the coefficient of the age-squared variable was negative. It appears that the number of fishing trips increases with the age of respondents within certain range only to decline as the respondent's age is well advanced. This result is plausible and supported by the observed behavior suggesting that anglers, who retire early increase time spent fishing, but decrease the number of fishing trips as they advance in years. The latter behavior is likely associated with the declining physical fitness and limited ability to cope with the physical demands of even recreational fishing. The age influence is consistent with the reported age distribution of freshwater participants by the Census Bureau (Statistical Abstract of the United States, 2001), where the largest numbers were in middle age categories. Men were more likely to undertake more trips than women. Men reported fishing as a hobby more often than women nationwide

(Statistical Abstract of the U.S., 2001) and this tendency is also true in the Southeast. Although many women participate in fishing, men are more likely to take more trips.

Implications

We built a model which enables to distinguish a potential user from a non-user in the probability decision stage. Of course, a potential participant should be treated differently than a non-participant on the basis of choice selection criteria although they may share some common properties.

The specified two equation model distinguishes between respondents participating and abstaining from freshwater fishing. In the joint decision making regarding the choice to undertake a fishing trip and selecting its destination it is important to identify those who choose not to fish because their underlying preference set from those who have been prevented from fishing by other factors. These two groups may share common characteristics, but the similarities vary in each empirical application.

The decision to undertake a fishing trip is likely made jointly with the choice of the trip destination. Economic factors, income in case of the trip decision and total expenditures in case of the destination choice, are essential in their influence of the observed outcomes. Changes in income may lead to direct changes in recreational fishing. Furthermore, the probability of undertaking fishing trips may be influenced by the general economic conditions if they affect incomes and change the total expenditures on enjoying this form of recreation.

The role of men in choosing to take a trip within the region has been confirmed by the results. Not surprisingly, many fishing tournament organizers attempt to create events for women or children to attract the whole families to fishing. Special competitions for women-anglers are

also organized including competitive bass fishing tournaments with sizable money prizes. The recreational and competitive forms of fishing already 'hooked up' men and women represent an opportunity to broaden the customer base. Because women may accompany men on some trips, their presence enables the promoters to offer a chance to try fishing in hopes of developing new interest in this hobby. Fishing placed seventh among the most popular leisure activities nationwide, but the mild climate in the Southeast may place it even higher.

Several practical recommendations can be derived from estimation results of the trip frequency equation. First, increasing the cost of trips will lower the observed frequency. Many southeastern anglers fish in state parks. An entry fee is charged each time a person visits a park although the fee varies across Southeastern states. Often the fee is on a 'per vehicle' basis rather than the number of persons in the vehicle. An increase in a fee will reduce the number of the trips, but by only a negligible amount. Given the budget deficits faced by many state governments and the need to balance their budgets, a park entrance fee increase may improve the state revenues. Because it is a 'user fee,' it is likely to affect only those who enter state parks. Such a limited population segment can make a fee increase popular with state politicians.

Stocking bass in freshwater lakes in state parks is recommended because many anglers choose to fish for this species. Disseminating information about releasing young bass at specific sites may also lead to increased frequency of visits by anglers. For example, if all state parks add young bass to its lakes, press releases to the media may stimulate more frequent visits contributing to the revenues generated from park entrance fees. If only selected state parks increase their stock of bass, state departments of natural resources may direct anglers to selected locations. Which option is more desirable will depend on site-specific conditions, state policy,

and other factors. In some cases, sites known to have abundant bass, may stimulate the growth of retail outlets in the area servicing the anglers. Although the actual effect may be small, it may still be important for the local economy. Trip expenditures of four in five anglers include food and transportation (Statistical Abstract of the United States, 2001) making groceries and gasoline most commonly purchased items, but the annual spending on fishing tackle approaches $2 billion nationwide.

The demographic profile of anglers is well defined. The number of trips increased with age and men were more often fishing than women These characteristics provide guidance how to reach this population segment with specific messages. Both state agencies and suppliers of services around freshwater lakes and ponds may communicate more effectively once they know who are their primary customers.

Interestingly, we did not find differences in the number of trips according to the level of education or income. Because our sample was regional, these findings may not apply to other regions or to the national sample. It appears that from the socio-economic standpoint, fishing in the Southeast is a class-less form of recreation. The absence of confirmed income effect may support raising park entrance fees because changes in income did not matter according to the results.

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Table 1. Descriptive Statistics of Variables

Variable name		Mean	Standard Deviation
Number of fishing trips	Average number of trips taken in the Southeast	6.4396	14.6002
Income	Household income in $	4.6409	2.6086
Expenditure	Average expenditure spent on a trip	228.6980	445.2815
Price	Average cost per trip	27.9716	52.8166
Bass fishing	1 if the individual takes a bass fishing trip, 0 otherwise	.2643	.4410
Days spent on fishing	Total number of days spent on a trip	7.4953	16.2421
Age	Years	.4535	.1432
Age^2	—	.2261	.1416
Marital status	1 if married, 0 otherwise	.6984	.4590
Gender	1 if male, 0 otherwise	.8157	.3878
Race	1 if white, 0 otherwise	.8782	.3271
Years in school	Years	13.1061	2.8280

Note: Income and age variables are scaled by 10,000 and 100, respectively.

Table 2. Maximum-likelihood Estimates of Bivariate Probit and Count Data Models

	1st Stage		2nd Stage	
Variable	Probability of being an angler	Probability of taking a fishing trip in the Southeast	Poisson	Negbin
Constant	-.3883 (-1.31)	.2603 (.56)	1.7150[a] (16.56)	1.0465[a] (3.93)
Income	.0234[a] (2.35)		.0348[a] (8.48)	.0177[b] (1.67)
Expenditure		.0005[a] (2.49)		
Price			-.0044[a] (-18.21)	-.0038[a] (-10.44)
Bass fishing		.4321[a] (3.53)	.2082[a] (10.46)	.2149[a] (4.24)
Days spent on fishing			.0278[a] (118.26)	.0447[a] (45.52)
Age	.3558 (.31)	-.6394 (-.42)	.3612 (.90)	1.5946 (1.49)
Age^2	-1.0202 (-.88)	-.1574 (-.10)	-.6414 (-1.52)	-1.8857[b] (-1.68)
Marital status	-.1038[b] (-1.63)	.1286 (1.45)	-.0199 (-.98)	-.0589 (-1.04)
Gender	.4213[a] (5.54)	.0955 (.83)	.0990[a] (2.92)	.1434[a] (1.95)
Race	.0835 (.98)	.0892 (.83)	.0122 (.46)	.0085 (.11)
Years in school	-.0001 (-.01)	-.0456[a] (-2.51)	-.0047 (-1.30)	-.0043 (-.47)
Rho (ρ)		.9789[a] (32.53)		
Alpha				.2682 (13.12)
Loglikelihood		-1883.61	-4062.57	-2955.95

Note: t-values are in parentheses.
[a] Significant at α = .05.
[b] Significant at α = .10.