Use of Bootstrap Method to Obtain Reliable Parameter Estimations on Travel Cost Demand Model

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Abstract:

We used poisson and negative binomial models to estimate future demand of recreation trips to a closed site using internet and intercept surveys. Parameter estimates were validated using 1,000 bootstrap replications. Result indicated a significant negative impact of travel time and positive impact of income on the future recreational demand.

Introduction

Travel cost approach has been one of the most common approach to a provide numerical value to the benefit of natural amenity in question. Survey sampling has been the way to gather information on users of such resources. Given such a method of data collection, the count of the recreational trips taken over a season or a year acts as a dependent variable in the model. The survey collects information on individual recreation sites, recreational trips, and demographic characteristics of individuals. As such, the individual trip counts are nonnegative integers in nature.

The survey data imposes additional restriction of unknown distribution of population, if onsite interview technique is chosen for the survey. Under such circumstances the traditional parametric assumptions of population-parameter distribution fails. When the true population distribution is unknown, obtaining the standard errors of the estimates is difficult or possibly mathematically intractable, although the parameter estimates are consistent (Guan). Further, parameter estimates may have unknown sampling distribution. A nonparametric approach, the bootstrapping can be employed to obtain standard errors of estimates when population distribution is not known (Guan). The approach relies on the assumption that the original sample represents the population and the distribution function can be estimated using a bootstrapping technique. The empirically estimated sample distribution will then represent the true distribution of population. The desired estimates can be obtained as empirical estimates of the true parameters from infinite numbers of random samples (Mooney and Duval).

The non-negative and integer nature of recreational trip-counts suggests the form of poisson or gamma distribution in the data and count data approach for analysis. Over-dispersion in the data again stresses the use of negative binomial approach. Shaw introduced count data techniques to estimate the travel cost using survey data and Monte Carlo experiment. Subsequent works expanded the application of the count data model to include poisson and negative binomial distribution of dependent variables. Grogger and Carson employed standard and truncated poisson and negative binomial model to estimate a fishing demand in Alaska. Creel and Loomis made use of both the poisson and negative binomial models to estimate deer hunting in California. Hellerstein reviewed the robustness of poisson and negative binomial models on estimating demand curve for the Boundary Waters Canoe Area located in Minnesota.

Most of these previous studies estimate the seasonal recreational demand and focus on how to estimate unbiased estimation. Engling and Shonkwiler estimated the long run demand of recreational hiking sites using the count data model. Their study completed a set of models by developing a truncated and endogenously stratified negative binomial model. Similarly, Englin *et al*. extended the count data model by utility theoretic system of demand equations for Canadian wilderness parks and suggested that the economic information added by economic theory is important in recreation demand estimation. Haggerty and Moeltner found that the perceived cost of driving is statistically different for every individual by using count data models and by treating driving cost as individual specific variable.

Generally, the travel cost demand model estimated with count data provides unbiased estimation of demand curve and provides numerical value to the natural resource. We analyzed onsite and online survey data using poisson and negative binomial approaches to estimate the demand for recreational trips. We employ bootstrapping technique to obtain confidence interval for the recreation demand estimates. Our study focuses on visitation patterns to one of the most popular but recently closed recreational fishing locations in the coast of Louisiana.

Methods

Recreation demand for the island depends on a search process which results in individuals' utility maximization subject to their budget constraints. Whether or not a visitor takes a trip depends upon the utility obtained from visiting the site. An individual evaluates whether the achieved utility from a recreational visit worth the travel cost, which is a measure of price paid for the trip and associated activities. Furthermore, the choice to visit Elmer's Island depends on the perceived site quality, alternative sites, and complementing purposes available. The consumer demand of recreation can be formulated as following;

$$y_i = f(P_i, x_i, \beta) + \mu_i \qquad i = 1, 2, \ldots, N \tag{1}$$

Where, y_i is the trip demanded by i^{th} individual to visit the Elmer's Island, P_i is the travel cost associated with visiting the site. In travel cost model, the expenditure associated with recreational trips represents the price for recreational use of that particular site. x_i is the vector of explanatory variables; β is a vector of unknown parameters and μ_i is vector of error terms.

In estimating recreational demand function, count data model has been widely used because of non-negative integer nature of the data. Creel and Loomis, Hellerstein, and Hellerstein and Mendelson present both econometric and conceptual reasoning to use count data model for recreational demand estimation. Hellerstein and Mendelson reported that a distribution function restricted to non-negative integers such as poisson and negative binomial distributions, increases the estimation efficiency. In addition, they suggested that the count data estimation is consistent with a utility maximization model with repeated choice.

This study uses Poisson and negative binomial measures of the count data model to estimate demand for recreational trips to Elmer's Island. The Poisson model imposes a restriction of equal mean and variance. However, negative binomial model relaxes the restriction by permitting differences between mean and variance. The general forms of the Poisson and negative binomial models employ an exponential form of trip demand which changes equation (1) into the following form (Green):

$$\lambda_i = \exp(P_i, x_i, \beta) \tag{2}$$

The probability density function for the Poisson model is expressed mathematically as:

$$prob(Y = y_i) = F_P = \frac{e^{-\lambda_i} \lambda^{y_i}}{y_i!} \tag{3}$$

Where, λ_i represents the conditional mean of y [E (Y/X)] which is y_i in equation (1). Under a poisson distribution, the underlying assumption is expressed as; E (Yi/X) = $\lambda_i = \exp(X, \beta)$ = Var (Y/X) which often creates problems with real world data. The mean variance relation conditional on regressors is violated under the presence of over-dispersion on a dependent variable. A more generalized form of Poisson distribution, the negative binomial, results when the parameters distribute with a gamma random distribution. By choosing the density function to be a negative binomial with a dispersion parameter α_i and mean y_i the model can be expressed as;

$$prob(Y = y_i) = F_{NB} = \left[\frac{\Gamma(y_i + 1/\alpha_i)}{\Gamma(y_i + 1)\Gamma\Gamma 1/\alpha_i)} \right] (\alpha_i \lambda_i)^{y_i} (1 + \alpha_i \lambda_i)^{-(y_i + 1/\alpha_i)} \tag{4}$$

Where, Γ represents the gamma distribution and α_i denotes the dispersion parameter. The mean and variances are different for this distribution: E (Yi/X) = $\lambda_i =$ exp$(X,\beta X$ and Var (Y/X) $= \lambda_i \ (1 + \alpha_i \lambda_i \ )$.

The estimators of the recreational demand are random variables due to the approach that generate them. The true distributions of such estimates are not known. We, therefore, make use of a bootstrapping technique to provide confidence interval for the estimates. The approach determines the statistical accuracy of the procedures.

Study Area and Data Collection

Elmer's Island, one of the most popular coastal recreation sites of Louisiana, has been closed since 2001 because of the dispute over the selling price by the owner of the land to the State of Louisiana. Elmer's Island had been very popular destination for people who choose coastal recreation with a small entrance fee. For the past thirty years, The Island had been operated as a commercial campground and primitive area. The property had become a popular destination not only to Louisiana residents but also to out of state tourists (Curole and St. Pe). For nominal fee, users had had access to the location for fishing, bird watching, camping and beach combing. The area also provides significant habitat for numerous bird species and other forms of coastal marine life. In addition, the island is one of the only three accessible beaches in Louisiana. This creates a public pressure to reopen the island for public recreational use. We attempt to estimate a demand function associated with recreational activity generating monetary value to the island in question.

Collecting data on individuals visiting the Elmer's Island is very difficult because of varying nature of recreational activities in the closed island. Intercept survey on proxy sites raises the concern of whether the sample represents general population visiting Elmer's Island (Shaw). Furthermore, the samples obtained by mailing the population impose extremely high cost and low response rate. This is mainly because most of household consists of zero visits to the site. We therefore, include internet survey where respondents are self selective and intercept survey where the respondents are randomly chosen at the exit point of the site. Respondents were informed about the survey through popular news media, outdoor newspapers, and outdoor radio shows. Using both intercept and internet survey our study expects to reduce interview bias and self selection bias, under a constrained budget.

Most of the observations (92%) are obtained from online survey posted on the web server of Louisiana State University, Department of Agricultural Economics and Agribusiness which provided a space for research questionnaire on their webpage. Survey remained on the web for 77 days starting from May 15th to July 31st, 2003. Online survey responses were formatted in such a way that responses were recorded in a Microsoft excels spreadsheet automatically, once submitted. Duplicate responses were identified and deleted for any submissions with same internet protocol address. Solicitation for the responses and announcement were posted on twenty eight media including direct mails, radio programs, newspapers, magazines, websites and newsletters.

Intercept survey was conducted at Grand Island State Park and Holley beach considering these sites as proxy for Elmer's Island. Commemorative hats were distributed to cooperating individuals on filling out a questionnaire set containing 34 individual questions. The intercept survey was conducted within 42 days using a series of multi-day trips to the sites during June and July, 2003.

Total of 2691 responses were gathered using both survey methods. Some of the observations with incomplete and irrelevant information were dropped from the data set. The dependent variable was a count of expected visits per year in future. The survey gathered a variety of information including demographic variables such as age, gender, income, preference over different site quality, and the purpose of their visit to evaluate whether joint or incidental visit have any affect on recreation demand.

Expenditure per trip is also included to capture the value of other attributes. The expenditure (travel cost) variable includes price paid by individual for recreational and non recreational activities during the trip. The variables contain cost of lodging, food, fuel, entry fee etc. One way travel time was also included in the questionnaire to obtain valuation of time. Ignoring value of travel time in estimating recreational demand model will result in a biased estimation of demand curve. The need for including travel time in recreation demand estimation is well documented in the past researches (Knetsch). Bockstael *et al*. suggest that time constraint cannot be incorporated with budget constraint. Loomis, Yorizane and Douglas also argue against trading recreation time and money at a wage rate. So, the time and trip costs are treated as two separate variables in our analysis. The travel time in our study is treated as independent variables, first, the two-way travel time to the destination and second, the time spent on site for recreational activities. The dependent variable used in the analysis includes the number expected future trips.

Measuring the Site Characteristics

The theory of consumer behavior assumes that individual choice decision is based on the utility from the good which is defined over the quality and price. The quality of recreational visit is often described by the measures of environmental quality factors such as pollution level, congestion, existence of wild life, or other environmental variables (Clark and Khan). Even though, site characteristics are important factors in modeling a recreation demand, existing literatures do not bear enough information to guide us which variables should be in the analysis. We, therefore, use our experience to select the variables that may have impact on consumer demand for coastal recreation.

In order to measure the impact of trip quality on recreational trip decision, the importance of site's physical and environmental characteristics have been measured (Table 1). Levels of importance of those characteristics in choosing to visit Elmer's Island are measured by using 5 scale preference scales (5 being very important). The level of importance for characteristics within physical and environmental quality is aggregated in order to change the preference level into a preference index for environmental quality and physical facilities as two separate variables. Environmental characteristics include existence of pollution, congestion and wildlife, while, physical characteristic consists of camping facility, interpretive signs, level of development, rules and regulations, nearby food and lodging, accessibility, and total catch of fish per trip.

Result and discussion

On an average, individuals have visited the island 2.34 times in the past year. The expected number of visits in the future is reported to be 4.12 on an average. Table 2 contains the summary of variables used in estimation process. Estimation of coefficients using count data regression models are presented in Table 3 and Table 4. Table 3 shows the coefficients, normal standard errors, bootstrap standard errors, and bootstrap confidence interval for poisson model and the Table 4 shows the same information from negative binomial count data model. The results show that most of the variables in the models are significant with expected signs and all the coefficients fall within the bootstrapped confidence interval.

We separate total time spent on recreational trip into two separate variables. First, the time spent for recreation on site has no effect on recreation demand, while the travel time to the destination is highly significant with negative effect. The negative effect of travel on recreation demand implies that an increase in travel time decreases the recreational demand to the island. One hour increase in two-way travel time decreases the expected trip counts by 11.1%.

Contrary to other similar studies (Ovaskainen *et al.*), our study result shows a total out-of-pocket expenditure incurred in recreational travel, “the price” has wrong sign on demand equation. This result suggests that the site might have some unique characteristic since it doesn’t have a “close” substitute. This may be also because individuals are more interested just because it is closed and they are exited to take a trip to the island. It may be also true that the individuals do not consider the substitute site the real “substitute site” for the island. Income shows a positive and significant effect on travel demand showing that an increase in income increases the demand for recreation. This finding is consistent with the results of Bockstael et.al., and Loomis et al. The result also shows that recreation demand associated with overnight stay is less than the demand for day visits (Table 3). However, the purpose of taking the trip has no impact on visiting Elmer’s Island.

The study result showed site’s physical and environmental characteristics were significantly important on travel decision. It showed increased trip demand if individuals were more concerned with environmental characteristics of the site. Increasing concern over the importance of pollution level, level of wildlife etc increased the demand for trip.

This implies that whoever is more concerned over the environmental quality are more likely to take the trip to the island. On the other hand, the physical characteristics of the recreational sites, such as food and lodging facility had no statistically significant impact on travel decision.

The next variable, the familiarity of respondents with Elmer's Island shows a significant positive response to trip demand for recreation. That is the result shows that if an individual is familiar with the island he/she decides to take more trips to the Elmer's Island. This implies that the island is attractive and more pleasurable for wetland and off-shore recreation.

Surprisingly, being a female in the equation increases the demand for recreation in the site which is more popular for fishing. We also included the type of transportation vehicle but turned out to be insignificant and thus are not included in the table.

In addition to coefficient estimation, we also present Likelihood Ratio (LR) test to verify if the poisson assumptions of equal mean and variance holds. The likelihood ratio test is normally distributed under the null hypothesis that the mean and variance of trip counts are equal. The LR test for dispersion parameter, the alpha is presented at the end of Table4. Significantly higher χ^2 with probability <0.0001 shows the hypothesis of equal mean and variance is rejected. The goodness of fit measures after the poisson model estimation also supports the difference in mean and variance of trip counts. Furthermore, from the summary statistics the mean of the trip counts is calculated to be 4.12 and variance is found to be 5.484. In general, our study result shows there is over-dispersion present in our data set.

In presence of over-dispersion in the dependent variable, negative bionomical count data model is suggested to provide better estimates of the parameters (Camaroon and Trivedi). We, therefore, also run negative binomial count data model, estimate the normal standard errors, bootstrapped standard errors, and bootstrapped confidence intervals. The significance of alpha in the standard negative binomial model reflects the level of over-dispersion in the analysis. This suggests the rejection of hypothesis of no over-dispersion in the data. This corresponds to the larger value of t-statistics in case of poisson as compared to negative binomial because of larger standard errors. However there is not much difference on coefficients from poisson count data model and negative binomial model. The purpose of visit now is insignificant at 5% confidence level with negative binomial model. This is because the standard errors are larger in case of negative binomial model which is due to the presence of over-dispersion in the data set.

Pseudo R^2 value or the likelihood ratio indices ($R^2 = 1 - \ln L/\ln Lo$) are also presented in Table 3 and Table 4. Pseudo R^2 value, analogous to standard R^2 provides the information regarding explanatory power of the maximized log likelihood estimations in a bounded figure between 1 and 0. The R^2 values in our study are smaller indicating that the explanatory power of the model is very low. However in social studies, where human behavior is involved lower R^2 value is not uncommon.

1. Conclusion

This study attempted to find variables affecting the future demand of a closed recreational site using poisson and negative binomial models. Study results showed positive impact of income on demand for recreation. The three types of bootstrap confidence interval include all the parameter estimates from original samples indicating that the non-randomness of the data is not a problem in our sample where more than 90% observation comes from online survey. However, contrary to expectations, both models showed statistically significant positive impacts of recreational expenditure to the demand for recreation in costal wetlands. The unconvincing estimation associated with, travel cost suggests a careful attention toward the model and/or data. Collinearity of travel cost with purpose of visit might have caused to have a wrong sign of the effect of travel cost on demand function. This issue still needs to be addressed.

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Table 1: Importance of Environmental Characteristics on Travel Decision

Description	Total Observation	Internet Survey	Intercept Survey
Lack of Pollution	4.77	4.78	4.47
Ease of access to site	4.31	4.31	4.33
Active enforcement of rules	4.15	4.14	4.32
Abundant wildlife	4.12	4.12	4.17
Low human congestion	3.95	3.96	3.87
Catch per trip	3.78	3.08	3.62
Lack of development	3.47	3.47	3.48
Near by/onsite food and lodging	3.25	3.2	3.98
Interpretive signs/naturalists	2.21	2.07	2.84
Camper hookups	2.05	1.98	2.91

Table 2: Characteristics of Variables

Variables	Mean	Std. Dev	Min	Max
Purpose of visit 1=pimary 0=joint+incedental			0	1
type of visit 1= day visit, 2=night visit			0	1
Total time spent in site (hours)	44.04839	36.9221	2	160
Total expenditure(dollars)	381.2934	343.2007	14	2485
Importance of envt. quality in trip decision			0	1
Sites physical Characteristics	22.21251	4.440479	7	35
Sites Environmental Characteristics	11.82662	3.355836	2	15
Familiarity 1= Familier 0=not			0	1
No of expected visit in future	4.21070	2.47630	0	10
Travel Time (hours two way)	2.837253	1.012315	0.15	18
Gender 1= Female 0 = Male			0	1
Marital Status 1=married 0=single			0	1
Flexibilty of Job 1= Flexible 2=not			0	1
Income (per year)	3.175676	0.860131	1	4
Job status 1= full time 0= not			0	1
Age (years)	42.34798	11.07908	18	81

Table 3: Estimated Recreation Demand Curves Based Poisson Count Data Model Using 1000 Bootstrap Samples

				Bootstrapped Confidence Interval					
				Normal		Percentile		Bias Corrected	
Variables	Coeff p-value	Std. Err.	Bootstrap Std. Err.	Lower limit	Upper Limit	Lower limit	Upper Limit	Lower limit	Upper Limit
_cons	0.869 (0.024)	0.386	0.384	0.116	1.622	0.046	1.593	0.147	1.666
Purpose of visit 1= primary 0=joint +incidental	-0.044 (0.333)	0.045	0.051	-0.144	0.057	-0.140	0.063	-0.143	0.059
Type of visit 1= day visit, 2=night visit	-0.101 (0.057)	0.053	0.063	-0.224	0.023	-0.223	0.022	-0.227	0.017
Total time spent in site (hours)	0.001 (0.178)	0.001	0.001	0.000	0.002	-0.001	0.002	-0.001	0.002
Total expenditure(dollars)	0.0002 (0.015)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Importance of envt. quality in trip decision	0.278 (0.018)	0.118	0.139	0.006	0.550	0.020	0.577	0.016	0.561
Sites physical Characteristics	0.006 ((0.328)	0.006	0.007	-0.007	0.020	-0.008	0.020	-0.007	0.021
Sites Environmental Characteristics	-0.027 (0.036)	0.013	0.015	-0.056	0.002	-0.056	0.001	-0.056	0.001
Familiarity 1= Familier 0=not	0.632 (0.004)	0.218	0.144	0.351	0.913	0.358	0.945	0.369	0.957
Travel Time (hours two way)	-0.111 (0.000)	0.026	0.026	-0.162	-0.060	-0.160	-0.060	-0.164	-0.066
Gender 1= Female 0 = Male	0.253 (0.020)	0.108	0.128	0.003	0.503	-0.015	0.502	-0.021	0.500
Marital Status 1=married 0=single	-0.053 (0.345)	0.056	0.066	-0.184	0.077	-0.178	0.083	-0.180	0.079
Job status 1= full time 0= not	-0.056 (0.609)	0.109	0.134	-0.319	0.207	-0.274	0.247	-0.292	0.214
Flexibilty of Job 1= Flexible 2=not	-0.030 (0.567)	0.052	0.062	-0.151	0.092	-0.150	0.092	-0.154	0.087
Income (per year)	0.073 (0.013)	0.029	0.032	0.010	0.137	0.011	0.140	0.010	0.137
Age (years)	0.002 (0.302)	0.002	0.003	-0.003	0.007	-0.003	0.007	-0.003	0.007

Number of observation= 530 Log likelihood = -1148.3791 Pseudo R2 = .0317

Table 3: Estimated Recreation Demand Curves Based on Negative Binomial Count Data using 1000 Bootstrap Sample

				Bootstrapped Confidence Interval					
				Normal		Percentile		Bias Corrected	
Variables	Coeff p-value	Std. Err.	Bootstrap Std. Err.	Lower limit	Upper Limit	Lower limit	Lower limit	Lower limit	Upper Limit
Cons	0.849 (0.043)	0.420	0.387	0.089	1.608	0.021	1.518	0.111	1.603
Purpose of visit 1= joint 0=joint+incedental	-0.042 (0.399)	0.050	0.052	-0.143	0.060	-0.140	0.060	-0.136	0.063
Type of visit 1= day visit, 2=night visit	-0.099 (0.089)	0.058	0.063	-0.223	0.025	-0.233	0.020	-0.221	0.024
Total time spent in site (hours)	0.001 (0.215)	0.001	0.001	0.000	0.002	0.000	0.002	-0.001	0.002
Total expenditure(dollars)	0.0002 (0.033)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Importance of envt. quality in trip decision	0.280 (0.028)	0.128	0.141	0.003	0.557	0.027	0.584	0.016	0.565
Sites physical Characteristics	0.007 (0.339)	0.007	0.007	-0.007	0.020	-0.007	0.021	-0.006	0.021
Sites Environmental Characteristics	-0.027 (0.06)	0.014	0.015	-0.056	0.002	-0.056	0.002	-0.056	0.002
Familiarity 1= Familier 0=not	0.630 (0.006)	0.231	0.145	0.346	0.914	0.379	0.950	0.392	0.989
Travel Time (hours two way)	-0.112 (0.042)	0.029	0.026	-0.162	-0.061	-0.160	-0.058	-0.168	-0.065
Gender 1= Female 0 = Male	0.250 (0.381)	0.123	0.138	-0.020	0.520	-0.044	0.494	-0.043	0.497
Marital Status 1=married 0=single	-0.055 (0.691)	0.063	0.066	-0.184	0.075	-0.177	0.078	-0.180	0.077
Job status 1= full time 0= not	-.048 (0.318)	0.121	0.135	-0.313	0.217	-0.265	0.263	-0.281	0.244
Flexibilty of Job 1= Flexible 2=not	-0.028 (0.022)	0.057	0.061	-0.148	0.091	-0.141	0.093	-0.146	0.088
Income (per year)	0.074 (0.101)	0.032	0.033	0.010	0.139	0.009	0.137	0.007	0.134
Age (years)	-0.028 (0.356)	0.017	0.016	-0.060	0.004	-0.060	0.005	-0.059	0.005
Alpha	.0527	.0180	1.411	-5.707	-.175	-4.54	-2.580	-3.499	2.322

Number of observation= 530 LR test for alpha = $\chi^2(1) = 11.43$ Log likelihood = -1142.665 Pseudo R2 = .025