ESTIMATING SUBSTITUTION EFFECTS FOR OKLAHOMA ANGLERS USING DISCRETE CHOICE ANALYSIS OF THE INDIRECT TRANSLOG UTILITY DEMAND MODEL

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I.

INTRODUCTION

Oklahoma fishermen (anglers) have an abundant number of choices of where to fish and type of fishing to pursue. Oklahoma has many lakes, rivers and small streams, each of which represents a potential fishery to the angler. Oklahoma anglers may fish at these state locations but they may also choose to fish at locations out-of-state.

Anglers may choose the number of fishing trips they make each year (or season) and the places (sites) at which they fish. Some anglers make many trips each year, others choose to make only a few trips. Some anglers fish only at one or a few sites, others choose to fish at many sites. Thus, sites may be competitive in the distribution of a limited number of angler trips.

Each angler creates his/her own market for the total number of trips per year and the number to each site based on the cost to visit each site, the attributes of each site, and the angler's own personal preferences and resources. Because each trip to each site is associated with an expected fishing experience and cost, if the relative cost per trip between different sites should change, anglers have a further choice as to their willingness to substitute their limited number of trips between the different sites.

This research is an analysis of choices available to two different groupings of Oklahoma anglers. The first set of choices is based on the decisions of the total population of Oklahoma anglers to fish in-state or out-of-state. From the population of 755,000 anglers in Oklahoma in 1996 (U.S. Fish and Wildlife Service, 1998) and a total of 11,679,000 trips, 144,000 anglers made 299,000 trips out-of-state. This is 19 % of the anglers that made one or more out-of-state trips representing 2.56 % of the total number of angler trips. But this also shows that 81% of the anglers chose not to make a single out-of-state trip. The reasons anglers make out-of-state trips are many and include a desire for a different fishing experience other than that available in Oklahoma, familiarity of trip sites in and out of Oklahoma, and relative cost of trips. What is not known is the willingness of anglers to substitute out-of-state for in-state trips given changes in relative cost of trips.

The rate at which anglers are willing to substitute out-of-state trips for in-state trips has certain implications for state economic development. Anglers spent $218,524,000 for 11,380,000 trips made in Oklahoma in 1996 for an average cost of $19.20 per trip (U.S. Fish and Wildlife Service, 1998). In other words, 579,000 anglers spent $218,524,000 in 1996 for an average cost of $ 366 per angler. If the relative cost of out-of-state trip to in-state trip should change, how does this affect the number of trips Oklahoma anglers make in-state versus out-of-state? This result will depend on the willingness of anglers to substitute trips and the magnitude of change in relative trip price. If the relative price of trips should change such that there are fewer in-state trips, angler expenditures could negatively impact Oklahoma's state economic development.

Trip costs vary for many reasons. For example, the cost of a fishing license varies between states and there is usually a cost discrimination between whether the angler is a resident or non-resident. If Oklahoma increases its resident fee relative to the non-resident fee an angler would pay out-of-state, relative trip costs would change. During periods of increasing energy costs, out-of-state trips will generally increase more than in-state trips because of longer travel distances to out-of-state sites.

Changes in quality of the fishing trip may affect site choices as well (see Amera and Schreiner, 1998 and Budiyanti, 1995 for empirical examples). If the number of fish caught per trip is an important factor in determining the quality of a trip, then any change in a fishery that requires the angler to stay longer to catch the same number of fish (and thus attaining the same quality of trip) may increase the cost of the trip at this fishery (site) versus an alternative site. This may be the case if fish populations are reduced because of environmental changes in habitat in any or all of Oklahoma's fisheries. For example, if the salt content of Lake Texoma is changed because of desalinization processes for purposes of municipal and industrial uses of the stored water this has a potential effect of changing the habitat for striped bass, reducing fish population, and increasing trip cost for achieving the same trip quality level (Amera and Schreiner, 1998). Thus, depending on anglers' willingness to substitute trips between sites the number of in-state trips may decrease. Similar results may occur if Oklahoma's water pollution laws are changed relative to other states thus having the affects of decreasing (increasing) fish populations, increasing (decreasing) trip costs, and reducing (increasing) in-state versus out-of-state trips. Thus, knowledge of anglers' willingness to substitute out-of-state trips for in-state trips, given a change in relative trip costs, is critical.

The second set of choices is based on the decisions of eastern Oklahoma small stream anglers to substitute stream-fishing trips for other types of fishing such as trips to reservoirs, lakes, large rivers and farm ponds. Little was known about small stream fishing in eastern Oklahoma until the Oklahoma Department of Wildlife Conservation commissioned a recent survey of Oklahoma fishing license holders that fished small streams. Results of that survey indicate that of the 627,000 Oklahoma license holders in 1993, an estimated 11.6 % (or 72,600) fished eastern Oklahoma small streams for an estimated 1,128,500 total trips (Oklahoma Department of Wildlife Conservation, 1996). A follow-up survey indicated these anglers also fished at reservoirs, lakes, large rivers and farm ponds. What is not known is how eastern Oklahoma small stream anglers are willing to substitute small stream fishing for other types of fishing given a change in relative trip costs.

The importance of this information becomes relevant when managing small natural streams in eastern Oklahoma. On the basis of the importance of 1,128,500 eastern Oklahoma small stream fishing trips, the Department of Wildlife Conservation could take a more active role in managing such streams for the benefit of all Oklahoma fishing license holders. In the process, this could change the quality and cost of small stream fishing. Knowledge of the willingness of small stream anglers to substitute stream trips for other types of fishing trips provides a better basis for the management of natural stream fishing.

Problem Statement

Even though most recreation trips have a primary destination, there is empirical evidence that multiple destination trips are common. Binkley and Hanemann (1978) were the first to use a discrete choice random utility model to account for multiple destinations including site qualities. Morey (1981, 1984), Feenberg and Mills (1980), Caulkins, Bishop and Bouwes (1982), Morey, Rowe, and Watson (1993), and Morey, Breffle, and Greene (2001) are among the authors who have used the discrete choice analysis of random utility model. In these studies, multinomial logit, nested logit, and to a lesser extent, probit models were widely used to examine the quality and individual characteristic impacts on trip consumption. Recent studies by Freeman (1993) and Bockstael, McConnell and Strand (1991) provide excellent reviews of the random utility models.

However, a common problem exists when economists attempt to model consumer behavior and utility maximization. The assumption that consumers respond to changes in prices, income, and other economic factors based on time-series or aggregate data is easily incorporated in a smooth continuous manner using regular econometric analysis (Gould, 1996). In contrast, with disaggregated data traditional regression methods cannot be used to capture the consumer responses due to an increase or a reduction in a commodity's price. Therefore, the use of micro data presents a major estimation problem. This problem arises from the fact that some anglers are observed to take in-state fishing trips leaving out-of-state fishing trips unvisited or vise versa during the survey period. Thus each individual faces three alternative choices. They may take in-state fishing trips without taking out-of-state fishing trips, or take out-of-state fishing trips leaving in-state fishing trips unvisited, or take both in-state fishing trips and out-of-state fishing trips. This condition is also applicable to the small stream fishing trips and all other water body fishing trips. Thus, the problem exists when a significant proportion of observations have expenditures equal to zero for one or more types of fishing trips in demand models. This is known as the limited dependent variable problem at corner solution in which the standard econometric approaches of utility demand systems do not take account of zero-trip consumption and therefore yield inconsistency in terms of parameter estimates including elasticities of trip substitutions.

Zero trips may be generated for several reasons including infrequency of trips, variations in individual preferences, and for economic reasons (Chio,1993). Zero fishing trip observations lead to zero expenditure and unobserved price.

In traditional demand analysis with cross-sectional data sets, it is usually assumed that prices are constant. Engel functions are estimated by regressing total expenditures on income, household size, and other demographic characteristics (Dong, Shonkwiller, and Capps,1998). Failure to specify such variation in prices in cross-sectional data would result in biased and misleading demand elasticities (Polinsky, 1977). Prices in a cross-sectional data set may reflect quality effects, which should be corrected for prior to estimation. If prices are not constant then the resulting Engel analysis may be inappropriate.

In traditional censored demand analysis with cross-sectional data and missing prices because of non-consuming households, those effects are not considered when utilizing price information for goods that are consumed. If the number of non-consuming individuals is large, using only observed prices is likely to be a serious problem due the exclusion of information relating to non-consumtion. Previous studies have overcome this problem by incorporating imputation methods such as first-order or zero-order methods in which missing prices are replaced with sample means or predicted prices (Choi, 1993). However these methods are considered only when the missing information is randomly missing. Anglers may not take a trip due to economic or other related factors.

Thus, when using spatial and temporal dummy variable techniques, one should predict missing prices and then use them to capture price effects in demand models.

In this study, estimation techniques are applied in the prediction of missing prices and then two discrete choice models are compared in estimating trip demands when a significant proportion of trip expenditures is zero on one or more types of fishing trips. The models are then used to estimate elasticities of substitution of out-of-state trips for in-state trips and natural stream trips for all other water body type trips.

Objective of the Study

The objective of this study is to evaluate two different choices by two different population groups of anglers in Oklahoma. The first evaluation is the potential impact of in-state and out-of-state fishing trip prices on Oklahoma anglers' demand function by using a translog indirect utility model. The impact is measured by the willingness of anglers to make trip substitutions. The second evaluation is to estimate the elasticity of substitution in conjunction with the impact of changing price and quantity related indices for eastern Oklahoma small stream fishing trips relative to all other water body type fishing trips in Oklahoma by using a constant elasticity of substitution utility demand model.

Each alternative fishing trip controls for quality attributes and accounts for all price impacts. Individual characteristics or site attributes are considered for the quality aggregator. In the trip model, assuming in-state trip to out-of-state trip, the first trip will be chosen if the ratio of its price to that of the second trip is lower than the ratio of their respective quality indicator. In the discrete choice problem, the aggregation problem arises since relative prices or quality indicators vary among sites. Thus the relationship between average relative prices and relative aggregate demands will always depend on the empirical distribution of these relative prices and quality indices. These quality indices can be in terms of individual characteristics or fishing site attributes. Variation in the quality indices has a variety of potential causes. There is no substitution between the total budget and its expenditure on fishing trips since quality or quantity of fixed inputs, such as management, may be unequally distributed among sites. Different climate conditions and legal restrictions, including environmental regulations, may cause geographic variation in relative quality indices. We expect the variation should be greater the shorter the time unit considered, resulting in the higher probability that trips will be made on an all- or –nothing basis.

Organization of the Study

The subsequent chapter presents a literature review on concepts and applications of site substitution in fishing trip demand analysis. This chapter also presents two versions of the translog indirect utility model, the Kuhn-Tucker Indirect Utility and the Dual Approach of Indirect Utility as well as the two-step censored demand models (Heckman's two-stage procedure) when expenditures exist on one or more fishing trip sites but fishing trips at some sites may be zero. The first study on the substitution of out-of-state trips for in-state fishing trips is presented in Chapter III, and emphasizes concepts, methodology, estimation procedures, data requirements, results, and discussion of the translog indirect utility demand model using the Dual Approach (the Lee and Pitt model) and the two-step censored demand model. The second study on the substitution between natural streams and all other fishing trips is presented in Chapter IV and gives the methodology, estimation procedures, data requirements, results and discussion for the two models used in the previous chapter. Chapter V presents the summary, conclusions, and limitations of the study.

CHAPTER

II.

LITERATURE REVIEW

Recreational demand has been estimated by using different approaches, including discrete choice models, pooled models, zonal models, and hedonic models. Economists have given considerable attention to multisite demand systems, which may include the total number of trips by individuals during a season as well as the number of trips made to each of several available sites. Recreational trips are treated as market goods in utility maximization procedure. In the literature, fishing site characteristics include catch rate, size of fishing site, water depth, and water quality, all of which can affect recreational demand (Englin, Lambert, and Shaw, 1997). Feather (1994) modified the utility of trip consumption subject to time and income constraints in deriving the demand equations. Bocksteal, McConnell, and Strand (1989) used public goods as characteristics for non-market goods. Ward et al. (1997) developed an utility-theoretic partial demand system in deriving substitution among sites, with several unpriced characteristics for New Mexico fishing reservoirs and streams. Feather, Hellerstein, and Tomasi (1995) used discrete choice in a multisite demand model for finding theoretically identified welfare changes.

Haab and McConnell (1996) modified a count data model for consumer demand in which a large number of zero observations were found for the dependent variable by introducing a random error term into the traditional count model demand function. If one cannot truly observe travel costs in the recreational demand system, the parameters of the model with error term are attenuated and standard error of variables associated with parameters will be inconsistent. Thus, Englin and Shonkwiler (1995) overcome this problem by using a latent variable in which the true individual travel cost is unobservable. Advantages of this model are, first, it accounts for unobservable individual travel cost. Second, parameters estimated by the model allow for variability by individual. Third, it accounts for an estimate of the dollar value for the indicator variables.

Frequently, in samples of anglers with choices of multiple sites, anglers who participate in recreation often choose to visit more than one site in a season. Thus it is an empirical fact that a significant proportion of anglers will show zero consumption of trips to one or more sites. The zero trips can arise for several different reasons. First, zero trips may be due to misreporting by the respondents or the survey enumerators (Chio, 1993). Second, zero trips may be due to angler health or preferences. Third, zero trips are often the result of an economic decision. For instance, if energy costs increase, an angler may not take the trip because of cost and income constraint, thus yielding a corner solution to his/her utility maximization. Fourth, because of experiences of the last trip including changes in water quality or catch rate, or because of social, psychological, or ethical reasons anglers may substitute one site for another or may forego a trip. As a result, they face binding non-negativity constraints (corner solution) which at current income and prices may make it optimal to take only one of two possible paired trip choices.

All corner solution approaches follow with the specification of a utility function. Primal approaches to the corner solution employ a direct utility function, while dual approaches start with an indirect utility function. Bockstael, Hanemann, and Strand (1986) were the first to discuss the extreme corner solution and the general corner solution within the context of recreation demand. They presented a consistent, utility theoretic model by incorporating site quality and allowing for the discrete/continuous nature of the decision problem. It is evident that for most recreation choices a general corner solution exits more than an extreme corner solution.

The Extreme Corner Solution

Hanemann (1984) describes the formulation of several extreme corner solution cases, which account for considerable flexibility in modeling price, income, and quality elasticities. The individual chooses to consume all but one of a set of discrete alternatives.

Following Bockstael, Hanemann, and Strand notation, let an individual have a utility function over the commodities $x_1,...,x_N$ and z, where z is assumed as the numeraire. Let $b(b_1,...,b_N)$ and $s(s_1,...,s_k)$ denote the goods attributes and individual characteristics, respectively. The utility maximization is:

$$\max_{x,z} \; u(x,b,z,s;\varepsilon) \quad \text{s.t. } \sum p_i x_i + q z = y. \tag{2.1a}$$

$$x_i \geq 0, \qquad z \geq 0 \tag{2.1b}$$

where u is strictly quasiconcave in x_i, z, q is equal to unity, y is income, and ε is error term known by individuals but not known by the researcher.

Suppose, the individual has decided to consume only one of the quality differentiated goods, good j. This can happen in the real world because there are either logical or institutional constraints for only one alternative to be consumed, e.g. either gas or electricity is consumed as the energy source, not both, or the utility function is such that maximized result is always in perfect substitution of the goods. Thus these constraints result in:

$$x_i x_j = 0 \qquad \text{all } i \neq j\,. \tag{2.2}$$

By assuming weak complementarity, the individual utility conditional on his previous decision is:

$$u_j = u(0,\ldots,0,x_j,0,\ldots,0,b,z;\varepsilon) \equiv u_j(x_j,b_j,z,s;\varepsilon). \tag{2.3}$$

The individual maximizes u_j subject to the conditional budget constraint $p_j x_j + z = y$ and non-negativity $x_j \geq 0, \quad z \geq 0$. The assumption of quasiconcavitiy ensures that the conditional utility maximization has a solution with $x_j > 0$ and if the indifference curve does not intersect the x_j axis, there is a solution with $z > 0$. Thus the conditional ordinary demand functions are $x_j(p_j,b_j,y,s;\varepsilon)$ and $z(p_j,b_j,y,s;\varepsilon) = y - p_j x_j(p_j,b_j,y,s;\varepsilon)$, and the conditional indirect utility function is $v_j(p_j,b_j,y,s;\varepsilon) \equiv u_j(x_j(p_j,b_j,y,s;\varepsilon),b_j,z(p_j,b_j,y,s;\varepsilon),s;\varepsilon)$. Since u_j is a well-behaved utility function, these three derived functions hold that v_j is quasiconvex and decreasing in p_j and increasing in y, and satisfies Roy's Identity,

$$x_j(p_j,b_j,y,s;\varepsilon) = -\frac{\partial v_j(p_j,b_j,y,s;\varepsilon)/\partial p_j}{\partial v_j(p_j,b_j,y,s;\varepsilon)/\partial y}. \tag{2.4}$$

Note that under random utility model, the quantities x_j, z and the indirect utility, v_j, are all known numbers to the individual, but, because preferences are incompletely observed, they are random numbers to the researcher, and their distribution can be derived from the joint density of error term as: $f_{\bar{v}}(\bar{v}_1,...,\bar{v}_N)$ induced by $f_{\varepsilon}(\varepsilon)$ and the corresponding cumulative distribution, $F_v(.)$.

The discrete choice of which good to select can be shown by a set of binary valued indices $d_1,...,d_N$, where $d_1 = 1$ if $x_j > 0$, and $d_1 = 0$ if $x_j = 0$. The binary choice can be shown in terms of the conditional indirect utility functions as:

$$d_j(p,b,y,s;\varepsilon) = \begin{cases} 1 & if \quad v_j(p_j,b_j,y,s;\varepsilon) \geq v_i(p_i,b_i,y,s;\varepsilon), \quad all\, i, \\ 0 & otherwise. \end{cases} \tag{2.5}$$

From the point of view of the researcher, the discrete binary choice indices are random variables. Let

$$E\{d_j\} \equiv \pi_j(p,b,y,s;\varepsilon) = \Pr\{v_j(p_j,b_j,y,s;\varepsilon) \geq v_i(p_i,b_i,y,s;\varepsilon), all \quad i\}$$

$$= \int_{-\infty}^{\infty} F_v^j(u,...,u)du \tag{2.6}$$

where $E\{d_j\}$ is the mean of the discrete choice indices that are random variables from the point of view of the investigator, F_v^j is the derivative of $F_v(.)$ with its j^{th} argument.

Now consider the unconditional problem of maximizing utility subject to individual budget constraints in the mutual exclusivity case or in the substitute goods case. The unconditional demand model resulting from this problem is:

$$x_j(p,b,y,s;\varepsilon), \; j = 1,...,N \text{ and } z(p,b,y,s;\varepsilon). \tag{2.7}$$

The unconditional indirect utility function is:

$$v(p,b,y,s;\varepsilon) \equiv u(x(p,b,y,s;\varepsilon),b,z(p,b,y,s;\varepsilon),s;\varepsilon). \tag{2.8}$$

The relationship between the unconditional and the corresponding conditional demand models and the unconditional indirect and the corresponding conditional indirect utility functions are:

$$x_j(p,b,y,s;\varepsilon)=d_j(p,b,y,s;\varepsilon)x_j(p_j,b_j y,s;\varepsilon) \quad j=1,\ldots,N. \quad (2.9)$$

$$v(p,b,y,s;\varepsilon)=\max(v_1(p_1,b_1,y,s;\varepsilon),\ldots,v_N(p_N,b_N,y,s;\varepsilon)). \quad (2.10)$$

The probability distributions of the x_j and v can be constructed using the above relationships. Using any of the statistical techniques (i.e. generalized Tobit model) the random utility extreme corner solution can be estimated by using maximum likelihood method.

Hanemann (1983) worked with several demand functions using this procedure for a set of Boston recreation data in which a subset of households (one quarter of the sample) displayed evidence of an extreme corner solution. Dubin and McFadden (1984) used the extreme corner solution in modeling the consumer choice of gas versus electricity. Chiang (1991) applied this approach to purchases of different brands of coffee.

The Primal Model (The Kuhn-Tucker Condition)

General corner solution was first proposed by two independent studies from Wales and Woodland (1983) and Hanemann (1978). General corner solution consists of applying Kuhn-Tucker conditions which allow more than one good in the individual choice set to be consumed in the positive quantities. The extreme corner solution model is a special case of the general corner solution model.

By following Wales and Woodland notation, the traditional consumer demand of constraint utility maximization assumes that consumer preferences over a set of non-negative alternatives $x = (x_1, \ldots, x_m)$ maximizing subject to budget constraint $v'x \leq 1$, where $v = \left(\frac{p_1}{y}, \ldots, \frac{p_m}{y} \right) = (v_1, \ldots, v_m)$ is a vector of normalized prices in which every p_i is divided by the corresponding income, y.

Specifically, the constrained utility model of consumer demand can be shown as:

$$H(v) = \max_x [G(x) : v'x \leq 1, x \geq 0] \tag{2.11}$$

where $G(x)$ is assumed to be a continuously differentiable, quasi-concave and monotonically increasing function. The necessary and sufficient conditions for Kuhn-Tucker solution are:

$$G_i(x) - \lambda v_i \leq 0 \leq x_i, \quad i = 1,2,\ldots,M \tag{2.12a}$$

$$v'x - 1 \leq 0 \leq \lambda \tag{2.12b}$$

where λ is the Lagrange multiplier associated with the budget constraint. Since $G(x)$ is assumed to be a monotonically increasing function, the individual will expend all income on the alternatives and hence λ will be positive if at least one good is consumed. Without loss of generality, let it be the first good. Thus the equation in (2.12a) implies that $G_1(x) = \lambda v_1$ or $\lambda = G_1(x) / v_1$. Using this result the Kuhn-Tucker condition can be written for utility maximization as:

$$v_1 G_i(x) - v_i G_1(x) \leq 0 \leq x_i, \; i = 2,\ldots,M. \tag{2.13a}$$

$$v'x = 1. \tag{2.13b}$$

If $x_i > 0$ then the model in equation (2.13a) equals zero, that is $\left({}^{G_i(x)}\!/_{G_1(x)} \right) = {}^{v_i}\!/_{v_1}$.

This condition implies that the marginal rate of substitution between goods i and 1 along the indifference curve at the solution is equal to the price ratio. If and only if $x_i < 0$, that is, it is not consumed, the marginal rate of substitution between corresponding goods and 1 is less than the price ratio.

To allow for individual differences in tastes, it is assumed that preferences are randomly distributed over the concerned population. A random utility function can be shown as:

$$G(x,u) = \overline{G}(x) + u'x \tag{2.14}$$

where $u = (u_1,...,u_m)$. For convenience, let the marginal utility consist of deterministic and random components, known by the individual, but unknown by the researchers:

$$G_i(x,u_i) = \overline{G_i}(x) + u_i \ , \ i = 1,2,...,M \ . \tag{2.15}$$

When replacing $G_i(x)$ in equation (2.13) by $G_i(x,u_i)$ in equation (2.15) one can obtain:

$$v_1\left(\overline{G_i}(x) + u_i\right) - v_i\left(\overline{G_1}(x) + u_1\right) \le 0 \le x_i \tag{2.16}$$

which implies:

$$\left(v_1 u_i - v_i u_1\right) + \left(v_1 \overline{G_i}(x) - v_i \overline{G_1}(x)\right) \le 0 \le x_i \, , i = 2,...,M \ . \tag{2.17a}$$

$$v'x = 1. \tag{2.17b}$$

Assuming u has a joint normal distribution with zero means and constant variance-covariance matrix Σ. Because the left-hand side of equation (2.17a) is linear with random components, u, it is written as:

$$y_i \equiv v_1 u_i - v_i u_1 \, , i = 2,...,M \tag{2.18}$$

with means zero and non-constant variance-covariance matrix, Ω. Using the budget constraint, one element of x, say x_1, can be eliminated and thus expressed as:

$$\overline{y}_i(\hat{x}) \equiv v_i\overline{G}_1(\hat{x}) - v_1\overline{G}_i(\hat{x}) \tag{2.19}$$

where $\hat{x} = (x_2,\ldots,x_m)$.

Equation (2.19) can be rewritten as:

$$y_i - \overline{y}_i(\hat{x}) \quad \le 0 \le x_i,\ i = 2,\ldots,M. \tag{2.20}$$

For the case without a corner solution, equation (2.20) implies that $y_i = \overline{y}_1(\hat{x})$,

$i = 2,\ldots,M$ thus the density function can be obtained as:

$$f(\hat{x}) = n(\hat{y},\Omega)abs[J(\hat{x})] \tag{2.21}$$

where $\hat{y} = (y_2,\ldots,y_m)$, $n(\hat{y},\Omega)$ is the normal density function for $\hat{y}$ with zero means and variance-covariance matrix Ω, and $J(\hat{x})$ is the Jacobean transformation from $\hat{y}$ to $\hat{x}$. Assuming the first good is consumed, then all $M-1$ conditions in equation (2.20) are inequalities. Hence the probability of the event $\hat{x}$=0 is:

$$f(0) = \int_{-\infty}^{\overline{y}_m}\cdots\int_{-\infty}^{\overline{y}_2} n(\hat{y},\Omega)dy_2\ldots dy_M. \tag{2.22}$$

In general, if the number of goods consumed is k, and they are ordered as the first k goods, then the density function can be written as:

$$f(x_2,\ldots,x_K,0,\ldots,0) = \int_{-\infty}^{\overline{y}_M}\cdots\int_{-\infty}^{\overline{y}_{K+1}} n(\overline{y}_2,\ldots,\overline{y}_K,y_{K+1},\ldots,y_M,\Omega)$$

$$x \quad [\ abs[J_K(\hat{x})]dy_{K+1},\ldots,dy_M\ ] \tag{2 .23}$$

where $J_K(\hat{x})$ is the Jacobean transformation from $(y_2,...,y_K)$ to $(x_2,...,x_K)$ when $(x_{K+1},...,x_M)=0$. If $K=M$, then equation (2.23) reduces to equation (2.21) and if the $K=1$ then the same equation can be reduced to equation (2.22). There are $M!\big/K!(M-K)!$ possible consumption patterns with K positive alternatives and $M-K$ zero consumption alternatives. For the complete density function for $\hat{x}$, there are $\sum_{K=1}^{M} M!\ /K!(M-K)!$ possible expenditure patterns.

Given a random sample of N observation on $\hat{x}$, the sample likelihood function may be written as:

$$L(\hat{x}_1,...,\hat{x}_N)=\prod_{i=1}^{N} f(\hat{x}_i) \tag{2.24}$$

where $\hat{x}_i$ is the i^{th} observation on $\hat{x}$. Given a functional form for the utility function $G(x,u)$, the parameters for this utility function and variance-covariance matrix Σ can be estimated by maximizing the likelihood function of equation (2.24). Wales and Woodland (1983) show that the maximum likelihood estimates will be consistent, asymptotically efficient and normally distributed.

Wales and Woodland (1983) applied this method in estimating the demand for various types of meat in a sample of Australian households using a Stone-Geary utility function. Phaneuf, Kling, and Herriges (2000) were the first authors to use the Kuhn-Tucker model within the context of recreation demand. They used a direct utility model for a corner solution when consumers visit a subset of available sites, setting demands equal to zero for the remaining sites.

Ransom (1987a) shows that the Wales and Woodland approach is equivalent to Amemiya's (1974) Simultaneous Equation Tobit model under certain conditions. Because Amemiya's estimation procedures are more practicable, especially when the number of the choice set is large and each individual consumes positive amounts of most of choice set, this procedure is attractive. Later, Ransom (1987b) used this procedure in specifying a quadratic utility function for the problem of households in which the wife may work, or may not.

The Dual Model (Lee and Pitt Approach)

A shortcoming of the primal solution to the consumer problem is the use of more flexible demand functions for which no explicit specification of the direct utility function can be given (Pitt and Millimet, 2000). The primal approach sometimes may not have closed-form specification or may have intractable first order conditions (Srinivasan, 1989). Hence, Lee and Pitt (1986) propose an alternative to Wales and Woodland for estimating a demand system with limited dependent variables. The dual approach resulting from deriving consumer demand systems directly from a utility function or indirect utility function by specifying virtual (reservation) prices, as originated by Rothbarth (1941), are dual to the Wales and Woodland approach of the Kuhn-Tucker conditions. The dual approach is easier to specify demand, cost or indirect utility functions, which can take into account a wide range of functional forms. To obtain the demand function, and thus, the direct utility function, we incorporate Roy's Identity.

Let $U(x)$ denote an K-dimensional consumer's direct utility function where $x = (x_1, \ldots, x_K)$ is the observable Marshallian demands, subject to the budget constraint

$p.x \le y$, where $p = (p_1,..., p_K)$ is the vector of prices and y is consumer's income. The indirect utility function relates the maximum utility the individual can achieve as a function of prices and an expenditure constraint assuming weak separability of the choice set.

The indirect utility function is defined as:

$$H(v;\theta,\varepsilon) = \max_q \{U(q;\theta,\varepsilon) | vq = 1\} \tag{2.25}$$

where $U(.)$ is a strictly quasi-concave utility function on K goods, $v = (v_1,...,v_K)'$ is a vector of prices of goods normalized by expenditure, p_i/y, θ is a vector of parameters, and $\varepsilon = (\varepsilon_1,...,\varepsilon_K)'$ is a vector of random components, known by the individual but unknown by the researchers.

Applying Roy's Identity, the notional demand equations $Q(v;\theta,\varepsilon)$ for a set of K goods are:

$$q_i = \left(\frac{\partial H(v;\theta,\varepsilon)}{\partial v_i} \right) \Big/ \left(\sum_{j=1}^{K} v_j \frac{\partial H(v;\theta,\varepsilon)}{\partial v_j} \right), \; i = 1,..., K. \tag{2.26}$$

The q_i's are called notional demand because they may take negative values since the indirect utility model derived in equation (2.25) does not account for non-negativity constraint. The notional demands are economically meaningless, thus notional demand should be considered latent variables corresponding to the observed vector of Marshallian demands $x = (x_1,...,x_K)$ as follows. For the case of binding non-negativity constraints, all restricted demands are zero rather than setting them as positive. Let the demands for the first l goods observed to be zero, then a vector of virtual prices $\xi_i = (\xi_1,...,\xi_l)$ are calculated from the following equations:

$$0 = \partial H\left(\xi_1(\bar{v}),\ldots,\xi_l(\bar{v}),\bar{v},\theta,\varepsilon\right) \Big/ \partial v_i \quad , i=1,\ldots,l \tag{2.27}$$

where $\xi_i(\bar{v})$ is the virtual price of the i^{th} good and $\bar{V}$ is the set of prices of the positively consumed goods $l+1$ to K. Virtual price of a good is the price at which the consumer does not consume that good. At or the above virtual price, the consumer will not consume the good. Thus, the virtual price of a good is that price which will exactly support zero demand for the good. Note that the virtual price is not some kind of absolute reservation price but is a function of the actual price of the positively consumed goods.

Figure 1 presents this phenomenon with a two good model. Note that the slope of budget line is $\frac{p_1}{p_2}$ which is the relative price levels. The observed consumption bundle for the utility maximization is a corner solution at $x_1 = 0$. It is evident that maximizing utility subject to budget constraint would result in notional demands (q_1, q_2) where x_1 is consumed at a negative quantity. If we reduced the price of x_1 holding price of the second good constant until a tangent point occurs on the x_2-axis, the slope of the new budget line is $\frac{\xi_1}{p_2}$ showing the virtual price of the first good relative to the price of the second good. Note that in the case of a corner solution the actual (market) price of x_1 is greater than its corresponding virtual price. However, if the actual price of a good is below its virtual price, the good will be consumed in positive amounts. Thus comparing the actual price of a good with its virtual price determines the concept of a corner solution. Virtual prices are also called reservation prices at zero consumption level (Srinivisan and Winer 1994).

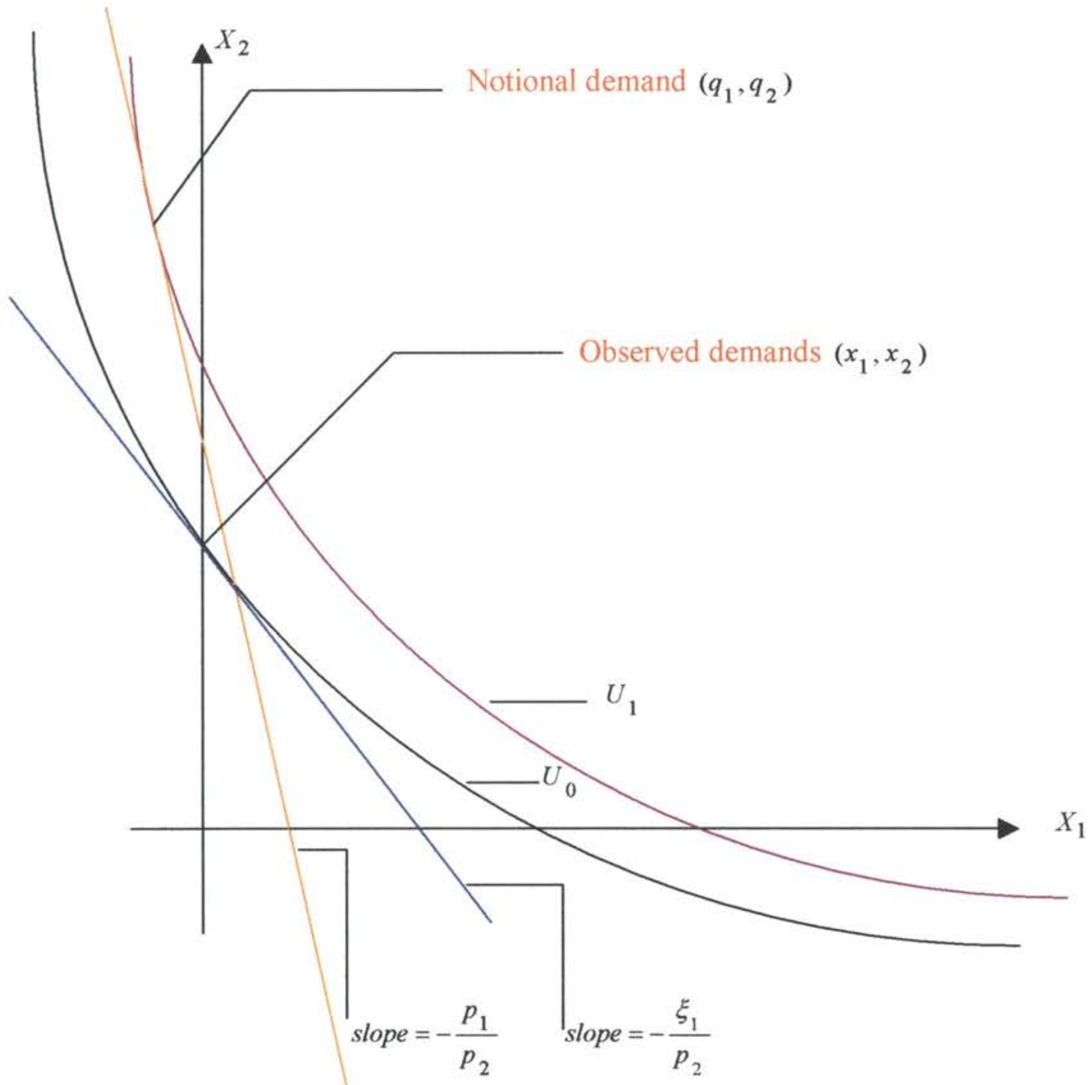

Figure 1. Illustration of Corner Solution and Virtual Price

The remaining positive demands are:

$$x_i = \left(\frac{\partial H(\xi_1,...,\xi_l,\bar{v};\theta,\varepsilon)}{\partial v_i} \right) \Big/ \left(\sum_{j=1}^{K} v_j \frac{\partial H(\xi_1,...,\xi_l,\bar{v};\theta,\varepsilon)}{\partial v_j} \right) \qquad (2.28)$$

where $\xi_i = v_i(\bar{v})$, $i = 1,...,l$.

Equation (2.28) is estimable, and the demand regime is determined by comparisons of virtual and market prices at which the set of positively consumed goods are optimum. If the first l goods are not consumed then the regime is captured by the conditions:

$$\xi_i(\bar{v}) \le v_i, \; i = 1,...,l. \qquad (2.29)$$

The regime comes from the relationship between the Kuhn-Tucker conditions and virtual prices. Let's consider the individual's choice problem with only binding non-negativity constraint. It is assumed that the first l goods are not consumed, i.e., $x_i = 0$, $i = 1,...,l$, and the remaining goods are consumed, i.e., $x_i > 0$, $i = l+1,...,K$.

The Lagrangean function for this problem is:

$$L = U(q) + \lambda(1 - vq) + \psi q. \qquad (2.30)$$

where λ and ψ are Langrange multipliers.

The Kuhn-Tucker conditions for this problem are:

$$\frac{\partial U(x)}{\partial q_i} - \lambda v_i + \psi_i = 0, \; \psi_i \ge 0, \; i = 1,...,l, \qquad (2.31a)$$

$$\frac{\partial U(x)}{\partial q_j} - \lambda v_j = 0, \; i = l+1,...,K, \qquad (2.31b)$$

$$\sum_{j=l+1}^{K} v_j x_j = 1,\ \lambda > 0. \tag{2.31c}$$

The virtual price for the first goods at x is:

$$\xi_i = \left(\frac{\partial U(x)}{\partial q_i} \bigg/ \lambda \right) = \left(v_k \frac{\partial U(x)}{\partial q_i} \bigg/ \frac{\partial U(x)}{\partial q_k} \right). \tag{2.32}$$

From the above equation, the Kuhn-Tucker conditions are equivalent to equation (2.29), and $x_i > 0$. Thus the first l goods are not consumed unless virtual prices exceed market prices.

Lee and Pitt (1986) implemented this dual approach by incorporating the indirect translog model to the Indonesian energy aggregator function to derive the elasticity of substitution among different sources of energy. Yen and Roe (1989) used a two-level demand system to analyze Dominican rural and urban household consumption of food and nonfood commodities at different income levels. Srinivasan (1989) used grocery store scanner panel data to estimate demand for alternative ketchup brand consumption by households. Recently Gould (1996) used Lee and Pitt's approach to estimate the demand for three different types of reduced-fat fluid milks for the U.S. Phaneuf (1999) uses total number of trips made and the allocation of these trips to available sites by using a dual approach of corner solution in the recreation demand.

Arndt, Liu and Preckel (1999) compared the Lee and Pitt approach with the modified Heckman's two-step procedure in a demand systems context for multiple goods and concluded that neither of the two procedures is compatible with economic theory and hence produce inconsistent estimates of price response. This is because when more than three goods are analyzed in the Lee and Pitt approach, the likelihood functions are nonlinear and highly complex as a result of high-dimensional integration. Thus the associated covariance matrix is dense. Recently Kao and Lee (1996) used a maximum simulated likelihood estimator (MSLE) for demand systems with many binding non-negative constraints to overcome the high-dimensional integration problem. They found that the econometric implementation of the MSLE avoids the complexity of high-dimensional integration by using the linear expenditure system for a seven-goods demand. Note that the dual approach uses the sample mean values for missing prices. This masks price variability across individuals in the sample, which may become severe when the sample has many non-consuming observations. Thus there have been very few applications of the dual approach in the literature.

Standard Censored Demand Model

The above models are explicitly derived within a utility maximization framework. On the other hand, some statistical techniques have been built to analyze the derived demand models when zero consumption occurs. The zero consumption is usually handled using censored or truncated regression models. For instance, when the data are censored, the standard Tobit model has been widely used. Heckman two-stage, double-hurdle, and infrequency-of-purchase models are for censored and truncated regression analysis for a single commodity framework (Gould, 1992; Gould, 1996; Deaton and Irish, 1984; Su and Yen, 2000; Shonkwiler and Yen, 1999; Heien and Wessells, 1990). Pudney (1989) gives an excellent summary of the general framework of the above models. Recently, Dong and Gould (2000) extended the Dong, Shonkwiler, and Capps (1998) framework by using double-hurdle model while endogenizing unit-values in an analysis of Mexican households for consumption of pork and poultry. Also, Yen (1994) used the Box-Cox double hurdle model for estimating the demand for alcoholic beverages for a sample of U.S. households. He found that price, income, household composition and other characteristics of the individual have significant effects on alcohol consumption. Shonkwiler and Yen (1999) proposed a two-step estimation procedure for a system of equations as an alternative to Heien and Wessells (1990) which uses Heckman-type sample selection correction factors derived from probit estimates with 0/1 purchase decision in the first step, and estimating the system of equations with seemingly unrelated regression (SUR) in the second step. Chiang and Lee (1992) generalized Hanemann's model to take into account the possibility of zero-consumption, where none of the available substitute alternatives are chosen.

For illustration, standard Tobit, the double-hurdle Tobit models, and two-step estimation method of the Heckman model for zero consumption problems are briefly presented. Under the Tobit model, let latent and observed variables for the i^{th} individual:

$$\begin{aligned} y_i &= y_i^* && \text{if } y_i^* > 0 \\ y_i &= 0 && \text{if } y_i^* \leq 0. \end{aligned} \tag{2.33}$$

The corresponding latent consumption variable is:

$$y_i^* = x_i\beta + \varepsilon_i \; i = 1,...,n \tag{2.34}$$

where y_i^* is the corresponding latent variable for y_i, x_i is a vector of explanatory variables determining consumption level, β is a vector of unknown parameters to be estimated, and ε_i are random errors, independently and normally distributed with mean zero and a common variance σ^2. This model was built by Tobin (1958) for estimating the demand for durable goods and later nicknamed the Tobit model by Goldberger (1964). The Tobit model is a censored normal regression model in which y_i is not observed for the entire sample. Consistency can be obtained by incorporating the maximum likelihood method as Tobin suggests. The likelihood function is:

$$L = \left[\prod_0 \Pr ob\left(y_i^* \le 0\right)\right]\left[\prod_1 \Pr ob\left(y_i^* > 0\right)\right]$$

$$= \left[\prod_0 (1 - F_i)\right]\left[\prod_1 \frac{1}{(2\Pi\sigma^2)^{1/2}} \exp\left(-\frac{1}{2\sigma^2}(y_i - x_i\beta)^2\right)\right] \qquad (2.35)$$

where the first product consists of observations for which $y_i = 0$ and the second product consists of observations for which $y_i > 0$, and $F_i = \Phi_i = \int_{-\infty}^{(x_i\beta/\sigma)} \frac{1}{(2\Pi)^{1/2}} \exp(-\frac{t^2}{2})dt$.

The log likelihood is:

$$LogL = \left[\sum_0 \log(1 - F_i)\right] + \left[\sum_1 \log\left(\frac{1}{(2\Pi\sigma^2)^{1/2}}\right) - \sum_1 \frac{1}{2\sigma^2}(y_i - x_i\beta)^2\right] \qquad (2.36)$$

where $\sum_0$ is the summation for individuals with no consumption, and $\sum_1$ is the summation for individuals with consumption. The parameter estimates can be obtained by maximizing equation (2.36) with respect to β and σ^2.

Zero expenditure shows a true corner solution under the Tobit model. However, one of the drawbacks of the Tobit model is that the decision to consume a given commodity in question is the same as the decision about the level of consumption. Thus the variables and parameter estimates that determine the probability of observing a positive consumption of a good also determine the level of expenditure of the good to be consumed in the same fashion (Yen and Su, 1995).

The double-hurdle model originally formulated by Cragg (1971), and used by Haines, Guilkey, and Popkin (1988), Blisard and Blaylock (1993), and Yen and Su (1995), has overcome this problem. The double-hurdle model assumes two different equations in which the first equation determines the probability of an individual participating in the market and the second equation determines the amount of the expenditure (or the amount of the good) to consume. The first equation is modeled in the probit format.

Following Yen and Su notation, let d_i be the dummy variable for the market participation and d_i^* be its corresponding latent variable for i^{th} individual. Also let y_i be the i^{th} observation and y_i^* be the corresponding latent variable. The two latent variables are:

$$d_i^* = X_i\alpha + u_i \tag{2.37a}$$

$$y_i^* = X_i\beta + v_i \tag{2.37b}$$

where X_i is a vector of exogenous variables, α and β are conformable parameter estimate vectors, and u_i and v_i are independent random errors with distribution $N(0,1)$ and $N(0,\sigma_i)$, respectively.

The observed positive consumption y_i relates to the two latent variables y_i^* and d_i^* as:

$$\begin{aligned} y_i &= y_i^* \quad \textit{if } y_i^* > 0 \textit{ and } d_i^* > 0 \\ &= 0 \quad \textit{otherwise.} \end{aligned} \tag{2.38}$$

The likelihood function for double-hurdle model is:

$$\log L = \sum_0 \log\left(1 - \Phi\left(\frac{X_i\beta}{\sigma_i}\right)\Phi(X_i\alpha)\right)$$

$$+\sum_+\left[-log\sigma_i + \log\phi\left(\frac{y_i - X_i\beta}{\sigma_i}\right) + \log\Phi(X_i\alpha)\right] \qquad (2.39)$$

where $\sum_0$ is the summation for individuals with no consumption, $\sum_+$ is the summation for individuals with consumption, and ϕ and Φ are the standard normal density function and the cumulative normal distribution function, respectively.

The double model reduces to the Tobit model when the probit function $(i.e., d_i^* > 0)$ is not used in the first step and $\Phi(X_i\alpha) = 1$. The Likelihood Ratio procedure can be used to test for selection between the Tobit model and the double-hurdle model.

Now consider the two-stage method for the Tobit model. Let's redefine equation (2.38) as:

$$\begin{aligned} y_i &= y_i^* \quad if \;\; d_i^* > 0 \\ &= 0 \qquad otherwise. \end{aligned} \qquad (2.40)$$

Let the expected value of y_i for observed sample be:

$$E(y_i \mid y_i > 0) = x_i\beta + E(u_i \mid u_i > -x_i\alpha)$$

$$= x_i\beta + \sigma\frac{\phi_i}{\Phi_i} \qquad (2.41)$$

where ϕ and Φ are the standard normal density function and the cumulative normal distribution function, respectively, evaluated at $X_i\alpha$. Since the expected value of error term is not zero, ordinary least squares (OLS) is no longer consistent and unbiased.

Redefine equation (2.41) as:

$$y_i = x_i\beta + \sigma\frac{\phi_i}{\Phi_i} + v_i \tag{2.42}$$

where the expected value of error terms, v_i, is zero. We cannot estimate this function with OLS because the ratio of $\frac{\phi_i}{\Phi_i}$ is not known. What Heckman (1976b) suggested is that we define a dummy variable as:

$$d_i = 1 \quad \text{if } y_i \geq 0$$

$$d_i = 0 \quad \text{otherwise.} \tag{2.43}$$

Because the likelihood function for the probit model is well-behaved, we can use the probit model to obtain the estimates of α. Now we obtain the consistent estimates of parameters of equation (2.42) by OLS, using $\frac{\hat{\phi}_i}{\hat{\Phi}_i}$ in place of $\frac{\phi_i}{\Phi_i}$. Unique convergence of ML estimates can be obtained because the iterative process is the EM algorithm.

If we use all the sample observations rather than the positive observations, we would have the expected value of y_i as follows:

$$E(y_i) = \Pr ob(y_i > 0).E(y_i \mid y > 0) + \Pr ob(y_i \leq 0).E(y_i \mid y_i \leq 0)$$

$$= \Phi_i\left(x_i\beta + \sigma\frac{\phi_i}{\Phi_i}\right) + 0$$

$$= (\Phi_i x_i)\beta + \sigma\phi_i. \tag{2.44}$$

As Blundell and Meghir (1987) and Gould (1992) have pointed out, in the standard Tobit model the same stochastic process affects both purchase decisions and consumption levels. However, when the purchase cycle of the good in question is longer than the length of survey, zero consumption may not truly represent a corner solution as assumed by the Tobit. One drawback of the Heckman two-stage procedure is that the probability of participation is influenced by the same vector of right hand side variables as used in the second stage of the quantity decisions. Thus, this forces the right hand side variables to work the same way in both decisions (Haab and McConnell, 1996).

If the sample contains a significant number of boundary solutions, Morey et al (1995) recommend a repeated nested-logit model, a multinomial share model, or the Kuhn-Tucker model for participation and selection of sites. The main issue is the number of unvisited sites by each of the individuals. If the number of unvisited sites is less than five, using the Kuhn-Tucker conditions is plausible and has a priories restriction on preferences. If the number of unvisited sites is greater than five, one should take caution until computers become sufficiently fast for simulation methods to become operational. Therefore, one should use a repeated nested-logit model, or multinomial share choice model.

Traditionally, discrete/continuous choice recreation demand models incorporate both relevant substitution and site quality effects in determining the individual choice set of where and how often trips are taken. Failure to incorporate potential complement and substitute sites may result in biased estimates of parameters and thus overestimate or underestimate welfare. The precise effect of omission of cross-price and quality terms depends on whether alternatives and their site-qualities are considered to be substitutes or complements by individual anglers for fishing trips. Many researchers have neglected to insert substitute variables in their recreation demand models. The difficulty arises because information from a wide-range of regional sites must be gathered in addition to the site under study and the cost associated with collecting such data is high.

When estimating welfare, aggregated data frequently has an advantage over micro-level data. Measurement error may cause serious problem when using individual observations rather than an aggregated observation because a wide variation in perceived cost may impose problems for estimating the demand function for fishing trips. Smaller variances for coefficients of the model are expected when using individual observations unless aggregated model and individual model are both either unbiased or equally biased. However, when we consider the measurement of error in the explanatory variable, the assumption may not be realistic (Brown et al, 1983). By using aggregated data we eliminate or rule out individual differences in consumer preferences.

In the subsequent chapters, we use the Lee and Pitt model and the two-step censored demand model beginning with a single utility maximization. To obtain the continuous and discrete aspects for fishing trip decisions by incorporating structure and explanatory variables including individual characteristics, the behavioral and econometric models are integrated to provide both theoretical and econometric advantages. Using methods stated in the following chapters, substitution effects between in-state and out-of-state trips and between natural streams in eastern Oklahoma and all other water body fishing trip types are obtained. It is also possible to conduct welfare analysis for changes in economic factors (price or cost) on Oklahoma's economy.

CHAPTER

III.

ELASTICITY OF SUBSTITUTION BETWEEN IN-STATE AND OUT-OF-STATE FISHING TRIPS

Introduction

Lee and Pitt (1986) use an indirect utility function based on the dual approach and show how a reservation (virtual) price relationship as originated by Rothbarth (1941) might take the place of the Kuhn-Tucker conditions. They implemented the indirect translog model to the Indonesian energy aggregator function to derive the elasticity of substitution among sources of energy. Yen and Roe (1989) used a two level demand system to analyze Dominican Republic rural and urban household consumption at different income levels. Srinivasan (1989) used scanner panel data to estimate demand for alternative ketchup brand consumption by households. Recently Gould (1996) used Lee and Pitt's approach to estimate three different types of reduced-fat milk consumption for the U.S. However, one drawback of Lee and Pitt's approach is that the sample mean values were used for missing prices. This violates price variability across individuals in the sample, even becoming more severe when the sample has large numbers of zero consumption. To allow price variability in the total sample, we construct a two-step censored demand model, comparable to the Lee and Pitt model. We use two-stage

Heckman's estimation procedure to compute predicted prices for missing prices to be used in the two step censored demand model.

Methods

Because the translog indirect utility model generally works well and is a popular flexible form among utility functional models, the application of corner solutions to this model is attractive. Thus we use indirect translog utility demand theory when expenditure on one or more goods (trip sites) is zero. This is required by the nature of the data for estimating the elasticity of substitution of out-of-state fishing trips for in-state fishing trips. Although it suffers somewhat in the presence of extreme price (expenditure) fluctuations or deviation from homogeneity conditions (Guilkey and Lovell, 1980), the translog indirect utility model generally works well and is a popular flexible form (Srinivasan and Winer 1994).

Van Soest and Koreman (1990) deal with sufficient conditions for coherency of the translog utility model in which regularity properties of the demand model are related. If the indirect translog utility demand model satisfies the regularity conditions at each observation, the likelihood is coherent in which the sum of the probabilities for all corresponding demand regimes is unity and thus, maximum likelihood estimates are consistent (Pitt and Millimet, 1999). It is assumed that the translog indirect utility function is weakly separable in fishing trips. This indicates a two-stage budgeting process, where in the first stage the angler chooses expenditures on total goods, including fishing trips, and in the second stage expenditure on fishing trips is allocated among in-state and out-of-state trips.

Consider the indirect utility translog model of Christensen, Jorgenson and Lau (1975):

$$H(v;\theta,\varepsilon)=\sum_{i=1}^{K}\alpha_i \ln v_i+\frac{1}{2}\sum_{i=1}^{K}\sum_{j=1}^{K}\beta_{ij}\ln v_i \ln v_j+\sum_{i=1}^{K}\varepsilon_i \ln v_i \tag{3.1}$$

where $v=\left(\frac{p_i}{M},...,\frac{p_k}{M}\right)'=(v_i,...,v_k)'$ is a vector of prices normalized by total expenditure, M, on fishing trips, error terms are $\varepsilon(\varepsilon_1,...,\varepsilon_K)\sim N(0,\Sigma)$, and $\theta=(\alpha,B)$ are parameters of the utility function, i.e. $\alpha=(\alpha_i,...,\alpha_K)'$, $B=(\beta_1,...,\beta_M)'$, and $\beta_j=(\beta_{j1},...,\beta_{jM})$. Because expenditure shares must add to one, we normalize $\sum_{i=1}^{K}\alpha_i=1$. The model enforces equality, $\sum_{i=1}^{n}\beta_{ij}=\sum_{i=1}^{n}\beta_{ik}$, $j,k=1,...,n$, and symmetry, $\beta_{ij}=\beta_{ji}$, $\forall i,j\neq j$, on utility maximization. To aid in the identification of the parameters and to make the error structure in the likelihood function tractable we also assume homogeneity, that the angler expenditure shares are homogeneous of degree zero in prices and total trip expenditures (Srinivasan, 1989). That is, $\sum_{i=1}^{n}\beta_{ij}=\sum_{j=1}^{n}\beta_{ij}$, which implies that if an angler were to increase his/her spending on fishing trips by 10%, assuming other things remain the same, the quantity consumed (by this angler) of each of the fishing trips in this category would increase by 10%. One should use caution, however, since with increasing total expenditure on fishing trips, anglers may trade quantity for quality of site.

Using Roy's Identity to the indirect utility function (3.1) we obtain the notional expenditure share equations:

$$v_i q_i = \frac{\alpha_i + \sum_{j=1}^{n} \beta_{ij} \ln v_j + \varepsilon_i}{D}, i = 1,\ldots,n \tag{3.2}$$

where q_i is the notional demand of good (trip) i, and $D = 1 + \sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln v_j$. On imposing

the restrictions shown above, $D = 1 + \sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln v_j = 1$ where $\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln v_j = 0$, and

thus notional shares of in-state and out-of-state fishing trips reduce to:

$$s_1 = v_1 q_1 = \left(\alpha_1 + \beta_{11} \ln\left(\frac{p_1}{p_2}\right) + \varepsilon_1 \right), \text{and} \tag{3.3a}$$

$$s_2 = v_2 q_2 = \left(\alpha_2 + \beta_{22} \ln\left(\frac{p_2}{p_1}\right) + \varepsilon_2 \right) \tag{3.3b}$$

With imposing adding up conditions α's are $\alpha_1 + \alpha_2 = 1$ and β's are $\beta_{11} = -\beta_{12} = -\beta_{21} = \beta_{22}$ by imposing homogeneity and symmetry conditions. Note that the notional demands q_i may take negative values because it does not include nonnegative constraints. Thus, it takes latent variables corresponding to the observed demand vector via the virtual price, which can exactly support these zero demands as long as the preference function is strictly quasi-concave, continuous, and strictly monotonic (Lee and Pitt, 1986).

Equation (3.3) shows the decomposition of the angler's overall preference for fishing trips into price effects and basic (non-price) preference. Notice that in the two-good case, prices are no longer normalized, but reduce to a relative price ratio. The parameter β_{11} shows the change in the expenditure share of fishing trip i for a unit change in the log (price) of fishing trip j. Notice that β_{11} captures the effects of changes in relative prices from the trip share equations. Assuming prices of in-state and out-of-state fishing trips are held equal, then β_{11} drops out and the notional share equations reduce to:

$$s_i = v_i q_i = -\alpha_i,\ i = 1,2\ . \tag{3.4}$$

Equation (3.4) implies that α_i is a function of the angler's basic preference for each of the fishing trips after removing the price effect. α_i can be a function of angler characteristics or site qualities, or both. Here we assume α_i represents the anglers' characteristics, that is, angler characteristics are the same for all sites. Let

$$s_{it} = X'_{it}\beta_i + \varepsilon_{it} = \alpha_{i0} + \sum_{k=1}^{K}\alpha_{ik}W_{ikt} + \beta\ \ln\left(\frac{p_{it}}{p_{jt}}\right) + \varepsilon_{it},$$

$$i = 1,2; k = 1,\ldots,K; t = 1,\ldots,T \tag{3.5}$$

where $\sum_{k=1}^{K}\alpha_{ik}W_{ikt}$ is the angler characteristics affecting the trip share equation. These characteristics might be age, age squared, marital status (1 if the individual is married, 0 otherwise), gender (1 if the individual is male, 0 otherwise), race (1 if the individual is Caucasian , 0 otherwise), and college (1 if the angler has a college degree, 0 otherwise). $\ln\left(\frac{p_{it}}{p_{jt}}\right)$ is the natural logarithm of ratio of price of good one to price of good two or visa versa . Note that adding up conditions hold if and only if $\sum_{i=1}^{2}\alpha_i = \alpha_1 + \alpha_2 = 1$. Thus, to be consistent with the adding-up condition, the following α_i's must sum to:

$$\alpha_{10} + \alpha_{20} = 1,$$

$$\alpha_{ik} + \alpha_{jk} = 0, \quad i,j = 1,2; k = 1,\ldots,K \ . \tag{3.6}$$

The Lee and Pitt Estimation Approach

Consider Lee and Pitt's model. There are three possible mutually exclusive demand regimes. First, consider the demand regime for which the quantity demanded for in-state fishing trips is zero, and out-of-state fishing trips is positive, i.e., $x_1 = 0$, $x_2 > 0$. Equating the in-state fishing share to zero, the virtual price of in-state fishing trips, ξ_1, is a function of p_2, which analytically is obtained as:

$$\ln \xi_{1t} = -\frac{1}{\beta_{11}}\left(\alpha_{10} + \sum_{k=1}^{K} \alpha_{1k} W_{1kt} - \beta_{11} \ln p_{2t} + \varepsilon_{1t} \right) \tag{3.7}$$

Substituting this virtual price for the non-observed market price in the second share equation, the remaining nonzero out-of-state expenditure share is:

$$s_{2t} = \left(\alpha_{20} + \sum_{k=1}^{K} \alpha_{2k} W_{2kt} - \beta_{11} \ln\left(\frac{\xi_{1t}}{p_{2t}} \right) + \varepsilon_{2t} \right) \tag{3.8}$$

Recall that the virtual price for in-state trips is defined as the price that would drive the demand for in-state trips to exactly zero. Thus, the market price for in-state fishing trips must exceed its virtual price. This condition can be identified as: $\ln \xi_1 \le \ln P_1$. Equating $\ln \xi_1 - \ln P_1 = 0$, the switching condition for non-consumed in-state fishing trip demand regime is:

$$-\frac{1}{\beta_{11}}\left(\alpha_{10}+\sum_{k=1}^{K}\alpha_{1k}W_{1kt}-\beta_{11}\ln p_{2t}+\varepsilon_{1t}\right)-\ln p_{1t}=0. \tag{3.9}$$

The switching regime is:

$$\varepsilon_1 \geq -\left(\alpha_{10}+\sum_{k=1}^{K}\alpha_{1k}W_{1kt}+\beta_{11}\ln\left(\frac{p_1}{p_2}\right)\right) \textit{ if and only if } \beta_{11}<0. \tag{3.10}$$

Assume that $f(\varepsilon_1)$ is the density function for ε_1. Then the likelihood function (L^1) for this demand regime for one observation is:

$$l^2(x_i;\theta)=\int_{\varepsilon_1}^{\infty} f(\varepsilon_1)\ d\varepsilon_1. \tag{3.11}$$

The log-likelihood of this equation is:

$$Ln(\ l^2(x_i;\theta)\ ) \ = \ \sum_{\substack{t=1 \\ s_1=0,s_2>0}}^{T}\ln(1-\Phi(X_{1kt}\beta_{1k}/\sigma_1)) \tag{3.12}$$

where Φ is the cumulative distribution function of ε_1 with standard deviation σ_1.

Similar approaches can be used to construct the likelihood functions for the other regimes. Let I_i^c be a dichotomous indicator such that if the observed consumption function for the angler i is demand regime c, then $I_i^c=1$, zero otherwise. The likelihood function for the regime c and observation i is, $l^c\ (x_i;\theta)$, then with aggregating the independent sample with N observations the likelihood function can be written as:

$$L=\prod_{i=1}^{N}\prod_{c=1}^{3}\left(l^c(x_i;\theta)\right)^{I_i^c} \tag{3.13}$$

and the log likelihood is:

$$Ln(L) = I_i^1 * \left(\sum_{t=1}^{T} \left(l^1 \left(x_i ; \theta \right) \right) \right) + I_i^2 * \left(\sum_{t=1}^{T} \left(l^2 \left(x_i ; \theta \right) \right) \right)$$

$$+ I_i^3 * \left(\sum_{t=1}^{T} \left(l^3 \left(x_i ; \theta \right) \right) \right) \tag{3.14}$$

Expanding equation (3.14) for the three mutually exclusive demand regime is:

$$Ln(L) = I_i^1 * \left(\sum_{\substack{t=1 \\ s_i > 0}}^{T} - \frac{1}{2} \left[\ln(2\pi) + \ln \sigma_i^2 + \frac{\left(s_{it} - X_{ikt} \beta_{ik} \right)^2}{\sigma_i^2} \right] \right)$$

$$+ I_i^2 * \left(\sum_{\substack{t=1 \\ s_1 > 0, s_2 = 0}}^{T} \ln \left[1 - \Phi \left(\frac{X_{2kt} \beta_{2k}}{\sigma_2} \right) \right] \right)$$

$$+ I_i^3 * \left(\sum_{\substack{t=1 \\ s_1 = 0, s_2 > 0}} \ln \left[1 - \Phi \left(\frac{X_{1kt} \beta_{1k}}{\sigma_1} \right) \right] \right) \tag{3.15}$$

The first part of the right hand side of equation (3.15) represents observations for which individuals took both in-state and out-of-state fishing trips. This is an interior solution, and we need only to use one of the share equations since shares are $s_1 = 1 - s_2$. The second part represents the case where only in-state fishing trips are consumed (the log-likelihood function for this regime is given in that part). The final part represents the case where only out-of-state fishing trips are consumed and the likelihood function is the last part. Assuming the model is correctly specified, the α, β and σ_i^2 that maximize this likelihood function are consistent and asymptotically efficient.

Note in the two-good case, the Lee and Pitt model is similar to the Tobit model. The estimation issue of the two-good model is that it ignores relevant information on shares (dependent variables) when one type of trip is consumed but the other is not. Consider the model when

$y_i^* = s_i$ if in-state and out-of-state fishing trips are consumed,

$y_i^* = 0$ if in-state fishing trips are only consumed,

$y_i^* = 0$ if out-of-state fishing trips are only consumed.

Share information is available on the left hand side when both types of trips are consumed. Because shares are not independent it takes only one of the shares into account. When only one of the types of trips is consumed, it will consider the non-consumed share, thus, yielding zero for left hand side. Therefore, the probability of non-response for dependent variable $y_i = 0$ is:

$$\Pr(y_i = 0) = \left(1 - \Phi\left(\frac{X_i \beta}{\sigma}\right)\right). \tag{3.16}$$

In the current survey, about 10 percent of anglers took both in-state and out-of-state fishing trips. On the other hand, 83.8 percent of the anglers took only in-state fishing trips and 6.2 percent of the anglers consumed only out-of-state trips. Therefore, the Lee and Pitt model ignores 90 percent of the relevant information on trip shares. Also it uses sample mean values for missing prices, ignoring price variability across individuals in the sample. Notice that the Lee and Pitt model is not biased itself but it depends on a data set that has limited number of non-consuming goods.

A Two Step Censored Regression Analysis

Predicting Missing Prices. To use the two-step censored regression model we need to predict missing prices. The usual assumption in cross-sectional demand analysis is that all individuals face the same prices, ruling out the estimation of price elasticities from time series data. Given constant prices, Engel functions are estimated where expenditure is regressed on income and individual characteristics. To estimate price elasticities with cross-sectional data one should have price variability. Hence, most price elasticity studies use time-series/cross-sectional data.

As Cox and Wohlgenant (1986) point out, economists focus their attention on the sources and meaning of price variability in demand estimation when using cross-sectional data. One should carefully analyze the causes of price variation in cross-sectional data prior to employing an estimation procedure. Price variations are generally in recreation studies due to region (location), price discrimination, seasonal effects, and quality differences. Total expenditures on trips vary across anglers for some of the same reasons thus resulting in price variations in cross-sectional data. Trip prices are implicit prices, obtained by dividing trip expenditures by the number of trips that each individual takes in a given period of time. Thus such a calculated price may reflect not only differences in the prices facing anglers over which they do not have control but also differences in quality levels of the trip over which anglers may have considerable choice.

The possibility of variation in prices across individuals is essential for demand analyses with cross-sectional data. Ignoring cross-sectional price variability results in biased and misleading demand elasticities. Notice that prices in cross-sectional data may reflect quality effects. Thus, these differences should be corrected prior to estimation.

Assuming weak separability, prices depend on total expenditure and angler characteristics, which induce quality effects. We use individual characteristics as proxies for angler preferences for unobserved trip quality characteristics. Hanemann (1984) shows that discrete/continuous choice of random utility model can be used to analyze quality/quantity decisions. The switching regression model can handle the simultaneous discrete/continuous choice of quality/quantity by anglers. Heckman's two stage Type 2 Tobit model is a special case of switching regression model for censored dependent variables. Thus, Heckman's model allows for the decision of whether to take a fishing trip and how much to pay if the trip occurs. This is modeled by two separate but related equations (Choi, 1993). In the first step, we use the probit model by incorporating the individual characteristics and income per capita into a binary choice problem. The second-step estimates the sub-sample hedonic price equation.

We write the participation equation for in-state and out-of-state fishing trips as follows:

$$T_{it} = 1\ (Z_{it}\gamma_i + \varepsilon_{it} > 0),\ i = 1,2 \text{ and } t = 1,\dots,T \tag{3.17}$$

where

$$Z_{it}\gamma = \gamma_0 + \gamma_1 Income_t + \gamma_2 Age_t + \gamma_3 Agesq + \gamma_4 MaritalSt_t + \gamma_5 Gender_t + \gamma_6 Race_t + \gamma_7 College_t \tag{3.18a}$$

and $\varepsilon_{it} \sim N(0,1)$. These variables are income per capita, age, age squared, marital status, gender, race, and college degree. An angler takes trips if $Z_{it}\gamma > -\varepsilon_{it}$.

The corresponding log likelihood function of equation (3.17) for probit model is:

$$LogLn = \sum_{T_{it}=0} \ln(1 - \Phi(Z_{it}\gamma)) + \sum_{T_{it}=1} \ln(\Phi(Z_{it}\gamma)) \text{(Greene, 1997)} \tag{3.18b}$$

where Φ is the cumulative probability function and $\varepsilon_{it} \sim N(0,1)$.

Houthakker (1952) and Theil (1952) in the early 1950s introduced the theoretical framework of price-quality adjustments. The model they used was accepted and adapted by Deaton (1986), Cox and Wohlgenant (1986) and Choi (1993). Heterogenous commodities with different characteristics are used for demand analysis. Theil suggests that the qualitative nature of an aggregate commodity, which is reflected in its average price, is the summation of the physical quantities of elementary goods in the group that can be explained by a vector of qualitative/quantitative characteristics. Houthakker's model is similar, except that the average commodity prices result from both the quantity and quality components of price.

Following Cox and Wohlgenant (1986) notation, anglers are assumed to maximize

$$\underset{q \geq 0,\, b \geq 0}{Max} \mathrm{U}(\mathrm{q}, \mathrm{b}, \mathrm{d}, \mathrm{c})$$

$$\text{subject to} \sum\nolimits_i p_i(b_i) q_i = y_i \tag{3.19}$$

where q is a vector of commodities consumed, b is a vector of commodity-specific characteristics, d is all other goods taken as the *numeraire*, c is a vector of angler characteristics, and y is per capita income. The utility model is assumed to reflect the usual neoclassical properties. The hedonic price function, $p_i(b_i)$, which is assumed to reflect the price-quality tradeoffs that anglers face, can be written as:

$$p_{ik} = \gamma_i + \sum_{k}^{n} \gamma_{ik} b_{ik} + \varepsilon_{ik} \text{ , } i = 1,2; k = 1,\ldots,n \tag{3.20}$$

where p is the calculated unit price, γ is interpreted as the quantity price and $\sum_{k}^{n} \gamma_{ik} b_{ik}$ is the sum of component quality prices per unit of q where b_{ik} are the variables affecting the angler choice of quality of a trip. The quality adjusted price is the difference between the calculated unit price and the expected price from its specific quality characteristics. Thus, the expected price can be obtained by a hedonic price/quality function defined in equation (3.20). The quality adjusted price can be obtained as:

$$P_{ik}^{*} = p_{ik} - \sum_{k}^{n} \hat{\gamma}_{ik} b_{ik} = \hat{\gamma}_{i} + \varepsilon_{ik} \tag{3.21}$$

where γ is the trip mean price, ε_{ik} is the regression residual, and b_{ik} are angler characteristics, including total expenditure of trips (the sum of in-state and out-of-state expenditures of trips), as proxies for angler preferences for unobserved trip quality characteristics. The model is appropriate for estimating trip demand so long as each trip has objectively measurable characteristics. However, it frequently is difficult to obtain trip characteristics due to data limitations. Thus, we substitute angler characteristics for trip-quality characteristics to obtain quality adjustments from individual characteristics on the average trip price paid. Therefore, the b_{ik} vector represents angler characteristics for quality of a trip.

The second step of Heckman's procedure involves the estimation of the sub-sample hedonic price equation as:

$$p_{ik} = \gamma_{i} + \sum_{k}^{n} \gamma_{ik} b_{ik} + \varepsilon_{ik} \text{ , } i = 1,2 \ \ k = 1,\ldots,n \tag{3.22}$$

where p_{ik} is the natural logarithm of the calculated unit price of trips and b might include common variables in both equations (3.18) and (3.22), or may be identical. k is the sub-sample of t.

The selectivity problem is removed by taking the conditional expectation of equation (3.22) over the sample of anglers who took trips:

$$E\left(P_{ik} \mid B_{ik}, T_{it}=1\right)=B_{ik}\gamma+E\left(\varepsilon_{ik} \mid \varepsilon_{it}>-Z_{it}\gamma\right) \tag{3.23}$$

If ε_{it} and ε_{ik} are jointly normally distributed then equation (3.23) can be written as:

$$\begin{aligned} P_{ik} &= B_{ik}\gamma+\sigma_{01}\lambda_{ik}+\varepsilon_{ik} \\ \Sigma &= \sigma_{00}^{2}\left(1-\rho^{2}\delta_{it}\right) \end{aligned} \tag{3.24}$$

where $\delta_{it}=\lambda_{it}\left(\lambda_{it}+Z_{it}\alpha_{i}\right)$ (Green, 1997), σ_{00} is the covariance between ε_{0i} and ε_{1i}, and λ is the inverse Mills ratio computed as follows:

$\lambda_{ik}=\left(\dfrac{\phi\left(Z_{ik}\dfrac{\gamma}{\sigma_0}\right)}{\Phi\left(Z_{ik}\dfrac{\gamma}{\sigma_0}\right)}\right)$, where $\phi(.)$ and $\Phi(.)$ are univariate standard normal probability density function and cumulative distribution function, respectively, and σ_0 is the standard deviation of error term of equation (3.24) normalized to one. The sample selection problem is most severe when there is a very high number of unobserved prices indicating that the Mill's ratio is large. We use the Mill's ratio to reduce the possibility of misspecification. Omission of the Mill's ratio will cause the parameter estimates to be biased where the Mill's ratio is correlated with any dimension of independent variables in the model (Bockstael, Hanemann, and Strand, 1986). We obtain estimated values of ϕ_i and Φ_i for each t observation from equation (3.18). Using least squares with only the positive observations on p_i in equation (3.24), we obtain consistent estimates of γ's by incorporating λ as an instrumental variable in equation (3.24). The error term in the final equation is heteroskedastic (Heckman, 1979). Therefore, we used weighted least squares to improve efficiency.

For missing prices there are two common and computationally simple solutions. The first approach is to discard all non-consuming households and estimate parameters using the remaining observations. The second solution is to use zero-order methods, which take sample means for missing values. Note that these zero-order methods imply that each non-consuming angler faces average quality trip price. To allow price deviation from average price across non-consuming anglers we use the individual characteristics with missing prices to determine an appropriate solution for price-quality. From Heckman's procedure, the missing prices of in-state and out-of-state fishing trips for non-consuming anglers are predicted as:

$$\hat{P}_{im} = B_{im}\hat{\gamma} + \hat{\sigma}_{01}\hat{\lambda}_{im}, i = 1,2, m = n+1,...,t \tag{3.25}$$

where $\hat{\lambda}_{im} = -\left(\frac{\phi_{im}(-Z_{im}\hat{\gamma})}{1-\Phi_{im}(-Z_{im}\hat{\gamma})}\right)$ is the Mills ratio for non-consuming individuals.

Following Cox and Wohlgenant (1986) the quality adjusted prices p_{ik}^* for consuming anglers can be calculated as:

$$P_{ik}^* = \hat{\gamma}_i + \varepsilon_{ik} \tag{3.26}$$

where γ_i are the trip average prices for anglers and ε_{ik} is the residual from equation (3.20) for consuming anglers.

After predicting missing prices, the censored system of equations for the indirect translog utility demand model imposing adding up, symmetry and homogeneity conditions is written:

$$s_{it} = X'_{it} \beta_i + \varepsilon_{it} \qquad if \;\; \mathrm{Y}_{it} = Z'_{it} \alpha_i + v_{it} > 0$$

$$= 0 \qquad otherwise \qquad i = 1,..,n;\; t = 1,...,T \qquad (3.27)$$

where, for the i^{th} equation and t^{th} observation, s_{it} is the trip share dependent variable, x_{it} and z_{it} are vectors of exogenous variables determining level and trip participation, respectively, β_i and α_i are conformable parameter estimates, and ε_{it} and v_{it} are error terms assumed to be normally distributed with $(0,\Sigma)$ and $(0,1)$, respectively. The model is a multi- equation counterpart to Amemiya's (1986) type 2 Tobit, also considered by several authors including Cragg (1971), Heckman (1976a, 1976b), Shonkwiller and Yen (1999) and Su and Yen (2000). This model is also a generalization of Amemiya's (1974) censored system in which censoring is determined by a binary trip participation decision with a stochastic process, $z'_{it} \alpha_i + v_{it}$, and the level component, $x'_{it} \beta_i + \varepsilon_{it}$.

The binary stochastic equation is:

$$Y_{it} = \alpha_i + \sum_{m=1}^{m-1} \alpha_m Z_{imt} + v_{it} \quad i = 1,2; m = 1,...,m-1; t = 1,...,T \qquad (3.28a)$$

where y_{it} is a i^{th} equation participation decision where if the angler takes a trip, $y_{it} = 1$ and if he/she does not take a trip $y_{it} = 0$. $\sum_{k=1}^{K} \alpha_{im} Z_{imt}$ is the individual characteristics that affect the participation decision.

The corresponding probit likelihood function for equation (3.28a) is:

$$LogLn = \sum_{Y_{it}=0} \ln(1-\Phi(Z_{it}\alpha)) + \sum_{Y_{it}=1} \ln(\Phi(Z_{it}\alpha)) \text{ (Greene, 1997).} \qquad (3.28b)$$

where Φ is the cumulative probability function and $v_{it} \sim N(0,1)$.

By imposing demand restrictions outlined earlier, the trip share equations for two goods are as follows:

$$s_{it} = X'_{ikt}\beta_{ik} + \varepsilon_{it} = \beta_i + \beta_{ii}\ln\left(\frac{p_{it}}{p_{jt}}\right) + \sum_{k=2}^{K-2}\beta_{ik}W_{ikt} + \varepsilon_{it}$$

$$i, j = 1,2; k = 1,\ldots,K; t = 1,\ldots,T \qquad (3.29)$$

where $\ln\left(\frac{p_{it}}{p_{jt}}\right)$ is the natural logarithm of the ratio of price of good one to the price of good two or visa versa, and $\sum_{k=1}^{K-2}\beta_{ik}W_{ikt}$ is the angler characteristics affecting the trip share equation. Note the same independent variables might be used for the binary choice model as well as for the trip share equation, thus z_{im} and w_{ik} may be common or even the same variables.

Demand restrictions on the trip share equation are:

adding-up conditions, $\beta_i + \beta_j = 1$ and $\beta_{ik} + \beta_{jk} = 0$ and symmetry and homogeneity conditions, $\beta_{ii} = \beta_{jj} = -\beta_{ij} = -\beta_{ji}$.

If we generalize Amemiya's (1986) single-equation by using only non-limit observations in a censored system, equation (3.29) is rewritten as:

$$s_{it} = x_{ikt}\beta + \sigma\lambda_{it} + \varepsilon_{it}, i = 1,2 \qquad (3.30)$$

where $\lambda_{it} = \frac{\phi_{it}}{\Phi_{it}}$ is the inverse Mill's ratio and $\xi_i \sim N(0, \Sigma\ )$.The variance-covariance is:

$$\Sigma = \sigma_{00}^2 (1 - \rho^2 \delta_{it}) \tag{3.31}$$

where $\delta_{it} = \lambda_{it}(\lambda_{it} + Z_{it}\alpha_i)$.

Parameter estimates of the sample selection model are estimated using maximum likelihood. However, it may be cumbersome to find global optimum values using existing computer algorithms. An alternative procedure is Heckman's two-step procedure, which is consistent and more easily computed. The traditional Heckman two-step model omits zero observations for the second stage. Heien and Wessells (1990) use equation (3.30), including the zeros on the left-hand side of the share equations since Heckman's two-step procedure for demand system estimation may require different patterns of censoring. Heien and Wessells (1990) conclude that the two-step estimators are more consistent and asymptotically efficient when using all observations compared to other two-step procedures. Our system is estimated by the two-step procedure.

First, estimate the probit equation for the first stage by maximum likelihood (ML) to obtain estimates of α. For each observation in the sample selection compute the inverse Mill's ratio, $\hat{\lambda}_{it} = \frac{\phi(Z_{it}\alpha_i)}{\Phi(Z_{it}\alpha_i)}$ and $\hat{\delta}_{it} = \hat{\lambda}_{it}(\hat{\lambda}_{it} + Z_{it}\hat{\alpha}_i)$. Because the ML probit parameters $\hat{\alpha}$ are consistent, using either ML or OLS estimation for equation (3.30) results in consistent estimates for the second stage. However, Shonkwiller and Yen (1999) show that the Heien and Wessells (1990) model is not appropriate based on all observations since the unconditional expectation of equation (3.30) is:

$$E(s_{it} \mid X_{ikt}, Z_{imt}) = X_{ikt}\beta_{ik} + 2\delta_i \phi(Z_{imt}\alpha_{im}). \tag{3.32}$$

As $Z_{imt}\alpha_m \longrightarrow -\infty$, the unconditional expectation of equation (3.32) goes to:

$$E(s_{it} \mid X_{ikt}, Z_{imt}) = X_{ikti}\beta_{ik} \tag{3.33}$$

Thus the internal inconsistency in the Heien and Wessells model is:

As $Z_{imt}\alpha_i \longrightarrow -\infty$, the unconditional expectation of equation (3.27) goes to zero as one would expect.

Following Su and Yen (2000) notation, assuming for each i^{th} equation given in equation (19), error terms $(\varepsilon_{it}, v_{it})$ are distributed as bivariate normal distribution with $Cov(\varepsilon_{it}, v_{it}) = \delta_i$. The unconditional mean of s_{it} given by Amemiya (1986) is:

$$E(s_{it} \mid x_{ikt}, z_{imt}) = \Phi(Z'_{imt}\, \alpha_i)x(X'_{ikt}\, \beta_i) + \delta_i \phi(Z'_{imt}\, \alpha_i)\,. \tag{3.34}$$

Generalizing Amemiya's single equation, equation (3.34) for the whole sample is rewritten as:

$$s_{it} = \Phi(Z'_{imt}\, \alpha_i)x(X'_{ikt}\, \beta_i) + \delta_i \phi(Z'_{imt}\, \alpha_i) + \xi_{it}$$

$$i = 1,2;\ k = 1,..,K; m = 1,...,M; t = 1,...,T \tag{3.35}$$

where $\Phi(Z'_{imt}\, \alpha_i)$ and $\phi(Z'_{imt}\, \alpha_i)$ are cumulative distribution and univariate standard normal probability density functions, respectively, $\xi_{it} = s_{it} - E(s_{it})$ and $E(\xi_{it}) = 0$. The system is estimated by the two-step procedure: (1) obtain maximum likelihood probit parameters $\hat{\alpha}_i$ of α_i for all i based on $y_{it} = 1$ if angler takes a trip $(s_{it} > 0)$ and $y_{it} = 0$ otherwise $(s_{it} = 0)$; (2) calculate $\Phi(Z'_{imt}\, \alpha_i)$ and $\phi(Z'_{imt}\, \alpha_i)$ and estimate parameters in equation (3.35) by applying either maximum likelihood or seemingly unrelated regression procedures where error terms and variances are :

$$\xi_{it} = \varepsilon_{it} + [\Phi(Z'_{imt}\alpha_i) - \Phi(Z'_{imt}\hat{\alpha}_i)]x(X'_{ikt}\beta_i)$$

$$+ \delta_i[\phi(Z'_{imt}\alpha_i) - \phi(Z'_{imt}\hat{\alpha}_i)] \qquad (3.36)$$

and

$$\Sigma = \sigma_i^2\Phi(Z'_{imt}\alpha_i) + [1 - \Phi(Z'_{imt}\alpha_i)]$$

$$x\left\{[X'_{ikt}\beta_i]^2\Phi(Z'_{imt}\alpha_i) + 2(X'_{ikt}\beta_i)\delta_i\phi(Z'_{imt}\alpha_i)\right\}$$

$$-\delta_i^2\left\{(Z'_{imt}\alpha_i)\phi(Z'_{imt}\alpha_i) + [\phi(Z'_{imt}\alpha_i)]^2\right\} \qquad (3.37)$$

Because the maximum likelihood probit estimators $\hat{\alpha}_i$ from the first-step on the trip participation model are consistent, the β s are also consistent for equation (3.35). However, the error terms ξ_{it} are heteroskedastic and consequently the covariance matrix of $\hat{\beta}$ derived from the usual procedure is incorrect yielding standard errors of $\hat{\beta}$ and related test statistics inconsistent. The correct covariance matrix of $\hat{\beta}$ adjusted by the procedure of Murphy and Topel (1985) is used to gain efficiency in estimation.

Following Murphy and Topel matrix notation, we construct the correct covariance matrix of $\hat{\beta}$ as follows:

for each observation let us redefine equation (3.35) as:

$$s_{it} = X_{ikt}\beta_{ik} + \delta_i\phi(Z'_{imt}\alpha_i) + \xi_{it} \qquad (3.38)$$

where $X_{ikt}\beta_{ik} = \Phi(Z_{it}\alpha_i)X_{ikt}\beta_{ik}$ with $1\,x\,k$ vector of exogenous variables and $\phi(Z'_{imt}\alpha_i)$ is a $1\,x\,1$ vector of variable from the first-step that determines the unobservables, $Y(.)$, which is a $1\, x\, m$ vector of functions determined by the unknown parameters α where $\alpha \sim N(0, V(\hat{\alpha}))$ and $E(\xi \mid X, \phi) = 0$ and $E(\xi^2 \mid X, \phi) = \sigma^2$. $Y(\alpha, Z_{im})$ is computed by probit model in equation (3.28) and the computed ϕ and Φ are then used in the second stage. We assume the vector α is estimated independently in the first step and β and δ are conformable vectors of estimates to be estimated in the second step.

The estimated asymptotic covariance matrix of β is:

$$\hat{\Sigma} = \hat{\sigma}^2 (K'K)^{-1} + (K`K)^{-1} K'Z * \hat{V}(\hat{\alpha}) Z*' K (K`K)^{-1} \tag{3.39a}$$

where $\hat{\sigma}^2 = t^{-1}(s - X\hat{\beta} - \phi\hat{\delta})'\, x\, (s - X\hat{\beta} - \phi\hat{\delta})$, where t is the number of observations and $K = [X \quad \phi]_{k+1}$ and $z^*_{ij} = \sum_{k=1}^{n} \hat{\delta}_k \frac{\partial \phi_k}{\partial \alpha_j}(\hat{\alpha}, z)$.

If we use MLE for the second step, the correct variance of matrix $\hat{\beta}$ is constructed as follows:

let the log-likelihood of the probit equation for the first step be $L_1(\alpha)$ and the log-likelihood of the second step equation be $L_2(\hat{\alpha}, \beta)$ where β s consist of both β and δ for using MLE.

$$\Sigma^* = \Sigma_2 + \Sigma_2 [C\Sigma_1 C` - R\Sigma_1 C` - C\Sigma_1 R`] \Sigma_2 \text{ (Greene, 1997).} \tag{3.39b}$$

where Σ^* is the consistent asymptotic covariance matrix of $\hat{\beta}$, Σ_1 is the asymptotic covariance of α from L_1, Σ_2 is the asymptotic covariance matrix of $\hat{\beta}$ from $L_2 \mid \alpha$,

$$C = E\left[\left(\frac{\partial L_2}{\partial \beta}\right)\left(\frac{\partial L_2}{\partial \alpha'}\right)\right], \text{ and } R = E\left[\left(\frac{\partial L_2}{\partial \beta}\right)\left(\frac{\partial L_1}{\partial \alpha'}\right)\right].$$

Data

Data are from the 1996 National Survey of Fishing, Hunting, and Wildlife Associated Recreation (FHWAR). The survey was conducted on U.S. residents for fishing, hunting, and fish-and wildlife- related activities. The survey was built in three waves with in-person and telephone screening of households. If any of the household members had participated in fishing or hunting between January 1, 1996 and the interview date, they were part of the sportsman sample (fishing and hunting), and the first detailed interview was conducted. This was followed by a second wave of interviewing in September and October, 1996 and then by a third wave of interviewing in January, 1997. The survey includes three types of fishing activities: (1) freshwater fishing, which excludes the Great Lakes, (2) Great Lakes fishing, and (3) salt water fishing. The sampling included licensed and non-licensed anglers.

There were 22,578 records in the national sample. For our research we used the sample of Oklahoma anglers pursuing freshwater fishing, which comprised 348 observations.

The survey also includes information on the angler's age, marital status, gender, education, ethnic background, occupation, number of trips to freshwater fishing sites, and trip related expenditures. Detailed descriptions of variables are given in Table 1.

Estimation Results

We first summarize the econometric results for predicting prices. The estimation results of the Lee and Pitt and two-step models are then presented and discussed. Then we explore the empirical results further by calculating and decomposing the elasticity of demand to assess the effects of variables on trip consumption.

Tables 2 and 3 summarize the estimated price/quality functions for in-state and out-of-state fishing trips, respectively. The probit MLE's for the trip participation equation and the weighted least squares for the price equation were obtained using SAS software package.

As expected, when income increases, the individual tends to make more trips. Because prices for trips are costs per trip we expect a positive correlation with income. Males generally make more trips than female. We expect a negative married angler effect because of devoting more of his/her free time to the family compared to unmarried angler. Higher educated individuals and Caucasian people may make more trips if fishing trips are correlated with income.

Table 2 shows that results, except race, are consistent with a priori expectations in the first stage. In the second stage, the signs for estimates, except gender and college degree, are also consistent with a priori expectations. In the first stage, race is statistically significant at the 10% probability level with a negative sign. College degree is significant with relatively large positive sign. The effect of income, age, age-squared, marital status, and gender are not statistically significant. Married anglers have non-significant negative correlation with the trip decision. Males tend to make more trips than their female counterparts, but the difference is not significant.

In the second stage in Table 2 age is statistically significant at the 10% probability level. Variables for total expenditure, age-squared, race, and college degree are statistically significant at the 5% probability level. College degree and gender are negatively correlated with dependent variable, price/quality, indicating males and people with higher education tend to spend less on in-state trips.

The Mill's-ratio is significant at the 0.05 probability level for in-state fishing trips for the price/quality model indicating that deleting the zero expenditures from the sample would have biased the coefficient estimates in the model. Total expenditure has a positive impact on the price/quality function. The low R-squared value for the in-state price/quality model indicates that considerable variation remains unexplained after using individual characteristics for quality effects. Because we lacked data on quality characteristics of the commodity (trips), residual variation resulting from the model is assumed to reflect nonsystematic factors. This indicates that quality correction likely will not have much impact on the price variables.

Table 3 shows the results for the trip decision and the price/quality function for out-of-state trips. In the first stage, income is significant at the 5% probability level with a negative correlation with trip decision. The probability of making out-of-state trips is reduced for Caucasian and educated people but the effects are not significant. Income, race, and college degree all reduce the probability of making out-of-state trips. Males tend to make more out-of-state trips than females but the coefficient is not significant. Married people are positively correlated with the probability of making an out-of-state trip but the effect is not statistically significant. Age and age-squared have the expected signs but are not significant.

In the second stage in Table 3 age-squared is statistically significant at the 10% probability level. Total expenditure and race are statistically significant at the 5% probability level. Race surprisingly is negatively correlated with the out-of-state price/quality variable. It is caused by few non-Caucasian (3 people) observations in the sub-sample. Age, married people, gender, and college are not statistically significant.

The inverse Mill's-ratio is statistically significant at 0.05 probability level. The sample selectivity bias would have been present if the zero expenditure observations were deleted from the sample. This is true because 83 percent of the anglers did not consume out-of-state trips thus resulting in unobserved prices. Notice that for out-of-state price/quality adjusted R-squared value indicates that considerable variation is explained by adjusting for quality effects.

Overall, there is considerable difference in the explanatory power of the variables of the two models based on R-square. The explanatory variables account for more of the variation in out-of-state price/quality effects than for in-state price/quality effects. Likelihood ratio test is carried out for goodness-of-fit for in-state and out-of-state price/quality functions in the first step, but the results are not significant. Gender was not statistically significant in the two models for the second stage. As expected, anglers tended to pay higher prices for in-state and out-of-state fishing trips as total expenditure increased. Not surprisingly, having a college degree has a positive but not significant effect on out-of-state price/quality variable. This indicates that educated people, generally with higher incomes, tend to take more out-of-state trips. On the other hand, as Table 2 shows, less educated anglers spend significantly more on in-state trips.

Using the parameter estimates given in Tables 2 and 3, predicted prices for in-state and out-of-state trips were calculated. The predicted price ratio (in-state trip price to out-of-state trip price) along with calculated unit price ratio was then used as explanatory variables in the indirect translog utility model as discussed in the following section.

To obtain parameter estimates for the Lee and Pitt and the two- step censored demand model we use the maximum likelihood module, MAXLIK, within the GAUSS software package and the SAS software package, respectively.

The estimated coefficients, standard errors, and t-values for in-state and out-of-state trip share equations are given in Table 4 for the Lee and Pitt model. The dependent variable is the trip share equation. The independent variables are the natural logarithm of the price of one good to the price of the other good, visa-versa, and age, marital status, gender, race, and college degree. Age-squared variable was deleted because of sever multicollinearity with age in the Lee and Pitt model. When interpreting marginal effects of a change in a continuous explanatory variable on the expected value of the left hand side, one should use caution because the Lee and Pitt model is a mixture of index and censoring variables. There are usually two types of marginal effects in the tobit-type model, one of which is the marginal effect for the index variable and the other is the marginal effect for a given censoring variable. We use the marginal effects for the index variable as follows: $\frac{\partial E[y_i^* \mid X_i]}{\partial X_i} = \beta$. Constant terms must sum to one for trip shares and parameter estimates for age, marital status, gender, race and a college degree must be of opposite sign for trip share equations because of the adding-up conditions.

Price ratio, a college degree, and the sigma parameter are significant at the 0.05 probability level. A one-percent increase in the price ratio decreases fishing trip share by

0.09 percent. This is a phenomenon of the usual demand model, that an increase (or decrease) in own price will have a negative (or positive) impact on its demand. A reduction in one share induces an increase in the opposite share because shares must sum to one. Anglers with less than a college degree will take more in-state relative to out-of-state trips. On the other hand, people having a college degree will make fewer in-state trips compared to out-of-state trips. This is probably because the better educated are likely to be in better economic condition, thus taking more out-of-state trips. The coefficient estimates for age, marital status, race, and gender are not significant.

We next consider results of the two step censored demand model. We estimate in-state and out-of-state trip participation decisions separately by using the probit model at the first stage. We obtain estimates of $\hat{\Phi}_i$ and ϕ_i from the probit model to be used in the second stage. At the second stage, we drop out-of-state trip share equation and estimate only in-state trip share for singularity purposes. Parameter estimates for the dropped equation (out-of-state trip share) are then recovered through the adding-up conditions. Standard errors of parameter estimates for in-state and out-of-state trip shares are calculated by the Murphy and Topel (1985) procedure.

The first step is the estimation of the probit regression models in which the dependent variable is measured by a binary variable reflecting the decision to take a trip or not to take a trip to in-state and out-of-state. The independent variables are the same as stated above for predicting price/quality functions for in-state and out-of-state. The results for parameter estimates in the first-step for trip decisions are the same as in the price/quality models in the first step. Thus, we will not discuss these parameter estimate results here for the first step for trip decisions.

The estimated parameters and standard errors are shown in Table 5. We will discuss the parameter estimate results only for in-state trip share equation because the parameter estimates for out-of-state trip share are calculated by the adding-up conditions. The variables in the second stage are products of variables themselves and the cumulative distribution function. For example, the variable for age is $age * \Phi(Z_{it}\alpha)$. Results show that the sign for the estimated parameters is consistent with prior expectation in the second step for in-state trip share.

The price ratio ($\ln\left(\frac{p_1}{p_2}\right) * \Phi(Z_{it}\alpha)$) and college degree are the only significant variables at the 5% probability level in the second step. The college degree variable has a significantly positive correlation with in-state trip share. This indicates that people with a college degree will take more in-state trips compared to people with less than a college degree. The probability of observing in-state trip share decreases significantly with an increase in the logarithm of the price ratio.

The parameters for the full model (second stage) generally appear reasonable with respect to sign. Males have a positive impact on in-state trip share compared to their female counterparts but it is not statistically significant. Caucasian people tend to make more trips in state compared to non-Caucasian people but it is not significant. Assuming in-state trips are correlated with income, Caucasian anglers with college degree will make more trips than non-Caucasian anglers with less than a college degree. Married people have a negative impact on in-state trip share as expected but it is not significant. Age and age-squared are not statistically significant in the second step.

The parameters in the second stage do not fully reflect the marginal effects on the dependent variable. The marginal effect is usually interpreted as a change in the expected value of the fishing trip share with respect to a one-unit change in an explanatory variable. However, parameter estimates and variables in the market participation probit equation are allowed to differ from those determining share equations in the second step. Thus, a change in an independent variable, which is in both market participation probit and share equation, may affect the probability of a taking trip differently from the way it affects the level of trip share (Blisard and Blaylock, 1993). Differentiating the unconditional mean in equation (3.38), the marginal effect of a common variable can be derived at the mean values as:

$$\frac{\partial E(s_{it} \mid X_{it}, Z_{it})}{\partial X_{ikt}} = \left[\left(\left(\frac{\partial \Phi(Z'_{it}\alpha_i)}{\partial X_{ik}}\right)(X'_{it}\beta_i)\right) + \left(\frac{\partial (X'_{it}\beta_i)}{\partial X_{ik}}(\Phi(Z'_{it}\alpha_i))\right)\right]$$

$$+\left(\frac{\partial \phi(Z'_{it}\alpha_i)}{\partial X_{ik}}\right)$$

$$= \Phi(Z'_{it}\alpha_i)\beta_{ik} + X'_{it}\beta_i\phi(Z'_{it}\alpha_i)\alpha_{ik}$$

$$-\delta_i(Z'_{it}\alpha_i)\phi(Z'_{it}\alpha_i)\alpha_{ik} \qquad (3.40)$$

This shows the magnitudes for parameters might be different between the full model and the marginal effect. On the other hand, the sign for parameters from the full and marginal effect calculation should be consistent.

Marginal effects for in-state fishing trip share are consistent in terms of signs and are not much different from the parameter estimates in the second step. Marginal effects for out-of-state trip share can be recovered from the marginal effects for in-state trip share through the adding-up conditions. By imposing homogeneity and symmetry conditions on the indirect translog utility demand model, the effect of total expenditure is reduced. Note that the first stage allows the decision of whether to take a fishing trip to be influenced by income. Thus, we measure the marginal effect of income per capita in the second stage. The marginal effect of income per capita of the angler is 0.0001 indicating a one-unit increase in the income results in a 0.0001 unit increase in the in-state-fishing trip share. Notice that this is not an income elasticity of demand. Using this parameter estimate and sample means of income and trip share, the income elasticity of demand for each type of trip can be derived.

Results of Table 5 for Pdf ($\phi_i(Z_{it}\alpha)$) show that the variables included to correct for selectivity bias is significant at the 0.10 probability level for in-state trip share in the second step. This suggests the sample selection bias would have been present for in-state-fishing trip share if zero observations for in-state trip share were deleted from the sample. The importance of the standard normal probability density function is that it links the trip participation decision stage to the expenditure share stage. Thus, the determination of marginal effects for variables included in the expenditure share equation has an impact on the normal probability density function. Failure to incorporate these variables would lead to biased estimates for marginal effects (Byrne, Capps, and Saha, 1996). The R-squared value indicates that 46 percent of variation is explained by the variables.

Marginal effects of price ratio and having a college degree for in-state trip share are about the same as with the Lee and Pitt model.

To obtain own and cross price elasticities and Morishima elasticity of substitution for both the Lee and Pitt and the two-step censored demand models from expenditure share equations of the indirect translog utility function we use the following (Chung, 1994):

Own-price elasticity: $\eta_{ii} = -1 + \frac{\partial S_i}{\partial P_i} x \frac{P_i}{S_i}$,

Cross-price elasticity: $\eta_{ij} = \frac{\partial S_i}{\partial P_j} x \frac{P_j}{S_i}$, and

Morishima Elasticity of Substitution: $\frac{\partial \ln (S_i / S_j)}{\partial \ln (P_i / P_j)} = 1 - M_{ij} = \eta_{ji} - \eta_{ii}$

where M_{ij} is the Morishima elasticity of substitution.

When evaluated at the sample means, Tables 6 and 7 show that all own-price elasticities have the expected negative sign and all are significant at the 0.05 probability level. Elasticities computed from the Lee and Pitt model are slightly higher in absolute value compared to the elasticities from the two-step censored demand model.

Definitionally, trip demand is elastic in nature when $\eta < -1.00$, indicating that a given percentage change in trip price induces a greater percentage change in the quantity of trip demand of the opposite sign. Both models show that the own price elasticity is price elastic. Note that out-of-state trip demand is more price elastic than for in-state trip demand. This is consistent in that out-of-state trips are considered a more luxury good compared to in-state fishing trips.

The Lee and Pitt model shows that a one percent increase (or decrease) in the out-of-state and in-state trip price increases (or decreases) the quantity demanded of in-state and out-of-state trips by about 1.09 and 1.85 percent, respectively. On the other hand, the two-step censored demand model shows that a one percent increase (or decrease) in out-of-state and in-state trip price would induce 1.09 and 1.78 percent increase (or decrease) in the quantity demanded of in-state and out-of-state trips, respectively. The estimated parameters are very similar. The estimated own price elasticities suggest that the quantity demanded of each type of trips are sensitive to price. This also indicates that for these trips, higher total revenue is achieved from lowered prices, not increased prices.

Cross price elasticity of trip demand relates the percentage change in the quantity demanded of one trip type to a percentage change in the price of the other trip type. Depending on the sign of the cross-price elasticities, trips are complementary when $\eta_{ij} < 0$ (negative) or substitutes when $\eta_{ij} > 0$ (positive). All cross-price elasticities are substitutes and statistically significant at the 5% probability level. Both models show that the cross-price elasticity is higher for out-of-state trips demand than for in-state trips demand.

Morishima elasticity of substitution accounts for an increase in the price ratio resulting in an increase in the share of good i compared to the share of good j. Blackborby and Russell (1989) show that the Morishima elasticity of substitution is sufficient by incorporating the effects of changes in price ratio on relative consumption goods shares. Thus, it matters how a change in price ratio is induced. Morishima elasticity of substitution is not symmetric, as in the Allen-Uzawa elasticity of substitution. By imposing demand restrictions (homogeneity and symmetry) on the demand model with two good, Morishima, and Allen-Uzawa elasticity of substitution are equal thus symmetric (See appendix).

The percentage change in relative trip shares evoked by a given percentage change in a trip price relative is:

$$\frac{\partial \ln\left[\frac{s_i}{s_j}\right]}{\partial \ln\left[\frac{p_i}{p_j}\right]} = 1 - M_{ij} = 1 - M_{ji} \tag{3.41}$$

where $M_{ij} = M_{ji}$. For our model, the Morishima elasticity of substitution is:

$$M_{12} = \left[\frac{\partial Q_2}{\partial p_1}\frac{p_1}{Q_2}\right] - \left[\frac{\partial Q_1}{p_1}\frac{p_1}{Q_1}\right] \tag{3.42}$$

where Q_i is the quantity demanded of trips. The first part on the right hand side of equation (3.42) is the cross price elasticity for out-of-state trip demand and the second part is the own price elasticity for in-state trip demand. It captures the difference between the cross price elasticity for out-of-state trip demand and the own price elasticity for in-state trip demand. A percentage change in in-state price would have an effect on percentage change in the quantity demanded for out-of-state as well as in-state trips. Morishima elasticity of substitution shows that a percentage change in in-state trip price will have a different percentage effect on the quantity demanded of both trips than a percentage change in out-of-state trip price. With a single estimated parameter resulting by imposing the demand restrictions, a percentage change in either in-state trip price or out-of-state trip price will have the same percentage change in the quantity demanded of both trips.

Mathematically, equation (3.42) is:

$$M_{12} = \left[\frac{\partial Q_2}{\partial p_1}\frac{p_1}{Q_2}\right] - \left[\frac{\partial Q_1}{p_1}\frac{p_1}{Q_1}\right]$$

$$= \left(\pm\right) - \left(-\right) = \left(\begin{matrix} + \\ or \\ - \end{matrix}\right) + . \tag{3.43}$$

The second part of the right hand side of equation (3.43) is always negative (sign for own price elasticity) resulting in this part of equation (3.43) always being positive. If the cross price elasticity shows substitutes for the second good then we will always have substitution in Morishima (or Allen-Uzawa) elasticity of substitution. However, if the cross price elasticity is complement for the quantity demanded of the second good then the Morishima elasticity of substitution will depend on the magnitude of the cross price and own price elasticities. If the own price elasticity is more elastic (or higher in absolute value) than the cross price elasticity (assuming $\eta_{ij} < 0$) then we will still have substitution effects.

Both models predict that trips are substitutes for Morishima elasticity of substitution and the parameters are statistically significant at the 5% probability level. Lee and Pitt's model shows that a one percent increase in the price ratio results in a 1.94 percent increase in the quantity ratio of fishing trips. On the other hand, the two-step censored demand model indicates that a one percent increase in the price ratio will have an increase of 1.86 percent in the quantity ratio of trips. Thus, the Lee and Pitt and the two-step censored models show that anglers substitute out-of-state trips for in-state trips when relative costs per trip between the two types change. An increase in energy costs would tend to reduce the quantity demanded for both in-state and out-of-state trips.

However, because longer travel distances are generally associated with out-of-state trips, transportation cost (energy cost) would be higher for out-of-state trips relative to in-state trips. Thus anglers would tend to substitute in-state trips for out-of-state trips, perhaps resulting in a positive impact on the Oklahoma regional economy. If water quality decreases, anglers at fisheries must stay longer and spend more to have the same quality of trip in terms of the catch rate. Therefore, changing habitat (water quality, harvest rate, etc) of Oklahoma fisheries could have a positive or negative effect on trips.

Note that the Lee and Pitt and the two-step censored demand models are consistent with the expected signs of the parameters. As previously stated, with the two-good case, the Lee and Pitt model does not require any substitution of the analytical solution for the virtual prices into the remaining share equation. Thus, the associated covariance matrix is simple. On the other hand, the two-step censored demand model depends on predicted market prices for non-consumed trips while anglers consider virtual prices for non-consumed trip types. As Arndt, Liu and Preckel (1999) point out, the direction of bias is potentially of interest. Use of average market prices as used in the Lee and Pitt model for non-consumed trips implies use of a price that is too high because the virtual price must be less than or equal to the market price. Thus it may yield to an underestimate of the cross price elasticity and, hence, the Morishima Elasticity of Substitution. As the number of goods increases the likelihood functions are highly non-linear and it becomes more difficult to estimate the Lee and Pitt model. If the model for predicting prices is correctly specified, the two-step censored demand model yields consistent estimates by using all observations. The two-step censored demand model for full observations has not received much attention by economists, perhaps for two reasons:

(1) because it does not produce more efficient estimates as contrary to Heckman's procedure for non-limit observations in the second stage; (2) because maximum likelihood can be easily specified for single equation models. We show that consistent and efficient estimates for the two-step censored demand model using all observations are obtained by incorporating the Murphy and Topel procedure, thus yielding consistent estimates for elasticities. Improvements or additions to the indirect translog utility demand model would be to incorporate opportunity cost of time, site quality differences, and catch rate in the model.

In the next chapter, we use the two-step censored demand model in estimating demand elasticities (including Morishima elasticity of substitution) between eastern Oklahoma small natural stream fishing trips and all other water-body fishing trips in Oklahoma. Because it is the same procedure we use here, it will not be presented in detail.

Table 1. Summary Statistics of Data

Variable Definitions	Units	Mean	Standard Deviation
Observed in-state expenditure share	%	0.901	0.266
Observed out-of-state expenditure share	%	0.099	0.266
Observed in-state cost (price) per trip	$	32.58	45.37
Observed out-of-state cost (price) per trip	$	255.52	345.827
Age	years	42	14.642
1 if the individual is married	0/1	0.67	
1 if the individual is male	0/1	0.69	
1 if the individual is Caucasian	0/1	0.86	
1 if the individual has college degree	0/1	0.29	
Observed number of in-state trips per angler	number	15.53	20.78
Observed number of out-of-state trips per angler	number	0.41	1.45
Observed total expenditures	$	404.36	895.64
Income	$	29687	21734

Source: U.S. Department of Interior, Fish and Wildlife Services, Division of Federal Aid, 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 1998.

Table 2. Parameter Estimates of In-state Price/Quality Function from Heckman Two-Step Censored Demand Model

Variables	Probit (1st Stage)		Full Model (2nd Stage)	
	Parameter Estimates	Standard Error	Parameter Estimates	Standard Error
Constant	-1.848	1.805	5.511	1.992**
Income	0.0001	0.0001		
Total Expend.			0.001	0.0001**
Age	0.005	0.087	0.065	0.037*
Age Squared	-0.0001	0.001	-0.001	
Marital Status	-0.056	0.444	-0.225	0.0004**
Gender	0.074	0.446	-0.214	0.236
Race	-0.899	0.486*	1.824	0.231
College Degree	1.062	0.453**	-1.816	0.663**
Millsratio			-2.121	0.881**
R-squared			0.231	0.804**
Log Likelihood	-29.668			
Likelihood Ratio Chi-Square Value	59.337			

*- indicates significance level at the 0.10 probability level.
**- indicates significance level at the 0.05 probability level.

Table 3. Parameter Estimates Of Out-of-state Price/Quality Function from Heckman Two-Step Censored Demand Model

Variables	Probit (1st Stage)		Full Model (2nd Stage)	
	Parameter Estimates	Chi-Square	Parameter Estimates	T-values
Constant	1.554	0.999	3.254	1.333**
Income	-0.0001	0.0001**		
Total Expend.			0.001	0.0001**
Age	0.001	0.048	0.094	0.063
Age Squared	-0.0001	0.001	-0.001	0.0007*
Marital Status	0.045	0.301	0.650	0.403
Gender	0.023	0.023	-0.267	0.390
Race	-0.025	0.378	-1.870	0.539**
College Degree	-0.300	0.289	0.098	0.411
Millsratio			2.275	0.938**
R-squared			0.773	
Log Likelihood	-69.418			
Likelihood Ratio Chi-Square Value	138.835			

*- indicates significance level at the 0.10 probability level.
**- indicates significance level at the 0.05 probability level.

Table 4. Parameter Estimates for In-state and Out-of-state Trip Share Equations for the Lee and Pitt Model.

Variables	Parameter Estimates for In-state Trip Share	Parameter Estimates for Out-of-state Trip Share
Constant	1.264** (0.038)	-0.264 (0.187)
LnPrice ratio	-0.088** (0.006)	-0.088** (0.028)
Age	-0.001 (0.001)	0.001 (0.003)
Marital Status	0.001 (0.018)	-0.001 (0.090)
Gender	-0.027 (0.018)	0.027 (0.089)
Race	-0.006 (0.025)	0.006 (0.119)
College Degree	-0.134** (0.018)	0.134** (0.028)
Sigma (σ^2)	0.277** (0.013)	0.277** (0.013)
Mean Log-Likelihood	-3.97	-3.97
Number of observations	167	167

Values in the parenthesis are standard errors of parameter estimates.
**- indicates significance level at the 0.05 probability level.

Table 5. Parameter Estimates for In-state and Out-of-state Trip Share Equations from Shonkwiller and Yen Two-Step Censored Demand Model

Variables	Probit (1^{st} Stage)		Full Model (2^{nd} Stage)		
	Parameter Estimates for In-state Trip	Parameter Estimates for Out-of-state Trip	Parameter Estimates for In-state Trip Share	Parameter Estimates for Out-of-state Trip Share	Marginal Effects for In-state Trip Share
Constant	-1.848 (1.805)	1.554 (0.998)	0.488** (0.219)	0.470** (0.139)	
Income	0.0001 (0.0001)	-0.0009** (0.0001)			0.0001
LnPrice ratio			-0.078** (0.008)	-0.078** (0.048)	-0.073
Age	0.005 (0.087)	-0.001 (0.048)	0.003 (0.006)	-0.003 (0.007)	0.004
Age squared	-0.0001 (0.001)	-0.0001 (0.001)	-0.0001 (0.0001)	-0.0001 (0.0001)	-0.0001
Marital Status	-0.056 (0.444)	0.045 (0.301)	-0.056 (0.041)	0.056 (0.045)	-0.064
Gender	0.074 (0.446)	0.023 (0.023)	0.021 (0.037)	-0.021 (0.041)	0.035
Race	-0.899* (0.486)	-0.025 (0.378)	0.108 (0.078)	-0.108* (0.056)	0.111
College Degree	1.062** (0.453)	-0.300 (0.288)	0.152** (0.099)	-0.152** (0.071)	0.131
Pdf ($\phi_i(Z_{it}\alpha)$)			-0.585* (0.457)	0.585* (0.374)	
R-Squared			0.46		
Log Likelihood	-29.668	-69.418			
Likelihood Ratio Chi-Square Value	59.337	138.835			

Values in the parenthesis are standard errors of parameter estimates.
*- indicates significance level at the 0.10 probability level.
**- indicates significance level at the 0.05 probability level.

Table 6. Own and Cross Price Elasticities and Substitution Elasticities from Lee and Pitt Model.

Commodity	Own and Cross Price Elasticities		Morishima Elasticity of Substitution	
	In-state Trips	Out-of-state Trips	In-state Trips	Out-of-state Trips
In-state Trips	η_{11} =-1.094** (-172.736)	η_{12} =0.094** (14.825)		M_{12}= 1.94** (30.601)
Out-of-state Trips	η_{21} =0.846** (14.825)	η_{22} =-1.846** (-32.352)	M_{12}= 1.94** (30.601)	

Values in the parenthesis are t-values of parameter estimates.
**- indicates significance level at the 0.05 probability level.

Table 7. Own and Cross Price Elasticities and Substitution Elasticities from Shonkwiller and Yen Two-Step Censored Demand Model

Commodity	Own and Cross Price Elasticities		Morishima Elasticity of Substitution	
	In-state Trips	Out-of-state Trips	In-state Trips	Out-of-state Trips
In-state Trips	η_{11} = -1.086** (-109.288)	η_{12} =0.086** (8.665)		M_{12}=1.862** (18.713)
Out-of-state Trips	η_{21} =0.776** (8.665)	η_{22} =-1.776** (-19.828)	M_{12}= 1.862** (18.713)	

Values in the parenthesis are t-values of parameter estimates.
**- indicates significance level at the 0.05 probability level.

CHAPTER

IV.

ELASTICITY OF SUBSTITUTION BETWEEN SMALL NATURAL STREAM AND ALL OTHER WATER BODY TYPE FISHING TRIPS

Introduction

There is little information available on the economic value of eastern Oklahoma small natural streams used for fisheries. Also, it is not known if there exists a substitution relationship between fishing trips to natural small streams and to all other fisheries (reservoirs, small/large rivers, and small lakes). The use of state policy in managing eastern Oklahoma's small natural streams and all other water-body sites within Oklahoma is limited without information on the values of these sites (Negash, 1999). State policy requires information on relative values to allocate resources across competing uses. However, recreational values are not directly observable to policymakers as values in markets.

We estimate trip-share demand for eastern Oklahoma small natural streams and all other water-body fisheries within Oklahoma by incorporating the two-step censored demand model as outlined in the previous chapter. We establish the presence of substitution effects between natural streams and all other water-body fisheries.

In the subsequent sections, we briefly outline the method for estimation of the two-step censored demand model and present the data. The results for the parameter estimates are then presented and the final section summarizes the findings for demand elasticities and impacts on the quantity demanded of each type of trip.

Methods

The expected prices are obtained by a hedonic price/quality function defined in equation (3.15). We use Heckman two stage procedure as outlined in the pervious chapter to estimate parameters. The participation decision for small natural streams and all other water body type trips is:

$$W_{it} = 1(Z_{it}\gamma_i + \varepsilon_{it} > 0), i = 1,2 \text{ and } t = 1,\dots,T \tag{4.1}$$

The corresponding log-likelihood is:

$$LogLn = \sum_{T_{it}=0} \ln(1 - \Phi(Z_{it}\gamma)) + \sum_{T_{it}=1} \ln(\Phi(Z_{it}\gamma)) \tag{4.2}$$

where $W = 1$ when the individual takes trips, $W = 0$ when he/she does not take trips, $Z_{it}\gamma = \gamma_0 + \gamma_1 Income_t + \gamma_2 Age_t + \gamma_3 Agesq + \gamma_4 Gender_t + \gamma_5 Race_t + \gamma_6 College_t + \gamma_7 Hsize_t + \gamma_8 \operatorname{Re} gion$, and $\varepsilon_{it} \sim N(0,1)$. The variables are income, age, age-squared, gender, race, college, household size, and region of residence.

The second step involves price/quality function for each of the trip types as:

$$P_{ik} = B_{ik}\gamma + \sigma_{01}\lambda_{ik} + \varepsilon_{ik}$$

$$\Sigma = \sigma_{00}^2(1 - \rho^2\delta_{it}) \tag{4.3}$$

where p is the natural logarithm of the calculated unit price, B's are angler characteristics, namely age, age-squared, gender, race, college , household size including the angler himself or herself and region of residence. These variables are assumed to affect the angler choice of quality of a trip, ε_{ik}, σ_{01}, σ_{00}, and Σ given in equation (3.24) of the last chapter.

The missing prices for small natural stream trips and all other water body type trips for non-consuming anglers are obtained as:

$$\hat{P}_{im} = B_{im}\hat{\gamma} + \hat{\sigma}_{01}\hat{\lambda}_{im}, i = 1,2, m = n+1,...,t \tag{4.4}$$

where $\hat{\lambda}_{im} = -\left(\frac{\phi_{im}(-Z_{im}\hat{\gamma})}{1-\Phi_{im}(-Z_{im}\hat{\gamma})}\right)$ is the Mills ratio for non-consuming individuals.

After predicting prices, the two-step censored demand models for small natural stream trips and all other water body type trips are constructed as follows:

The binary stochastic equation for the first step is:

$$Y_{it} = \alpha_i + \sum_{m=1}^{m-1} \alpha_m Z_{imt} + v_{it} \quad i = 1,2; m = 1,...,m-1; t = 1,...,T \tag{4.5}$$

$$\Sigma = \sigma_{00}^2 (1 - \rho^2 \delta_{it}) \tag{4.6}$$

where y_{it} is a i^{th} equation participation decision where if the license holder takes a trip, $y_{it} = 1$ and if he/she does not take a trip $y_{it} = 0$. $\sum_{k=1}^{K} \alpha_{im} Z_{imt}$ is the individual characteristics that affect the participation decision. These variables are described above. v_{it} and Σ are given in equations (3.28a) and (3.31), respectively.

The corresponding probit likelihood function for equation (4.5) is:

$$LogLn = \sum_{Y_{it}=0} \ln(1 - \Phi(Z_{it}\alpha)) + \sum_{Y_{it}=1} \ln(\Phi(Z_{it}\alpha)). \tag{4.7}$$

where Φ is given in equation (3.28a). Equations (4.2) and (4.7) are the same trip decision function.

The second step trip share equations for small natural stream and all other water body trips are:

$$s_{it} = \Phi(Z'_{imt}\alpha_i)X_{ikt}\beta_{ik} + \delta_i\phi(Z'_{imt}\alpha_i) + \xi_{it} \tag{4.8}$$

where s is the trip type share, X 's are variables, namely, the natural logarithm of the price of one good to the price of another good, age, age-squared, gender, race, college, household size, region, and Φ and ϕ are the cumulative and density distribution functions from the first step, respectively. β and δ are conformable vectors to be estimated in the second step, and ε_{it} are error terms given in equation (3.37).

The correct computation of the covariance of β 's and δ is shown in equations (3.38a) through (3.39b).

Data

The data were obtained from a screening survey (sample) of Oklahoma license holders conducted by the Department of Agricultural Economics, Oklahoma State University. This screening survey identified license holders who fished in eastern Oklahoma natural streams in 1992. A follow-up survey in 1993 was conducted on the 163 license holders making a trip to eastern Oklahoma natural streams in the 1992 screening survey. The follow-up survey contained information on angler socio-demographic characteristics, number of fishing trips to all water body types, average travel distance, and average trip-related costs (Oklahoma Department of Wildlife

Conservation, 1996). The sample was reduced to 99 individual observations because of the presence of the following (Negash, 1999):

1. 45 license holders made no trips in 1993 or did not buy a license.
2. Seven senior citizen license holders were excluded from the study since the license type is based on the age of the angler and creates a problem when using the age factor as a characteristic of individuals.
3. Ten observations had poor response and missing information.
4. One angler was an out-of-state resident.

We divided Oklahoma into four regions (northwest, northeast, southwest, and southeast) by I-35 and I-40 quadrants. However, because few of the anglers were from the northwest and southwest regions we reduced regions to two (north and south). Descriptions for the variables with descriptive statistics are given in Table 8.

Empirical Results

We first summarize the findings for predicting prices. The estimation results for the two-step models for small natural stream trip share are presented and discussed. In the last section of this chapter, we compute own and cross price elasticities and Morishima elasticity of substitution and discuss the impacts on the quantity demanded of each trip type.

The probit maximum likelihood and the second stage least squares estimates are presented in Tables 9 and 10 for the price/quality function for small natural stream and all other water body type trips, respectively. The first step involves the estimation of probit regression models for each type of trip. In these tables, the dependent variable for the first stage is a dichotomous choice of whether to take a trip or not to take a trip. Independent variables are the individual characteristics including income. Description of the variables with descriptive statistics is given in Table 8. The variables are income, age, age-squared, gender, ethic background, education level, household size and region. These models are then used to compute the inverse Mill's ratio for each angler. The computed inverse Mill's ratio is then used as a regressor to capture sample selection bias in the second step estimation of the price/quality variable.

The dependent variable for the second stage is the natural logarithm of price (travel cost) per trip to eastern Oklahoma small natural streams, and to all other water body types (including reservoirs, small and large rivers, and small lakes) in Oklahoma. The independent variables for the second stage are the individual characteristics stated above and total expenditure on both trips.

As expected, when income rises, the probability of making a trip increases, thus anglers tend to spend more. Males, on average make more trips than females and females choose more accessible fishing sites (Negash and Schreiner, 1999). Caucasian license holders make more trips. Higher educated anglers make fewer trips. Therefore, the probability of making trips and the price/quality function increase with a high school education or less. Household size may have a negative impact on the probability of making trips as well as on the price/quality function.

Table 9 shows that age and age-squared are statistically significant at the 10% and 5% probability level in the first stage, respectively. Household size is statistically significant at the 5% probability level with a negative sign. This indicates that the probability of making small natural stream trips decreases with an increase in household size. Income, race, and above high school education have expected signs but are not statistically significant in the first stage. Anglers from the north region have a negative impact on the probability of making small natural stream trips, but it is not statistically significant.

The goodness-of-fit statistic for the first stage is the log likelihood chi-square test but it is not significant.

The expected signs are more consistent in the second stage than in the first stage. Total expenditure is statistically significant at the 5% probability level with a positive impact on price/quality variable, as one would expect. Age and age-squared are also significant at the 5% probability level. Price/quality variable initially increases with age and then declines as suggested by significantly positive and negative signs of the age and age-squared variables. Household size is significant with a negative sign, indicating household size is negatively correlated with the price/quality function. Males spend more than females, but the coefficient is not significant. Surprisingly, Caucasians have a negative impact on the price variable, but it is not significant. There is a negative correlation between price/quality variable and anglers with more than high school education, but it is not statistically significant. Anglers from the north region spend more on small natural stream trips than anglers from the south region, but it is not statistically significant.

The parameter estimate for the inverse Mill's ratio is not statistically significant suggesting that deleting individuals who did not take small natural stream trips from the sample would not bias the coefficient estimates, but they would cause efficiency losses in the model.

Table 10 on the all other water body type price/quality function indicates that, except for income, signs on the variables are consistent with prior expectations. However, none of the variables are statistically significant in the first stage. The log likelihood test for goodness-of-fit is not significant in the first stage.

In the second stage, we also have consistent expected signs for the parameter estimates. Trip expenditure variable is statistically significant at the 5% probability level for the price/quality variable for all other water body type fishing trips. Age and gender have positive effect on the price/quality function, but not significant. Age-squared, race, education, and region have negative impacts on the price function, but none are statistically significant.

The parameter estimate for the inverse Mill's ratio is statistically significant at 5% probability level suggesting that deleting the observations corresponding with unobserved price would introduce sample selection bias.

Overall, the second step least squares for small stream and all other water body type price/quality variables have a low R-squares, indicating considerable variation remains unexplained after adjusting for quality effects.

After predicting prices, the two-step censored demand model is used to estimate small natural stream and all other water body type fishing trip shares. The first step involves the estimation of the probit regression models in which the dependent variable is measured by a binary variable reflecting the decision to take a trip or not to take a trip to the eastern Oklahoma small natural streams and to the all other water body types. The independent variables are the same as outlined earlier for predicting price/quality functions. The findings in the first-step for both trip decisions are the same as in the price/quality models in the first step.

The estimates of Φ and ϕ from the first step are used in the second step estimation. The independent variables are products of the variables themselves and the computed cumulative distribution function. The variables are the natural logarithm of the price ratio (the price of small natural stream trips to the price of all other water body type fishing trips), age, age-squared, gender, race, education, household size, and region. The ϕ is a new regressor used in the second step. We drop all other water body type trip share equation and estimate only small natural stream trip share for singularity purposes. Parameter estimates for the dropped equation are then calculated through the adding-up conditions.

The estimated parameters and standard errors are shown in Table 11 for small natural stream and all other water body type fishing trip share equations. We explain the parameter estimate results only for the estimated trip share equation, namely for the small natural stream trip share. Parameter estimates for the price ratio is the only statistically significant variable at the 5% probability level. The price ratio has a positive impact on the small natural stream trip share dependent variable. Age-squared, gender, race, education, household size, and region variables have negative signs but are not statistically significant. Age and age-squared have the expected signs, but are not significant. Education variable has a negative impact on the small natural stream trip share, indicating anglers with more than a high school degree will have a lower natural stream fishing trip share. However, this variable is not statistically significant.

The parameter estimate for the probability density function is significant at the 10% probability level, indicating that deleting observations with zero share for the small natural stream trips would have introduced sample selection bias.

Demand elasticities and Morishima elasticity of substitution for both types of trips are given in Table 12. All elasticities are statistically significant at the 5% probability level. Morishima elasticity of substitution is statistically significant at the 10% probability level. Own demand elasticities for both types of trips are inelastic, indicating the percent change in quantity demanded of each type of trip is less than the percent change in price. The magnitudes for own price elastities are similar for the two types of trips. The signs of the cross price elasticities indicate that the trips are either substitutes when the sign is positive or complements when the sign is negative. The signs for the cross price elasticities for both types of trips indicate that trips are complements. A one percent increase (decrease) in the price of all other water body type trips will decrease (increase) the quantity demanded of small natural streams by 0.45 percent. On the other hand, a one percent increase (decrease) in the price of small natural stream trips will induce a decrease (an increase) in the quantity demanded of all other water body trips by 0.32 percent. However, the sign for the Morishima elasticity of substitution indicates that trips are substitutes. Elasticity of substitution captures the difference between cross price and own price elastitities resulting from a change in the own price. A change in own price will have impacts on the quantity demanded of own trips as well as on the quantity demanded of competitive trips, indicating the quantity of both trips is sensetitive to own price of a trip. A one percent change in the price ratio will induce a 0.23 percent change in the ratio of quantity demanded.

The results show, somewhat surprisingly, that the decision to make trips does not depend on the individual characteristics due to the small number of non-participants in our sample. A methodological limitation of this study also includes small sample size. Extension of this study may consider more than two types of trips and quality of sites, such as catch rate, water clearness and the opportunity cost of time.

Table 8. Summary Statistics of Data

Variable Definitions	Units	Mean	Standard Deviation
Observed small natural stream expenditure share	%	0.41	0.36
Observed all other water body type expenditure share	%	0.59	0.36
Observed small natural stream cost (price) per trip	$	18.49	33.52
Observed all other water body type cost (price) per trip	$	32.51	54.21
Age	years	42	13.67
1 if the individual is male	0/1	0.87	
1 if the individual is Caucasian	0/1	0.85	
1 if the individual has above high school education level	0/1	0.45	
Household size	head	3	1.39
1 if the individual is from North Region	0/1	0.50	
Observed number of small natural stream trips per angler	number	20.65	35.08
Observed number of all other water body type trips per angler	number	24.97	33.44
Observed total expenditures	$	1193	2332
Income	$	33859	36849

Table 9. Parameter Estimates of Natural Small Stream Price/Quality Function from Heckman Two-Step Censored Demand Model

Variables	Probit (1st Stage)		Full Model (2nd Stage)	
	Parameter Estimates	Standard Error	Parameter Estimates	Standard Error
Constant	-2.756	2.291	-0.294	1.234
Income	0.00001	0.0000		
Total Expend.			0.0002	0.0001**
Age	0.174	0.102*	0.216	0.087**
Age Squared	-0.002	0.001**	-0.003	0.001**
Gender	-0.391	0.481	0.058	0.393
Race	0.043	0.488	-0.358	0.334
Above High School	-0.393	0.327	-0.120	0.315
Household Size	-0.444	0.170**	-0.324	0.179*
Region	-0.256	0.360	0.218	0.265
Millsratio			-1.214	1.218
R-squared			0.242	
Log Likelihood	-41.312			
Likelihood Ratio Chi-Square Value	82.623			

*- indicates significance level at the 0.10 probability level.
**- indicates significance level at the 0.05 probability level

Table 10. Parameter Estimates of All Other Water Body Type Price/Quality Function from Heckman Two-Step Censored Demand Model

Variables	Probit (1^{st} Stage)		Full Model (2^{nd} Stage)	
	Parameter Estimates	Standard Error	Parameter Estimates	Standard Error
Constant	-0.892	1.742	1.818	1.152**
Income	-0.00001	0.00001		
Total Expend.			0.0002	0.0001**
Age	0.012	0.079	0.009	0.049
Age Squared	-0.0002	0.001	-0.0001	0.001
Gender	0.388	0.603	0.012	0.327
Race	-0.093	0.482	-0.444	0.286
Above High School	-0.073	0.338	-0.029	0.205
Household Size	-0.078	0.144	-0.061	0.080
Region	-0.124	0.354	-0.193	0.217
Millsratio			0.814	0.256**
R-squared			0.367	
Log Likelihood	-38.599			
Likelihood Ratio Chi-Square Value	77.198			

*- indicates significance level at the 0.10 probability level.

**- indicates significance level at the 0.05 probability level

Table 11. Parameter Estimates for Small Stream and All Other Water Body Type Trip Share Equations from Shonkwiller and Yen Two-Step Censored Demand Model

Variables	Probit (1st Stage)		Full Model (2nd Stage)		
	Parameter Estimates for Small Natural Stream Trip	Parameter Estimates for All Other Water Body Type Trip	Parameter Estimates for Small Natural Stream Trip Share	Parameter Estimates for All Other Water Body Type Trip Share	Marginal Effects For Small Natural Stream Trip Share
Constant	-2.756 (2.291)	-0.892 (1.742)	0.747** (0.316)	0.253 (0.280)	
Income	0.00001 (0.00001)	-0.00001 (0.00001)			0.0000
LnPrice Ratio			0.187** (0.029)	0.187** (0.030)	0.150**
Age	0.174* (0.102)	0.012 (0.079)	0.019 (0.022)	-0.019 (0.022)	0.027
Age squared	-0.002** (0.001)	-0.0002 (0.001)	-0.0002 (0.0003)	0.0002 (0.0003)	-0.0003
Gender	-0.391 (0.481)	0.388 (0.603)	-0.185 (0.134)	0.185 (0.130)	-0.176
Race	0.043 (0.488)	-0.093 (0.482)	-0.027 (0.102)	0.027 (0.108)	-0.019
Above High School	-0.393 (0.327)	-0.073 (0.338)	-0.047 (0.098)	0.047 (0.093)	-0.065
Household Size	-0.444** (0.170)	-0.078 (0.144)	-0.044 (0.058)	0.044 (0.044)	-0.065
Region	-0.256 (0.360)	-0.124 (0.354)	-0.126 (0.086)	0.126 (0.089)	-0.119
Pdf ($\phi_i(Z_{it}\alpha)$)			-1.064* (0.591)	1.064* (0.583)	
Log Likelihood	-41.312	-38.599			
Likelihood Ratio Chi-Square Value	82.623	77.198			
R-Squared			0.300		

Values in the parenthesis are standard errors of parameter estimates.
*,**- indicate significance level at the 0.10 and 0.05 probability levels, respectively.

Table 12. Own and Cross Price Elasticities and Substitution Elasticities from Shonkwiller and Yen Two-Step Censored Demand Model

Commodity	Own and Cross Price Elasticities		Morishima Elasticity of Substitution	
	Small Natural Stream Trips	All Other Water Body Type Trips	Small Natural Stream Trips	All Other Water Body Type Trips
Small Natural Stream Trips	η_{11} = -0.549** (-7.199)	η_{12} = -0.451** (-5.915)		M_{12} =0.231* (1.772)
All Other Water Body Type Trips	η_{21} = -0.319** (-5.915)	η_{22} = -0.682** (-12.656)	M_{12} = 0.231* (1.772)	

Values in the parenthesis are t-values of parameter estimates.
**- indicates significance level at the 0.05 probability level.

CHAPTER

V.

SUMMARY AND CONCLUSION

This study focuses on two separate analyses of Oklahoma anglers. The first analysis focuses on consumption by anglers of in-state versus out-of-state trips. The second study examines the consumption of trips by anglers to small natural streams in eastern Oklahoma versus trips to all other water body types within Oklahoma. The study explores the effects of own and cross price elasticities and the Morishima elasticity of substitution on the consumption behavior of anglers.

The study utilizes cross-sectional data to estimate trip share expenditure for each type of trips. A common characteristic of cross-sectional data is that the dependent variable for trip expenditure may include zero values for some types of trips for a substantial number of non-consuming anglers. Thus, the sample data may contain a large number of zero expenditures yielding unobserved prices for non-consuming trips. This violates the unbiased assumption in ordinary least squares, thus bias and non-consistent estimators and inappropriate statistical inferences.

We used the Heckman's two stage procedure for predicting missing prices which are theoretically sound and empirically appropriate under the individual's economic behavior. This estimation provides variation in prices, thus resulting in better estimates for elasticities. The procedure incorporates individual characteristics in the model and corrects for selectivity bias. Results show that selectivity bias is present if the related zero expenditure variables were excluded from the sample.

The Lee and Pitt (1986) model, which utilizes the concept of virtual prices and two-step censored demand which is similar to the work by Shonkwiller and Yen, is used to obtain consistent parameter estimates for trip share equations where a significant proportion of anglers reveal zero consumption of one type of trip. Both models are based on the consistent indirect translog utility model. The two-step censored model is used to obtain parameter estimates for small natural streams versus all other water body type trips.

In the two-step model, the first step uses probit regression to determine probability of trip consumption. The second step involves a linear least squares estimation procedure. All individual characteristics except income are used in the first step and total expenditure is used in the second step for estimation purposes. Marginal effects were corrected for the respective variables and used to obtain estimates of the cumulative distribution function and the probability density function.

Overall, the estimated trip share equations were found to be consistent with prior expectations for both studies. However, only above high school and the price ratio were consistently found to be significant in the Lee and Pitt model for in-state and out-of-state trip share equations, indicating most of the individual characteristic variables did not play an important role in determining trip share expenditure. The price ratio variable is found to be similar in both models. On the other hand, household size and price ratio were found to be statistically significant in the two-step censored demand model for small natural streams and all other water body type trips. As household size increases, the probability of making a trip as well as trip share for each type of trip decreases. This indicates that larger households are less likely to participate in the trip consumption and to make a trip. We found that anglers from the north region of the state are less likely to participate in trip consumption as well as in making a trip. Overall, both studies indicate that the individual characteristics do not provide complete insight for trip share expenditure.

In-state and out-of-state trips are substitutes and elasticities are statistically significant. All own and cross price elasticities for in-state and out-of-state trip demand were statistically significant. Own price and cross price elasticities are greater than one and less than one, respectively. Given a budget constraint, anglers tend to substitute one type of trip for another type. Assuming the trip share expenditure is an approximation for total trip revenue (total expenditure), an increase (or decrease) in own price will tend to decrease (or increase) total revenue because the own price elasticity is greater than one for in-state trip demand. This suggests that for these trips, higher total revenue is realized from lowered prices, not increased prices. Given a budget constraint, a decrease in total revenue (total expenditure) results from an increase in own price. Thus an increase in in-state trip price reduces in-state trip expenditure resulting in potential negative effects on the state's economy. An increase in total revenue (expenditure) results from a decrease in own price.

All own and cross price elasticities and the Morishima elasticity of substitution for small natural steams versus all other water body type trips are statistically significant. All own and cross price elasticities are less than one. Even though cross-price elasticities show that trips are complements given a budget constraint, anglers will substitute one trip for another in relatively small magnitudes. An increase (or a decrease) in own price will lead to an increase (or decrease) in total trip revenue (expenditure) because the demand elasticity for own price is inelastic.

The model developed here allows policymakers to identify how different groups of the anglers view the substitutability of trips. The differences in substitution elastitities for these two subgroubs of anglers may assist policymakers in targeting recreation information to specific fisheries to more effectively achieve goals of managing fishery facilities. The difference in elasticity of substitution for the two subgroubs is useful to organizations such as the Oklahoma Department of Wildlife Conservation in identifying substitution possibilities among alternative fisheries in Oklahoma.

Limitations of this study may be reduced by increasing the number of commodities (types of trips) included in the censored demand analysis. An increase in the sample size for the second study will give greater insight for parameter estimates. Additional regional and demographic information may be required for the participation decision stage in the consumption of trips. Site qualities of each type of trips including the opportunity cost of time could be incorporated into the model to obtain better insight for welfare impacts of trips.

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APPENDIXES

APPENDIX I

ASYMMETRIC CONDITION FOR MORISHIMA ELASTICIY OF SUBSTITUTION UNDER DEMAND RESTRICTIONS FOR A TWO-GOOD CASE

Asymmetric condition for Morishima elasticity of substitution is given as:

$$M_{12} = M_{21}$$

$$\left[\frac{\partial Q_2}{\partial p_1}\frac{p_1}{Q_2}\right] - \left[\frac{\partial Q_1}{p_1}\frac{p_1}{Q_1}\right] = \left[\frac{\partial Q_1}{\partial p_2}\frac{p_2}{Q_1}\right] - \left[\frac{\partial Q_2}{p_2}\frac{p_2}{Q_2}\right] \tag{1}$$

where $\frac{\partial s_2}{\partial p_1} = -\beta_{11}\frac{1}{p_1}$, $\frac{\partial s_1}{\partial p_1} = \beta_{11}\frac{1}{p_1}$, $\frac{\partial s_1}{\partial p_2} = -\beta_{11}\frac{1}{p_2}$, and $\frac{\partial s_2}{\partial p_2} = \beta_{11}\frac{1}{p_2}$.

Substituting these values into equation (1) yields:

$$\left[-\beta_{11}\frac{1}{p_1}\frac{p_1}{s_2}\right] - \left[-1+\beta_{11}\frac{1}{p_1}\frac{p_1}{s_1}\right] = \left[-\beta_{11}\frac{1}{p_2}\frac{p_2}{s_1}\right] - \left[-1+\beta_{11}\frac{1}{p_2}\frac{p_2}{s_2}\right]$$

$$\left[-\beta_{11}\frac{1}{s_2}\right] - \left[-1+\beta_{11}\frac{1}{s_1}\right] \quad = \quad \left[-\beta_{11}\frac{1}{s_1}\right] - \left[-1+\beta_{11}\frac{1}{s_2}\right]$$

$$1-\beta_{11}\left(\frac{1}{s_2}-\frac{1}{s_1}\right) \quad = \quad 1-\beta_{11}\left(\frac{1}{s_1}-\frac{1}{s_2}\right)$$

$$1-\beta_{11}\left(\frac{1}{s_1 s_2}\right) \quad = \quad 1-\beta_{11}\left(\frac{1}{s_1 s_2}\right). \tag{2}$$

Allen-Uzawa partial elasticity of substitution for a two-good case is as follows:

$$M_{12} = \frac{H\left(\dfrac{\partial^2 H}{\partial p_1 \partial p_2}\right)}{\left(\dfrac{\partial H}{\partial p_1}\right)\left(\dfrac{\partial H}{\partial p_2}\right)} = 1 + \frac{\beta_{12}}{D^2 s_1 s_2} \tag{3}$$

where H is the indirect translog utility model given in equation (3.1) and

$D = 1 + \sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln v_j$. By imposing homogeneity and symmetry conditions, $D = 1$ and

$\beta_{12} = -\beta_{11}$. Substituting these results into equation (3), the Allen-Uzawa elasticity of substitution is equal to the Morishima elasticity of substitution.

APPENDIX II

CALCULATION OF VARIANCE- COVARIANCE FOR DEMAND ELASTICITIES AND MORISHIMA ELASTICITY OF SUBSTITUTION

We need to create a matrix of elasticities from the individual definitions given in Chapter III. The matrix is:

$$\underbrace{\begin{bmatrix} \frac{1}{S_1} \\ \frac{1}{S_1} \\ \frac{1}{S_2} \\ \frac{1}{S_2} \\ \left(\frac{1}{S_2}-\frac{1}{S_1}\right) \end{bmatrix}_{5x1}}_{\mathbf{A}} [\beta_{11}]_{1x1} + \underbrace{\begin{bmatrix} -1 \\ 0 \\ 0 \\ -1 \\ 1 \end{bmatrix}_{5x1}}_{\mathbf{C}} = \underbrace{\begin{bmatrix} \eta_{11} \\ \eta_{12} \\ \eta_{21} \\ \eta_{22} \\ M_{12} \end{bmatrix}_{5x1}}_{\mathbf{D}}$$

The first four elements of Vector D are demand elasticities. The last element is the Morishima elasticities of substitution.

The variance-covariance of elastities comes from the following:

$\beta_{11} \to N\left(\beta_{11}, \sigma^2\right)$ then $A\beta_{11} \to N\left(\mathrm{A}\beta_{11},\ \mathrm{A}\sigma^2 A'\right)$, where β_{11} is the estimated parameter for price ratio given in Chapter III, and σ^2 is the variance of β_{11}.

d

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