2.5 0-315-15935-9

PERMISSION TO MICROFILM — AUTORISATION DE MICROFILMER

• Please print or type — Écrire en lettres moulées ou dactylographier

Full Name of Author — Nom complet de l'auteur

WILLIAM ROBERT WILSON

Date of Birth — Date de naissance

March 9, 1950

Country of Birth — Lieu de naissance

CANADA

Permanent Address — Résidence fixe

190 RUE LE MAIRE
Winnipeg, Manitoba

Title of Thesis — Titre de la thèse

A VALUATION OF ALBERTA'S MAJOR CONSUMPTIVE WILDLIFE RESOURCES.

University — Université

U. of Alberta

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée

Ph.D.

Year this degree conferred — Année d'obtention de ce grade

1983

Name of Supervisor — Nom du directeur de thèse

DR. W.E. Phillips

Date

March 1, 1983

Signature

W.R. Wilson

THE UNIVERSITY OF ALBERTA

A VALUATION OF ALBERTA'S MAJOR CONSUMPTIVE WILDLIFE RESOURCES

by

N. ROBERT WILSON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

IN

Agricultural Economics

DEPARTMENT OF RURAL ECONOMY

EDMONTON, ALBERTA

Spring, 1983

To Whom it May Concern.

Pages 149-153 inconlusive are not copyright material.

W. R. Wilson
March 1, 1983

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR W. Robert Wilson

TITLE OR THESIS A Valuation of Alberta's Major Consumptive Wildlife Resources

DEGREE FOR WHICH THESIS WAS PRESENTED Ph.D.

YEAR THIS DEGREE GRANTED 1983

Permission is hereby granted to THE UNIVERSITY OF ALBERTA LIBRARY to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

(Signed) W. R. Wilson

PERMANENT ADDRESS:

115-3030 Pembina Highway

Winnipeg, Manitoba R3T 4K4

DATED March 1 1983

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Valuation of Alberta's Major Consumptive Wildlife Resources" submitted by W. Robert Wilson in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Agricultural Economics.

William E. Phillips
Supervisor

V. Salnykov

Michele Veeman

T. S. Veeman

Mylvilla McMillan

Richard C. Bishop
External Examiner

Date March 1, 1983

To Louise

ABSTRACT

The focus of this study is the valuation of outdoor recreational opportunities, with an empirical emphasis on Alberta's wildlife resources. Three types of hunting activities--big game, upland bird, and waterfowl hunting--are evaluated using three estimation techniques. Two of the estimation models, willingness to pay (WTP) and willingness to sell (WTS), are examples of direct market simulation approaches. The third method, a hedonic approach, is an indirect market simulation technique.

Marginal valuations for a day of and bag from the three hunting activities are estimated using ordinary least squares (OLS), cross-sectional regressions, using the WTP and WTS values as dependent variables. The hedonic approach involves the estimation of a set of implicit day and bag prices for each hunting activity. The implicit prices are estimated using a total expenditure function for each of the three hunting activities. The calculated implicit prices and other specific explanatory variables are then used to construct a system of individual demand functions, which are estimated as seemingly unrelated regressions (SUR) because the equations are interrelated.

Empirical results include the following. (1) Waterfowl hunting had the largest number of active participants, the greatest number of trips per hunter and per season, and the largest harvested count. (2) Big game hunting had the highest mean days active hunting per season and per hunter, the greatest total number of hunter days, and

the lowest harvest count. (3) Big game hunters had the highest mean expenditures per season and upland bird hunters the lowest. (4) Estimated total WTP and total WTS values were very similar. (5) The dominant reason for hunting was outdoor enjoyment, followed by a desire to acquire meat; trophy hunting ranked third. (6) Big game hunters were relatively more likely to hunt for meat, whereas upland bird and waterfowl hunters were more likely to hunt for outdoor enjoyment. (7) Big game hunters had relatively lower mean incomes and may hunt to augment household incomes. (8) Marginal value estimates from the WTP models are comparable to those reported elsewhere, with the exception of higher values for a bagged big-game animal. (9) Results of the hedonic model indicate a day of upland bird hunting had the highest marginal value (waterfowl hunting the lowest) and the big game bag had the highest marginal value (waterfowl bag the lowest).

The data for all three econometric models are drawn from a mail survey designed to provide a representative sample of Alberta residents who were active hunters during the 1975 season. An analysis of the socioeconomic information obtained from the survey is undertaken to examine reasons for hunting, hunter characteristics, and hunting expenditure patterns.

Also included in the study are a theoretical discussion of the concept of economic surplus and its use in the valuation of outdoor recreation resources, a discussion and assessment of the major valuation techniques (both simulation and nonsimulation), and a detailed examination of the household production function and hedonic technique.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the financial support of the people of Alberta in the form of a Province of Alberta Graduate Scholarship (1979) and a Province of Alberta Graduate Fellowship (1980). A tradition of public sector investment in human capital has generated and will continue to generate a positive return to society.

This project was partially completed while the author was in residence at Oregon State University and benefitted from discussions with members of the Department of Agricultural and Resource Economics and the Department of Economics. In particular I would like to thank Drs. Ron Oliveira, Mike Martin, and Tom Bible.

I would also like to thank Dr. W.E. Phillips for providing access to the primary data used in this study and for serving as thesis supervisor. Finally, a hearty thank you to Dr. Travis Manning for intercepting the hounds of conservatism before they could completely ingest liberal innocence. The man came out smoking.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF TABLES--Continued

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The focus of this thesis is the valuation of outdoor recreational opportunities, with an empirical emphasis on Alberta's consumptive wildlife resources. Three types of hunting activities (big game, upland bird, and waterfowl hunting) are examined and evaluated using three different estimation techniques. Two of the estimation methods, willingness-to-pay and willingness-to-sell models, are examples of direct market simulation approaches. The third method, a hedonic or household production function model, is an indirect market simulation technique. All three models are used to develop marginal dollar values for a bagged animal and a day of hunting. The data for the econometric models are based on a resident hunter survey administered in 1976 by Phillips et al. (1977). The survey was designed to provide a representative sample of Alberta residents who were active sport hunters during the 1975 season.[1]

The desirability of obtaining dollar values for wildlife or wildlife related activites stems from the increasing stress on our wildlife populations and their habitats. In the past few decades the demand for outdoor recreation seems to have increased dramatically. Further, nonrecreational demand for the other (e.g., mineral, timber) resources of areas traditionally considered as recreation areas has created a number of serious allocative problems among competing uses of particular natural resources or recreational sites.

A substantial portion of outdoor recreational opportunities are public or quasi-public goods, and as such are provided as free or nearly free public services. Traditionally, public provision is a response to certain characteristics of the good involved, such as nonrivalness in consumption, nonexcludability, and the difficulty of eliciting accurate user preferences.[2] The nonrivalness property is that the consumption (utility) of one individual does not affect the consumption (utility levels) of others. The nonexcludability characteristic relates to direct exclusion from use and indirect exclusion from spillover benefits accruing to others (e.g., an individual might be excluded from the direct benefits of police protection through nonresponse, but could not be excluded from the benefits of living in a safer community). Furthermore, provided an individual gains some measure of utility from a public good, it would be inefficient to apply exculsion even if exclusion were feasible. The problem of accurate preference revelation has been discussed by various economists (see, for instance, Arrow 1969, Randall et al. 1974, and Tullock 1967), but unfortunately has been largely ignored in much of the research relating to the valuation of various recreational and wildlife resources (see Gum and Martin 1975, Brookshire and Crocker 1979). Efforts to solicit meaningful measures of individuals' preferences are complicated by at least two major difficulties. The first involves the assumption that the individual can actually put forth an accurate representation of his preferences. Even abstracting from the fundamental concerns about rationality and transitivity, the problem remains that the individual must be sufficiently well-informed and cognisant of his own peculiar utility function to be able to state his preferences accurately. (If, for example, a person has never had to pay to bird watch, how can he accurately price his valuation of that activity?) A second difficulty that has been examined in the literature is the existence of incentives for individual strategic behavior. Various researchers have developed a variety of techniques to attempt to remove strategy-inducing incentives (see Freeman 1979).

An obvious consequence of the large volume of outdoor recreational opportunities being vested with the nonmarket sector is that the related decision-making is also nonmarket. The decision-making process has been increasingly complicated by the growing demand for recreational resources, the concomitant reduction in relative or absolute recreational potential (the supply), and the void of market-generated prices for a large number of recreational opportunities. Economists, inter alios, have proposed a variety of models that can be used to estimate a price proxy for various outdoor recreation resources. Some of these valuation methods have made positive contributions toward optimal resource utilization, whereas other methods may have induced less optimal utilization. Unfortunately, some economic valuation models have been used to foster the interests of vested-interest groups.

The problem of resource valuation is certainly far from being solved. A major remaining problem is the inclusion of constraints other than the consumers' budgets in the demand-estimating equations. The empirical specification of the effects of substitutes on the demand for particular recreational resources and measurement of option and existence demand are all in primitive stages of development. There also remain difficulties in the specification of the quantity and price variables commonly adopted for use in recreation-demand models.

In Chapter II a theoretical discussion of the concept of economic surplus and its use in the valuation of outdoor recreational resources is presented. Chapter II includes a discussion and assessment of the various major valuation techniques, both nonsimulation and market simulation models, and Chapter IV a thorough presentation of the household production function technique. The following chapters (V to VIII) focus on the empirical application of the models. In Chapter V the sample format and data collection are outlined and descriptive findings summarized. Chapter VI provides an outline of the various valuative methods used in this study and Chapter VII presents and discusses the results. In the final chapter a series of conclusions and recommendations based on the findings of this study is made and the difficulties encountered during model development noted.

Footnotes

1. The survey by Phillips et al. was designed to accommodate the generation of descriptive data for the Alberta resident hunter population and not for the subsequent econometric modelling undertaken in this study. Also, the descriptive results reported in this study are based on an adjusted sample (N of 543) and are not the same as the results reported in Phillips et al. (N of 640). The adjustment reflects missing data for the variables included in the econometric models. For a discussion of the socio-economic findings based on this data see: W. Phillips, D. DePape and L. Ewanyk. A Socioeconomic Evaluation of the Recreational Use of Fish and Wildlife Resources in Alberta, with Particular Reference to the AOSERP Study Area. AOSERP Resport 43. Edmonton: Alberta Oil Sands Environmental Research Program. December 1978, 116pp.

2. See Samuelson (1955) and Musgrave and Musgrave (1976).

CHAPTER II

CHANGES IN WELFARE: THE THEORY

This section of the paper presents a discussion of the theory of consumer surplus in relation to the assessment of environmental changes. D.M. Winch (1971, p. 135) states that "The essential problem in assessing any policy decision is to determine whether welfare would be higher if some policy change is implemented than if it is not." In a system in which individual preferences are paramount (i.e. a Paretian system)[1] such a determination requires an evaluation of the effects of the particular policy decision upon individual utility levels and of the effect that these changes in individual utility manifest in social utility or overall welfare. Freeman (1979) notes that changes in environmental quality can affect individuals' utilities through the following avenues: changes in prices received for factors of production (e.g., labour), changes in the prices of goods and services, and changes in the quantities of nonmarketed (e.g. public) goods. The focus of this section will be on the concept of economic surplus and its role in assessing the effects of changes in environmental quality, particularly as these changes affect product prices and quantities.

The concept of surplus as an approach to the measurement of utility changes occupies a controversial but important place in economic theory. While various economists have argued that the concept is of vital importance to economic theory, other economists have countered that it is a "...totally useless theoretical toy" (Little 1960, p. 180) or that the concept is of "...historical and doctrinal interest with a limited amount of appeal as a purely mathematical puzzle" (Samuelson 1967, p. 195). Par contre, Winch (1971, p. 135) viewed the concept as "one promising approach..." and Hicks (1955, p. 116) concluded:

> "It is the foundation of an important branch of Economics, a branch cultivated with superb success by Marshall, Edgeworth, and Pigou, shockingly neglected in recent years, but urgently needing reconstruction on a broader basis...capable of much further development..."

A recent paper by Willig (1976) and a response by McKenzie (1979) suggest that this debate is far from settled.

Marshallian Measures of Consumer Surplus

The concept of consumer surplus dates back to 1844 when a French public works engineer named Dupuit noted that a buyer could receive a surplus as a result of a transaction (the particular transaction in this case being the construction and subsequent use of a bridge). Dupuit defined this surplus as the difference between the magnitude of sacrifice an individual would willingly incur in a transaction and the actual sacrifice that was incurred. This surplus, sometimes called the "Dupuit triangle," can be measured as the integral of the area below the demand curve and above the price line. The pragmatic Dupuit was concerned only with a monetary measure of consumer surplus, believing that monetary expression was the sole avenue available for measuring the intensity of a preference.

Marshall (1930) was concerned with developing the notion that a consumer derives a surplus utility from being in a position to acquire a commodity at a particular price. George and Shorey (1978, p. 49) quote Marshall:

> "The price which a person pays for a thing can never exceed, and seldom comes up to that which he would be willing to pay rather than go without it; so that the satisfaction which he gets from its purchase generally exceeds that which he gives up in paying away its price; and he thus derives from the purchase a surplus of satisfaction."

A basic definition of Marshallian consumer surplus "...would seem to be the excess of the total utility afforded by [an individual's] consumption of the commodity over the utility he foregoes on other commodities by buying that commodity" (Currie, Murphy and Schmitz 1971, p. 743). Marshall used the Dupuit triangle (figure 1) and the difference between willingness to pay and the actual payment ("extra expenditure") as measures of this surplus. Bishop (1943) argues that a degree of the confusion surrounding the Marshallian concept of economic surplus is removed if extra expenditures and the Dupuit triangle are held as alternative measures of the true surplus.

Marshall assumed that marginal utility of money (MUM) is approximately constant in order to justify use of the extra expenditure and the triangle as economic measures of the true surplus. Bishop has argued that Marshall's MUM assumption is necessary because it allows for the use of money as an acceptable cardinal index of utility. Thus, the extra expenditure measure affords an approximation of the utility surplus accruing from the transaction. A second reason offered for use of the MUM assumption is that if the MUM remains approximately constant for movements along the consumer's demand curve, the area below this demand curve would provide an acceptable measure of the total utility from the commodity and the Dupuit triangle would approximately equal the true surplus. Bishop has also shown that in a situation in which the MUM assumption is violated and for large magnitudes of consumer surplus the triangle measure is preferred, whereas for small surpluses the extra expenditure measure may be superior.

The Dupuit-Marshall concept of surplus, which is readily depicted in classical utility theory, is illustrated in figure 1 (cf. Winch 1971, pp. 137-139). Assuming that the level of factor services provided by the individual and the volumes of all other goods (X_2) consumed are both constant, then the curve AH shows the marginal utility from acquiring good X_1. If the consumption of X_1 increases from OF to OG, there is an increase in utility of FGDB cardinal utils. In addition, if surplus is to be measured as a function of price rather than quantity, it is necessary to assume that the prices of all other commodities are fixed and that the marginal utility of money is constant. The constant marginal utility of money allows calibration of the ordinate in monetary terms, and AH is then a demand curve. Under these assumptions a rational individual will maximize utility at any P_1 by equating the marginal utility of X_1 with P_1 times the marginal utility of money (X_2).

In figure 1 a fall in price from OC to OE results in an increase in consumption of X_1 from OF to OG, giving a total rise in consumer surplus of ECBD. The total surplus is composed of the surplus on the FG additional consumption of X_1, which is the area JBD, plus the surplus arising from the price reduction on the first OF units, CBJE. A price change will induce a transference of expenditure to or from X_1 unless the elasticity of demand is unity. However, with a constant MUM this transference will be of little consequence. In addition, important qualifications are required if the price decrease affects a change in the price of other commodities. The aggregate demand curve is a <u>ceteris paribus</u> demand curve and changes in the underlying

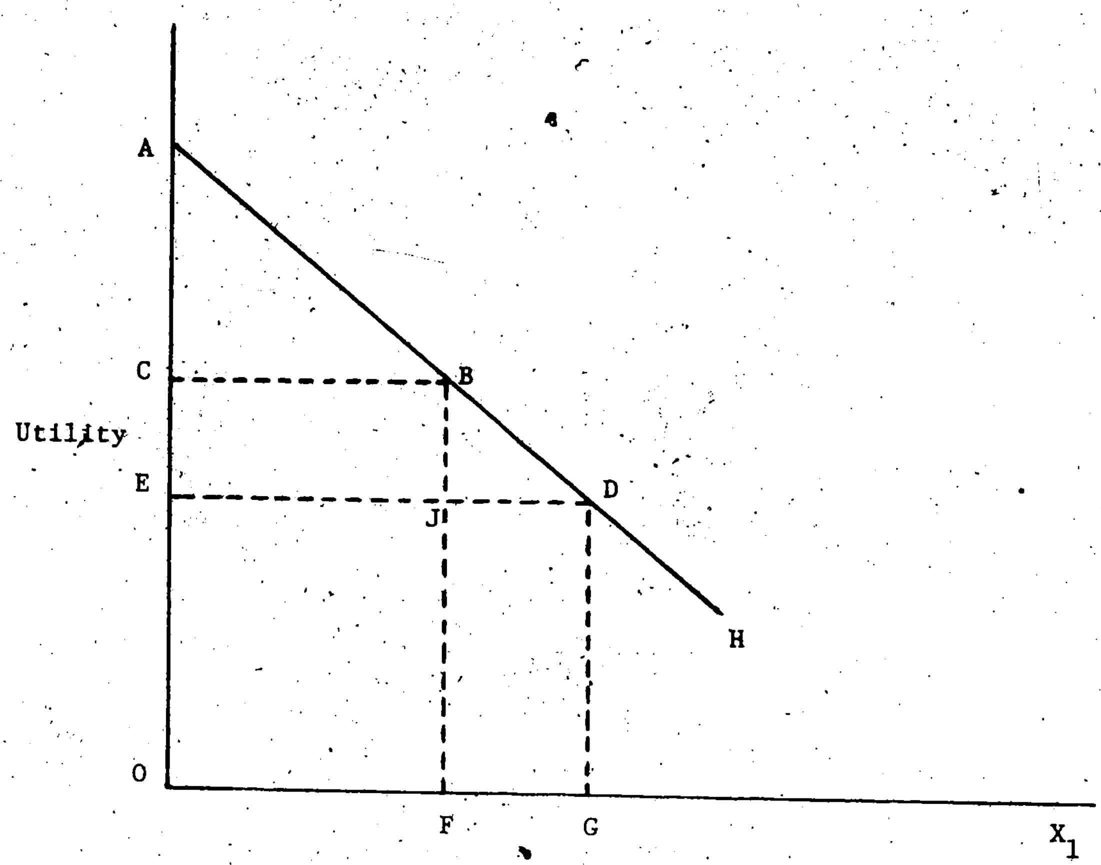


Figure 1. Dupuit-Marshall Consumer Surplus

variables will shift the demand curve for the particular commodity. Any shift in the demand curve will necessarily alter the area under the demand curve that is used as the measure of consumer surplus (cf. George and Shorey, pp. 50-53).

The Dupuit-Marshall method of expressing consumer surplus (hereafter referred to as ordinary consumer surplus or S) and changes in S in money units are based on cardinal utility and the assumption of a constant MUM. The neoclassical ordinalists have argued that these explicit assumptions are unacceptable and have proposed the alternative measures discussed below.

Hicks and Henderson on Consumer Surplus

The classical concept of surplus with its foundation of cardinal utility was largely forgotten until Hicks (1940-41, 1946) redefined the concept based on an ordinal system of indifference curves. A Hicksian definition of surplus is "...the amount of income variation that would leave the consumer on his original indifference curve following the introduction of the commodity at the particular price" (Currie et al., p. 745). In an early comparison of the Dupuit-Marshall extra-expenditure measure and the Hicksian measure, Henderson (1940-41) noted that the extra-expenditure measure is peculiar in constraining the consumer to purchasing a specific quantity of a commodity. Henderson argued that the relevant compensating variation in income would depend on whether the consumer is paying to acquire the new good or is compensated for not receiving the new good (cf. Randall 1977, pp. 4-6).

Subsequently, Hicks (1943, 1945-46, 1946) actually defined four welfare measures of the change or proposed change in the price of a commodity. Each of these measures can be defined in terms of underlying ordinal preference functions of an individual, as expressed by indifference curves. Figure 2 shows a portion of an individual's utility surface. The price of a unit of the numeraire good X_2 (all other goods), is assumed to be unity; X_2 can be taken to represent income, and welfare, which is defined in terms of X_2, will be measured in monetary units.[2] In figure 2 it is assumed that the price of X_1--a commodity, production of which depends on some environmental quality factor--drops from p_1' to p_1'' as a result of a reduction in the cost of producing X_1. This reduction in cost could result from many factors, such as increased surveillance and enforcement of regulations on, for example, ambient river quality; enforcement of the regulations could contribute to a reduction in the water-bourne contaminants that must be removed from the feed-stock prior to production of X_1 (e.g., waterfowl).

The four Hicksian measures of welfare change or surplus can be defined and delineated in figure 2 as follows.[3] The difference between variations and surpluses is that variations are measures which are calculated _ex post_ to the consumer's making optimizing adjustments, whereas the surpluses do not account for any such adjustments. The compensating measures are defined as the amount of compensation paid or received which would keep the consumer at his initial welfare level after the price change. The equivalent measures are defined as the amount of compensation paid or received which would bring the consumer to his subsequent welfare level in the absence of the price change. These terms have been discussed in respect to a change in price, but can also be used in reference to a change in quantity or quality.

The compensating variation (CV) measure asks what compensating change in income or offsetting payment is required to render an

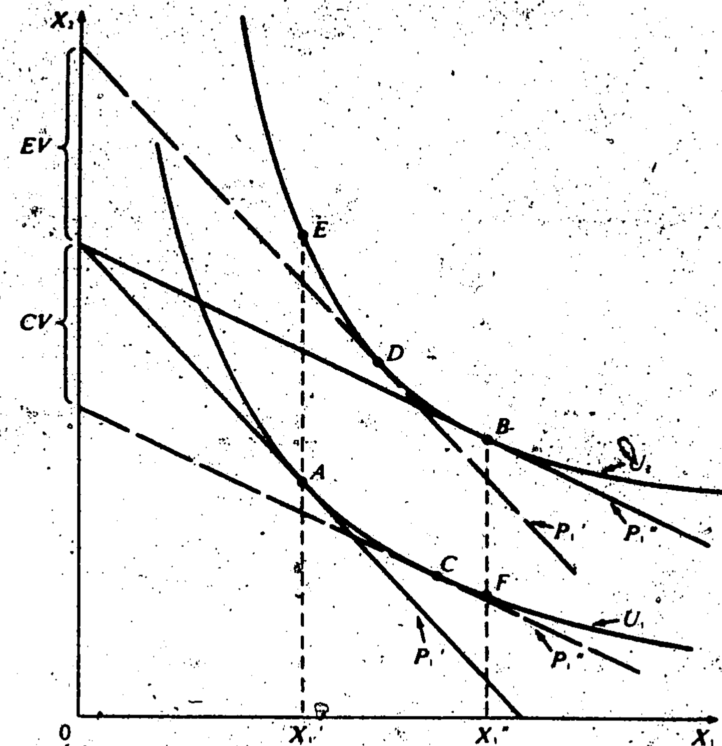


Figure 2. Four measures of the welfare gain from a price decrease

Source: Freeman 1979.

individual indifferent between the new price set (p_1'') and the original welfare level (A). With the new price set the individual is at point B. Thus, the individual could have his income reduced by an amount CV and is indifferent between A with the original price set and money income and C with a new price set and money income. The amount CV is a measure of the welfare afforded the individual by a price change, provided there is no change in money income. For a price decrease the CV measure is the maximum amount ($CV \leq Y$) that an individual is willing to pay for an opportunity to consume at the new price set, whereas for a price increase CV measures the minimum level of required compensation to make an individual indifferent between old and new price sets.

Given the original price set, the equivalent variation (EV) measure asks what income change is required to generate a utility change equal to the new price set. Figure 2 shows that an individual could reach utility level U_2 at D given the original price set p_1' if income were increased by an amount EV. This EV is the income change equivalent to a welfare gain fostered by a price change. The EV measure for a price decrease is the minimum compensation an individual would demand to forego the opportunity to purchase a good at the new price set. Alternatively, for a price increase EV is the maximum amount an individual would be willing to pay to retain the old price set.

The compensating surplus (CS) measure asks what compensating payment or offsetting income change will render an individual indifferent between the initial situation (A) and the opportunity to purchase the new optimum quantity (x_1'') of the good whose price has changed (p_1' to p_1''). The CS measure is the vertical distance BF between the two indifference curves U_1 and U_2 at the point x_1''. If an individual's income were reduced by an amount BF and the individual achieved B, he would be indifferent between points F and A. The CS measure is different from the CV measure in its restriction on adjusting the purchased quantity of X_1 in response to the compensating income change.

Given the original price set and the original consumption level of X_1, the equivalent surplus (ES) measure asks what change in income is required to allow the attainment of the same utility level that can be experienced under conditions of the new price set and consumption point B. If the amount AE were added to individual income at the original position (A), the individual would move to indifference curve U_2 at point E, with the consumption of X_1 held constant. Again, the reasons for the difference between the ES and EV measures is a consequence of the adjustment restriction on the ES measure.

The above discussion has focussed on the surplus measures for price decreases, but can be readily applied to price increases as well. Winch (1971, p. 141) notes that:

> "...the [CV] for the price rise equals the [EV] for the price fall, and the [EV] for the rise equals the [CV] for the fall...the [CS] for the rise equals the [ES] for the fall and the [ES] for the rise equals the [CS] for the fall."

The remainder of this section will concentrate on the CV and EV measures because, as Freeman (1979), Henderson (1940-41), and Mishan (1947-48) contend, both CS and ES measures are too restrictive in their assumptions to be useful.[4]

In an observation of particular importance to analysis of environmental goods, Randall (1977, pp. 4-5) notes that the different surplus measures inherently assume different initial assignments of property rights. Randall contends that the compensating measures assume the individual is endowed with a right to his initial welfare position and as a consequence has the right to avoid the uncompensated imposition of a welfare loss, but has no right to a windfall welfare gain. Alternatively, the equivalent measures assume the individual is not endowed with a right to his initial welfare position and thus has either no right to avoid an imposed and uncompensated welfare loss, or has a right to a windfall welfare gain.

> "Whether a particular measure of [welfare change] is a compensating or equivalent measure depends on the assignment of rights to the consumer, and his initial consumption set." (Randall, p. 5)

The implied differences in the assignment of property rights will have significant effects on the selection of an appropriate measure to assess the welfare implications of changes in environmental policy (cf. Hebert et al. 1978).

Having reviewed the basic measures of economic surplus, this section will now focus on the application of these measures in showing the effect on consumers' welfare of introducing a commodity price change. A major contribution to the theory of consumer surplus was the development of the Hicksian compensated demand curve (HCDC): a schedule of the price/quantity relationship with the individual restricted to a constant level of utility via appropriate income adjustments.[5] The HCDC represents the maximum marginal WTP, assuming that the maximum WTP has been paid for each preceeding unit. Hicks (1946) and Patinkin (1963) have demonstrated that the area below the HCDC and above the price line constitutes an exact measure of the compensating variation in income that would leave the consumer indifferent between being able to purchase the commodity at the specified price and not being able to buy the commodity at any price. Thus, the HCDC can be employed to show the welfare effect of providing a new commodity at a specific price.

To measure theoretically the welfare effect of a price change, it is necessary to construct an HCDC based on the individual's indifference curve prior to the change in price. The relevant measure is the area between the compensated demand curve and the two price lines. To determine the equivalent variation associated with a price change or the introduction of a new commodity it is necessary to use a compensated demand curve based on the ex post or optimally adjusted indifference curve.

HCDC would be derived from an expenditure function which is a variation of the standard utility maximization problem and which yields a set of ordinary or Marshallian demand functions. The dual of the standard problem is:

$$\text{minimize} \sum_i p_i x_i \tag{1}$$

subject to $U(X) = U^o = U_m$.

The solution to this optimization problem is the minimum dollar expenditure that is required to achieve a specific utility level (U_m) given a set of market prices. This relationship can be expressed as:

$$E = E(P, U^o) \tag{2}$$

where,

E is total dollar expenditure,

P is a price vector, and

U^o is the specified utility level.

Solving the expenditure minimization problem yields a set of demand functions conditional on the specified price set and utility level.

These Hicksian compensated demand functions are of the form:

$$x_i^*(P,U^o) \tag{3}$$

which shows the quantities consumed at various price levels, assuming income is compensated to restrict utility to a constant level, U^o. The derivation of the CV measure and the difference between the HCDC and the ordinary demand curve (ODC) are illustrated in figure 3. The case for EV is illustrated in figure 4.

Panel a in figure 3 shows the preference mapping of an individual in a two-good case. If the price of X_1 decreases from p_1' to p_1'', the individual adjusts his consumption by moving from his original equilibrium level of A to B on the new price (budget) line. These equilibrium positions are plotted in price and quantity space in panel b. Points A and B are on the ODC (ceteris paribus), holding both the price vector for other goods (X_2) and income constant.

If individual income is adjusted (in response to the price change) in a magnitude just sufficient to keep the individual at his original utility level (U_1), then the individual would be in equilibrium at C in panel a. The expenditure function affords the calculation of the requisite amount of income to constrain the individual to U_1 despite the price change. Point C is also plotted in panel b and, with A, is on the HCDC, which is a schedule reflecting only the substitution effect of changes in relative prices, because the income effect has been removed by compensating money withdrawals. Assuming that X_1 is a normal good, the HCDC must be less elastic than the ODC because the positive income elasticity associated with a normal good is contained in the ODC but not in the HCDC.

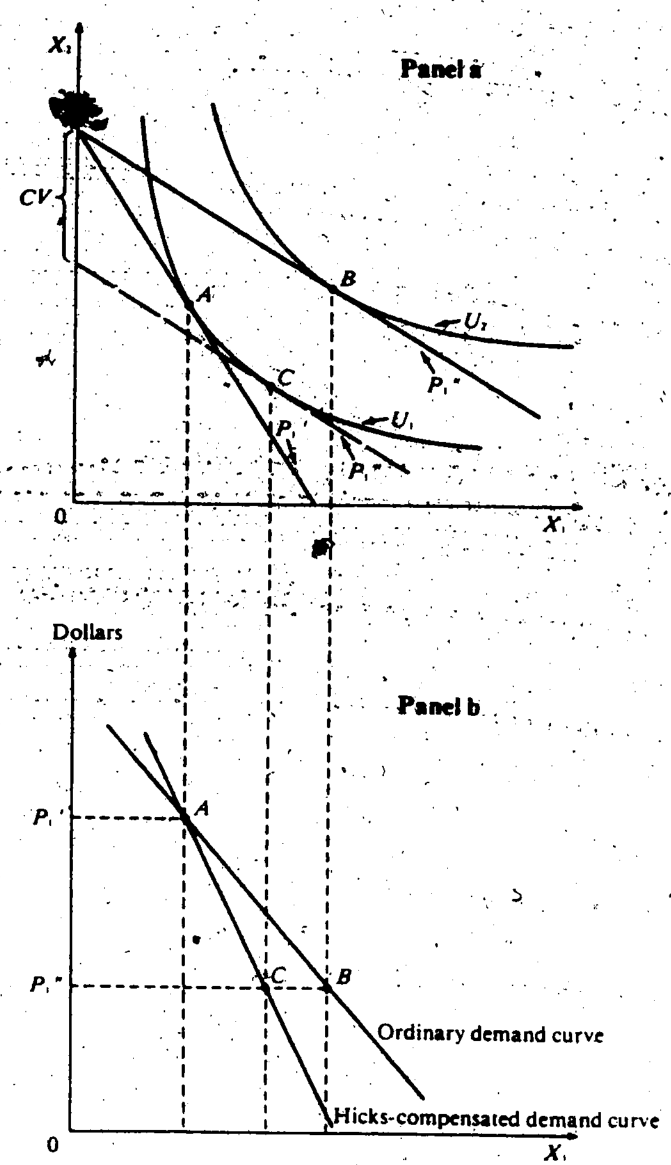


Figure 3. The compensating variation and the Hicks-compensated demand curve

Source: Freeman 1979.

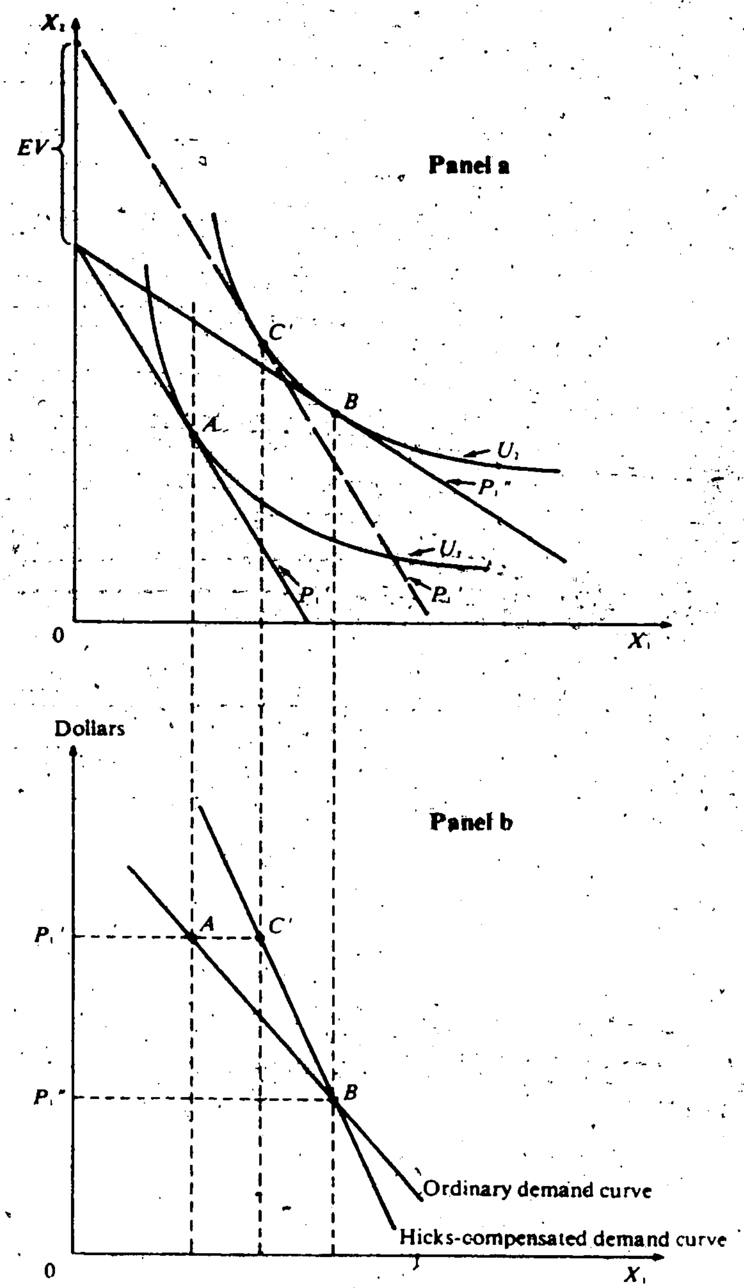


Figure 4. The equivalent variation and the Hicks-compensated demand curve

Source: Freeman, 1979.

The CV measure of welfare change associated with the change in P_1 is illustrated in panel a (figure 3) and is also represented by the difference between the expenditure functions for the two price sets, given a fixed utility level, U_1:

$$CV = E(U_1, p_1', p_2) - E(U_1, p_1'', p_2). \quad (4)$$

The CV is equal to the area to the left of the HCDC and between the two prices (i.e. $p_1''p_1'AC$). Taking the derivative of E with respect to P_1 gives the change in E necessary to keep the individual on U_1 for marginal changes in P_1 (i.e. the HCDC); the integral of this derivative falls to the left of the HCDC and comprises the measure of CV.

Alternatively, the EV measure can be derived from the expenditure function. Figure 4 illustrates the same preference mapping and price change as figure 3. For a price decrease the EV is defined as the additional expenditure necessary to affect the same increase in utility (U_1 to U_2) had the price been implemented (i.e. given the original price set). In panel a, the EV is the additional expenditure required to move from A on U_1 to C' on U_2. Again, this can be translated to a difference between two expenditure functions, but with utilities varying and prices constant:

$$EV = E(U_2, p_1', p_2) - E(U_1, p_1', p_2). \quad (5)$$

However, since the level of money expenditures at A and B is the same [i.e. $E(U_1, p_1', p_2) = E(U_2, p_1'', p_2)$], this equation can be rewritten as:

$$EV = E(U_2, p_1', p_2) - E(U_2, p_1'', p_2). \quad (6)$$

The EV is therefore defined in terms of the expenditure function associated with U_2. Taking the derivative of this expenditure function with respect to P_1 gives an HCDC through B in panel b, the integral of which is the area to the left of the HCDC; this area between the two price lines is the EV.

A situation that is often discussed in the literature (see for example Gordon and Knetsch 1979 and Mann 1977) is the case of a zero income effect (i.e. in the above example the income elasticity of demand for good X_1 is zero). In such a case the HCDC and the ODC will coincide, with the result that all four Hicksian measures and the Dupuit-Marshall surplus measure are identical. "If the income effect is not zero, the sign of the income effect will determine the direction of the bias from using the relevant area below the ordinary demand curve" (Currie et al., p. 150). A price decrease for a normal good will mean the HCDC is to the left of the ODC and the Dupuit-Marshall measure will exceed the CV but will be less than the EV.

If it is accepted that there are going to be instances in which the requisite zero income effect assumption is unacceptable, then a comparison and evaluation of the measures will prove useful.[6] The following discussion will again concentrate on the CV, EV, and the ordinary consumer surplus (S) measures of welfare change.

A pragmatic concern is the degree to which the welfare change can be estimated using data which are readily obtainable from the market. Providing an econometric estimation of the demand curve for the particular commodity can be developed, determination of S through calculation of the area beneath the demand curve and over a specified range is straightforward. However, because the CV and EV measures are derived from areas under an HCDC (for different fixed utility levels), and the HCDC is not directly observable from market data, the CV and EV measures are difficult to estimate.[7] Thus, on a pragmatic basis alone, the S measure is more useful than CV or EV.

Another criterion for evaluation of alternative welfare measures concerns whether a measure affords a unique estimate of welfare change even in instances of multiple price changes, regardless of the order in which the price changes are evaluated. The degree of order sensitivity is important because the summation of measures of welfare effects of each particular price change determines the aggregate measure of welfare change for the complete change in the price set. Silberberg (1972) and Mohring (1971) have concluded that the CV is independent of the evaluation order, but that in general the EV is sensitive to the order in which multiple price changes are evaluated so there is seldom a unique EV in multiple price cases.[8] On the other hand, it turns out that in the two-good case the EV always provides a ranking of alternatives consistent with the individual's underlying preference function, but the CV may not provide a consistent ranking.

Although all three measures--CV, EV, and S--are in dollar units which facilitate a comparison of alternative resource uses or policy options, the CV and EV dollar measures inherently represent different aspects of the welfare changes manifested by price changes. The CV is a compensating adjustment necessary to forestall a change in utility level and is not a measure of utility change. However, EV represents an income change with an effect on utility commensurate to the particular price change. These ambiguities in a concise relationship between the meaning of a welfare change and certain of the accepted surplus measures are manifestations of the property rights inherent to peculiar measures discussed above (cf. Randall 1977, Gordon and Knetsch 1979, Hébert et al. 1978, Knetsch 1980).

Freeman (1979) notes that the ordinary consumer surplus (S) is not itself consistent with any theoretical definition of welfare change, but that for any specific change affecting a welfare change, S generally is bounded by the CV and EV measures. Willig (1976) has developed a rigorous derivation of expressions relating S, CV, and EV which affords a means to calculating the actual magnitude of the differences among the three measures (for prescribed prices, quantities, and incomes). In the above discussion it was shown that inter-measure differences are a function of the income elasticity of demand for the particular good and the proportion of income or expenditure attributable to consumer surplus. Willig's calculations suggest that differences among measures are small even when there are substantial income effects, likely smaller than econometric demand function estimation errors. Willig's analysis was, however, confined to price space.

In conclusion, two points are worth restating. The first is that the ordinary surplus measure is more readily applicable (especially in terms of data availability) than the Hicksian measures and provides an acceptable approximation of the Hicksian measures, particularly if the income effect or the price change is small. The second point is that in many instances the income effect is apt to be small (particularly for public goods such as recreation). A major difficulty outstanding to estimation of consumer surplus accruing to environmental resource consumers is the accurate quantification of the price/quantity relationships for traditionally nonmarket goods. The following chapter provides an overview of various environmental resource valuation methods.

Footnotes

1. Winch (1971, p. 137) notes that "The connection between surplus and the concept of a Paretian optimum is direct. Optimality requires that it be impossible to make one person better off without simultaneously making someone else worse off, which is to say that it is impossible to effect an increase in one person's surplus without reducing that of someone else." Surplus can be a useful means of assessing policy changes.

2. X_2 would more appropriately be viewed as a composite of various other goods. Such an aggregation presents no conceptual problems to the graphical representation, provided there are no relative price changes within the bundle of goods.

3. For a thorough discussion of the four measures in the standard neoclassical indifference curve format see Currie et al. (pp. 745-747) and Winch (pp. 139-143). A different approach to the same material, which is quite readable, is contained in Randall (1977, pp. 2-7). The definitions used in this paper borrow heavily from Currie et al.

4. Currie et al. (p. 747) note that Patinkin disagreed with the contention that only CV and EV measures are useful in cases of imperfectly competitive markets. Such cases are particularly common for nonmarket environmental goods, which occur in "markets" which might be viewed as controlled by an imperfectly discriminating monopolist.

5. An ordinary demand curve is a price/quantity schedule for a utility maximizing consumer who has a fixed income level.

6. George and Shorey (1978, p. 56) argue that "In many cases income effects are indeed likely to be small, for each person's total expenditure is spread over a large variety of goods and services, the expenditure on any one typically being small in relation to total income. There are instances, however (housing, for example) where this is not so."

7. Freeman (1979) suggests that, in principle, it is possible to calculate HCD functions from market data. The first step is to estimate the complete set of demand functions as a system of simultaneous equations. The system must satisfy the integratability conditions, thus assuring "...the demand equations are of a functional form derivable from an underlying utility function" (p. 44). The expenditure function can be derived from the system of equations. Computing the HCD functions and EV or CV is relatively straightforward, given the expenditure function.

8. Mohring (1971) and Silberberg (1972) argue that the EV will lead to a unique measure for a multiple price change only in the case of a homothetic utility function (i.e. unitary income elasticities of demand for the goods).

CHAPTER III

TECHNIQUES FOR ESTIMATING THE VALUE OF NONMARKET OUTDOOR RECREATION

The innovative work of Hotelling (1947), Clawson (1959) and Davis (1964) resulted in development of a methodology conducive to the estimation of the demand for nonmarket outdoor recreational services, thereby removing an important previous technological constraint to more efficient management of recreational resources. Subsequent to removal of this constraint, there has been a plethora of research directed at a broad range of nonmarket policy issues involving the allocation, evaluation, and pricing of outdoor recreational services. This section of the paper will provide an introduction to and an assessment of certain techniques used in the valuation of nonmarket goods or in the estimation of demand for non-unique outdoor recreational services.

Non-Simulation Methods

Methods classified as non-simulation and used to estimate the value of outdoor recreation services predate market simulation methods. Although non-simulation methods are unacceptable to economists because they do not provide a meaningful measure of willingness to pay (Phillips *et al.* 1977), many of them continue to be used primarily because they are easy to understand and implement. Discussed below are some non-simulation techniques cited by Brown *et al.* (1973) and Kneese and Smith (1966).

Cost Method

The cost method for estimating benefits assumes that the value of the good is equal to or some multiple of the cost of generating it. This method was employed by the U.S. National Park Service:

> "A reasonable estimate of the benefits arising from a reservoir itself may be normally considered as an amount equal to the specific costs of developing, operating, and maintaining the recommended facilities..." (Brown et al., p. 5)

The cost method is an example of circular reasoning, cannot measure the loss of benefits associated with a change in existing recreational opportunities, and is of little use in assessing the benefits arising from marginal additions to the stock of recreational opportunities. It implicitly assumes that the reservoir or other recreational project was justified on a cost-benefit basis in the first place.

Gross National Product Method

The concept of Gross National Product (GNP) has also been applied to the measurement of benefits from outdoor recreation. First suggested by Ripley (1958) of the California Department of Fish and Game, this approach attempts to evaluate the contribution of recreation to GNP by assuming that recreation is a factor of production or a direct stimulant of production. Ripley contends that the mean value of a recreation day can be assumed to be equivalent to GNP divided by the product of domestic population and the number of days in a year (a crude opportunity cost notion; the denominator reflects the number of total potential working units).

This GNP method does not permit an economic comparison of alternative uses of the same resource. However, different recreational activities which provide varying numbers of recreation days could be compared in terms of their relative contributions to GNP. A major criticism of this approach is that it treats recreation as a factor of production. Although recreation may and likely will affect productivity, recreation should logically be classed as a consumer good.

Gross Expenditures Method

The gross expenditures method assumes that the value of recreation is equivalent to the total amount a user spends on recreation. Expenses generally include travel and equipment costs and costs incurred while in the recreation area. The justification of use of this method is that individuals or groups incurring such expenditures must have received benefits commensurate with expenditure levels, otherwise the expenditures would not have been made; that is, in a situation of consumer sovereignty the expenditures on recreation must at least equal the opportunity cost of the money expended. This method has been used by Pelger (1955) to provide the California State Department of Fish and Game with estimates of sportfishing values, and on occasion by the Army Corps of Engineers and the U.S. Bureau of Reclamation.

Values estimated with the gross expenditures method are useful indicators of the amount of money that is spent on particular outdoor recreation activities but are inappropriate as measures of the value of recreational services. There is an inherent aggregation problem because both market and nonmarket goods are included in the expenditures. The inclusion of nonmarket-established prices for various services (e.g., campground fees) requires an adjustment for potential consumer surplus if the aggregate value estimate is to be meaningfully related to perceived benefits. Although the monetary expense incurred in the use of a recreational service would have been allocated among alternative goods and services had the particular opportunity been denied, economists argue that the loss from such a reallocation would not have equalled the total expenditure but some other measure quite different from total expenditures.

Gross expenditures do not indicate the value of the losses sustained through the denial of a particular recreational opportunity, nor do they measure the net gains in value from an increase in a particular recreation alternative. Use of gross expenditure makes it difficult to compare the estimates of gross benefits to estimates of net economic benefits estimated for alternative (and often competing) uses of a natural resource. These shortcomings impose major limitations on the efficacy of using the gross expenditures method for estimating the value of nonmarket recreation.

Market Value of Fish Method

This proposed method for estimating recreation benefits afforded to fishermen (hunters) imputes to sportfishing (hunting) a market value to the fish (meat) harvested. Such an approach could be used to estimate the value of other consumptive-type recreational activities but could not be used in the case of other nonconsumption recreation activities that have more prominant public good characteristics (nonrivalness, nonexclusion, etc.). Another major objection to this procedure regards the implication that the only value accruing to the individual from the activity is the value of the fish caught. Recent research has shown that U.S. sportsmen place a higher value on the nonconsumptive (public good) aspects of their hunting and fishing activities than on the consumptive (private good with a retail proxy price) aspect (see Arthur

1978, Arthur and Wilson 1979). This measure based only on a market value for the consumptive aspect of the activity will have a pronounced downward bias in estimating the benefits from that activity.

Market Value Method

This measure is related to the market value of fish method above and involves a schedule of charges judged to reflect the market value of the recreational services produced. In general these charges are based on an examination of comparative market sector services. The appropriate charges are then multiplied by the actual or expected utilization figures to provide a recreation value for the services.

Conceptually, the method is an improvement over the fish-pricing method because it emphasizes the willingness of users to incur expenses to achieve their desired recreation choices. However, it can be argued that it is inappropriate to employ charges levied on a private recreation service as a price proxy for recreation in public areas because the willingness of individuals to incur the full cost of a private recreation service is a reflection in part of perceived differences in the recreation opportunities. Another limitation in the applicability of this technique is the tendency of nonmarket recreation areas to be physically and spatially unique areas without representative alternatives within the market sector.

Market Simulation Methods

Market simulation methods include a number of methods developed by economists to overcome the inability of non-simulation techniques to provide a meaningful measure of recreational benefits or willingness to pay or sell. The market simulation methods attempt to simulate the operation of a market for outdoor recreation services and basically can be distinguished as being either direct or indirect. The indirect methods use the actual behavior of recreation consumers as the basis for determining recreation values, whereas the direct methods determine willingness to pay from the recreation consumers' responses to direct questions related to real or hypothetical situations. In general economists prefer the indirect techniques because the valuations are observable rather than hypothetical; the use of observable data circumvents the problem of consumers' inability to accurately reveal their preferences and difficulties with overcoming incentives for strategic misrepresentation of preferences in attempts, for instance, to insure free-rider status. The intent of both direct and indirect measures of simulating an outdoor recreation market is to measure a net willingness to pay--a consumer surplus. Net willingness to pay is the difference between the total amount that individuals are willing to pay for a recreation activity and the cost actually incurred to partake in that activity.

Before examining certain of the market simulation models it will be useful to consider briefly some elements of demand analysis (see Green 1976, pp. 46-75). First, the indifference curves (U_i) are assumed to be well-behaved.[1] Each indifference curve reflects a particular level of satisfaction and, moving outward from the origin, each successive indifference curve indicates a higher level of satisfaction, with $U_3 > U_2 > U_1$. Along any particular indifference curve the consumer is indifferent about consuming any of the various combinations of outdoor recreation (X_1) and all other goods (X_2) represented along that curve.

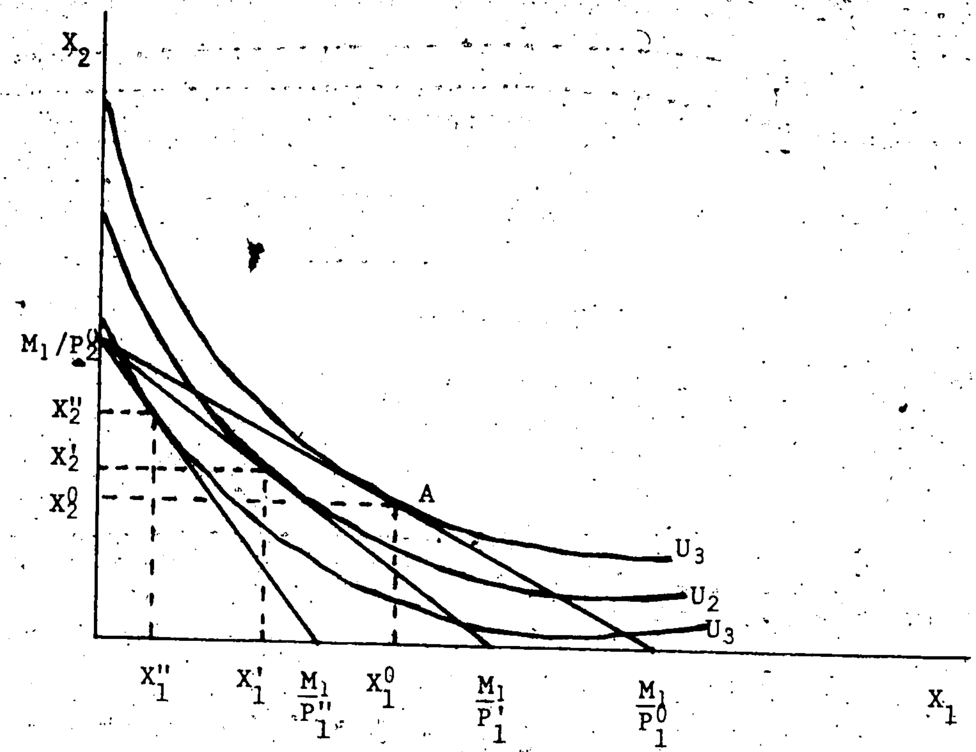
If it is assumed that both X_1 and X_2 are market commodities, the combinations of X_1 and X_2 which would be obtainable by the consumer are a function of his budget and of the commodity prices. The consumer will optimize or maximize his utility subject to his budget constraint and the relative prices of the commodities. Assuming the consumer's budget is M_1 and the prices of X_1 and X_2 are P_1^o and P_2^o, respectively, the straight line connecting the points M_1/P_1^o and M_1/P_2^o indicates the limit of attainable bundles of x_1 and x_2. In figure 5 satisfaction is maximized at point A with consumption of x_1^o and x_2^o. Because the relevant budget constraint M_1/P_1^o, M_1/P_2^o is tangent to indifference curve U_3, no higher level of utility can be achieved than the level indicated by U_3.

If the price of X_1 rises, the slope of the budget line (i.e., ratio of prices) also increases. For the price increases represented by P_1' and P_1'' the optimal allocation will be given by x_1', x_1'' and x_2', x_2'', respectively. The demand curve for X_1 is yielded by plotting these prices against their respective quantities of X_1 (figure 5).

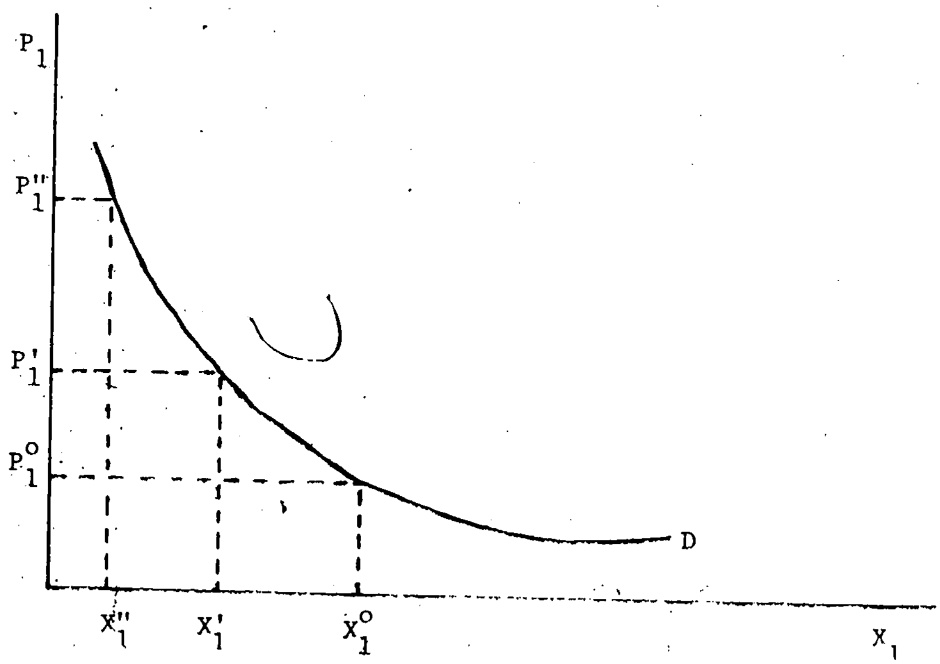
One obvious difficulty in using this approach for estimating a demand curve for the various kinds of outdoor recreation services under consideration in this study is that requisite market prices are not available. The market simulation techniques discussed below represent attempts to generate proxy market prices for the nonmarket recreation services. Certain of these techniques are in an early stage of development, while others are more established and have contributed toward more efficient interpersonal and intertemporal resource utilization.

Survey Methods

In direct surveys individuals are asked how much they value



a. The consumer's preferences for X_1 and X_2 and his budget constraints, given three prices of X_1



b. The consumer's demand curve for X_1

Figure 5. The simple analytics of demand analysis

a particular recreation service. This value information is combined with additional information about use frequency to determine a net willingness to pay for a service, usually on an annual basis. The required information can be gathered from individuals either through self-administered questionnaires or through some form (i.e., telephone or in-person) of personal interview. Thus, the direct approach of estimating recreation service benefits attempts to establish a demand curve by inquiring of the recreators the maximum amount they would be willing to pay for use of or access to a recreation service, rather than being excluded (see Hammack and Brown 1974, Knetsch and Davis 1965, and U.S. Fish and Wildlife Service 1975). This approach implicitly assumes a theoretical structure that annual consumer surplus is a function of the relevant arguments of the demand function.

The survey questions concerning willingness to pay (WTP) can be framed in one of two ways.[2] An individual could be asked his total WTP to receive a specified level of provision of a public good as opposed to receiving nothing. That is, he is asked what he would be WTP to consume a superior bundle of services than is now available. An unbiased answer is a compensating variation measure of welfare gain, assuming the good is in fact provided at the newly specified level. This compensating variation measure is the integral of the Hicks compensated demand curve for the public good, which by definition holds utility constant at a level tantamount to zero provision of the public good. Alternatively, individuals could be asked to indicate their <u>marginal</u> WTP for an addition to the existing stock of a particular public good, Q^o. The answer to this question is the derivative of the expenditure function with respect to Q, or the marginal demand for Q. The latter, marginal approach is more often used because it presents a more realistic situation to the respondents.

The demand estimates obtained from direct methods are theoretically defensible, but the major practical difficulty with this type of approach lies in obtaining unbiased and reliable information this type of approach lies in obtaining unbiased and reliable information from consumers by merely confronting them with hypothetical questions about recreational services which have traditionally been regarded as free or very nearly free. Many economists have argued that consumers have an incentive to strategically misrepresent their preferences (Bohm 1971, Hammack and Brown 1974, Mäler 1974, Tideman 1972). One such bias is that rational individuals may understate their WTP for a recreational service, hoping thereby to avoid being charged as much as they might actually willingly pay and to continue to enjoy the activity at its present cost and level of use. Alternatively, a rational individual who feels that his favorable response will lead to improved service and that the repayment obligation--if any--will not be related to his response will tend to overstate WTP in order to generate a stronger case for the improvement or preservation of a recreational service, preferably without any increase in payment obligation. In either case, the response has no relationship to preferences or WTP, but is based on the individual's anticipated influence on the decision of whether to supply the public good and its potential acceptance by the authorities collecting the data.

Efforts to provide a solution to the problem of rational strategic behavior have generally either attempted to measure the bias and adjust actual responses accordingly, or to structure questions purposefully to eliminate incentives for strategic behavior. Kurz (1974) has shown that if the functional relationship between the true WTP and the individual's WTP response can be specified, it is possible to estimate the coefficients of this function and compute the true WTP from the WTP response. Kurz was able to identify the bias function only for particular specifications of the functional relationships between true WTP and WTP responses, and only when the bias function was the same for all individuals. Because the degree of bias is influenced by expectations of the affect of responses on the public good supply and repayment obligation, homogeneity in bias functions across individuals is highly unlikely.

A more operationally fruitful avenue to solving the strategic behavior problem has been the design of experimental situations or a set of questions that attempts to eliminate the incentive for strategic behavior. Incentives can be circumvented by phrasing the WTP question in a manner ill-suited to affording the consumer an impression that he is being asked to respond to the suitability of existing uses or charges. Some researchers have asked respondents to reveal their WTP in obvious hypothetical situations (Gordon and Knetsch 1979, Randall _et al_. 1974) and in one instance respondents were explicitly informed that their answers were completely independent from the supply (Hammack and Brown 1974). Other researchers have argued that individuals recognized interviewers were not acting in any official capacity, and thus they could infer that their responses would have no direct impact on the supply of public goods or on repayment obligations (Brookshire _et al_. 1976, Cicchetti and Smith 1976).

Although careful survey design may eliminate many of the problems of strategic behavior, there are several difficulties inherent to this approach. The first is that despite the efforts of the researcher, the individual may opt to look beyond the specific experimental situation and attach a positive probability to the likelihood that the survey results will eventually affect provision of the public good.[3] A second difficulty is that individuals may see no advantage to articulating an accurate response. An accurate response would be one that is consistent with the underlying preference ordering or utility function peculiar to an individual and with the behavior that would be displayed if the public good were offered in a private market with exclusion mechanisms. The accuracy of an individual's responses is governed by the incentive for accuracy and the ability of the individual to make an accurate determination of his preferences.

The latter aspect presents a third problem; incentives aside, the individual may not be capable of stating his WTP for a previously unpriced good, particularly if the situation is a hypothetical one with no close market counterpart. Assuming, however, that an individual can accurately express his preferences, an individual with a true demand function for a private good, $x = D(p)$, will avoid acting in accordance with a different demand function, $x = D^*(p)$, in order to avoid a potential utility loss. However, in a hypothetical situation the individual is not called upon to live with the consequences of his response; there is no actual utility loss associated with an incorrect response and no incentive for an accurate response. The need for accuracy incentives poses a dilemma because the questions which most effectively avoid the biased responses also eliminate any incentives for accurate responses

This thorny problem has been either ignored or assumed away in the theoretical literature on preference revelation.[4]

Response accuracy is costly to an individual in terms of the time and mental energy (both in a direct and in an opportunity cost sense) that must be expended to gather information, process it, and reach a conclusion. Freeman notes, "if accuracy is viewed as an output, its cost is an increasing function of the degree of accuracy" (p. 97). The difficulty introduced by the positive correlation between the degree of accuracy and the cost to the respondent is further exacerbated by the absence of incentives (benefits) to induce the individual to develop more accurate estimates.

Abstracting from preference revelation bias,[5] there are a number of remaining difficulties inherent to a direct approach. First, the survey method and the surveyor must have neutral effects on the responses provided and the value of the activities or experiences must equal or exceed the participation costs incurred, implying consumer rationality. Second, there is a problem of modeling the demand for a recreational activity when the recreation experience is not a single commodity, but may vary across persons, across trips for a single person, etc. Thus, it is difficult to determine the correct econometric specification of a WTP function implied by utility maximization and the correct arguments of the utility function. Aggregation problems, joint products and temporal shifts in commodities from a public to a private good all complicate the direct approach further. Ultimately there is no scientific method by which a researcher can reject "wrong" results.

The Bidding Game Approach

The bidding game approach to valuing nonmarket goods is not a theoretical construct, but an iterative procedure designed to reveal preferences from responses to hypothetical situations. This approach, which is a complex variant of the direct survey method, has been used to measure the value of public goods in the form of environmental disamenities (Hébert et al., Randall and Brookshire 1978, Randall et al. 1974) and to measure the value of a public input into the private production process. The approach has been summarized succinctly by Randall and Brookshire:

> "(a) The alternative levels of provision of the public good are described...(b) A hypothetical market is created in substantial...detail...(c) The respondent reacts to prices posed by an enumerator, indicating whether he would ...pay the price or go without the good. The price is varied iteratively, until the price at which the respondent is indifferent is identified." (pp. 10-11)

Researchers have devoted considerable attention to the problems associated with bidding games, especially to the problems dealing with bias and the potential differences between equivalent and compensating measures of welfare (Randall and Brookshire 1978). Although a good deal of progress has been made and the bidding game approach is the most promising of direct interview techniques, some shortcomings persist. For example, the approach is designed to measure the marginal value of a unit of quality or success (e.g., hunting or fishing success, short ski-tow lines, etc.), but from the literature it is not clear how the demand for the individual quality component relates to demand for the activity generating the quality or success. There appears to be no direct relationship between utilization rates and the degree of quality or success. Without such a relationship it is difficult to ascertain the implications of a change in policy on recreation quality. The implication is that individuals do not adjust participation rates in response to changing success or quality and thus equivalent and compensating surplus measures are more appropriate than variation measures.

Bockstael and McConnell (1978) argue that the seemingly omnipresent confusion over whether the marginal value of success variable refers to an annual or a per trip figure causes econometric problems. A further difficulty is that results are scientifically irrefutable given current institutional constraints. Despite these shortcomings, the bidding game approach has been a useful tool, particularly when it is used to value public goods (i.e., when used to compute equivalent and compensating surpluses) and to anticipate public responses to future marketing of heretofor unmarketed goods.

Revealing Preferred Quantity

As an alternative to asking individuals to indicate their WTP for a given level of public good provision, an individual could be asked to indicate his preferred quantity or level of supply of a public good, given a specified repayment obligation or tax share. In a seminal contribution to this procedure Bowen (1943) attempted to show that a nonmarket decision-making mechanism based on votes which reveal preferred quantities could generate an optimal level of public good provision.

Conceptually, the model asserts that if all individuals share equally in the cost of public good provision (Q/N, where N = population), and if voters' preferences are distributed so that the mean quantity ($\overline{Q}$) preferred by the jurisdiction is equal to the preference of the median voter, then $\overline{Q}$ will also be the efficient level of provision of the public good. Freeman (1979) affords the following summary of this model, based on the Samuelson (1955) condition for efficient public goods supply:

$$\Sigma B_i(Q) = MC(Q) \qquad (1)$$

where,

$B_i(Q) = w_i(Q)$, the ith individuals marginal WTP or demand price for Q, and

$MC(Q) =$ the marginal cost of Q.

Each individual selects (e.g., via a voting mechanism) a particular quantity that equates his marginal cost (tax share) to his WTP, and since the total cost (tax burden) is borne equally by all, his tax share is MC(Q)/N. Thus, by definition the optimizing condition for the median voter is

$$W_m = MC(Q)/N \qquad (2)$$

where W_m is the median voter's marginal WTP.

Assuming that the median coincides with the mean implies that $N \cdot W_m = \Sigma w_i = MC(Q)$, which corresponds to the Samuelson efficiency condition.

If an individual understands that his revealed preference will only be employed to generate a level of provision in accordance with the median voter model and that the tax share is fixed, then there are no incentives for strategic behavior. Again, however, there are only minor incentives for accurate revelation of preferred quantities.

The model will yield one point on each individual's marginal WTP or demand schedule. If these preferred quantities were regressed against certain socioeconomic variables (including income, for example), which are hypothesized as determinants of preference and demand, the regression equation could be used to derive a cross-sectional estimate of the income elasticity of demand for a particular public good. However, to determine other points on each individual's demand function for the public good it would be necessary to repeat the revelation procedure for a newly specified tax share (price variable). Such a repetition would violate the assumption that a voting outcome is used only to determine the optimal Q and reintroduce the problem of strategic behavior.

Voting Models

Individuals are seldom asked to indicate directly their WTP for a preferred level of provision of a public good. Instead individuals are asked to vote on a specific proposal or among various electoral platforms. An interesting model focusing on the typical yes-no, binary referenda on public goods supply was used by Borcherding and Deacon (1972) and by Bergstrom and Goodman (1973) in attempts to estimate the demand for a variety of traditionally viewed public goods (e.g., fire and police protection, parks and recreation, general government expenditures, education, and highways) in the United States. In a study examining the determinants of demand for municipally funded recreation and cultural services in Ontario, Arthur et al. (1980) provided a useful summary of this basic voter model, which can be applied even when there is not referendum-type voting. In the case of most municipally financed public goods, the budget provides an indirect measure of public preferences. Presumably decisions regarding the quantity of the public good to be provided by the municipality--and thus the costs to be shared by jurisdictional constituents--are collective decisions of the constituents. If the political process works, the candidates' platforms will cluster around the preferences of the median voter in the jurisdiction. The outcome of the vote may be assumed to represent a point on the demand curve of the median voter, and the outcomes for a number of jurisdictions represent points from which the general price and income elasticities of demand for the public good can be estimated.

The above studies and a major research effort by McMillan et al. (1980, 1981) suggest that the voter model can provide useful information on the demand for certain types of public goods (e.g., fire, police and recreation services). However, the approach will be of limited use for public goods which have a significant element of interjurisdictional spillover costs and benefits (e.g., education and pollution abatement). Pauly (1970) has argued that the existence of spillovers can contribute to less than optimal levels of provision. Another shortcoming of the voting model is an aggregation problem in jurisdictions with replicated services units (e.g., a network of parks or fire stations) and the potential discontinuities in the level of demand (e.g., two fire stations is insufficient and three stations is too many), which may be masked in the aggregate demand measure. It is also generally not possible to incorporate a quality measure for the supply of public good. The incorporation of a quality measure is necessary to adjust for differences among the actual utilities afforded per unit of expenditure.

The median voter model is based on current expenditure levels or marginal increments to the existing supply of public goods. However, the demand for a public good is at least in part serviced by the existing supply of public good; thus, an adjustment is required to accommodate differences in the existing supply among the various jurisdictions. For example, newer jurisdictions may be spending a good deal more to provide recreational services than an established jurisdiction, not because the desired level of supply is greater, but because the established jurisdiction has previously provided for certain of the various elements inherent to providing a recreation service (i.e., capital stock, land, etc.). Despite these shortcomings, the voter model is a useful contribution to the study of municipally financed public goods based on voter inputs. Platform misrepresentation, voters' lack of information, poor voter representation, and unfulfilled campaign promises can become greater problems in state, provincial, or national elections.

Hotelling-Clawson Method[6]

In a manner akin to Von Thuenen's use of transportation costs of moving agricultural products to market centres as a principal explanatory variable for observed differences in land use, Hotelling (1947) used transportation costs to account for differences in recreational behavior patterns among individuals. As with other indirect methods, the required values are inferred from the observed behavior of participants. Hotelling postulated that demand curves could be derived by observing the participation rates of certain population groups at specific recreation sites. The demand curve thus derived could be interpreted in the same manner as standard demand curves and could form the basis for an estimate of the value of the particular recreation site.[7]

By utilizing Hotelling's concentric zone concept, Clawson (1959) was able to quantify participation-travel cost relationships for numerous U.S. national parks. However, in the model, which describes participation as a function of requisite travel costs, the quantity variable was specified as a participation rate for outdoor recreation at a particular site and by a given population group. To express the participation (quantity) variable in a more absolute measure (e.g., actual recreation days consumed per unit of time), the price proxy (i.e., transportation costs) is varied, and the response in the quantity utilized is observed for the various population groups. Thus, a second function directly relating price to some absolute measure of quantity used is derived.

Clawson could thus project participation rates for each concentric zone and for various assumed user charges by assuming that consumers view a change in user charge as tantamount to a change in transportation costs. Multiplying projected visitation rates by various user charges, it is possible to estimate the monetary recreational value for a given site.

The travel-cost method requires a number of restrictive assumptions, including some strong assumptions about the homogeneity of preference structures among the various population groups, unique-purpose trips (i.e., no joint products), similar recreational consumption patterns across groups, and the similarity of alternative consumptive uses for all groups. Another serious deficiency of Clawson's analysis is that the non-price effects of distance and time are ignored, which could contribute a bias to recreational value estimates.

One study that has expanded the travel-cost model is the Oregon salmon-steelhead study by Brown et al. (1964), which included both income and physical distance variables. The Oregon study also employed composite price variables, comprised of travel costs, food, lodging, etc. Other studies have included the nonmonetary effects of the pleasure/displeasure of driving and time involved in travel (see also the variation discussed in the section below).

The Hotelling-Clawson model also abstracts from the quality differences of particular outings. In an interesting extension of the basic model Stevens (1966) approached the quality problem by including a success variable, which was based on angling success per unit of angling effort, as an explanatory variable in the function. Numerous other variations of this travel-cost method could be cited, as it is one of the most popular of recreation valuation models, but most variations have only solved one of the many problems of the model, and often at the cost of creating additional problems. A variant is discussed below.

The Brown et al. and Edwards et al. Approach

In an interesting attempt to avoid the restictive assumptions of the model by Hotelling and Clawson, Brown *et al*. (1973) and Edwards *et al*. (1976) focussed on the individual recreational consumer. The authors argue that a more realistic explanation of the behavior of recreation consumers is made possible by disaggregating recreational costs into components representing the cost of travelling to the site and the costs expended on-site.[8] In the Edwards *et al*. demand model the price variable is the individual's annual on-site costs and the quantity variable is the number of recreation days consumed by the individual at the site. This information was used to determine the average user's site demand curve, from which the economic value per visit was computed using consumer surplus (net of travel costs). The total site value equalled the product of per-visit values times the aggregate number of visits.

Despite some difficulties (e.g., in determining the critical recreation price and total site values), this study properly utilizes individual observations to econometrically estimate the demand curve for a recreational resource. The specification of the demand equation is an improvement over earlier models in its consistency with the economic theory of consumer behavior.

The Gravity-Potential Model

The gravity-potential or spatial interaction approach is a specialized form of the travel cost model, wherein distance is substituted for travel costs. The gravity model is a trip distribution model which is used to estimate trip interchanges between all pairs of origins and destinations. The model's theoretical foundation is Newton's Law of Gravitational Force, which states that the gravitational force between two bodies of dense matter is directly proportional to the product of their massses and inversely proportional to the square of the distance between the bodies, that is:

$$F = G(M_1 M_2 / D_{12}^2)$$

where,
F = gravitational pull;
G = constant,
M_i = masses of the two bodies, and
D_{12} = distance between the two bodies.

Although the model is theoretically founded in physics (see Isard 1975), work has been focussed on accommodating the principles of social behavior. For example, McAllister and Klett (1976) have adapted the gravity model to explain ski trip traffic; Anderson (1979) provided a theoretical explanation of the model as applied to commodities;

and Niedercorn and Bechdolt (1969) derived a gravity model from consumer theory by using a logarithmic and power utility function.

Sutherland (1980) notes that the gravity model is a distribution model; it takes a given number of recreation activity days eminating from population centers and distributes these days in accordance with the relative attractiveness and spatial impedance between origin and destination. Origin factors represent the push or stimulus exerted by the origin, and this propensity to generate recreation trips is explained by socioeconomic variables such as age, income, occupation, population, and education (Clawson and Knetsch, 1966). The destination or site factors, often called attractiveness factors, represent the pulling force exerted by the site. Proxy variables used to express this difficult-to-quantify site attractiveness factor may include ski hill capacity, water acreage, or the number of campsites, inter alia. The third element of most gravity models is a linkage factor representing the distance between the origin and the site. This linkage factor is usually measured in miles.

A basic gravity model has two important properties (Ewing, 1980). First, the model allocates trips emanating from origin i by considering the substitutability (in terms of attractiveness and spatial impedance) among j alternative recreation sites. Second, the total number of trips (ΣP_i) is exogenous; adding sites to the system or altering the comparative attractiveness of existing sites will foster an adjustment in prevailing site usage (i.e., some sites will gain at the expense of others).

Numerous variations in the model have been specified, but most can be represented by the following equation developed by the Bureau of Public Roads (1965):

$$T_{ij} = P_i(A_j F_{ij} / \Sigma A_j F_{ij}) \qquad (3)$$

and with the constraints:

$$\sum_j T_{ij} = P_i \qquad (4)$$

$$\sum_{ij} \Sigma T_{ijk} = \sum_k A_{jk}, \qquad (5)$$

where,

T_{ij} = the number of activity days produced at origin i and attracted to site j,

P_i = the total number of activity days produced at origin i,

A_j = total number of activity days attracted to site j,

F_{ij} = a calibration term for interchange ij, which reflects the effect of distance, and

k = a recreation planning region.

In this generalized gravity model, activity days are expressed as a function of site attractiveness, a linkage factor, and the attractiveness of substitute sites. However, in equation (3) the linkage variable (i.e., distance) does not distinguish between time and travel costs, which may result in biased estimates, and the quantification of an attractiveness variable is a difficult task (see Arthur, 1977). Another major problem with this simple gravity model is that the total number of recreation trips (ΣP_i) is unknown and must be estimated [illegible]

Clearly, as the socioeconomic factors of a population change, the estimates of ΣP_i must accommodate these changes.

McAllister and Klett (1976) formulated a variant of the basic gravity model that statistically estimates a regional total of recreation trips by separating recreation participation into trip-generation and trip-distribution elements. Trip generation refers to the total number of recreation trips expected from a population region. The trip-distribution component refers to the number of total trips apportioned to each of the j recreation sites.

The basic gravity model is unresponsive to the nonlinear relationship between distance and the perceived distance (Wolfe, 1970); as a consequence the model overestimates the number of short recreation trips and underestimates long trips (Wilkinson, 1973; Beaman, 1974). The nonlinear relationship is thought to be the product of recreator inertia. Inertia is held to forestall a number of short trips, but once a trip is actually initiated, momentum may foster a trip of greater distance than that predicted by the model. An inertia model is an improvement over the gravity model as distance is no longer constrained to a linear relationship with trips.

Basically, the gravity model (including its variants) is a travel cost model which uses distance instead of travel costs _per se_. Because distance and travel costs are directly related, the relationship between trips and distance (travel costs) is applicable in both travel cost and gravity models. The gravity approach also requires a number of the same restrictive assumptions of the travel cost models. For example, the recreation site is assumed to be the primary destination; elements in the site vector should be relatively homogeneous; and individual distances traveled must have sufficient variation to allow demand estimation.

The gravity approach does not account for the joint production aspect typical of recreational trips and any attempt to isolate a particular activity will result in an incorrect estimate of trip demand. Also, the model uses distance as a price proxy, which inherently enforces the assumption that recreators have similar access opportunities for all sites offering equal recreation experiences. On the other hand, the gravity model is relatively easy to implement because the requisite data are more readily available than travel-cost data.

Logit Model

While the logit model is not an evaluative technique *per se*, it provides a means for accomodating qualitative data inherent to the recreation experience. The undertaking of a hunting trip or acquisition of a hunting license or bagged animal can be viewed in a binary context, as a yes/no response. In such instances the dependent variables in the models are qualitative, reflecting this binary choice. A recent econometric adaptation applicable to situations of a qualitative dependent variable is the general logit model, a probabilistic model that delineates an S-shped curve (Intriligator 1978, Wonnacott and Wonnacott 1979).

Theory of the Logit Model. In binary choice situations a numerical dependent variable can be obtained by computing the sample frequencies of one of two relevant alternatives. If the relative frequencies are influenced by the exogenous variables $X_1 \ldots X_k$, one approach to estimating the relationship is to specify a simple linear regression model:

$$p = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + u \qquad (6)$$

where,

p is the probability of an event (e.g., a trip, bag, etc.)

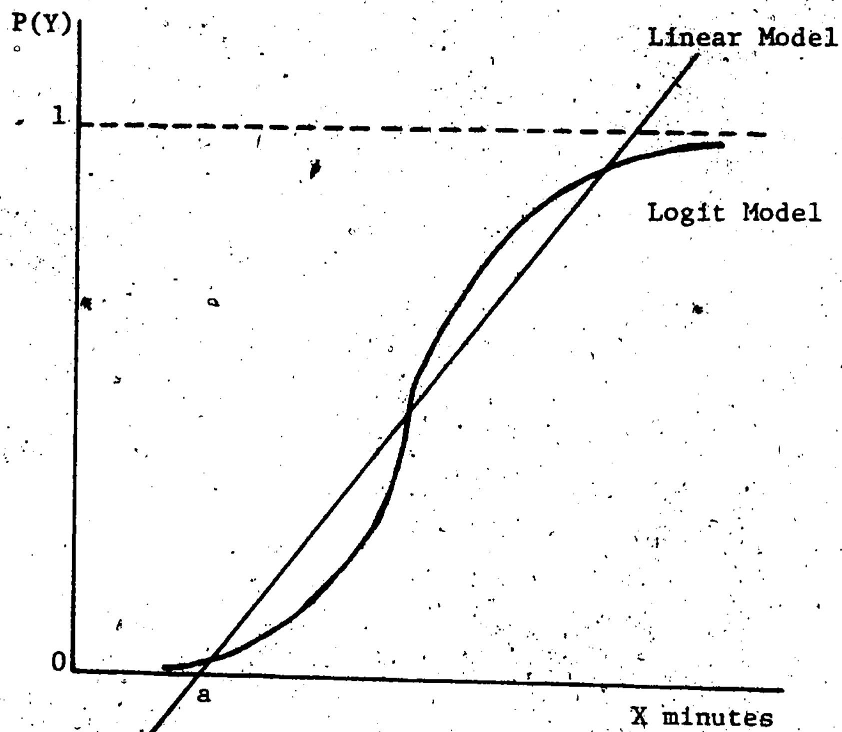
β are estimated regression coefficients, and

u is a stochastic disturbance term.

Interpreting equation (6), a unit increase in X_n produces a β_n increase in the probability (p) that the event will occur.

Use of a linear function to represent probability presents some fundamental theoretical inconsistencies. With a linear equation, constant increases in X_n always produce constant increases in p. Thus with this approach it is possible for a predicted value of p to be negative or greater than one, contradicting its meaningful interpretation as a relative frequency (see figure 6). One can adjust for these counterintuitive values by truncating the linear model at zero and one. Such an adjustment is appropriate if constant changes in X_n affect constant changes in p. However, it is more likely that a given change in X_n will produce a decreasing rate of change in p as p approaches the limits of zero and one. In such instances, a gradual tapering to the limits (i.e., a constant change in X_n produces a relative change in p) is more theoretically appropriate, necessitating the employment of an alternative specification.

One such alternative specification is the logit form of regression analysis in which the linear function is transformed to reflect the



where,
P is the probability of participation in hunting,
X is time,
Y = 1 when participation occurs and 0 when no participation occurs, and
a is the intercept of the linear regression model.

Figure 6. Linear and logit probability models

nonlinear relationship by stipulating that the natural logarithm of p depends linearly on X_n (Intriligator, 1978).

$$\ln\{(p/(1 - p)\} = \alpha + \phi_n X_n + v \tag{7}$$

where,

ϕ_n is a vector of coefficients $(\phi_1, \phi_2, \ldots, \phi_n)$ for n explanatory variables and

v is a stochastic disturbance term.

Intriligator (1978) notes that this procedure:

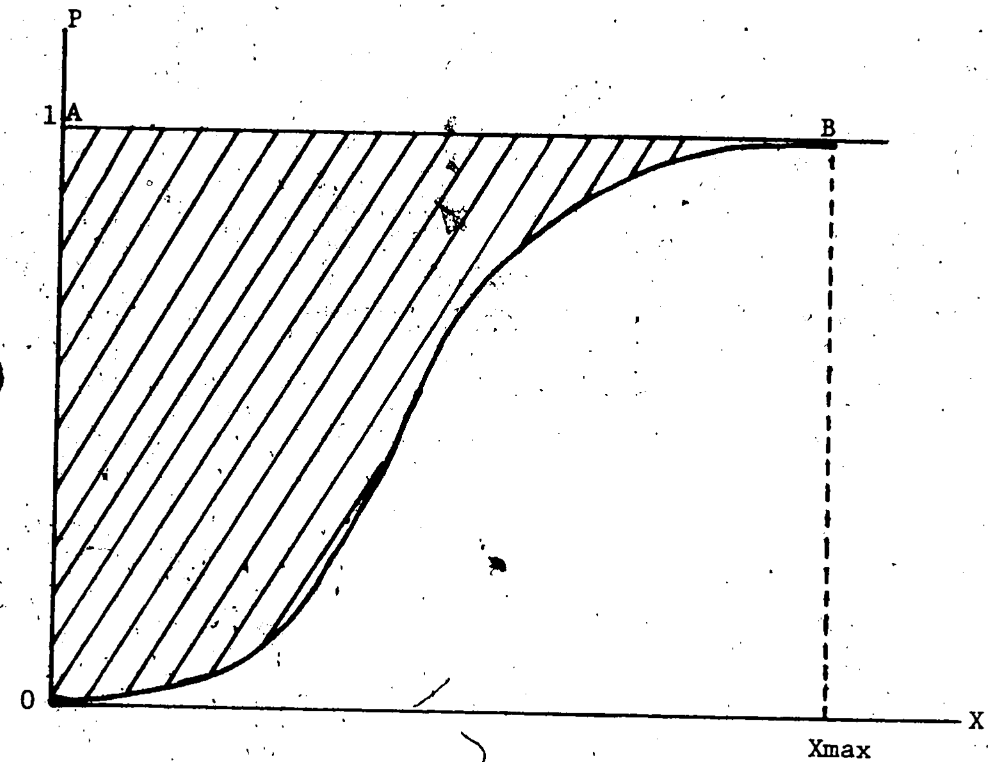
> "...ensures that no matter what values are taken by the explanatory variables $[X_n]$, the implied or predicted value of the relative frequency must be positive and less than one." (p. 175) [9]

The ratio of p/1-p is the odds ratio in favor of an activity being undertaken and the natural logarithm of this odds ratio is called a log odds or logit (Wonnacott and Wonnacott, 1979). Solving equation (7) in terms of p produces

$$p = 1/\{1 + e^{-(\alpha + \phi_n X_n)}\} \tag{8}$$

Equation (8) is termed a logistic curve, and produces an S-shaped curve similar to the one shown in figure 7, the difference being that as $X \to -\infty$, $p \to 0$ and as $X \to +\infty$, $p \to 1.00$.

There are difficulties in estimating the logit model, however. Wonnacott and Wonnacott (1979) have noted that the logarithm of p/(1-p) will behave in an unexpected manner when the dependent variable is a binary variable. This effect can be reduced by partitioning the independent variables, but with a cost of increased bias and econometric complexity (particularly if X_n is a large vector). The $\hat{\phi}$ estimates are



where,

P ≡ the probability of a hunter accepting the offer
X ≡ the dollar amount offered to a hunter
Xmax ≡ the maximum offer presented to any one hunter
OAB ≡ the shaded area representing the expected value or average consumer surplus associated with one permit
OB ≡ the curve expressing the relationship between the dollar amount offered and the probability of a hunter accepting that offer.

Figure 7. Valuation with the logit probability model

best estimated using maximum likelihood estimates where the parameters are estimated recursively until the vector best describing the data set is determined.

Another empirical difficulty with the logit model is that there is no assurance that the probabilities sum to unity over all cases. Consequently, there is a tendency for minor biasing of the exponent values and major biasing of the coefficients. Effective employment of the logit model for evaluation or forecasting purposes requires that the probabilities be adjusted to sum to one (Peterson, Lime and Anderson, 1980).

A Discussion of the Application of Logit Methods.[10] In a recent study by Bishop and Heberlein (1980) the logit model is used to value the take-it-or-leave-it responses of Canada Geese hunters in Wisconsin. Resident hunters were sent checks through the mail and were then requested to return either the check or their hunting license. The situation is constructed in which the hunter is confronted with the binary choice of accepting the compensatory payment in exchange for his hunting rights or rejecting the payment and maintaining his hunting rights. With use of the logit model, the value of this choice is converted into a measure of willingness to sell.

In the logit model used by Bishop and Heberlein (pp. 20-23), p represents the probability that a randomly selected hunter from the resident hunting population will exchange hunting rights for an offer of X dollars. This relationship is expressed in equation (9) and illustrated in figure 7.

$$p = 1/\{1 + e^{-(\alpha + \phi \ln X)}\} \qquad (9)$$

Because any hunter willing to sell a license for a given amount of money, X, would rationally do so at any higher monetary level, X + Y, the curve in figure 7 is analogous to a cumulative density function. As X + Y increases, the p value approaches unity. Bishop and Heberlein contend that if the density function in figure 7

> "...is truncated at some relatively large offer level such as [Xmax] ...Then it can be shown the expected value of a permit [license] is given by the shaded area [OAB in figure 7]." (p. 22)

This expected value of a hunting license (V) may be interpreted as the compensating surplus for the mean hunter and is mathematically expressed as:[11]

$$V = Xmax - \int_0^{Xmax} [1/\{1+e^{-(\alpha + \phi \ln X)}\}]dx \qquad (10)$$

The total consumer surplus is the product of V times the number of hunting licenses issued.

An examination of two extreme cases illustrates that the shaded area OAB in figure 7 is the consumer surplus associated with hunting licenses. At one extreme, the hunter-respondent would willingly exchange his hunting rights without compensation (i.e., X = 0) and the license valuation is p = 1 multiplied by zero. Thus, the probability of accepting the compensating offer is always unity, irrespective of the X value, and there is no area above the probability function. At the other extreme, a hunter-respondent is not willing to sell his hunting rights for any value less than Xmax. At Xmax p = 1 and license valuation is p = 1 · Xmax. However, because p = 0 for any X less than Xmax, the probability function is coincidental to the X axis. Consequently, the rectangle OABX corresponding to the license value is above the probability function.

A major advantage of the logit model is that it facilitates the quantification and incorporation of a dichotomous dependent variable for econometric analysis, thereby providing an avenue for analysis of markets created for valuation of nonmarket goods. Bishop and Heberlein note that the objective of recreation valuation research is to estimate the consumer surplus that would accrue if a market existed. They argue that creation of a temporary market for the relevant recreational activity removes many of the incentives for strategic behavior inherent to hypothetical market estimation techniques such as a direct questioning or bidding game approach.[12]

A market creation could provide some distinct advantages over the traditional travel cost approach as well. The measurement problems associated with evaluating monetary costs, inclusion of temporal opportunity costs, incorporation of consumption substitutes, and the need to control for individual differences in tastes and income levels are some of the major shortcomings of the travel cost approach. In a simulated market such as that employed by Bishop and Heberlein, the above measurement problems are circumvented because the individual includes all of these considerations in his decision to maintain or sell his hunting rights.

Despite the potential positive contributions of models similar to Bishop and Heberlein's, a number of impediments to their application to resource valuation remain. Institutional barriers and intransigent bureaucrats are likely to impede attempts to further test and perhaps employ such methods. There also may be high management costs, particularly if only participants' willingness to sell is tested. A final monetary constraint involves enforcement costs required to prohibit individuals from participating in the recreation activity after they have exchanged their rights, although this latter problem is faced in management of all wildlife resources with limited hunter access.

In conclusion, this section has discussed a number of methods that have been used to evaluate recreation resources. One theoretically appealing approach to the study of recreation demand has been to employ so-called household production functions (see Chapter IV). Other recent approaches have involved a combination of hedonic and voting models, variations of bidding games in combination with a direct survey and variations of the expenditure function approach to evaluation.

It is apparent from the discussion above that every type of valuation model has some relative weaknesses, whether conceptual, methodological, or practical. However, it is also apparent that most models have made positive contributions to the development of recreation valuation techniques and that further progress toward aiding in the efficient use of finite recreational resources is likely forthcoming.

Footnotes

1. For a discussion of the properties of a well-behaved indifference curve see Greene (1976, pp. 21-45).

2. There are numerous ways of eliciting WTP values. Individuals could be asked outright, or an iterative, high-low process could be employed. Another approach used to indicate relative preferences among goods is to assign quantities of scrip or coupons and ask individuals to allocate this budget across the goods in accord with their preferences; see Pendse and Wyckoff (1974) and Strause and Hughes (1976).

3. For a discussion of this difficulty and experiments related to to it see Bohm (1971), Freeman (1979), Groves and Ledyard (1977), Kürz (1974), Mäler (1974), Tideman (1972), and Tideman and Tullock (1976).

4. Certain researchers have considered what circumstances might enhance response accuracy; see Bohm (1972), Knetsch and Davis (1966), and Randall _et al_. (1977).

5. It is also possible that the problem of preference misrepresentation may not be as significant as anticipated. Recent research by Bohm (1972) has shown that WTP for publicly provided commodities did not vary, regardless of whether the estimates were collected through direct or indirect types of questions. The results of Heberlein's experiments, however, suggest that response bias may vary substantially depending on the issues involved (see Bishop and Heberlein, 1979).

6. The term Hotelling-Clawson is used in a generic sense to represent a myriad of methods used to estimate the demand for nonmarket recreational services; they all draw on the fundamentals of the work of Hotelling (1947) and Clawson (1959).

7. For a thorough discussion of the procedures, the inherent difficulties, and the requisite data see Clawson (1959) and Phillips _et al_. (1977).

8. Edwards _et al_. (1971) have also argued that the analysis of recreational demand is more properly confined to the sample of recreators than to the base population used in the Hotelling-Clawson methodology. (See also Pearse 1963)

9. At the zero end of the linear function the condition is expressed as $\ln p = \alpha + \phi X_n + v$. At the upper end the condition is expressed as $\ln(1 - p) = \alpha + \phi X_n + v$. Combining both conditions yields the conditioned linear function: $\ln p - \ln(1 - p) = \alpha + \phi X_n + v$, which can be written as equation (7).

10. For a thorough theoretical discussion of the logit model see Pindyck and Rubinfeld, 1976, pp. 249-254.

11. The variable Xmax should be the offer price at which the last hunter would sell his hunting rights. Bishop and Heberlein use $200 as Xmax, but note that the data predicted approximately 10 percent of the hunter sample would require offers in excess of this arbitrary Xmax. Consequently, the estimated compensating surplus in aggregate was a conservative estimate.

12. "Hypothetical" is the term used by Bishop and Heberlein and describes the nature of the market, not the technique used to simulate it.

CHAPTER IV

THE HOUSEHOLD PRODUCTION FUNCTION OR HEDONIC PRICING TECHNIQUE

The term hedonic is given to this valuation technique because the pleasure-generating characteristics of a good are of prime interest in this approach. One of the first authors to present the idea of hedonics was Gorman (1956), but Lancaster (1966 a and b, 1971) generally is credited with the origin of the concept. The Lancasterian approach differs from classical utility theory in that consumers derive utility from the attributes or characteristics inherent to the good and not from the good itself. Thus, the demand for consumer goods is a derived demand; the characteristics of a good generate utility, and the goods are merely the inputs or the intermediate products in a utility production function.

Generally a good will possess a number of different characteristics and any particular characteristic will not be unique to any single good. In addition, a combination of goods may foster different characteristics than any individual good in the mix (Lancaster, 1966 a, b). Translating this concept into hunting terms, the hedonic concept implicitly assumes that hunting consumers acquire utility from the hunting experience derived from a site and not from the hunting site *per se* (Ravenscraft and Dwyer, 1978).

This fundamental change in utility theory has been combined with classical production economic theory. The product, termed the household production approach, has afforded an interesting and theoretically rigorous avenue to the generation of implicit or shadow prices for nonmarket recreation goods such as hunting. Brown, Charbonneau and Hay (1978) provide the following overview of this technique:

> "These [implicit] prices could be obtained if we could observe total expenditures of many individuals otherwise alike except for the different quantities of characteristics each consumes. A change in the quality of a given characteristic would then be associated with a change in total expenditure. The set of these marginal values is...a demand curve under competitive conditions." (p. 1)

Consumer goods are viewed as being purchased by households and used to produce commodities or characteristics.

Rosen (1974) defines hedonic prices as the shadow prices of household produced characteristics. The hedonic prices are obtained by observing prices of the particular products associated with specific amounts of characteristics and are statistically estimated using regression equations in which product expenditure is a function of activity characteristics. The resulting hedonic prices are then used to determine the demand curve for the activity, after which the associated consumer surplus can be estimated in the standard fashion.

A number of recent outdoor recreation demand studies have employed the household production function approach because it is particularly effective in the case of outdoor recreation. Johnson (1979) notes that the approach (1) accommodates heterogeneous consumption activity; (2) incorporates the inherent role of the consumer in producing the consumption good; (3) allows for the wide variety of recreation associated expenditures; and (4) of particular significance is that the approach explicitly includes the opportunity cost of the consumer-recreator's time. The facility with which the household production function approach accommodates certain of the difficult analytical aspects associated with outdoor recreation demand research has fostered the following studies: Brown 1978; Brown, Charbonneau and Hay 1978; Cicchetti, Fisher and Smith 1976; Deyak and Smith 1978; Oliveira and Rausser 1977; Smith 1975; and Becker 1965.

The Theoretical Foundation of the HPP Method

The theory underlying the hedonic approach begins with the individual consumer (see Brown 1978 and Rosen 1974). It is assumed that the individual controls production technology and by utilizing this technology is able to transform a vector of goods $X = (X_1, \ldots, X_n)$, obtainable at market-established prices $V = (V_1, \ldots, V_n)$, into a vector of characteristics, $R = (R_1, \ldots, R_n)$.

The typical inputs into household production (X's) include the opportunity cost of the individual's time, miles traveled, and capital equipment expenditures. The characteristics (R) produced from such inputs include days engaged in the activity and bag obtained. Of course, the specific inputs and characteristics will reflect the recreational activity being examined.

In order to facilitate an illustration of the theory it is assumed that there is some acceptable manner of partitioning a sample population into n groups according to some demand shifter such as income or geographic location. Employing this abstraction, figure 8 shows hypothetical willingness-to-pay fuctions (TWP_i) and respective total cost functions (TC_i) for groups 1 to n.[1] Neither TWP or TC is observed. Only the equilibrium total expenditure level, the locus of which is denoted by E, is observable. (In figure 8, E is purely hypothetical.)

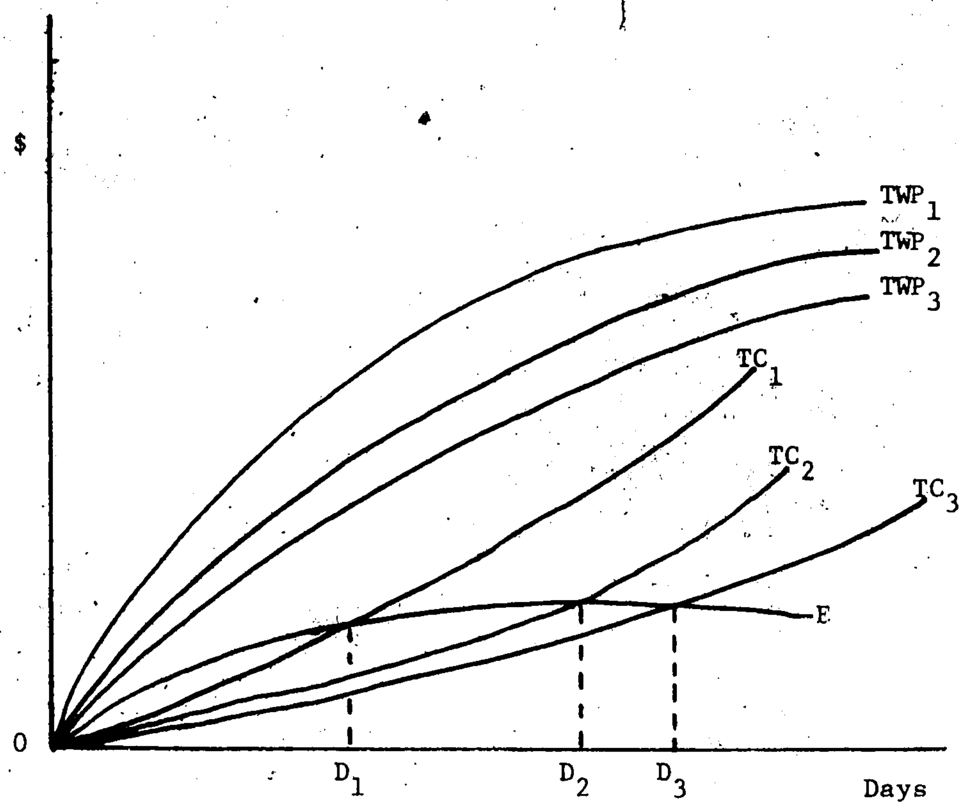


Figure 8. The equilibrium total expenditures function

The functional relationship expressed by the cost curve is constant across all individuals because it is assumed that the same technology is available to all (Brown 1978). The constraint of a homogeneous technological capability necessarily limits the factors which can affect differences in the TC (and MC) curves to differential input prices. Again, the partitioning of the sample (by location or income) will yield n supply curves, as illustrated in figure 9, which is a marginal analogue to figure 8.

Holding quality exogenous (an option discussed in the following section), the individual is assumed to have affected a cost minimization. Then the individual chooses the characteristics and other goods to maximize utility subject to his budget constraints. This utility maximization can be written in standard Lagrangean form as:

$$\text{Maximize: } U = u(G, R) \tag{1}$$

$$\text{subject to: } Y - PG - \pi R = 0 \text{ and } LT - \sum_i t_i R_i = 0$$

where,

G = quantity vector for other goods acquired,

R = quantity vector of recreation characteristics,

Y = income,

P = price vector of other goods acquired,

π = price vector of characteristics,

LT = time available to individual for recreational use,

t_i = time spent in activity i, and

R_i = characteristic-generating activity.

The individual's ordinary demand function (i.e., Marshallian demand function) can be derived from the analysis of utility maximization.

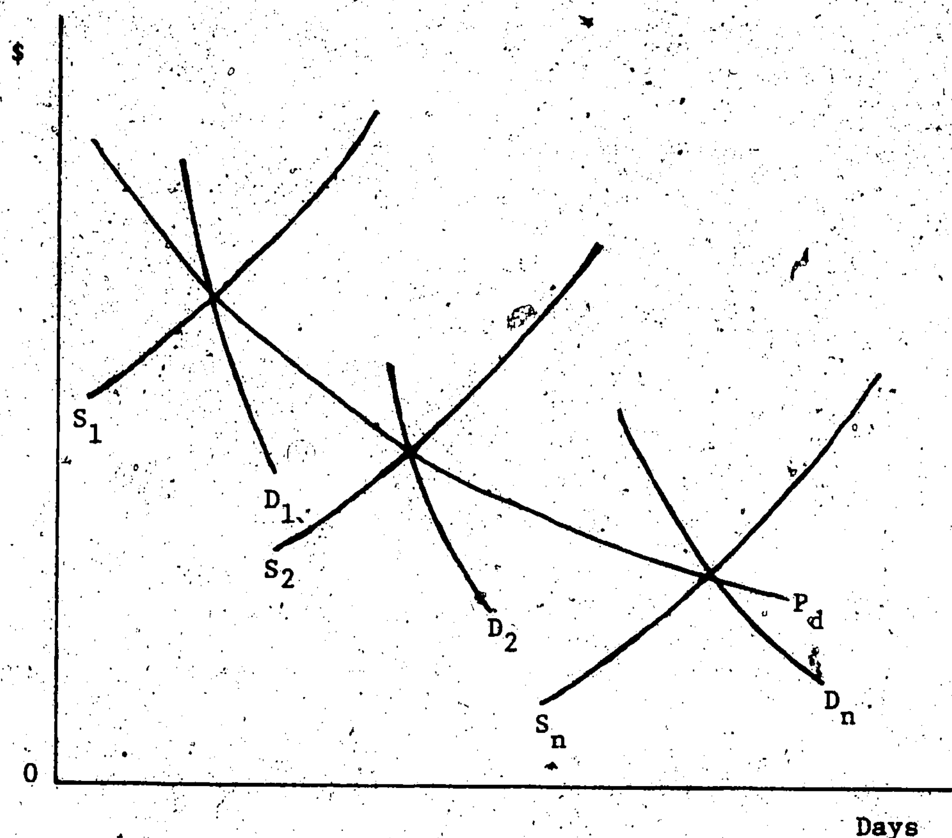


Figure 9. Individual demand and supply functions

The first order conditions for maximization of (1) using Lagrange multipliers consist of four equations and four unknowns: G, R, λ, μ, where λ and μ are Lagrange multipliers.[2] The demand functions are obtained by solving the first order condition for the unknowns in terms of the parameters (Henderson and Quandt 1971).

The first order conditions are:

$$\begin{aligned} \partial U/\partial G &= U_G - \lambda P \\ \partial U/\partial R &= U_R - \lambda\pi - \mu t_i \\ \partial U/\partial \lambda &= Y - PG - \pi R \\ \partial U/\partial \mu &= LT - \sum_i t_i R_i \end{aligned} \qquad (2)$$

This system of equations is set equal to zero and solved. λ is the marginal utility of income and μ is the marginal utility of time.

The individual selects R to equate the marginal utility of the activity with its total cost in terms of money and time. The total costs consist of the opportunity cost of the income used (i.e., $\lambda\pi$) and the opportunity cost of time used (i.e., μt_i). This latter component is the opportunity cost of time, measured in dollars, associated with preparation, engagement, and subsequent disengagement in R. It is implicitly assumed that the marginal utility of preparation and disengagement not attributable to the particular activity is zero.[3] For example, getting prepared to hunt and recalling the hunting experience provide the participant with the measure of utility and this measure is included in the valuation μt_i. Thus, the shadow price μt_i includes the time value for preparation, engagement, and recollection.

Because the first order conditions describe the equilibrium conditions for the choice of G and R with respect to time and money costs, a demand function can be derived. For example, the first derivative of the constrained utility function (1) with respect to days hunted (i.e., R_d) yields a demand curve for days hunted. The demand curve for days hunted is of the following form:

$$R_d = D(\pi_d, t_d, Y, LT) \qquad (3)$$

Estimation of (3) requires that individuals are confronted with a gradient of alternative characteristic prices and is contingent on continued optimizing behaviour by the individual.[4]

Each individual is assumed to have his own characteristics equilibrium expressed by the intersection of the supply and demand curves (the S_n and D_n derived above). Considering several individuals, there exists a series of such equilibrium points. Their locus (P_d in figure 9) is neither a demand nor a supply curve but a mixture of both. The first derivative of E (figure 8) with respect to a characteristic--for example, days hunted (R_d)--produces an equilibrium price for R_d. In equilibrium π_d is both the marginal cost and marginal benefit of obtaining the last unit of R_d, i.e., the hedonic price for the characteristic in equilibrium.

The utility function discussed above is somewhat limited empirically because a number of recreation alternatives and general substitute consumption activities are often, for pragmatic reasons, ignored.[5] This model underspecification necessitates an assumption that an individual's utility function be weakly separable between the included and excluded activities (Brown 1978, Pollack and Wachter 1975). This assumption implies that the marginal rates of substitution among charactersitics included in R are completely independent from consumption of non-R characteristics (see, for example, Muellbauer 1974, Muth 1966). The assumption of weak separability also allows similar commodities to be grouped, thereby reducing the number of demand parameters to be estimated, and implies that hedonic price-induced changes in quantity are the same for each of the commodities in the group as they are for the entire group.[6]

Consistent with economic tradition and the legacy of Marshall, the inverse of the demand function, wherein the quantity demanded is placed on the abscissa as the dependent variable, is used. More significantly, the demand curve subscribes to traditional demand theory in that it is homogeneous of degree zero and follows the Slutsky sign and symmetry conditions (Pollack and Wachter 1975).

The homogeneity condition means that only relative changes among the inputs to the demand equation (income, characteristics prices) affect the quantity of characteristic demanded. The Slutsky conditions insure a negative own-price elasticity of demand and that $\partial R_j/\partial \pi_j$ is less than zero. Utility functions are identical across individuals, limiting the causal factor affecting differential individual demand curves to the level of income. Because hedonic prices are expressed as a function of input prices, household income and household technology, the assumption of constant tastes allows the development of a series of demand curves from a cross-section of individuals with different income levels.

The observations along P_d would also permit the estimation of supply equations if observations on supply shifters were available. Ideally, demand and supply functions should be estimated simultaneously. However, there is generally insufficient information to allow the incorporation of supply shifters into the analysis. Thus, generally it is assumed that individuals with comparable preferences and technologies, but with peculiar intermediate product prices, will have different marginal costs of participation and will attain an equilibrium optimum of characteristic consumption (Brown, Charbonneau and Hay 1978).

Discussion and Critique of the Hedonic Method

The hedonic model is a variant of the travel cost technique. Recall that in the travel cost method households located a greater distance from the recreation site are confronted with relatively higher travel costs, i.e., higher prices for participation. By comparing participation rates across households of varying distances from the site, it is possible to employ this price proxy to develop a demand curve. The travel cost method is based on site price whereas the hedonic method is based on characteristic price. Consequently, the travel cost method predicts site demand by regressing travel costs on trips, holding destination constant. Par contre, the hedonic method predicts characteristic demand by regressing activity cost (travel and other) on the level of characteristic acquired, holding origin constant. Holding the origin constant confines the observations to a particular market in which all households face the same input price vector.

Hedonic models, similar to most economic models, are limited by the necessary underspecification, but they also are often limited by insufficient variance in quantifiable and identifiable characteristics. For example, in estimating implicit prices for seasonal bag from big game hunting, the researcher is generally dealing with a binary type of response, i.e., the bag is limited to a single animal killed. A similar data shortcoming is often encountered with survey-generated income data which are obtained via truncated and stratified scales designed to reduce non-response bias, but thereby reduce variation.

Several necessary assumptions underlie hedonic models. First, as noted above, the functional relationships of each recreator's (hunter's) total cost curve and utility curve are assumed to be identical, resulting in cost curves that differ only with respect to input prices and demand curves that differ only by income. Weak separability of included versus excluded characteristics is assumed, allowing aggregation of similar characteristics and implying that marginal rates of substitution among included characteristics are not affected by the exclusion of other characteristics. Also discussed above is the homogeneity (of degree zero) condition of the demand function, which results in quantity demands which respond only to changes in relative (versus absolute) prices and the assumption that recreators are in equilibrium with respect to the supply of and demand for included characteristics.

Second, tastes are assumed to be constant across recreators, production of charactersitcs is assumed non-joint, and household technology is assumed to be homogeneous of degree one (Pollack and Wachter 1975). Thus, recreators are price takers and hedonic prices are independent of the particular characteristics bundle; i.e., only income affects demand. Under conditions of joint production and non-constant returns to scale, hedonic prices are functions of the particular set of characteristics, which may vary by tastes as well as income (and in an unexplainable manner).

Third, there is the question of how to account for the opportunity cost of time, though there is little question that such costs should be included (see Brown et al. 1978). When used as an input into household production, time generates utility, but the same unit of time can generate varying degrees of utility depending on the recreator's preference for the current activity relative to alternate activities. Thus, recreators must be assumed to be indifferent among alternative uses of time (Pollack and Wachter 1975). Under this assumption, opportunity costs are usually expressed as some fraction of the wage rate (see Chapter VIII).

The remaining problems associated with the hedonic approach lie in the practical rather than theoretical realm. Because hedonic prices cannot be observed directly, they must be estimated from total expenditures. If the expenditure function is linear and marginal costs constant, hedonic prices can be calculated directly (e.g., E/days). However, in the linear instance there is no variation in hedonic prices among individuals so the demand function cannot be estimated. Thus, nonlinear expenditure functions are estimated, hedonic prices are calculated as a derivative of expenditures with respect to days (bag), and simultaneous equation bias results following estimation of the demand function. Both days (bag) and hedonic prices of days(bag) are endogenous, but the expenditure and demand functions cannot be estimated simultaneously (Bockstael and McConnell 1978).

A few means of resolving the resulting identification problem have been suggested, but only the most amenable to empirical estimation will be noted here.[7] Bockstael and McConnell (1978) suggest the partitioning of the total sample into several subsets with differing marginal cost functions (possibly on the basis of distance to the activity site), but with enough variation in demand shifters (such as income and experience hunting) to provide more than one equilibrium point along each marginal cost function. Several expenditure functions would be independently estimated and used to determine hedonic prices. The simultaneous demand system would then be estimated as before. Simultaneous equation bias would remain, but the identification problem would be avoided. This partitioning of the sample according to marginal costs will not be possible in all applications (e.g., the one presented below) and would require a very large sample size; surveys should be specifically designed to this end.

In addition, the appropriate method for including a quality variable in a hedonic model remains a difficult and unsettled issue associated with use of the technique (see Bockstael and McConnell 1981).[8] Several studies employing hedonic models, including this one, have elected to treat quality as an exogenous variable. This exogenous treatment is generally adopted over the endogenous alternative for empirical facility. Although conceptually quality is not entirely exogenous to the individual, neither is it entirely endogenous. Rather, quality is a composite of factors controlled by the individual (e.g., time and money spent, location selected) and factors beyond the individual's direct control (e.g., climate, wildlife population).

If quality is exogenously determined, the success rate may vary across individual hunters as experience varies, for example, but success will not be influenced by the individual's current decisions. Such a specification is consistent with the widely used travel cost technique for estimating recreational benefits. Policy changes which affect the quantity of, temporal access to, or spatial distribution of wildlife will affect the individual hunter's welfare by altering the quality of a trip and thereby will shift trip demand. Measurement of the area between the two demand curves and above the supply curve would provide an approximation (with error bounds as demonstrated by Willig 1976) to the equivalent area under the compensated demand curve. If weak complementarity conditions hold, when the compensated demand function is integrated back to the expenditure function, the constant of integration is not functionally related to quality (Mäler 1974). Thus, the consumer surplus measure derived using the compensated demand curve is a satisfactory approximation of the compensating variation or welfare change associated with an exogenously-generated change in activity quality.

Alternatively, if quality is endogenously determined (i.e., directly influenced by the individual or household), quality and quantity are no longer independent. Although benefit estimation is more difficult in the endogenous case, Just et al. (1981) have shown that error bounds on compensating variation (similar to Willig's) can be calculated from consumer surplus in a situation in which changes occur in several related markets.[9] Bockstael and McConnell note that if estimates of the compensated demand curves for quantity and quality were available, the appropriate measure of welfare change would be calculated from the line integral over the range of change. A change in a policy variable would affect total WTP via its effect on the quantity of, temporal access to, or spatial distribution of wildlife. As a consequence, the marginal cost functions for quantity and quality would shift and a new equilibrium for quantity and quality would be effected. The change in consumer benefits due to the policy initiative would be estimated by taking the difference between net benefits in the initial situation and net benefits after the policy change.[10]

Footnotes

1. Conceptually, the discussion can be expanded to n dimensions to include n characteristics.

2. The discussion assumes that the second order conditions are fulfilled.

3. The data provided only a total figure for participation. Also, it is not unreasonable to assume that hunter anticipation and recollection of the hunting experience are of value equal to active engagement. For a discussion of the implications of differing utilities across anticipation, engagment and recollection see Freeman (1979, pp. 204-208).

4. Brown and Mendelsohn (1980) note that in early hedonic formulations a precondition to demand estimates was that the price of characteristics vary as a greater quantity is acquired. In the hedonic travel expenditures approach the implicit prices can be either linear or nonlinear.

5. Rosen (1974) notes that inclusion of the characteristics relevant to a recreation experience would require massive amounts of data and would likely defy current empirical estimation techniques. Thus, as with any other economic model, only those characteristics of interest and those readily measured are included in hedonic models.

6. For a thorough discussion see Muth (1966).

7. Other solutions which are useful under very specific conditions are discussed in N.E. Bockstael and K.E. McConnell. "Theory and Estimation of the Household Production Function for Wildlife Recreation." Journal of Environmental Economics and Management, 8 (1981) 199-214.

8. Ibid.

9. R. Just, D. Hueth, and A. Schmitz. Applied Welfare Economics and Public Policy. Englewood Cliffs, N.J.: Prentice-Hall, 1981.

10. Bockstael and McConnell, op. cit., pp. 201-204.

CHAPTER V

COLLECTION OF AND A DESCRIPTION OF THE DATA SAMPLE

Collection of the Data

The primary data utilized in this study were obtained through a 1976 mail survey of a sample of Alberta hunters.[1] Provincial residents holding a wildlife certificate during 1975-76 comprised the population from which the sample was selected. The format of the questionnaire is provided in Appendix A.

The questionnaire was designed to elicit socioeconomic as well as hunting value and participation data from the sample. The socio-economic information included residence, age, sex, occupation, family size, family income, and education (cf. Questions 1-7, Appendix A). Socioeconomic information was viewed important as it contributes to the hunter's decision matrix. The balance of the questionnaire sought information regarding the actual hunting experience. These latter items included times, locations, and durations of hunting trips; travel distances; species sought; hunting successes; ratings; hunting expenses; and a respondent's extramarket valuations of hunting experiences.

Sampling was designed to achieve statistical randomness, a necessary condition if inferences about the population are to be drawn meaningfully from an analysis based on the sample. The randomness property implies that each individual wildlife certificate holder within the population has the same probability of inclusion in the sample. The names and addresses of all Alberta resident wildlife certificate holders are stored in a computer file by the Alberta Fish and Wildlife Division. During the 1975-76 season there was a total of 142,814 resident individuals holding various combinations of Alberta hunting licenses. Based on this list, the Division provided a randomly drawn sample of 1,994 names and addresses, constituting 1.6 percent of the total population (see table 1).

The first mailing of the resident hunter survey (1,994 questionnaires) resulted in a return of 458 questionnaires, of which 21 were returned unopened. A follow-up mailing of 1,587 questionnaires (mainly to those names failing to respond to the original mailing) produced an additional 326 questionnaires and 53 unopened, returned questionnaires. After adjusting the effective sample size to net out the 74 unopened questionnaires, the effective sample response rate was 37 percent (table 1).[2] This response rate is above that typical of extensive mail surveys and yielded a sufficiently reliable sample of the population.

The returned questionnaires were coded and key punched on data processing cards. Subsequently, the punched cards were verified and read into a computer file. The data for the analysis in this study were taken from a data tape generated at the University of Alberta and converted to a form compatible with the system at Oregon State University, where the actual analysis was done.

Description of the Data

Critical to the analysis undertaken in this study is the information on hunting trips and the resulting expenditures (Questions 12 and 14 in Appendix A, respectively). Those questionnaires returned without

Table 1. Sample Response to the Hunting Survey.

	First Mailing	Second Mailing	Cumulative
Population	124,814	124,814	124,814
Number Sampled (%)	1,994 (1.6)	1,587 (1.3)	1,994 (1.6)
Questionnaires Returned Unopened	21	53	74
Effective Sample Size (%)	1,973 (1.6)	1,534 (1.2)	1,920 (1.5)
Questionnaires Returned	437	273	710
Percent of Effective Sample Responses	22.1	17.8	37.0

Source: Phillips, DePape, and Ewanyk, 1977.

this information were removed from the analysis. Thus, the basic sample size was reduced from the 710 returned questionnaires to 543 usable questionnaires (344 from the first mailing and 199 from the second).[3] The following section is a description of the aggregate sample employed in this study.

Socioeconomic Characteristics of the Sample

The general sample characteristics of this slightly more limited sample were very similar to those described in the data summary of Phillips et al. (1977). Approximately 54 percent of the 1975-76 hunting license holders sampled resided in the nine most populated communities in the Province, and 38 percent resided in Edmonton and Calgary. The ages of the sample respondents range from a minimum of 14 years to a maximum of 75, with a mean of 34.04. As is typical of sport hunting populations, 94.1 percent of the sample was male (see Table 2).

Respondent's occupations (Question 4, Appendix A) were grouped into 17 categories. Among these categories tradesmen accounted for the largest proportion (15.5 percent), followed by professional and technical occupations (14.0 percent each). Two other categories, managerial and laborer groups, each accounted for 9.6 percent of the sample. The remaining 50 percent of the respondents that indicated an occupation were spread across the thirteen remaining employment categories (table C.6, Appendix C).

As income is a critical variable in determining willingness to pay, sample participants were asked to indicate their total household income for the 1975 period (households ranged from one to nine persons with a mean of 3.55).[4] It is generally difficult to obtain income information through a direct questionnaire format, because individuals

Table 2. Socioeconomic Characteristics.[1]

Item	Resident Hunters
Number Licensed Resident Hunters (Persons)	124,814
Useable Sample Size (Households)	543
Mean Age (Years)	34
Male/Female Ratio	.941
Mean Household Size (Persons)	3.5
Mean Household Income (Dollars)	17,775
Mean Formal Education (Years)	12
Actively Hunted in 1975 (Percentage)	82.2
Estimated Number of Resident Hunters During 1975 (Persons)	102,600

1. *Supra* footnote 1, Chapter I.

are typically quite reticent to provide any income information, they may either refuse to answer or strategically misrepresent their incomes. One approach which has been adopted by surveyers (see Dillman, 1978) is to provide an income gradient summarized in a number of discrete brackets. This approach was employed in the Alberta survey; resident hunters were asked to indicate the appropriate income bracket from eight alternatives. Approximately 96 percent (or 510) respondents answered the income question (Question 6, Appendix A).

Forty-seven percent of resident hunters sampled had a 1975 household income between $10,001 and $20,000 (see table C.4). Approximately 34 percent had annual household incomes in excess of $20,001; and 19 percent of sample respondents had annual household incomes of $10,000 or less. Based on this distribution of incomes and some simplifying abstractions, the mean annual household income for the sample is estimated to be $17,775.[5]

Examination of the survey results for the education level attained (Question 7, Appendix A) indicates that 24.6 percent of the sample achieved high school matriculation 20.3 percent had a minimum of one year at university, and an additional 15.5 percent had at least one year of formal technical training.

In summary, the socioeconomic data afford the following characteristic description of an "average" resident hunter. The hunter would be an urban-dwelling male, 34 years old, a high school graduate and head of household totaling 3-4 persons. Average annual household income was estimated to be $17,775 and half the sample were employed in the trades and as professionals, managers and laborers.

Hunting Consumption Activity

The sample used in this study does not include licensed resident hunters who were inactive during the 1975 season, so it is not possible to make an appropriate adjustment to infer the active hunting population. However, Phillips et al. (1977) concluded that during the 1975 season approximately 102,600 (82.2 percent) of all license holders actively engaged in hunting (see table 2). This figure suggests that 22,200 (17.8 percent) members of the population of license holders were willing to spend approximately $155,400 (or $7.00 per license) merely to acquire the (unexercised) option to hunt. The active resident hunters spent an average of $178.81 in variable costs, $13.21 in fixed costs (i.e., license fees) and an additional $189.87 on hunting capital (table 3). Annual total hunting expenditures in 1975 were estimated to have been approximately 39 million dollars (table 4). Big game hunters had the highest mean per hunter expenditures.

Resident hunter seasonal hunting activity is summarized in table 5. Waterfowl hunting had the largest number of active participants (59,303), the greatest number of trips per hunter (4.15) and per season, and the largest total number of animals harvested (646,996 units). Big game hunting had the highest average days active per season per hunter (6.2), the greatest number of days active (352,408), and the lowest harvest count (13,073 or .23 units per active hunter). Upland bird hunting had the lowest average number of trips per season per hunter (2.46) but almost 30,000 active participants harvesting 66,581 birds. On the basis of the estimated 102,600 resident hunters active during the 1975 season, resident recreation trips totaled 584,673 and resident recreation hunting days totaled 920,120.[6]

Table 3. Hunting Costs Per Person for 1975 Hunting Season.

Item	Mean Cost			
	Big Game	Upland Bird	Waterfowl	Hunting Total[1]
Travel Costs	$ 66.05	$ 37.04	$ 44.98	$ 73.37
Lodging Costs	8.69	7.48	7.13	11.11
Food Costs	39.98	19.05	19.39	38.90
Beverage Costs	10.21	7.18	7.68	12.19
Rental Costs	.90	.44	2.34	1.53
Guide Costs	.24	.16	.10	.24
Ammunition Costs	12.35	13.58	30.22	28.26
Service Costs	8.60	3.86	1.26	6.61
Miscellaneous Costs	4.19	5.44	4.67	6.60
Total Variable Costs	$151.20	$ 94.23	$117.77	$178.81
License Fees[2]	9.56	6.50	7.50	13.21
Capital Costs[2]	N.A.	N.A.	N.A.	189.87
Total Costs	$160.77	$100.73	$125.27	$381.89

1. Mean total costs are weighted to reflect the mixed aspect of hunting activity. It is estimated that 55.4 percent of the sample hunted big game, 29.1 percent upland bird and 57.8 percent hunted waterfowl.

2. Source for these numbers is Phillips, et al. (1977) p. 20.

N.A. = Not available from the data collected.

Tabel 4. A Simple Valuation of Annual Hunting Activity for Alberta in 1975.

Item	Big Game	Upland Bird	Waterfowl	All Hunting[1]
Mean WTP/DAY Above Expenditures	$ 24.18	$ 18.29	$ 20.73	$ 21.92
Mean WTP/BAG Above Expenditures	651.83	32.23	9.98	---
Mean WTP/TRIP Above Expenditures	48.21	29.22	26.22	---
Annual Mean WTP Above Expenditures	149.92	71.88	108.83	166.88
Total WTP[2]	310.69	172.61	234.10	548.77
Mean Annual WTS	N.A.	N.A.	N.A.	554.65
Annual Total Hunter Expenditures[3]	---	---	---	39,337,314
Annual Total WTP[3]	---	---	---	56,458,202
Annual Total WTS	---	---	---	56,907,090

1. Weighted to reflect mixed aspect of hunting; see table 3.

2. With the exception of All Hunting these totals do not include capital expenditures.

3. Figure includes $155,400 license fees paid by nonactive residents.

N.A. = not available.

Table 5. Hunting Activities of Resident Hunters During 1975 Season.[1]

Item	Hunting Activity		
	Big Game	Upland Bird	Waterfowl
Number of Active Hunters	56,840	29,857	59,303
Mean Number of Trips Per Season	3.11	2.46	4.15
Mean Number Days Per Season	6.20	3.93	5.25
Mean Days Per Trip	1.99	1.60	1.27
Mean Bag (units)	.23	2.23	10.91
Total Number of Trips	176,772	73,448	246,107
Total Number of Days	352,408	117,338	311,341
Total Animals Harvested	13.073	66,581	646,996

1. Supra footnote 1, Chapter I.

As discussed above, extramarket benefits over incurred hunting costs are a component of the total value of a hunting experience to the hunter-consumer. In the 1975 hunter survey the participants were asked to indicate the amount they would be willing to pay (beyond current expenditures) for each day of hunting (by type of hunting) and the amount they would require in compensation for loss of an entire season of hunting rights.[7] A hunter's total WTP is held to be the sum of actual expenditures plus any additional amount he is willing to pay to maintain the right to participate in the activity (i.e., the hunter's extramarket benefits or consumer surplus). Par contre, the WTS measure is not as clearly defined in the recreation literature. Some researchers (e.g., Phillips, DePape and Ewanyk 1977, Mathews and Brown 1970) have estimated WTS directly from respondents' required compensation values, generating a surplus estimate without netting out actual expenditures.[8] Others (e.g., Brown, et al. 1978) have chosen to assume WTS is a gross measure and thus they net out expenditures to obtain surplus estimates. Further, WTS measures often ignore the individual's perception of available interregional realignment in consumption; Albertans selling their hunting rights may view other regions as ready substitute hunting grounds and thus understate WTS. These concerns may place limitations on direct WTS valuations.

Drawing from the active hunting population estimates of Phillips et al., mean total WTP for a season of hunting is $548.77 per hunter (consisting of $310.69 for big game, $172.61 for upland birds, and $234.10 for waterfowl), yielding a provincial total WTP of $56.46 million (table 4).[9] Mean WTP net of expenditures for a season of hunting is $166.88 per hunter of $17.12 million for the province. Mean annual WTS for all hunting activities is estimated to be $554.65, for a provincial total of $56.91 million.[10] If the WTS estimate is a gross or total measure, the consumer surplus estimates based on total WTP and total WTS are very similar; the difference between the two estimates is less than one percentage point. Alternatively, if the WTS estimate is viewed as a net estimate, the net WTP value is only 30 percent of the net WTS value. It is generally argued in the recreation economics literature that an individual's income constraint will manifest a low WTP relative to WTS.

The annual values of the provincial wildlife resources estimated in this section do not include a number of major factors, the omission of which renders conservative estimates. The study only includes active resident hunters and is limited in scope to three types of hunting activities (albeit the major three types). The values do not include active nonresident hunters, the recreational and option values of wildlife resources to resident nonhunters, and the recreational and option values to nonresident hunters.[11]

Reasons for Hunting

Each sample participant was asked to provide an ordinal ranking of four alternative reasons for hunting: outdoor enjoyment, meat, trophy, and other (respondents were asked to specify the "other"). The responses are summarized in table 6 and are consistent with previous findings of a nationwide survey of U.S. hunters (Arthur and Wilson 1979, Arthur 1978).[12] The dominant reason for hunting was

Table 6. Reasons for Hunting.

Reason	Rank of Choice 1	2	3	4	Checked but Not Ranked	No Answer[1]
	Number of Persons[2]					
Outdoor enjoyment	365	131	7	1	28	11
Meat	139	255	60	2	27	60
Trophy	5	54	242	16	4	222
Other	7	15	39	6	1	475

1. This includes b[illegible]onresponses and valid zero responses.

2. N = 543.

easily outdoor enjoyment, followed by a desire to acquire meat; trophy hunting was third. Other cited reasons included relaxation, exercise, sport (challenge or stalking), and companionship.

Type of hunting was crosstabulated with the importance (rank) of various reasons for hunting to test for statistical relationships. The results in table 7 suggest that statistically more big game hunters were motivated to hunt for meat than were either upland bird or waterfowl hunters.[13] Reinforcing this relationship is the finding that upland bird and waterfowl hunters were statistically more likely to hunt primarily for outdoor enjoyment than were other hunters.[14] These results suggest that big game hunters may be relatively more motivated to increase household incomes by augmenting market food purchases through the capture of nonmarket big game. This secondary hypothesis is further examined with an analysis of variance of type of hunting by income category.[15] The results in table 8 support the income hypothesis. As a group, the big game hunters had a mean income level that was significantly lower than the mean incomes of the upland bird and waterfowl hunters.[16] Thus, these simple statistical tests support the contention that big game hunters are more often motivated to hunt for meat, and this motivation may be in response to their lower income levels.[17]

The above findings with respect to the socioeconomic characteristics of the resident hunter population, hunting activity and the analysis of reasons for hunting provide useful information to the development and interpretation of the econometric models discussed in the following chapter.

Table 7. Analysis of Reason for Hunting and Type of Hunting.

Hunter Type	Outdoor Enjoyment			Meat			Trophy		
	N	$\overline{X}$ [1]	S.D.	N	$\overline{X}$ [1]	S.D.	N	$\overline{X}$ [1]	S.D.
Big Game	299	1.383	0.532	287	1.737	0.641	199	2.823	0.545
Non-big Game	233	1.204	0.400	196	1.934	0.623	122	2.840	0.507
F Value		18.324***			11.233***			0.049	
Upland Bird	167	1.223	0.420	152	1.974	0.673	101	2.837	0.553
Non-upland Bird	365	1.343	0.510	331	1.745	0.612	202	2.830	0.521
F Value		7.160**			13.676***			0.012	
Waterfowl	323	1.234	0.434	282	1.922	0.652	185	2.819	0.533
Non-waterfowl	209	1.414	0.541	201	1.699	0.595	136	2.84[illegible]	0.528
F Value		17.952***			18.988***			1.256	

1. The lower the $\overline{X}$ value the greater the importance of the tested reason for hunting.

** and *** = $p < .01$ and $p < .001$, respectively.

Table 8. Type of Hunting and Income Level.

Item/Hunter Type	N	$\overline{X}$[1]	S.D.
Big Game	292	3.93	1.77
Non-big Game	218	4.33	2.05
F Statistic		5.55*	
Upland Bird	163	4.44	2.01
Non-upland Bird	347	3.95	1.84
F Statistic		7.54**	
Waterfowl	309	4.40	1.95
Non-waterfowl	201	3.65	1.74
F Statistic		19.53***	

1. The lower the $\overline{X}$ the lower the mean income level of the hunter group.

*, **, *** = $p < .025$, $p < .01$ and $p < .001$ respectively.

Footnotes

1. For thorough discussion of the data generation and a descriptive analysis see W. Phillips, D. DePape and L. Ewanyk, Socioeconomic Evaluation of the Recreational Use of Fish and Wildlife Resources in Alberta With Particular Reference to the Athabasca Oil Sands Area. Volume 3. Recreational Hunting. Dept. of Rural Economy, The University of Alberta, Edmonton Alberta, February 1977 (Mimeo).

2. Unfortunately, the survey procedures used in the original study were not readily adaptable for an analysis of response bias. However, the selective follow-up mailing greatly reduced the bias introduced by strongly-opinioned sample members double submitting. Phillips, *et al.* (1977) were able to test for response bias by comparing the results of the first and second mailings and concluded that "...the results are indeterminate in supporting or negating the assumption [of response bias]..." (p. 14).

3. The basic sample size in this study (i.e., N = 543) will vary somewhat in response to missing data or the use of a specific sub-sample of hunters.

4. It is possible that some members in the sample provided gross annual income for the head of the household, others gross household income and still others income net of taxes. The potential value of income in kind accruing to rural residents or agricultural producers is attenuated in part by the demographic concentration of resident Alberta hunters in urban centers.

5. The simplyfying abstractions involve using the midpoints for each of the first seven income brackets and using $35,001 for the eighth. While these assumptions are arbitrary, hopefully they result in a conservative estimate. This mean income estimate is not directly used in the following analysis, although opportunity cost estimates will be derived from it.

6. These totals may be somewhat misleading if it is not noted that there is inherent "double counting" due to hunters actively engaging in some hunting activities simultaneously.

7. This direct valuation approach is subject to the difficulties of strategic misrepresentation and consumer ignorance. These reservations are discussed in the Survey Methods section of Chapter III.

8. In an *ex post* personal communication Dr. Phillips has informed the author that their analysis assumes the individual has netted expenses from his estimated WTS.

9. The estimated total WTP includes total annual expenditures of 39.34 million dollars.

10. From the data gathered on WTS it was not possible to determine a WTS value for each particular type of hunting. These calculations implicitly assume that the WTS values given by respondents are gross, not net values. The significance of this distinction is noted below.

11. Some of these data are available for Alberta but were not analyzed here. See Phillips, et al. (1977, 1978).

12. In an interesting paper Arthur and Wilson (1979) show that both hunters and nonhunters get much more enjoyment from viewing animals and knowing they exist than from hunting them.

13. This type of comparison used in table 7 was necessary due to data aggregations and hunters' tendencies to participate in various types of hunting.

14. The results reported in table 7 are tested for statistical significance using analysis of variance and an F test. However, because the reason-for-hunting variable is ordinal rather than interval, it is not statistically rigorous to employ a parametric test (i.e., an F test). The results based on the F test are reported to facilitate comprehension. The more statistically appropriate and conservative (i.e., nominal data assumption) Chi Square test findings are reported in tables C.1, C.2, and C. 3 (Appendix C). In these more conservative tests, upland bird hunters' rankings of outdoor motives are not statistically higher than the rankings of other hunters.

15. Again, the ordinalizing of the income data renders F tests somewhat improper. Appendix C (table C.4) includes Chi Square tests. Due to the cross tabulation of the ordinally-scaled variables with nominally-scaled variables, more sophisticated tests accounting for the ordinality were not available.

16. A cross tabulation of reason for hunting by income level also supports the hypothesis that hunters who ranked meat high (as a reason to hunt) also had relatively lower incomes. Table C.5 (Appendix C) shows that the ranking of the meat hunting motive was inversely related to income, whereas outdoor enjoyment and trophy reasons were positively related to income.

17. Table C.4 (Appendix C) outlines the number of hunters in each of the eight income categories by hunter type. Clearly, alternative hypotheses (e.g., sociological and cultural factors) could be posited.

CHAPTER VI

METHODOLOGY

The 1975 Hunter Survey requested a variety of information that is requisite to a meaningful evaluation of hunting opportunity. Although the annual expenditure questions (see Appendix A, questions 14 and 15) were not conformable to the travel cost technique without certain restrictive assumptions with respect to apportioning total expenditures on a per trip basis, the survey format did afford sufficient information to employ three market-simulating, valuation techniques to estimate the consumer surplus or net economic value to hunters of Alberta's wildlife resources. Two of the techniques are examples of the direct questioning method, and the third is an indirect method that derives wildlife value estimates from the individual's annual aggregate hunting expenditures.

Direct Questioning Method

As noted above, in the direct questioning (or survey) method respondents are asked how much more they would be willing to pay (WTP) to maintain access to their current activity patterns. Alternatively, respondents can be asked the magnitude of compensation they would accept for the withdrawal of current activity access (called "willingness to accept compensation" or WTS). Direct WTP or WTS questions such as those used in the 1975 Survey have been employed in a number of previous studies to measure net benefits of hunting (see Chapter

III). The economic models for deriving marginal values from WTP or WTS responses are discussed in Brown, Charbonneau and Hay (1978), Davis (1964), Gum and Martin (1975), Hammack and Brown (1974), and Mathews and Brown (1970).

Willingness to Pay

The WTP question (Appendix A, question 16), which was asked only of respondents who were active hunters during the 1975 season, asked hunters to indicate in dollars per day the "...worth to you, above what you spent on travel and other expenses..." of various types of hunting. The responses are interpreted as measures of each respondent's mean consumer surplus per activity day. This information was gathered for three activities: big game hunting, upland bird hunting, and waterfowl hunting.

The average consumer surplus for an activity is useful in determining the total net benefits currently generated by an activity (i.e., the product of mean net benefits and the number of activity days) or the expected costs of a proposal to remove or dramatically affect the currently available activity. It is more likely, however, that resource management decisions related to Alberta's wildlife would involve incremental or marginal changes, such as changes in the number of days a licensed individual can legally engage in a hunting activity. For example, questions may be asked regarding the value of a two-week reduction in the moose hunting season. These types of issues require the derivation of marginal values.

The first step in deriving marginal values from the WTP data is to convert the average consumer surplus response to a consumer surplus for the hunting season. This transformation is accomplished by multiplying the respondent's WTP value by the total number of days actually engaged in each of the three hunting activities in 1975:

$$v_{ij} = \overline{V}_{ij} \cdot D_{ij} \qquad (1)$$

where,

v_{ij} = total consumer surplus for individual i and activity j,

$\overline{V}_{ij}$ = consumer surplus per day for individual i and activity j,

D_{ij} = number of days individual i participated in activity j in 1975, and

j = big game, waterfowl, or upland bird hunting.

Based on the seasonal consumer surplus values derived in equation (1), the following functions can be used to derive marginal values for day and bag, equations (2) and (3), respectively. Two separate formulations are needed as bag and day are different characteristics of one hunting activity. (B_j/D_j in (2) is a quality proxy.)

$$V_j = f_1(T, C_j, Y, S_j, D_j, B_j/D_j) \qquad (2)$$

$$V_j = f_2(T, C_j, Y, S_j, B_j) \qquad (3)$$

where,

V_j = seasonal consumer surplus for activity j,

T = previous hunting experience,

C_j = expenditures on activity j in 1975,

Y = gross household income in 1975,

D_j = number of days of participation in activity j in 1975,

B_j = seasonal bag in activity j, and

S_j = total WTP (i.e., cost plus WTP) per day of non-j hunting.

Equations (2) and (3) are estimated for each of the three hunting activities (j) using ordinary least squares (OLS), a double log functional form, and respondents as observations.

$$LnV_j = \beta_o + \beta_1 T + \beta_2 LnC_j + \beta_3 LnY + \beta_4 LnS_j + \beta_5 LnD_j + \beta_6 Ln(B_j/D_j) + u_{1j} \quad (4)$$

$$LnV_j = \beta_7 + \beta_8 T + \beta_9 LnC_j + \beta_{10} LnY + \beta_{11} LnS_j + \beta_{12} LnB_j + u_{2j} \quad (5)$$

where β_i are regression coefficients and u_1 and u_2 are error terms. The double log form was adopted to ensure a decreasing marginal value (i.e., a downward sloping demand curve for the hunting activity).

T and C_j reflect differences in strength of hunting preferences across individuals. Both of these consumer taste proxies are expected to be positively related to V_j. For example, two individual duck hunters may be similar with respect to bag, days hunted and income, but if one of the hunters incurs much higher activity-associated expenditures, it is posited that this individual has a relatively higher seasonal consumer surplus. Similarly, the a priori expectation is that hunting tenure will directly affect the respondent's consumer surplus. In this study this potential relationship between preference strength and WTP is examined using a dummy variable reflecting the binary response to the question: "Have you ever hunted before the 1975 season?" (Appendix A, question 8a). Previous studies have had interval measures available (see USFWS 1977).

Income is expected to be negatively related to big game hunting consumer surplus based on the hypothesis that individuals will attempt to increase the purchasing power of their incomes through a big game bag. This hypothesis was founded on the statistical relationship between the tendency to hunt big game and the reasons for hunting

(Appendix A, question 9, tables 6 and 7). The actual measure of income is hypothesized to be partially responsible for the negative income coefficient because it is truncated at $35,000; any positive effect due to wealthier hunters who do not need to augment food supplies may be lost.

Par contre, it is expected that income will be positively related to individual consumer surplus accruing through upland bird and waterfowl hunting activities. The relationship between the reason for hunting and participation in these two activities was more consistent with display of hunting skills and non-consumptive aspects of the hunting experience (tables 6 and 7; see also Arthur and Wilson, 1979). Thus, on the assumption that income acts as a constraint on the individual's WTP, then *ceteris paribus*, the greater the gross household income, the higher the consumer surplus generated by the activity.[2]

Substitute hunting activities (S_j) were included via a measure of WTP per day of the other two hunting activities. For example, the measure of the substitute for big game hunting is the sum of daily WTP values for upland bird and for waterfowl hunting. Brown and Charbonneau (1978) note that the inclusion of such proxy variables to capture the effect of alternatives may introduce a degree of simultaneous equation bias into the system. The estimated coefficients could be biased if the random error terms u_1 and u_2 were correlated via their associations with the S_j coefficient. A proclivity of respondents to overstate or understate WTP could foster such a correlation.

D_j is the number of days hunters engaged in activity j during the 1975 season, and B_j is the seasonal bag. B_j/D_j is an interaction term representing seasonal bag per day of activity j. All of these variables are expected to have a positive influence on seasonal consumer surplus.

Marginal values for an additional day or bag are obtained by differentiating equations (4) and (5). The marginal value of an additional day is equal to $\hat{\beta}_5\overline{V}_j/\overline{D}_j$, where $\hat{\beta}_5$ is the estimated coefficient of D_j, and $\overline{V}_j$ and $\overline{D}_j$ are geometric means.[3] The day variable in B_j/D_j is not included in the calculation because its role in equation (4) is that only of a quality proxy. The marginal value of an additional bagged animal is equal to $\hat{\beta}_{12}\overline{V}_j/\overline{B}_j$ from equation (5), where $\hat{\beta}_{12}$ is the estimated coefficient of B_j, and $\overline{V}_j$ and $\overline{B}_j$ are again geometric means.

The value of an additional day of activity j is the partial derivative of (4) with respect to days or $\partial V_j/\partial D_j$. This is a marginal value for a day of constant quality because B_j/D_j is held constant in the differentiation of (4). The value of an additional season's bag is obtained by differentiating equation (5) with respect to bag, or $\partial V_j/\partial B_j$. However, this differentiation gives the change in consumer surplus from an additional unit of bagged game but without days or bag/day constant. Thus, additional seasonal bag can be the product of increased activity days, higher bag per day, or a combination of both.

Willingness to Sell

A major theoretical constraint of the WTP measures of consumer surplus is the limitation of the respondent's income level on his declared WTP. Mathews and Brown (1970), Hébert (1978), and Bishop and Heberlein (1979) have attempted to remove this constraint by estimating consumer surplus from the obverse side, by estimating WTS (see Dwyer et al. 1977 for a discussion of the relationship between WTP and WTS as consumer surplus measures).

The 1975 Survey also asked the sample hunters to indicate how much money they would have to be paid not to hunt in Alberta for one complete season (Appendix A, question 17). The stated willingness to sell the right to hunt was not subdivided into three hunting activities, making direct comparisons between the WTS and WTP measures difficult. As there were very few hunters who engaged solely in one of the hunting activities in 1975, only aggregate measures of WTS could be estimated. These aggregate WTS measures were assumed to be functions of the same factors as were WTP measures (equations 4 and 5):

$$SV_j = f_3(T, C_j, Y, S_j, D_j, B_j/D_j) \quad (6)$$

$$SV_j = f_4(T, C_j, Y, S_j, B_j) \quad (7)$$

where SV_j is the WTS consumer surplus for participants in activity j and the reamaining variables are defined as for equations (2) and (3). To determine marginal values from WTS measures equations (6) and (7) are estimated with OLS procedures and a double log functional form, yielding equations similar to (4) and (5).

b Indirect Valuation Method

The third procedure used to valuate Alberta's hunting activities is fundamentally different from the previous two in that a market is simulated using actual expenditure data. This indirect valuation method is based on household production theory or the hedonic approach (see Chapter IV). The methodology employed in this study is derived from the hedonic approach developed by Rosen (1974) and applied by Brown (1978) and Brown, Charbonneau and Hay (1978).[4]

As in the WTP and WTS procedures, the hedonic model is used to determine values for each hunting activity individually. The first step is to estimate a total expenditure function for each of the three hunting activities.

$$E_j = f(D_j, DS_j, B_j, BS_j) \qquad (8)$$

where,

E_j is the total seasonal expenditures on ALL hunting by individuals participating in activity j;

D_j is the number of days each individual participated in activity j in 1975;

B_j is the season bag in activity j;

DS_j is the days of hunting in the two activities other than j, 1975; and

BS_j is the bag from the two alternative activities.

The dependent variable in the equation (E_j) is the sum of the respondent's total 1975 season expenditures including an imputed measure of the opportunity cost for the time the individual is engaged in hunting activities. The seasonal opportunity cost is approximated for each individual in this study using 35 percent of gross household income per day, multiplied by the total number of days the particular individual hunted (see Brown, Charbonneau, and Hay, 1978).[5]

This equation was estimated using a double log functional form:

$$LnE_j = \beta_0 + \beta_1 LnD_j + \beta_2 LnDS_j + \beta_3 LnB_j + \beta_4 LnBS_j + u \quad (9)$$

where u is an error term.

The estimated expenditure equation is used to calculate the hedonic prices. Implicit prices for the big game hunting characteristics, for example, are derived by differentiating equation (9) with respect to each independent variable. Due to the nonlinearity of the expenditure function, each individual will have a peculiar set of implicit prices. The implicit prices for each hunting activity are defined as:

$$\partial E_j / \partial D_j = P_d^j \quad (10)$$

$$\partial E_j / \partial B_j = P_b^j \quad (11)$$

where,

P_d^j = implicit price of the jth type (activity) of day, and

P_b^j = implicit price of the jth activity bag.

Implicit prices are estimated in a similar fashion for bag, for days and bag in alternate hunting activities and for waterfowl and upland bird hunting.[6]

The second step is to use the calculated implicit prices and other specific explanatory variables to construct a system of individual demand functions. The other independent variables included as demand shifters in this study were income, previous participation in Alberta hunting (strength of preference proxy), and the individual's rating of the particular type of hunting being examined (included as a quality proxy; Appendix A, question 13). The system of demand equations constructed for big game hunting included the following:

$$LnD_{bg} = \alpha_{10} + \alpha_{11}LnP_{dbg} + \alpha_{12}LnP_{doth} + \alpha_{13}LnP_{bbg} + \alpha_{14}LnP_{both} + \alpha_{15}LnZ + u_1 \quad (12)$$

$$LnD_{oth} = \alpha_{20} + \alpha_{21}LnP_{dbg} + \alpha_{22}LnP_{doth} + \alpha_{23}LnP_{bbg} + \alpha_{24}LnP_{both} + \alpha_{25}LnZ + u_2 \quad (13)$$

$$LnB_{oth} = \alpha_{30} + \alpha_{31}LnP_{dbg} + \alpha_{32}LnP_{doth} + \alpha_{33}LnP_{bbg} + \alpha_{34}LnP_{both} + \alpha_{35}LnZ + u_3 \quad (14)$$

$$LnB_{bg} = \alpha_{40} + \alpha_{41}LnP_{dbg} + \alpha_{42}LnP_{doth} + \alpha_{43}LnP_{bbg} + \alpha_{44}LnP_{both} + \alpha_{45}LnZ + u_4 \quad (15)$$

where,

bg = big game hunting,

oth = the other two hunting activities,

D_{bg} = days of big game hunting in 1975,

B_{bg} = bag of big game in 1975,

P_{dbg} = the price of a day of big game hunting,

Z = other socioeconomic demand shifters (e.g., income, education, hunting experience), and

u_i = stochastic disturbance terms.

Similar sets of equations are estimated for those individuals who participated in waterfowl hunting and in upland bird hunting.

rating of the particular type of hunting being examined (included as a quality proxy; Appendix A, question 13). The system of demand equations constructed for big game hunting included the following:

$$D_{bg} = \alpha_{10} + \alpha_{11}P_{dbg} + \alpha_{12}P_{doth} + \alpha_{13}P_{bbg} + \alpha_{14}P_{both} + \alpha_{15}Z + u_1 \quad (12)$$

$$D_{oth} = \alpha_{20} + \alpha_{21}P_{dbg} + \alpha_{22}P_{doth} + \alpha_{23}P_{bbg} + \alpha_{24}P_{both} + \alpha_{25}Z + u_2 \quad (13)$$

$$B_{oth} = \alpha_{30} + \alpha_{31}P_{dbg} + \alpha_{32}P_{doth} + \alpha_{33}P_{bbg} + \alpha_{34}P_{both} + \alpha_{35}Z + u_3 \quad (14)$$

$$B_{bg} = \alpha_{40} + \alpha_{41}P_{dbg} + \alpha_{42}P_{doth} + \alpha_{43}P_{bbg} + \alpha_{44}P_{both} + \alpha_{45}Z + u_4 \quad (15)$$

where,

bg is big game,

oth is other hunting (i.e., upland bird and waterfowl in the big game example),

D_{bg} is days of big game hunting in 1975,

B_{bg} is bag of big game,

P_{dbg} is the price of a day of big game hunting,

Z represents other socioeconomic demand shifters, and

u_i are stochastic disturbance terms.

Similar sets of equations are estimated for those individuals who participated in waterfowl hunting and in upland bird hunting.

Due to the restrictions imposed to satisfy integrability conditions, equations (12) through (15) are related and cannot be estimated separately. The estimation procedure used is outlined in Pindyck and Rubinfeld (1976, pp. 302 - 304) and is basically the application of generalized least squares estimation to a group of seemingly unrelated regressions (SUR). Johnston (1972, pp. 238 - 241) discussed the potential for grouping the demand equations for a number of consumption goods when the set of independent variables is not constant across commodities and when at least two of the equations are related through nonzero covariances among the stochastic error terms.[7] When these conditions exist, the generalized least squares estimators proposed by Zellner (1962) will be consistent and statistically more efficient than those developed using the application of OLS to each equation individually.[8]

The Zellner estimation of the seemingly unrelated system of demand equations can be generalized in matrix form as in equation (16), again using big game as an example (cf. Pindyck and Rubinfeld, p. 302).

$$\begin{bmatrix} D_{bg} \\ D_{oth} \\ B_{oth} \\ B_{bg} \end{bmatrix} = \begin{bmatrix} X_{1i} & 0 & 0 & 0 \\ 0 & X_{2i} & 0 & 0 \\ 0 & 0 & X_{3i} & 0 \\ 0 & 0 & 0 & X_{4i} \end{bmatrix} \begin{bmatrix} \alpha_{1i} \\ \alpha_{2i} \\ \alpha_{3i} \\ \alpha_{4i} \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{bmatrix} \qquad (16)$$

The X_{ki} are row vectors of the explanatory variables. The α_{ki} are the estimated regression coefficients and the U_k are stochastic error terms.

Economic theory suggests that the rational hunter-consumer does not suffer from money illusion, that the hunter will not change his pattern of purchases when income and prices change by the same percentage rate, ϕ. The rational consumer will rearrange his consumption bundle in response to changes in relative prices. This *a priori* information implies that if the demand for big game hunting, for example, is expressed as a function of its own day and bag prices, cross day and bag prices, and certain other socioeconomic variables (Z), in double log form

$$D_{bg} = a_0 P_{bg}^{a_{11}} \cdot P_{oth}^{a_{12}} \cdot B_{bg}^{a_{13}} \cdot B_{oth}^{a_{14}} \cdot Z^{a_{15}} \cdot u_1, \quad (17)$$

the sum of the coefficients of the variables must equal zero. Thus, the restriction is imposed on equations (12) to (15) that the values of the elasticities sum to zero, i.e., $\sum_{i=1}^{5} a_{ki} = 0$.

The symmetry conditions imposed by the above added constraint also ensure that the integrability conditions are honored. The observance of this condition is required to retain conceptual consistency with the expenditure function, which is defined as a locus of equilibrium points based on individual demand (or WTP) and supply (or MC) curves. These equilibrium points necessarily imply that:

$$\partial P_h^k / \partial D_j = \partial P_h^j / \partial D_k \quad (18)$$

and

$$\partial P_h^k / \partial B_j = \partial P_h^j / \partial B_k \quad (19)$$

for all k, j, where k and j are big game, upland bird, and waterfowl hunting, and h = D if days and B if bag. Equations (18) and (19) accommodate the assumed rational behaviour of individual hunters.

Marginal values (MV) are calculated using equation (20).

$$MV_{Dj} = -\hat{\beta}_1 \overline{E}_j / \hat{\alpha}_{11} \overline{D}_j \quad (20)$$

where,

$\hat{\beta}_1$ is the estimated coefficient of D_j from the double log expenditure function for activity j,

$\hat{\alpha}_{11}$ is the estimated coefficient of P_{D_j} from the double log, simultaneous demand equations for activity j, and

$\bar{E}_j$ and $\bar{D}_j$ are geometric means of expenditures and days of hunting in activity j, respectively.

Marginal values for incremental bag are calculated accordingly.

Footnotes

1. The respondent's age as a preference intensity proxy was also tested, but this proxy inherently assumes that hunters begin participating in hunting at approximately the same age (Appendix A, question 2).

2. The survey suffered from the standard difficulty associated with the use of income brackets to gather income data in that the analyst is left with an integer system which can mask potential statistical relationships (due to range and magnitude insufficiency). It is also possible that the termination of the brackets at "greater than $35,000" attenuates positive relationships between V and income.

3. The logarithm of the geometric mean of a set of positive numbers is the arithmetic mean of logarithms of the numbers. M. R. Spiegel, <u>Theory and Problems of Statistics</u>. Schaum's Outline Series, 1961., p. 60.

4. A more rigorous mathematical summary of the hedonic (implicit pricing) model employed in these two studies of U.S. hunting and fishing is provided in Appendix B.

5. For a discussion of alternative empirical measures of opportunity cost see Cesario (1976), Sorhus, Brown, and Gibbs (1981). The need to include the opportunity cost of transfer time and time of engagement is well recognized by recreation economists. McConnell (1975), for example, suggests that recreationists consider both the foregone earnings and the foregone leisure alternatives in their recreation decisions.

6. Due to the double log estimation procedure, these values can be obtained more directly from the regression coefficients; e.g., for big game hunting $P_D^{bg} = \hat{\beta}_1(E_{bg}/D_{bg})$.

7. In equations (12) to (15) Z varies across equations.

8. The systems of equations were estimated using the Statistical Package for the Social Sciences software program, SPSS-G3SLS.

CHAPTER VII

EMPIRICAL RESULTS AND DISCUSSION

Results of the Direct Valuation Methods

WTP Method

The ordinary least squares (OLS) regression results for the net WTP (i.e., consumer surplus) equations (equations (4) and (5) in Chapter VI) are summarized in table 9. Although the R^2 values for all but one equation are quite low, the F tests of the models are consistently high ($p < .001$), and the t values for individual coefficients, particularly those needed for the marginal valuations are generally significant. Low R^2 values are expected from analyses of socioeconomic survey data (cf. studies cited above).

In most of the regressions the constant is approximately zero[1] and statistically significant at $p < .1$. A constant equal to zero implies that hunter respondents acquire no surplus without any hunting activity. The expenditure variable (C_j) is positive and statistically significant with the exception of the upland bird day equation. The positive cost coefficient supports the posited direct relationship between activity-associated expenditures and the magnitude of seasonal consumer surplus. The income variable is statistically significant ($p < .01$) only for the case of big game hunting. The negative coefficients for the big game regressions support the hypothesis that income is negatively related to big game hunting consumer surplus because

Table 9. The Willingness to Pay for a Hunting Activity Regression Results.[1]

Dependent Variable (V_j)	Constant	C_j[2]	Y	S_j	D_j	B_j/D_j	B_j	R^2	N
V_{bg}	-3.389 (2.299)	1.999*** (.599)	-2.143** (.722)	-0.827 (.039)	2.118*** (.342)	0.133* (.059)	---	.196	209
V_{bg}	-3.356$^{\Delta}$ (1.921)	1.989*** (.337)	-2.136*** (.657)	-0.008 (.039)	---	---	0.133* (.058)	.196	209
V_{ub}	-1.968 (2.444)	0.352 (.707)	0.942 (1.084)	0.116 (.094)	1.911*** (.445)	0.379*** (.091)	---	.547	100
V'_{ub}	-4.169* (1.986)	1.233** (.411)	0.355 (1.021)	0.120 (.094)	---	---	0.374*** (.091)	.282	100
V_{wf}	-3.999* (2.067)	0.956$^{\Delta}$ (.584)	-0.205 (.745)	0.045 (.043)	2.517*** (.313)	0.115 (.092)	---	.256	222
V_{wf}	-7.232*** (1.642)	2.175*** (.331)	-0.970 (.689)	0.053 (.043)	---	---	0.142 (.092)	.235	222

1. The variables are as defined in equations (2) and (3) of Chapter VI.

2. Expenditures are on a per day basis for equations including the variable D_j to reduce multicolinearity.

Δ, *, **, *** = $p < .1$, $p < .05$, $p < .01$ and $p < .001$ respectively.

individuals attempt to increase the purchasing power of their incomes through a big game bag (cf. Chapters V and VI).

As predicted, hunter days actively engaged (D_j) has a significant, positive affect on seasonal consumer surplus. This finding suggests that the magnitude of consumer surplus accruing to an active hunter is directly related to the number of days "consumed" during the hunting season.

The coefficient of the seasonal bag variable is positive and statistically significant with the exception of the regression for waterfowl hunting, suggesting that in most cases the capture of a bag unit directly contributes to the hunter-participant's consumer surplus. A possible explanation for the nonsignificance of bag to waterfowl hunters' consumer surplus is that the mean seasonal bag for this type of hunting is greater than for the other two types of hunting (see table 5). Examination of the data reveals that only thirty-one active waterfowl hunters did not bag at least one bird, and the mean across all waterfowl hunters was 10.91 birds, compared to 0.23 big game and 2.23 upland birds.

A seasonal bag per day of active hunting interaction term, B_j/D_j, is included in the consumer surplus regressions for valuating days in an attempt to incorporate a quality or success measure.[2] This quality proxy is positive and statistically significant for big game and upland bird hunting types, but was not significant for waterfowl hunting. These findings also support the contention that acquiring a bag directly contributes to a hunter's consumer surplus. The relatively high bag rates among waterfowl hunters is again a possible explanation for the nonsignificance of the success measure.

Total WTP for alternative hunting activities (S_j) was included in the regressions to test whether the non-j activities were positively or negatively related to the consumer surplus accruing through participation in activity j. The coefficient for substitute "price" proxy employed, the WTP per day for non-j activities, is statistically insignificant in all the regressions. The implication of this result is that the consumer surplus accruing via participation in activity j is unaffected by the consumer surplus accruing via participation in non-j activities.

In addition to the cost variable two different hunting tenure variables were tested as proxies of consumer taste. The age of the hunter was included in early regressions but was consistently insignificant. In the final equations the age tenure proxy was omitted both because it lacked explanatory power and because to employ it necessitated the unreasonable implicit assumption that all hunters begin hunting at the same age. A second hunter tenure proxy was a dummy variable reflecting the binary response to the survey question on active hunting prior to 1975 (Appendix A, question 8a). This attempt proved statistically untenable; because only 20 respondents had not hunted prior to 1975, there was insufficient variation.

Average and marginal consumer surplus values per day and bag for each of the three types of hunting were calculated using the WTP regression results (see table 10). The average consumer surplus for a hunting day was greatest for big game ($7.08) and lowest for waterfowl ($3.65). The average consumer surplus attributable to a bag unit was also highest for big game ($21,041.50) and lowest for waterfowl ($2.37). Upland bird hunting generated per day and bag surpluses of

Table 10. Hunting Activity Consumer Surplus Estimates Based on Willingness to Pay Regression Results.

Hunting Activity	Average Valuation[1]		Marginal Valuation[2]	
	Day	Bag	Day	Bag
Big Game[3]	$7.08	$21,041.50	$14.99	$2,802.73
Upland Bird	3.73	13.20	7.13	4.94
Waterfowl	3.65	2.37	9.19	0.34

1. Calculated using $\overline{V}_j/\overline{D}_j$ or $\overline{V}_j/\overline{B}_j$ where, these values are derived from the regression sample. Geometric means are employed.

2. Calculated using $\hat{\beta}_{kj}$ $(\overline{V}_j/\overline{D}_j)$ or $\hat{\beta}_{kj}$ $(\overline{V}_j/\overline{B}_j)$ where, $\hat{\beta}_{kj}$ is the estimated coefficient for D_j or B_j. Geometric means are employed.

3. In the case of big game the estimates may be affected by the low success rate, short season, and limit of one bagged animal.

$3.73 and $13.20, respectively. The mean value per bag of big game is much higher than for the other types of hunting primarily because approximately 80 percent of active big game hunters did not attain a big game bag in 1975.[3]

The marginal or incremental valuation estimates (i.e., the consumer surplus associated with an additional day or unit bag) are outlined in table 10. The marginal consumer surplus accruing from an additional activity day is greatest for big game ($14.99) and lowest for upland bird ($7.13). The marginal value of consumer surplus for an additional bag unit is also greatest for big game ($2,802.73), but it is lowest for waterfowl (again reflecting the high bag rate among waterfowl hunters).

WTS Method

To accommodate the analysis within the data limitations imposed by the ambiguity inherent to the WTS responses (cf. Chapter VI), two sets of regressions were used. The first used the entire WTS estimate (as a net measure), and the second used WTS as a gross figure, deriving consumer surplus only after actual expenditures were deducted from the gross WTS.

A further complication in the WTS analysis arose because survey participants were asked only for their estimates of the compensation required for foregoing all hunting for one year. In order to analyze these data by type of hunting it was necessary to create three subsamples. The data limited this disaggregation to establishing the set of j-type hunters solely by eliminating all hunters who did not participate in activity j, the result being that the WTS response within any subsample is generally an estimate for more than just type-j hunting.

The OLS regression results for the gross WTS and the net WTS equations (equations 6 and 7 in Chapter VI) are summarized in Appendix D, tables D.1 and D.2, respectively. The R^2 values are extremely low, but the F tests for the models without expenditure adjustments are consistently high ($p < .01$) and the t values for the coefficients needed in the marginal valuations are significant. One major exception is that the coefficient for the bag variable in the net WTS equations is never significant.

Reducing the WTS responses to net WTS by removing expenditures introduces a conceptual difficulty because many respondents spent more on hunting than they required in compensation for not hunting. This apparantly irrational behavior[4] (i.e., a negative consumer surplus) could not be accommodated either theoretically or statistically (due to the double log regression form) and necessitated removal of the negative surplus cases. This case removal greatly reduces the sample size (see the N values in tables D.1 and D.2) and inflates the geometric mean consumer surplus (SV_j), which consequently inflates the valuation estimates (see table D.3). The gross WTS results (table D.1), par contre, are reasonably compatible with the WTP results in table 9 (see also tables 10 and D.3).

Results of the Indirect Valuation Method

Expenditure Functions

The OLS regression results for the total expenditure functions for each of the three hunting activities (equation 8 in Chapter VI) are summarized in table 11. The R^2 values are high (for socioeconomic data), as are the F tests of the models ($p < .001$). While the total expenditure equations were estimated primarily for purposes of deriving hedonic prices for the demand estimations, some of the results provide interesting insights into the data base and hunting patterns.[5]

In each regression the constant is large (particularly when antilogged), positive and highly significant, suggesting that some expenditures may be independent of any bag or active days. The number of days in activity j participation (D_j) has the expected positive effect on E_j and the estimated coefficients are all statistically significant; that is, the magnitude of hunting expenditures is directly related to the degree of hunting comsumption (measured in terms of active days). Because the dependent variable E_j includes expenditures for all hunting by participants in activity j, and most hunters tend to participate in more than one activity, it is not surprising that expenditures on hunting activity j are also positively related to the number of days engaged in non-j activities; the days of hunting in the two activities other than j, variable DS_j, consistently has a positive and highly significant coefficient.

The season bag variable (B_j) is only statistically significant for waterfowl hunting, where it is positively related to E_{wf}. As noted above, waterfowl hunters were relatively more likely to acquire a bag than hunters in other activities. The waterfowl bag rate is high enough to suggest that to hunt waterfowl is to bag waterfowl. If participation is a necessary and almost sufficient condition for a waterfowl bag and if participation is directly related to expenditures, then bag and expenditures are also positively related; the more one participates in waterfowl hunting, the more waterfowl are bagged. Alternatively, the B_{bg} and B_{ub} coefficients are not significant due to the lack of statistical variation; the likelihood of a bag on any given trip was much lower for big game and upland bird hunters.

The bag from the two alternative hunting activities (BS_j) is only significant and positive for big game expenditures. This relationship reflects the observation that many big game hunters were also active in upland bird and waterfowl hunting (recall that E_{bg} includes expenditures for upland bird and waterfowl hunting). The inclusion of the low variance big game bag in the BS_j measures used in the upland bird regressions likely attenuated the affects of waterfowl bag.

In an attempt to further examine the effect of the two bag variables on expenditures, a dummy variable was included in the regressions. The dummy variable for E_j was based on whether or not the hunter had any bag in activity j (1 if bag, 0 if no bag). Inclusion of a binary variable based on bag capture was not a useful addition to the E_{bg} regression because approximately 99 percent of those big game hunters making a bag made only a single big game bag. As a consequence, a dummy variable for bag would be almost perfectly colinear with the quantity of bag variable. Par contre, inclusion of the intercept shifter did improve the B_{ub} estimate--although still not to a level of statistical significance--and the B_{wf} coefficient was improved to statistical significance.

Demand Equations

Using the regression results from table 11, a set of implicit prices for the hunting characteristics--P_{dj}, P_{doth}, P_{bj}, and P_{both}--

Table 11. Regression Results for the Total Expenditure Functions.[1]

Dependent Variable	Constant	D_j	DS_j	B_j	BS_j	DUM_j	R^2	N
E_{bg}	4.944*** (.101)	0.653*** (.045)	0.059*** (.015)	0.011 (.008)	0.032** (.014)	---	.587	307
E_{ub}	5.995*** (.744)	0.431*** (.079)	0.161*** (.020)	0.098 (.078)	0.018 (.014)	-0.966 (.823)	.586	171
E_{wf}	6.107*** (.563)	0.596*** (.067)	0.102*** (.013)	0.128* (.055)	0.019 (.013)	-1.378* (.638)	.521	328

1. The variables are as defined in equation (8) in Chapter VI.

j = type of hunting activity indicated by dependent variable.

*, **, *** = $p < .05$, $p < .01$ and $p < .001$ respectively.

are calculated in accordance with equations (10) and (11) in Chapter VI. A computer subroutine was employed to perform these calculations because the implicit prices are peculiar to each individual hunter included in the sample. The derived implicit prices are then used to construct a system of demand equations for each of the three types of hunting (see equations 12 through 15 in Chapter VI).

The three systems of demand equations were run as seemingly unrelated regressions (SUR) with the imposed constraint that the values of the coefficients sum to zero, i.e., $\sum_{i=1}^{5} \alpha ki = 0$. The statistical significance of imposing this restriction was examined with an F-test. In the big game demand equations system the unrestricted SUR coefficients are significantly different from $\Sigma \alpha = 0$ ($p < .025$). In the upland bird and waterfowl systems, on the other hand, the sums of the unrestricted coefficients are not significantly different from zero. Because the big game regression equations system requires implementation of the restriction and in order to maintain conformability, all the SUR systems are presented here with the restriction imposed. However, Appendix E contains summary tables for each system of regression equations performed as unrestricted OLS, unrestricted SUR, restricted OLS and restricted SUR.

The results from the restricted SUR systems are reported in tables 12, 13, and 14 for big game, upland bird and waterfowl respectively. Among the various socioeconomic variables included in the regressions (i.e., the Z variables) only the income variable (Y) is significant and consistently positive.[6] This result suggests the demand for hunting days and bag are both directly related to hunters' incomes, indicating a positive income elasticity of demand.

Table 12. Restricted Seemingly Unrelated Regression Results for Big Game Hunting.[1]

Equation Number	Dependent Variable	Constant	P_{dbg}	P_{doth}	P_{bbg}	P_{both}	Z Variables: Y	Z Variables: Age	Z Variables: Rating	Z Variables: Family Size
1	D_{bg}	2.295*** (.200)	-.433*** (.089)	-.015 (.021)	-.003 (.012)	.029^ (.019)	.416*** (.089)	.005 (.018)	-6.47E-6 (.006)	2.13E-5 (.002)
2	D_{oth}	-.106 (.200)	.567*** (.089)	-1.015*** (.021)	-.003 (.012)	.029^ (.019)	.416*** (.089)	.005 (.017)	---	2.32E-5 (.002)
3	B_{oth}	-.729*** (.199)	.568*** (.089)	-.015 (.021)	-.003 (.012)	-.971*** (.019)	.420*** (.089)	---	---	---
4	B_{bg}	-1.826*** (.199)	.567*** (.089)	-.015 (.021)	-1.003*** (0.12)	.029^ (.019)	.416*** (.089)	.005 (.016)	---	---

1. The variables are as defined in equations (12), (13), (14) and (15) in Chapter VI.

$n = 229$.

^, *, **, *** = $p < .1$, $p < .05$, $p < .01$ and $p < .001$ respectively.

Table 13. Restricted Seemingly Unrelated Regression Results for Upland Hunting.[1]

Equation Number	Dependent Variable	Constant	P_{dub}	P_{doth}	P_{bub}	P_{both}	Z Variables: Y	Z Variables: Age	Z Variables: Rating	Z Variables: Family Size
1	D_{ub}	1.216*** (.238)	-.337*** (.129)	-.002 (.028)	.005 (.019)	.001 (.019)	.312* (.137)	.066 (.057)	-.048 (.052)	.002 (.013)
2	D_{oth}	.363Δ (.213)	.660*** (.134)	-1.002*** (.029)	.005 (.020)	.002 (.020)	.322** (.136)	.013 (.031)	---	-1.555E-5 (3.56E-6)
3	B_{oth}	-1.790*** (.208)	.662*** (.136)	-.002 (.029)	.005 (.021)	-.998*** (.020)	.333** (.135)	---	---	---
4	B_{ub}	-.132 (.213)	.660*** (.134)	-.002 (.029)	-.995*** (.020)	.002 (.010)	.320** (.136)	.014 (.031)	---	---

1. The variables are as defined in equations (12), (13), (14) and (15) in Chapter VI.

N = 136.

Δ, *, **, *** = $p < .1$, $p < .05$, $p < .01$ and $p < .001$ respectively.

Table 14. Restricted Seemingly Unrelated Regression Results for Waterfowl Hunting.[1]

Equation Number	Dependent Variable	Constant	P_{dwf}	P_{doth}	P_{bwf}	P_{both}	Z Variables			
							Y	Age	Rating	Family Size
1	D_{wf}	1.873*** (.203)	-.503*** (.101)	.009 (.016)	-.022$^{\Delta}$ (.016)	.027* (.016)	.496*** (.102)	.016 (.030)	-.021 (.032)	-.001 (.008)
2	D_{oth}	.154 (.194)	.496*** (.103)	-.992*** (.012)	-.122$^{\Delta}$ (.016)	.122* (.016)	.491*** (.101)	1.45E-4 (.008)	---	-1.302E-5 (.002)
3	B_{oth}	-1.879*** (.193)	.496*** (.103)	.008 (.015)	-.021$^{\Delta}$ (.016)	-.973*** (.016)	.491*** (.101)	--- ---	--- ---	--- ---
4	B_{wf}	.374* (.194)	.496*** (.103)	.008 (.016)	-1.002*** (.016)	.127* (.016)	.491*** (.101)	1.036E-4 (.006)	---	---

1. The variables are as defined in equations (12), (13), (14) and (15) in Chapter VI.

N = 221

Δ, *, **, *** = p < .1, p < .05, p < .01 and p < .001 respectively.

The coefficients for the own price for days variables, P_{dj} and P_{doth}, are always negative and significant for the day demand equations D_j and D_{oth}. The estimated coefficients for own price for bag, P_{bj} and P_{both}, are also consistently negative and significant for the bag demand equations B_j and B_{oth}. These findings conform with the a priori expectation of a negative substitution effect.

The cross price estimated coefficients are only significant when positive, suggesting a degree of substitutability in bag and days across types of hunting. As the relative price per day or unit of bag increases for hunting activity j, the demand for non-j hunting also increases, as hunters attempt to maximize their utility subject to a budget constraint.

The positive coefficients for own price of a day of activity j in equation 4, tables 12 to 14 are more difficult to interpret. A possible explanation is that the estimated coefficients reflect the positive statistical relationship between total expenditures (from which implicit prices are determined) and success.

Employment of SUR techniques does not provide a ready measure of goodness of fit for the model.[7] However, SUR does provide a meaningful standard error for the estimated coefficients which are essential for this study, and t statistics can be used to test their significance (Pindyck and Rubinfeld 1976).

Estimated marginal values, calculated as outlined in Chapter VI, are presented in table 15 for an additional day and unit of bag for each of the three types of hunting activities. The results indicate that a day of upland bird hunting has the highest marginal value and

Table 15. Incremental Valuations of Hunting Activity Based on the Household Production Function Approach.

Type of Hunting Activity	Marginal Valuation of a Day[1]	Marginal Valuation of a Bag[2]
Big Game	$ 81.97	$1,190.23
Upland Bird	133.79	37.32
Waterfowl	75.37	7.65

1. Calculated using $MV_{Dj} = -\hat{\beta}_1\overline{E}_j/\hat{\alpha}_{11}\overline{D}_j$ where, $\hat{\beta}_1$ is the estimated coefficient of D_j from the total expenditure function (see table 11), $\hat{\alpha}_{11}$ is the estimated coefficient of P_{Dj} from the restricted SUR results (see tables 12, 13 and 14), and $\overline{E}_j$ and $\overline{D}_j$ are geometric means of expenditures and days of hunting.

2. Calculated, mutatis mutandis, using $MV_{B_j} = -\hat{\beta}_3\overline{E}_j/\hat{\alpha}_{43}\overline{D}_j$.

waterfowl hunting the lowest. However, the big game bag had the highest marginal value and, again, waterfowl bag the lowest. A comparison of these indirect marginal values and the direct marginal values to the findings of previous researchers is presented in Chapter VIII below.

Footnotes

1. The constants reported in table 9 are in log form and will be close to zero when the antilogs (e^x) are taken.

2. If the quality proxy is included, the partial derivative of equation (4) in Chapter VI with respect to days is the marginal value for a day of constant quality.

3. Geometric means are employed in the calculations of the average and marginal valuations to account for the extreme skew in the distributions. Per day consumer surplus estimates based on arithmetic means are reported in table 4, Chapter V. In addition, the mean consumer surpluses per unit of bag based on arithmetic means are: $651.83 for big game, $32.23 for upland birds, and $9.98 for waterfowl. The direction and magnitude of the arithmetic mean bias is a function of the nature and degree of skewness in the respective distributions.

4. Clearly, a methodology which results in the conclusion that a large proportion of the respondents acted irrationally is failing to account for some information critical to their decision matrices.

5. Note that the dependent variable (E_i) includes an imputed measure of the opportunity cost for the time the individual engaged in hunting activities (c.f., p. 101).

6. Although the remaining Z variables were highly insignificant, they were included to provide for a statistical requirement. Without some variation among each of the equations included in any system it is not possible to calculate an inverse matrix; when one equation is a multiple of another, the matrix is less than full rank and the determinant vanishes. The models were extremely robust with respect to variations in the Z variables.

7. It is possible to test the SUR models' performances using approximations of R^2 or measures of the error of the predicted dependent variable, but none of these tests was available in the computer package employed (partially because the meaning of the tests is questionable); a substantial financial and time commitment would have been required to perform the tests. As goodness of fit is not critical to this study--prediction using the system of equations is not an objective--and the t values for the variables needed for subsequent analysis are significant, no attempt was made to approximate measures of goodness of fit.

CHAPTER VIII

CONCLUSIONS

A Comparison of Results

A comparison of the marginal valuations presented in tables 10 and 15, and summarized in table 16 reveals marked differences among the estimates from the direct-question and the indirect-hedonic methods. The differences occur even though both sets of values, in theory, measure the net economic value or the consumer surplus accruing via active participation in hunting. This discrepancy may be the product of fundamental differences between the two valuation techniques. As discussed in Chapter III above, survey respondents are confronted with a hypothetical question regarding their WTP or WTS a particular activity. Inherent to any direct approach is the fundamental problem of the respondent's natural inability to respond accurately to a hypothetical, nonmarket situation. The WTS and WTP questions are likely new to the respondents and require an effort expenditure prior to any meaningful subjective estimate. The cost inherent to the provision of an accurate estimate is directly related to a second major difficulty characteristic of the direct approach, the incentives for accurate preference representation. Abstracting from the ability to provide an accurate estimate in response to a situation which the respondent has never faced, rational individuals must perceive some benefit accruing through accuracy to compensate for the costs inherent to accuracy achievement. Unfortunately, providing

Table 16. A Comparison of Recreation Valuation Study Results.

Source, Activity, Location, Year	Valuation Technique	Marginal Value Estimates[1] Days	Bag
		dollars	
Wilson (1981) Hunting, Alberta, 1975.	Mail survey, direct-question (WTP) consumer surplus.	15 big game 7 upland bird 9 waterfowl	2,803 big game 5 upland bird — waterfowl
	Mail survey, indirect, Hedonic consumer surplus.	82 big game 134 upland bird 75 waterfowl	1,190 big game 37 upland bird 8 waterfowl
Bishop and Heberlien (1980) Canada goose hunting, Wisconsin, 1978.	Logit model, (WTS) consumer surplus.	30 per permit[2]	
Brown, Charbonneau and Hay (1978). Hunting, United States, 1975.	Mail survey, direct-question (WTP) consumer surplus.	9 deer 12 upland bird 7 waterfowl	3 upland bird 4 waterfowl
	Mail survey, indirect, Hedonic consumer surplus.	86 deer 94 other big game 32 upland bird 29 waterfowl	18 upland bird 25 waterfowl
Charbonneau and Hay (1978) Waterfowl hunting, United States, 1973	Mail survey, direct-question (WTP) consumer surplus.	23 waterfowl	15 waterfowl

Table 16. A Comparison of Recreation Valuation Study Results (cont.).

Source, Activity, Location, Year	Valuation Method	Marginal Value Estimates[1]	
		Days	Bag
		dollars	
Gum and Martin (1975) Various activities, Arizona, 1975.	Mail survey, Travel cost (WTP) consumer surplus.	53 per deer trip 57 per other big game trip 10 per waterfowl trip.	
Hammack and Brown (1974) Waterfowl hunting, Pacific flyway, 1969.	Mail survey, direct-question (WTP) consumer surplus.	21 waterfowl	7 waterfowl
Brown, Nawas and Stevens (1973) Big Game hunting,[3] Oregon, 1968.	Mail survey, Travel Cost (WTP) consumer surplus.	5 big game	62 big game
Water Resources Council (1973) All outdoor recreation, United States.	Unknown.	1-2 general 3-9 specialized	

1. The marginal value estimates are rounded off to the nearest dollar value. The Wilson result for a bag of waterfowl was $.34.

2. The permit was valid for the period October 1 - 15, 1978.

3. Included in the category of big game were deer and elk.

incentive for accurate preference revelation often simultaneously creates incentives for preference misrepresentation.

Alternatively, the indirect hedonic technique is based on the actual reported expenditures (and imputed costs of time) of individual hunter-respondents. The method inherently assumes that individual hunters have optimized their consumption bundles, including hunting expenditures, across all possible alternatives and subject to their finite income levels. Although there are shortcomings with the hedonic approach--for example, the data are gathered with a post-season user survey and serious identification and bias problems in estimation exist--the approach is held to be an improvement over the direct WTP method. For a discussion of additional limitations to the hedonic approach see Chapter IV.

Table 16 presents a summary of the estimates of hunting values from this and previous studies. It is difficult to make any definitive comparisons across the various studies because the methodologies, activities, regions, and time periods differ. However, a comparison of the relative magnitudes suggests that the values for an activity day are generally consistent with values found using similar methods, but the big game bag values were much higher than anticipated based on other (albeit non-hedonic) studies. The big game bag values found in this study may have an upward bias due to the low success level, multiple hunting activities on a single trip, and the one unit bag limit. However, actual payments by hunters for "guaranteed bags" of big game animals in some regions of the U.S. and for the right to hunt on private lands in England suggest the hedonic values estimated may indeed reflect willingness to pay.

The differences among the results reported in table 16 also suggest a high degree of sensitivity to the estimation technique employed. This sensitivity is further illustrated by the divergent results generated in this study using various valuation techniques but a basically constant data sample. The hedonic values are consistently higher, perhaps due to the estimation problems noted above.[1] Alternatively, direct methods may understate true WTP. Travel cost methods (which avoid many of the estimation problems of hedonic methods; see Bockstael and McConnell 1975) yield results similar to those of hedonic methods. Additional work is required but the results of this study in combination with the empirical work by Bishop and Heberlein (1980)[2] suggest that direct question techniques may be subject to preference representation problems. Techniques that afford an alternative or attempt to induce an accurate response warrant further investigation and resource expenditure.

The models employed in this study proved to be statistically acceptable (given the data limitations, which prevent solution of identification problems in the hedonic models) and robust. The direct WTP model produced low R^2 values, but F tests for the models were statistically significant, supporting the hypothesis that the models fit the data (i.e., the models explain a significant amount of the data variation).[3] The coefficients (particularly those coefficients required in the marginal valuation calculations) were statistically significant and had signs conforming with theoretical prediction. The indirect hedonic approach produced relatively high R^2 values and highly significant F statistics. More importantly, the t values for the coefficients were generally significant. However, the bag coefficient was not always significant across all types of hunting, likely due to a low degree of statistical variation in the bag variable. This lack of variation was particularly pronounced for big game hunting. The restricted SUR demand equation systems provided coefficients which were generally significant for the basic variables and for income. Own price coefficients were negative, as expected, and cross-price coefficients positive (when significant), suggesting a degree of substitutability among the types of hunting examined here. The models produced robust coefficient estimates.

The WTS modelling was limited by an inability to determine whether responses were gross or net WTS and by the low sample size for any one exclusive type of hunting. Attempts were made to circumvent these difficulties by utilizing the responses in one instance as gross values and then as net values. To provide a meaningful sample size it was necessary to eliminate only non-j hunters from the j subsample (while j hunters may also have participated in non-j activities). With these modifications the WTS models produced very low R^2 values, high F statistics, and generally significant coefficients with the expected signs. Marginal values derived from WTS measures (table D.3) were reasonably similar to marginal values based on WTP measures (table 16).

Valuation Estimates and Policy Making

Determination of optimal stock levels and the associated optimal harvesting rates are of major importance in wildlife management. Meaningful policies involving changes in wildlife populations via investment or harvest changes will require accurate wildlife valuations.

Wildlife habitat and populations will be increasingly involved in allocative decisions and decisions involving mutually exclusive spatial use patterns.

The marginal valuations developed in this study provide public decision makers with a means to assess the effects of environmental changes on hunters' welfare. Such changes might involve a change in resource utilization which affects wildlife habitat (e.g., irrigation expansion, reducing waterfowl habitat), or changes in the hunting institutional framework or public expenditures designed to improve and expand wildlife stocks. A decision to reduce the duck hunting season, for instance, will foster a reduction in the volume of active hunting days (both in terms of the number of hunters and days per hunter) and the number of waterfowl bagged. A conservative estimate of the welfare loss to the hunting population would be the product of total hunting days foregone and the marginal value of a hunting day or the product of the reduced bag and the marginal value of a bagged animal.

Welfare loss estimates generated as above would be conservative because the downward sloping demand curve implies a negative relationship between the WTP (i.e., the demand curve) and quantity. Also, the marginal valuations calculated in this study do not include existence value, option value (with the exception of the license fee expenditures by inactive hunters), the value placed on Alberta's wildlife by nonresidents, and nonconsumptive values.

Recommendations

A useful extension of this study would be to develop participation equations to actually evaluate the effects on hunting of various changes in habitat, wildlife populations, season, and other supply related variables. Basically the procedure involves estimating probability, participation, and success equations based on a behavioral model. The forecasts for numbers of participants, days active, and bag obtained are then combined with the marginal valuation estimates.[4]

Additional work is required on the empirical measurement of the opportunity cost of time. Study of the sensitivity of value estimates to imputed costs of time by comparing the values derived with and without an opportunity cost adjustment and with various adjustment magnitudes indicates that the time factor is important (Brown, Charbonneau and Hay 1979, Sorhus and Brown 1981, Sutherland 1981). It might prove useful to attempt to elicit from survey participants information concerning whether their hunting activity is on weekends, paid vacation time, or perhaps on work days without pay. Such information would enable a more accurate determination of the respondents' opportunity costs of time.

Further exploration of the time factor by arbitrarily varying the imputed value by trial and error "curve fitting" is of questionable benefit. Substantial work of this type has already been completed and, as expected, the "best" estimate varies with the data set. The value used in this study is somewhat ad hoc in that the proportion is constant across individuals, but the absolute value varies with the individual's income. The fixed proportion selected was based on findings of others (see footnote 5, Chapter VI).

Hedonic estimation techniques would be strengthened by producing a data set on a greater range of characteristics of the activities being examined. In this study the inclusion in the analysis of substitute day and bag variables provided much additional information. It would be preferable if demand and supply functions could be specified and estimated simultaneously, thereby removing the problems of identification and simultaneous equation bias.

This study retained in the analysis those hunters without a success to avoid understating expenditure levels, thereby hopefully producing more accurate marginal valuations. However, further work on the statistical effects of retention of these cases and comparative results is desirable.

Finally, it should be noted that if hunting characteristics such as bag were not actually produced by the household, but determined by the site, many of the hedonic estimation problems could be circumvented. Unfortunately, quantity (days) and quality (bag) are often interdependent. Perhaps a means will be developed to test assumptions regarding the exogenous nature of quality characteristics (see footnote 5, Chapter IV). Many of the big game hunters in the sample used in this study would likely agree that bag (success) was exogenously determined.

Footnotes

1. Including an imputed measure of the opportunity cost for the time an individual engaged in hunting activities should produce increased marginal value estimates relative to estimates without an imputed time cost. Charbonneau and Hay (1978) tested the sensitivity of estimated hunting and fishing values to the inclusion of an opportunity cost measure. Their results showed that including the opportunity cost increased the incremental values significantly. Thus, economic theory suggests the need to include time costs and empirical analysis has illustrated the downward bias of activity value estimates resulting from time cost omission.

2. For a discussion see Chapter III. Bishop and Heberlein found marked differences in stated WTS values and actual selling behavior when dollars were exchanged for hunting rights.

3. Low R^2 values are typical for nonaggregated, cross-sectional socioeconomic data. See, for example, Cicchetti and Smith (1973), Hammack and Brown (1974), McConnell (1977), and Cocheba and Langford (1978).

4. Participation equations are generally used to test hypotheses about determinants of participation and to forecast numbers of participants and days of activity. For a detailed discussion and an applied example, respectively, see the following: C. Cicchetti, Forecasting Recreation in the United States. Lexington Books, 1973. J. Miller and J. Hay. "The Determinants of Hunter Participation: A Study of Migratory Waterfowl." American Journal of Agricultural Economics (Vol. 63, No. 4, Nov. 1981) 677-684.

REFERENCES

ANDERSON, J. "A Theoretical Foundation for the Gravity Equation." American Economic Review 69 (1, March 1969) 106-116.

ARROW, K. "A Difficulty in the Concept of Social Welfare." In K. Arrow and T. Scitovsky (eds). Readings in Welfare Economics. Homewood, Ill.: Richard D. Irwin, Inc., 1969.

ARTHUR, L.M. "Predicting Scenic Beauty of Forest Environments: Some Empirical Tests." Forest Science 23 (2, June 1977) 151-159.

ARTHUR, L.M. Attitudes Toward Wildlife Management: A Study of Hunters and Fishermen in the U.S. The U.S. Fish and Wildlife Service, Working Paper Number 10, 1978. 105 pp.

ARTHUR, L.M. and W.R. WILSON. "Assessing the Demand for Wildlife Resources: A Fist Step." The Wildlife Society Bulletin 7 (1, Spring 1979) 30-34.

ARTHUR, L.M., W.R. WILSON, and M. MCMILLAN. "Determinants of Demand for Municipally Funded Recreation and Cultural Services in Ontario." Canadian Journal of Agricultural Economics, Proceedings (August 1980) 31-38.

BEAMAN, J. "Distance and the 'Recreation' to Distance as a Function of Distance." Journal of Leisure Research 6(3, September 1974) 220-231.

BECKER, G. "A Theory of the Allocation of Time." The Economic Journal (229, September 1965) 493-517.

BERGSTROM, T. and R. GOODMAN. "Private Demands for Public Goods." American Economic Review, 63(3, June 1973) 280-296.

BISHOP, R. "Consumer's Surplus and Cardinal Utility." Quarterly Journal of Economics 58(May 1943).

BISHOP, R. and T. HEBERLEIN. Simulated Markets, Hypothetical Markets, and Travel Cost Analysis: Alternative Methods of Estimating Outdoor Recreation Demand. University of Wisconsin, Agricultural Economics Staff Paper Series, Number 187, December 1980.

BISHOP, R. and T. HEBERLEIN. "Measuring Values of Extramarket Goods: Are Indirect Measures Biased?" Paper presented at Annual Meetings of the American Agricultural Economics Association. [Pullman, Wash.; August 1979].

BOCKSTAEL, N. and K. MCCONNELL. "Measuring the Economic Value of Wildlife Recreation: An Evaluation of Techniques." Paper presented at Annual Meeting of American Agricultural Economics Association [Blacksburg, VA,; August 1978].

BOHM, P. "An Approach to the Problem of Estimating Demand for Public Goods." Swedish Journal of Economics 73(1, March 1971) 94-105:

BOHM, P. "Estimating Demand for Public Goods: An Experiment." European Economic Review 3(1972) 111-130.

BORCHERDING, T. and R. DEACON. "The Demand for Services of Nonfederal Governments." American Economic Review 62(5, December 1972) 891-901.

BOWEN, H. "The Interpretation of Voting in the Allocation of Economic Resources." Quarterly Journal Economics 58 (1943) 27-48.

BROOKSHIRE, D. and T. CROCKER. "The Use of Survey Instruments in Determining the Economic Value of Environmental Goods: An Assessment." In Daniel, Zube and Driver (eds.). Assessing Amenity Resource Values. USDA Forest Service, Technical Report RM-68, 1979.

BROOKSHIRE, D. B. IVES, and W. SCHULTZE. "The Valuation of Aesthetic Preferences." Journal of Environmental Economics and Management. 3(4, 1976) 325-346.

BROWN, G. Valuating Non-Market Natural Resources with a Hedonic Technique. University of Washington, Institute for Economic Research Discussion Paper Number 78-16, 1978.

BROWN, G. J. CHARBONNEAU and M. HAY. The Value of Wildlife Estimated by the Hedonic Approach. U.S. Fish and Wildlife Service, Division of Program Plans Working Paper Number 6, 1978.

BROWN, G. J. CHARBONNEAU and M. HAY. Estimating Values of Wildlife: Analysis of the 1975 Hunting and Fishing Survey. U.S. Fish and Wildlife Service, Division of Program Plans Working Paper Number 7, 1978.

BROWN, G. and R. MENDELSOHN. The Hedonic-Travel Cost Method. University of Washington, Department of Economics (Mimeo), 1980.

BROWN, W. and F. NAWAS. "Effect of Aggregation Upon the Estimation of Statistical Outdoor Recreation Demand Functions. Paper presented at Annual Meeting of Western Agricultural Economics Association, July 25, 1972.

BROWN, W. F. NAWAS and J. STEVENS. The Oregon Big Game Resource: An Economic Evaluation. Oregon State University, Agricultural Experiment Station Special Report Number 379, March 1973.

BROWN, W. A. SINGH, and E. CASTLE. An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery. Oregon State University, Agricultural Experiment Station Technical Bulletin Number 78, 1964.

Bureau of Public Roads. Calibrating and Testing a Gravity Model for Any Urban Sized Area. U.S. Department of Commerce, Washington D.C., 1965.

CESARIO, F. "Value of Time in Recreation Benefit Studies." Land Economics 52(1, January 1976) 32-41.

CHARBONNEAU, J. and M. HAY. Determinants and Economic Values of Hunting and Fishing. Paper presented at the 43rd North American Wildlife and Natural Resources Conference [Phoenix, Arizona; March 18-22, 1978].

CICCHETTI, C. A. FISHER and V. SMITH. "An Econometric Evaluation of a Generalized Consumer Surplus Measure: The Mineral King Controversy." Econometrica 44(6, November 1976) 1259-76.

CICCHETTI, C. and V.K. SMITH. The Costs of Congestion: An Econometric Analysis of Wilderness Recreation. Cambridge, Mass: Ballinger Press, 1976.

CLAWSON, M. Methods of Measuring the Demand for and Value of Outdoor Recreation. Reprint Number 10, Resources for the Future, Washington, D.C., 1959.

CLAWSON, M. and J. KNETSCH. The Economics of Outdoor Recreation. Baltimore, Md.: The Johns Hopkins Press, Inc., 1966.

CURRIE, J. J. MURPHY and A. SCHMITZ. "The Concept of Economic Surplus and Its Use in Economic Analysis." The Economic Journal 81(December, 1971) 741-99.

DAVIS, R. The Value of Big Game Hunting in a Private Forest. Transactions of the Twenty-Ninth North American Wildlife and Natural Resources Conference (1964).

DEYAK, T. and V. SMITH. "Congestion and Participation in Outdoor Recreation: A Household Production Function Approach." Journal of Environmental Economics and Management 5(1, January 1978) 63-80.

DILLMAN, D. Mail and Telephone Surveys: The Total Design Method. New York, N.Y.: Johns Hopkins Press, Inc., 1966.

DUPUIT, J. "On the Measurement of the Utility of Public Works." In Arrow and Scitovsky (eds.). Readings in Welfare Economics. Homewood, Ill.: Irwin, Inc., 1969.

DWYER, J. J. KELLY and M. BOWES. Improved Procedures for Valuation of the Contribution of Recreation to National Economic Development. University of Illinois, Water Resources Center Research Report Number 128, 1977.

EDWARDS, J. K. GIBBS L. GUEDRY and H. STOEVENER. The Demand for Non-Unique Outdoor Recreational Services: Methodological Issues. Oregon State University, Agricultural Experiment Station Technical Bulletin Number 133, May 1976.

EWING, G. "Progress and Problems in the Development of Recreation Trip Generation and Trip Distribution Models." Leisure Sciences 3(1, January 1980) 1-23.

FREEMAN, A.M. The Benefits of Environmental Improvement: Theory and Practice. Baltimore: Johns Hopkins Univ. Press, 1979.

GEORGE, K. and J. SHOREY. The Allocation of Resources: Theory and Policy. London: George Allen and Unwin, 1978.

GORDON, S. and J. KNETSCH. "Consumer's Surplus Measures and the Evaluation of Resources." Land Economics 55(1, February 1979) 1-10.

GORMAN, W. A Possible Procedure for Analysing Quality Differentials in the Egg Market. London School of Economics Discussion Paper Number 134, January, 1976.

GREEN, J. Consumer Theory. Revised Edition. London: The MacMillan Press, 1976.

GROVES, T. and J. LEDYARD. "Optimal Allocation of Public Goods: A Solution of the 'Free-Rider' Problem." Econometrica 45(4, May 1977) 783-809.

GUM, R. and W. MARTIN. "Problems and Solutions in Estimating the Demand for and Value of Rural Outdoor Recreation." American Journal of Agricultural Economics 57(4, December 1975) 558-566.

HAMMACK, J. and G. BROWN. Waterfowl and Wetlands: Toward Bioeconomic Analysis. Baltimore: Johns Hopkins University Press, 1974.

HERBERT, J. R. SHIKIAR, and R. PERRY. Valuing the Environment via Bidding Games: A Psychological Perspective. Seattle: Batelle Human Affairs Research Center Mimeograph, October 1978.

HENDERSON, A. "Consumer's Surplus and the Compensating Variation." Review of Economic Studies 8(February 1940-41).

HICKS, J. A Revision of Demand Theory. London: Oxford University Press, 1946.

____________. "The Generalized Theory of Consumer's Surplus." Review of Economic Studies 13(1945-46).

____________. Value and Capital. Second Edition. Oxford University Press, 1946.

____________. "The Four Consumer's Surpluses." Review of Economic Studies 11 (Winter 1943).

_______________. "The Rehabilitation of Consumer's Surplus." Review of Economic Studies 8(February 1940-41).

HOTELLING, H. Letter cited in the Economics of Public Recreation: An Economic Study of the Monetary Evaluation of Recreation in the National Parks. U.S. National Park Service, Washington, D.C., 1947.

I.M.P.A.C.T. Environomics, Ltd. The Role of Economics in Shorelands Evaluation. University of Alberta, Edmonton, 1976.

INTRILIGATOR, M. Econometric Models, Techniques and Applications. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1978.

ISARD, W. Journey-to-Work and Other Travel Patterns in the Metropolitan Region: The Gravity Model. In Introduction to Regional Science. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1975.

JOHNSTON, J. Econometric Methods. Second Edition. New York, N.Y.: McGraw-Hill Book Co., 1972.

JOHNSON, T. A Note on the Use of the Household Production Function Approach in Outdoor Recreation Demand Analysis. Oregon State University, Agricultural Experiment Station Technical Paper Number 5052, 1979.

KNEESE, A. and V. SMITH. Water Research. Baltimore: Johns Hopkins University Press, 1966.

KNETSCH, J. "Property Rights, Land Use Conflicts, and Compensation." Canadian Journal of Agricultural Economics, Proceedings (August 1980) 20-30.

KNETSCH, J. and R. DAVIS. "Comparisons of Methods for Recreation Evaluation." In Kneese and Smith (eds.). Water Research. Baltimore: Johns Hopkins University Press, 1966. pp. 125-142.

KURZ, M. "An Experimental Approach to the Determination of Demand for Public Goods. Journal of Public Economics 3 (1974) 329-348.

LANCASTER, K. "A New Approach to Consumer Theory." Journal of Political Economy 74(2, April 1966) 132-57.

_______________. Consumer Demand: A New Approach. New York, N.Y.: Columbia University Press, 1971.

_______________. "Change and Innovation in the Technology of Consumption." American Economic Review 56(2, May 1966) 14-23.

LIPSEY, R. and P. STEINER. Economics. Sixth Edition. New York, N.Y.: Harper and Row, Publishers, 1981.

LITTLE, I. A Critique of Welfare Economics. Oxford: Oxford University Press, 1965.

MALER, K.G. Environmental Economics: A Theoretical Inquiry. Baltimore: Johns Hopkins University Press, 1974.

MANN, J. "Techniques to Measure Social Benefits and Costs in Agriculture: A Survey." Agricultural Economics Research 29(October 1977) 115-126.

MARSHALL, A. Principles of Economics. London: MacMillan, 1930.

MATHEWS, S. and G. BROWN. Economic Evaluation of the 1967 Sport Salmon Fisheries of Washington, Washington Department of Fisheries Technical Report Number 2, 1970.

MCALLISTER, D. and F. KLETT. "A Modified Gravity Model of Regional Recreation Acitvity with Application to Ski Trips." Journal of Leisure Research 8(1, January 1976) 21-34.

MCCONNELL, K. "Some Problems in Estimating the Demand for Outdoor Recreation." American Journal of Agricultural Economics. 58(3, August 1975) 330-334.

MCKENZIE, G. "Consumer's Surplus Without Apology: Comment." American Economic Review 69(3, June 1979) 465-468.

MCMILLAN, M. "Criteria for Jurisdictional Design." Journal of Environmental Economics and Management 3(1976).

MCMILLAN, M. W.R. WILSON, and L.M. ARTHUR. "The Publicness of Local Public Goods: Evidence from Ontario Municipalities." Canadian Journal of Economics 14(4, November 1981) 596-608.

MCMILLAN, M. W.R. WILSON, and L.M. ARTHUR. A Note on the Publicness of Local Public Goods. University of Alberta, Department of Economics Research Paper Number 80-11, May 1980.

MISHAN, E. "Realism and Relevance in Consumer's Surplus." Review of Economic Studies 15(1947-48).

MOHRING, H. "Alternative Welfare Gain and Loss Measures." Western Economic Journal 9(4, December 1971) 349-68.

MUELLBAUER, J. "Household Production Theory, Quality, and the 'Hedonic Technique'." American Economic Review 64(6, December 1974) 977-994.

MUSGRAVE, R. and P. MUSGRAVE. Public Finance in Theory and Practice. New York: McGraw-Hill Publishing Company, 1976.

MUTH, R. "Household Production and Consumer Demand Functions." Econometrica 34(3, July 1966) 699-708.

NIEDERCORN, J. and B. BECHDOLT. "An Economic Deviation of the 'Gravity Law' of Spatial Interaction." Journal of Regional Science 9(2, May 1969) 273-282.

OLIVEIRA, R. and G. RAUSSER. "Daily Fluctuations in Campground Use: An Econometric Analysis." American Journal of Agricultural Economics 59(2, May 1977) 283-293.

PATINKIN, D. "Demand Curves and Consumer's Surplus." In C. Christ, et al. (eds). Measurement in Economics: Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld. Palo Alto: Stanford University Press, 1963.

PEARSE, P. "A New Approach to the Evaluation of Non-Priced Recreational Resources." Land Economics 4(1, January 1968) 87-99.

PELGEN, D. "Economic Values of Striped Bass, Salmon and Steelhead Sport Fishery in California." California Fish and Game 41 (1955) 5-17.

PENDSE, D. and J. WYCKOFF. "Scope for Valuation of Environmental Goods." Land Economics 50(1, February 1974) 89-92.

PETERSON, G. D. LIME and D. ANDERSON. National Trends in River Recreation Demand. USDA Forest Service, St. Paul, Minnesota, 1980. (Mimeo)

PHILLIPS, W. D. DEPAPE and L. EWANYK. Socioeconomic Evaluation of the Recreational Use of Fish and Wildlife Resources in Alberta With Particular Reference to the Athabasca Oil Sands Area. Recreational Hunting. Volume 3. The University of Alberta, Department of Rural Economy; Edmonton, 1977. (Mimeo)

PINDYCK, R. and D. RUBINFELD. Econometric Models and Economic Forecasts. New York, N.Y.: McGraw-Hill Book Company, 1976.

POLLAK, R. and M. WACHTER. "The Relevance of the Household Production Function and its Implications for the Allocation of Time." Journal of Political Economy 83(2, April 1975) 255-278.

RANDALL, A. Evaluating Non-Market Goods and Services: Some Conceptual Considerations. University of Kentucky, Department of Agricultural Economics, Staff Paper Number 51, July 1977.

RANDALL, A. and D. BROOKSHIRE. Public Policy, Public Goods, and Contingent Valuation Mechanisms. University of Kentucky, Department of Agricultural Economics, Staff Paper Number 68, 1976.

RANDALL, A. B. IVES, and E. EASTMAN. "Bidding Games for Valuation of Aesthetic Environmental Improvements." Journal of Environmental Economics and Management, 1974.

RAVENSCRAFT, D. and J. DWYER. Reflecting Site Attractiveness in Travel Cost-Based Models for Recreational Benefit Estimation. University of Illinois, Department of Forestry, Forestry Research Report Number 78-6, 1978.

RIPLEY, W. "The Gross National Product Method for Measuring Outdoor Recreation, the Ripley Method." In L. Lerner (ed.). Quantitative Indices for Recreational Values. Western Farm Economics Association, 1958.

ROSEN, S. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." Journal of Political Economy 82(1, January/February 1974) 34-55.

SAMUELSON, P. Foundations of Economic Analysis. New York: Atheneum, 1967.

SAMUELSON, P. "Diagrammatic Exposition of a Theory of Public Expenditures." Review of Economics and Statistics (November 1955) 350-56.

SILBERBERG, E. "Duality and the Many Consumer's Surpluses." American Economic Review 62(5, December 1972) 942-52.

SMITH, V. "Experimental Comparisons of Three Public Good Decision Mechanisms." Scandanavian Journal of Economics (1979).

SMITH, V. The Estimation and Use of Models of the Demand for Outdoor Recreation, Assessing the Demand for Outdoor Recreation. U.S. Department of the Interior, Bureau of Outdoor Recreation, 1975.

SORHUS, C. W. BROWN and K. GIBBS. Estimated Expenditures by Salmon and Steelhead Sport Anglers for Specified Fisheries in the Pacific Northwest. Oregon State University, Agricultural Experiment Station Special Report 631, July, 1981.

STEVENS, J. "Recreation Benefits from Water Pollution Control." Water Resources Research 2 (2, May 1966) 167-82.

STRAUSS, R. and G.D. HUGHES. "A New Approach to the Demand for Public Goods." Journal of Public Economics 6(3, October 1976) 167-82.

SUTHERLAND, R. A. Regional Recreation Demand and Benefits Model. U.S. Environmental Protection Agency, Corvallis Environmental Research Lab, September, 1980.

TIDEMAN, N. "The Efficient Provision of Public Goods." In S.J. Mushkin (ed.). Public Prices for Public Products. Washington, D.C.: The Urban Institute, 1972.

TIDEMAN, N. and G. TULLOCK. "A New and Superior Principle for Collective Choice." Journal of Political Economy 84(6, November - December 1976) 1145-59.

TULLOCK, G. "On the General Irrelevance of the General Impossibility Theorem." Quarterly Journal of Economics (May 1967) 256-270.

U.S. Fish and Wildlife Service. 1975 National Survey of Hunting, Fishing and Wildlife-Associated Recreation. U.S. Government Printing Office, Washington, D.C., 1977.

Water Resources Council. Water and Related Land Resources, Establishment of Principles and Standards for Planning. Federal Register 38(10, September 1973) Part III, Number 174.

WILKINSON, R. "The Use of Models in Predicting the Consumption of Outdoor Recreation." Journal of Leisure Research 5(1, January 1973) 34-48.

WILLIG, R. "Consumer's Surplus Without Apology: Reply." American Economic Review 69(3, June 1979) 469-474.

________. "Consumer's Surplus Without Apology." American Economic Review 66(4, September 1976) 589-97.

WILSON, W.R. A Case for Property Rights in the Internalization of Environmental Externalities. University of Alberta, Department of Rural Economy, Edmonton, 1980. (Mimeo)

WINCH, D. Analytical Welfare Economics. London: Penguin Books, 1971.

WOLFE, R. "The Inertia Model." Journal of Leisure Research 4(1, January 1972) 73-76.

WONNACOTT, R. and J. WONNACOTT. Econometrics. Second Edition. New York, N.Y.: John Wiley and Sons, 1979.

APPENDIX A

CONFIDENTIAL

ALBERTA HUNTING SURVEY 1975 HUNTING SEASON

1. Residence (city or town) ______________________ 2. Age ______________

3. Sex Male ☐ 4. Occupation ______________________
   Female ☐

5. Including yourself, how many of your immediate family are living at your residence? (Please circle the appropriate number.)

   1 2 3 4 5 6 7 8 9

6. Approximately what was the total amount of money earned by you and your family in 1975? Estimate and check one.

Less than $5,000 ☐	$20,001 - $25,000 ☐
$ 5,001 - 10,000 ☐	$25,001 - 30,000 ☐
$10,001 - 15,000 ☐	$30,001 - 35,000 ☐
$15,001 - 20,000 ☐	$35,001 or over ☐

7. Education: (Please circle highest year completed.)

Grade School	0	1	2	3	4	5	6	7	8	9
High School	10	11	12							
University	1	2	3	4	5	6	7	8	9	
Technical School	1	2	3	4						

8. Please respond to each question below by checking the appropriate answer.

	Yes	No
(a) Have you ever hunted before the 1975 season?	☐	☐
(b) Have you ever hunted in Alberta before the 1975 season?	☐	☐
(c) Have you ever hunted in the Athabasca Oil Sands Area before the 1975 season? (see the map attached for a description of this area).	☐	☐

9. What are the main reasons that you go hunting? Rank the following items in order of importance; 1st, 2nd, 3rd choices.

   (a) for meat ________
   (b) for a trophy ________
   (c) for outdoor enjoyment ________
   (d) other (please specify ______________________ ________

10. Which Alberta licenses did you hold in 1975? (Please check where applicable).

- ☐ Bird Game
- ☐ Migratory Bird Game
- ☐ Mule Deer
- ☐ Whitetailed Deer
- ☐ Angling License (1975-76 season)
- ☐ Moose
- ☐ Moose (Zone I)
- ☐ Elk
- ☐ Caribou
- ☐ Black Bear
- ☐ Grizzly Bear

Other (please specify) ______________________

____

11. Did you hunt for sport AT LEAST ONCE during the 1975 hunting season in Alberta? (check.)

YES ☐ IF "YES" PLEASE COMPLETE ALL THE QUESTIONS THAT FOLLOW.

NO ☐ IF "NO" PLEASE RETURN THIS QUESTIONNAIRE IN THE SELF-ADDRESSED ENVELOPE THAT HAS BEEN PROVIDED

12. If you DID hunt in Alberta during the 1975 season, please complete the following information for each hunting trip taken. (NOTE: 1 FULL day of hunting is 4 or more hours spent in the activity.)

Trip No.	Area(s) Hunted: Nearest Town, Landmark or Wildlife Management Unit	Days Hunted in Area (Estimate to nearest 1/2 day)	Miles to Area	No. in Hunting Party	Game you Hunted in Area	Game Bagged by Yourself Only (type & number)
Example	Vermilion	3 1/2	100	2	Ducks & Geese	10 ducks, 2 geese
1.						
2.						
3.						
4.						
5.						
6.						
7.						

13. Based on your experience, how would you rate your hunting trips in Alberta during the 1975 season? (check where applicable).

	Very Good	Good	Fair	Poor	Very Poor
Big Game					
Upland Bird Game					
Waterfowl					

14. Please estimate as best you can the amount of money you personally spent for hunting purposes in Alberta during the 1975 season. Please estimate for each category below as it applies to you.

	HUNTING FOR:		
	Big Game	Upland Birds	Waterfowl
TRAVEL COSTS (includes gasoline, oil, air fare, etc.)	$ ______	______	______
LODGING (includes hotels, motels, camping fees, etc.)	$ ______	______	______
FOOD (includes restaurant meals and food purchased for hunting trips, etc.)	$ ______	______	______
BEVERAGES	$ ______	______	______
RENTALS (includes rental of hunting equipment, etc.)	$ ______	______	______
GUIDES (includes guiding fees, etc.)	$ ______	______	______
AMMUNITION	$ ______	______	______
HUNTING SERVICES (includes packer fees, taxidermy, etc.)	$ ______	______	______
OTHER (please specify) ______________	$ ______	______	______
______________	$ ______	______	______

15. If you made any major purchase in Alberta in 1975 that are used in whole or in part for hunting in Alberta please list the item(s) purchased, the purchase price and the extent to which this item is used for hunting in Alberta.

ITEM	PURCHASE PRICE $	AMOUNT OF USE FOR ALBERTA HUNTING 100%	75%	50%	25%	0%
e.g. rifle	$160	✔				

16. If you participated in the following hunting activities in Alberta during the 1975 season, how much value in dollars per day was it worth to you above what you spent on travel and other expenses (circle the appropriate dollar value).

Hunting For	Average Dollar Value Per Day											Higher or Other Dollar Value (specify)
Big Game	0	1	2	3	4	5	6	7	8	9	10	
		12	14	16	18	20	22	24	26	28	30	$ ______
Upland Birds	0	1	2	3	4	5	6	7	8	9	10	
		12	14	16	18	20	22	24	26	28	30	$ ______
Waterfowl	0	1	2	3	4	5	6	7	8	9	10	
		12	14	16	18	20	22	24	26	28	30	$ ______

17. Approximately how much money would you have to be paid NOT to hunt in Alberta FOR ONE YEAR (Estimate and circle the least amount acceptable to you).

$	0	1	2	3	4	5	6	7	8	9
$		10	20	30	40	50	60	70	80	90
$		100	200	300	400	500	600	700	800	900

If higher or other dollar value please specify. $ ______

18. Give any additional comments that might help evaluate the sport hunting in Alberta.

______

______

______

19. Of the hunting trips you took during the 1975 season, were any of them to the Athabasca Oil Sands Area? (see the map attached for a description of this area).

YES ☐ IF "YES" PLEASE COMPLETE ALL THE QUESTIONS THAT FOLLOW.

NO ☐ IF "NO" PLEASE RETURN THIS QUESTIONNAIRE IN THE SELF-ADDRESSED ENVELOPE THAT HAS BEEN PROVIDED.

20. Please indicate with X's on the map attached, the areas you hunted during the 1975 season in the Athabasca Oil Sands Area. Please be as accurate as possible.

21. How would you rate the hunting trips to the Athabasca Oil Sands Area compared to your other hunting trips in Alberta as a whole? (check where applicable).

	Better Than	As Good As	Worse Than
Big Game			
Upland Birds			
Waterfowl			

22. If you participated in the following hunting activities in the Athabasca Oil Sands Area during the 1975-76 season, how much value in dollars per day was it worth to you above what you spent on travel and other expenses? (circle the appropriate dollar value).

HUNTING FOR:	AVERAGE DOLLAR VALUE PER DAY											HIGHER OR OTHER DOLLAR VALUE (SPECIFY)
Big Game	0	1	2	3	4	5	6	7	8	9	10	$ ______
		12	14	16	18	20	22	24	26	28	30	
Upland Birds	0	1	2	3	4	5	6	7	8	9	10	$ ______
		12	14	16	18	20	22	24	26	28	30	
Waterfowl	0	1	2	3	4	5	6	7	8	9	10	$ ______
		12	14	16	18	20	22	24	26	28	30	

23. Provide any additional comments that might help evaluate the sport hunting in the Athabasca Oil Sands Area.

____

____

____

THANK YOU VERY MUCH FOR YOUR CO-OPERATION IN ANSWERING AND RETURNING THIS QUESTIONNAIRE.

Source: Phillips *et al.* 1977.

APPENDIX B

DERIVING THE MARGINAL VALUATION FUNCTION WITH THE HEDONIC APPROACH

This discussion draws extensively on papers by Brown, Charbonneau, and Hay (1978) and Rosen (1974). Recall that hunters' household expenditures are expressed mathematically as a function of characteristics of the hunting experience, in this study the number of days and seasonal bag:

$$E = g(D_i, B_i) \qquad (1)$$

Defining $\partial E/\partial D_i = P_d^i$ as the implicit price of the ith type of day, and $\partial E/\partial B_i = P_b^i$ as the implicit price of the ith type of bag, the inverse of conditional demand functions have the form:

$$P_h^i = f^i(D_i, B_i, Z) \qquad (2)$$

where,

h = d if days and b if bag, and

Z = a vector of demand shifters.

Demand functions are typically written as $D = g(p)$. Taking the inverse yields $f(D) = g^{-1}(D) = P$, which is illustrated in figure B1.

WTP (i.e., actual payment plus consumers surplus) is given by:

$$\int_0^{D_2} f(D)\,dD = WTP(D) \qquad (3)$$

(see figure B1). A total cost function (C(D)) is needed to enable the calculation of marginal net WTP or marginal consumer surplus (CS). The consumer surplus associated with a day of hunting activity is then:

$$CS(D) = WTP(D) - C(D) \tag{4}$$

To obtain a measure of marginal consumer surplus, equation (4) is differentiated with respect to days (bag).

$$\partial CS(D)/\partial D = \partial WTP(D)/\partial D - \partial C(D)/\partial D \tag{5}$$

To estimate (5), assume each hunter is in equilibrium with respect to hunting, is a price-taker, and faces a constant marginal cost for a day of hunting.[1] In figure B1 those hunters in equilibrium at D_1 and D_2 face MC_1 and MC_2, respectively. In equation (5) the first term on the right hand side of the equality is simply f(D), and the second term can be expressed as f(D) + Df'(D).[2] Thus, rewriting equation (5) yields:

$$\partial CS(D) = f(D) - [f(D) + Df'(D)] \tag{6}$$

$$\partial CS(D) = -Df'(D) \tag{7}$$

Because $f'(D) < 0$, equation $(7) > 0$.

The demand function is estimated in the conventional (i.e., non-inverse) form.

$$D = g(P_d, \ldots, Z) \tag{8}$$

Note that f'(D) in equation (7) is the derivative of price with respect to days, but that the demand estimates are the inverse of this. Thus,

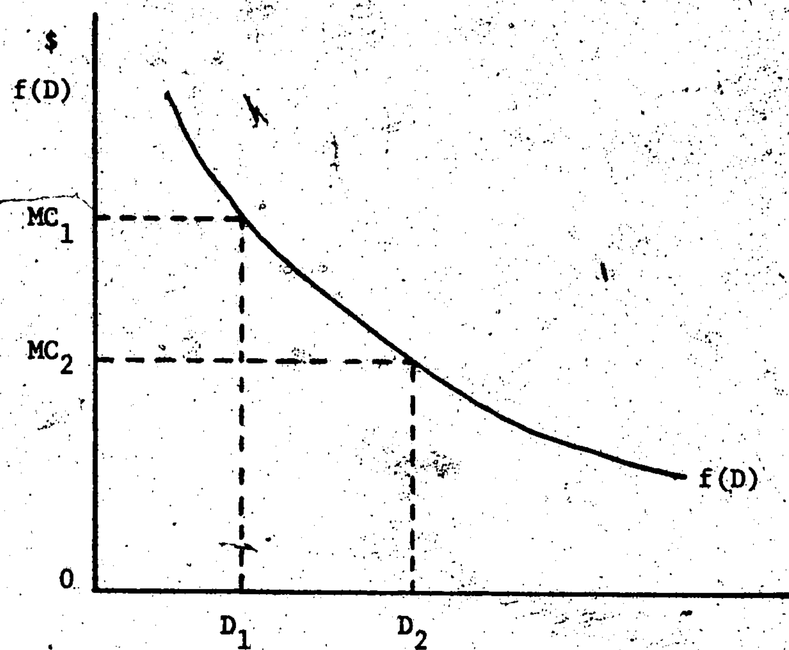


Figure B1. Typical Demand Function

$$\partial D/\partial P = \alpha D/P, \tag{9}$$

and alternatively

$$\partial P/\partial D = P/\alpha D \tag{10}$$

where α is the coefficient of P from demand equation (8), which can be rewritten in the multiplicative form $D = aP_1^{\alpha_1} \ldots Z^{\alpha_n}$.

From differentiating the expenditure function with respect to days equation (11) can be obtained.

$$P_d = \partial E/\partial D = \eta E/D \tag{11}$$

where η is the regression coefficient for days from the expenditure function, again expressed in multiplicative form. Substituting equation (11) into (10) yields:

$$\partial P/\partial D = (\eta E/D)/\alpha D, \tag{12}$$

and substituting equation (12) into (7) gives:

$$\partial CS(D) = -Df'(D)$$
$$= -D\,\{(\eta E/D)/\alpha D\} \tag{13}$$

Solving equation (13):

$$\partial CS(D) = -\eta E/\alpha D \tag{14}$$

Equation (14) is the marginal valuation function and measures the change in consumer surplus from an additional day (bag) of hunting.

Footnotes

1. The assumption of constant MC in equilibrium is necessary to accommodate the empirical estimation of equation (5). Brown et al. (1978) argue that this assumption imparts a downward bias on estimates from equation (14) if the actual equilibrium MC functions are rising, and an upward bias if the MC functions are falling. It is likely that the MC function of additional hunting activity is rising and estimates generated with this process conservative.

2. By the assumption of constant MC, $C(D) = Df(D)$, simply price times quantity. Taking the derivative of this product with respect to days (bag) gives $C'(D) = f(D) + Df'(D)$.

APPENDIX C

SELECTED RESULTS OF THE SOCIOECONOMIC ANALYSIS

Table C.1. Importance of Being Outdoors by Activity.

Rank	Type of Hunting Activity											
	Big Game		Non-Big Game		Upland Bird		Non-Upland Bird		Waterfowl		Non-Waterfowl	
	N	%	N	%	N	%	N	%	N	%	N	%
1	201	(65.5)	192	(81.4)	134	(78.4)	259	969.6)	257	(78.4)	136	(63.3)
2	91	(29.6)	40	(16.9)	32	(18.7)	99	(26.6)	63	(19.2)	68	(31.6)
3	6	(2.0)	1	(.4)	1	(.6)	6	(1.6)	3	(.9)	4	(1.9)
4[1]	1	(.3)	0	(0)	0	(0)	1	(.3)	0	(0)	1	(.5)
No rating	8	(2.6)	3	(1.3)	4	(2.3)	7	(1.9)	5	(1.5)	6	(2.8)
Total	307	(100.0)	236	(100.0)	171	(100.0)	372	(100.0)	328	(100.0)	215	(100.0)
χ^2	17.93***				5.81				15.85**			

1. Rating of 4 is possible only if "other reasons for hunting" are included.

**, *** = $p < .01$ and $p < .001$, respectively.

Table C.2. Importance of Meat Motive by Activity.

Rank	Type of Hunting Activity											
	Big Game		Non-Big Game		Upland Bird		Non-Upland Bird		Waterfowl		Non-Waterfowl	
	N	%	N	%	N	%	N	%	N	%	N	%
1	117	(38.1)	49	(20.8)	38	(22.2)	128	(34.4)	77	(46.4)	89	(41.4)
2	137	(44.6)	118	(50.0)	85	(49.7)	170	(45.7)	158	(48.2)	97	(45.1)
3	33	(10.7)	2	(11.4)	27	(15.8)	33	(8.9)	45	(13.7)	15	(7.0)
4[1]	0	(0)	2	(.8)	2	(1.2)	0	(0)	2	(.6)	0	(0)
No rating	20	(16.9)	40	(6.5)	19	(11.1)	41	(11.0)	46	(14.0)	14	(6.5)
Total	236	(100.0)	307	(100,0)	171	(100.0)	372	(100.0)	328	(100.0)	215	(100.0)
χ^2	29.76***				15.52***				27.19***			

1. Rating of 4 is possible only if "other reasons for hunting" are included.

**, *** = $p < .01$ and $p < .001$, respectively.

Table C.3. Importance of Trophy Hunting by Activity.

Rank	Type of Hunting Activity											
	Big Game		Non-Big Game		Upland Bird		Non-Upland Bird		Waterfowl		Non-Waterfowl	
	N	%	N	%	N	%	N	%	N	%	N	%
1	7	(2.3)	2	(.8)	2	(1.2)	7	(1.9)	3	(.9)	6	(2.8)
2	32	(10.4)	22	(9.3)	20	(11.7)	34	(9.1)	38	(11.6)	16	(7.4)
3	150	(48.9)	92	(39.0)	72	(42.1)	170	(45.7)	134	(40.9)	108	(50.2)
4[1]	10	(3.3)	6	(2.5)	7	(4.1)	9	(2.4)	10	(3.0)	6	(2.8)
No Rating	108	(35.2)	114	(48.3)	70	(40.9)	152	(40.9)	143	(43.6)	79	(36.7)
Total	307	(100.0)	236	(100.0)	171	(100.0)	372	(100.0)	328	(100.0)	215	(100.0)
χ^2	10.59*				2.58				9.09			

1. Rating of 4 is possible only if "other reasons for hunting" are included.

* = $p < .05$.

Table C.4. Family Income by Activity.

Income Category	Type of Hunting Activity											
	Big Game		Non-Big Game		Upland Bird		Non-Upland Bird		Waterfowl		Non-Waterfowl	
	N	%	N	%	N	%	N	%	N	%	N	%
< 5,000	14	(4.8)	14	(6.4)	8	(4.9)	20	(5.8)	12	(3.9)	16	(8.0)
5,001 - 10,000	44	(15.1)	24	(11.0)	17	(10.4)	51	(14.7)	33	(10.7)	35	(16.4)
10,001 - 15,000	80	(27.4)	47	(21.6)	33	(20.2)	94	(27.1)	71	(23.0)	56	(27.9)
15,001 - 20,000	63	(21.6)	50	(22.9)	40	(24.5)	73	(21.0)	68	(22.0)	45	(22.4)
20,001 - 25,000	41	(14.0)	28	(12.8)	21	(12.9)	48	(13.8)	48	(15.5)	21	(10.4)
25,001 - 30,000	21	(7.2)	14	(6.4)	12	(7.4)	23	(6.6)	22	(7.1)	13	(6.5)
30,001 - 35,000	8	(2.7)	10	(4.6)	10	(6.1)	8	(2.3)	15	(4.9)	3	(1.5)
> 35,000	21	(7.2)	31	(14.2)	22	(13.5)	30	(8.6)	40	(12.9)	12	(6.0)
Total [1]	292	(100.0)	218	(100.0)	163	(100.0)	347	(100.0)	309	(100.0)	201	(100.0)
χ^2	11.45				11.69				21.12**			

1. 33 missing observations.

** = $p < .01$. For other χ^2 values $p < .13$.

Table C.5. Reason for Hunting and Mean Income Level.

Rank	Outdoor Enjoyment			Meat			Trophy		
	N	$\overline{X}^1$	S.D.	N	$\overline{X}^1$	S.D.	N	$\overline{X}^1$	S.D.
0	11	3.73	2.20	58	4.83	2.03	214	4.10	2.00
1	367	4.35	1.96	156	3.39	1.62	8	4.25	1.98
2	125	3.43	1.55	242	4.11	1.87	47	5.06	1.77
3	6	3.83	1.47	53	5.34	1.75	227	3.89	1.80
4	1	4.00	0	1	8.00	0	14	4.43	1.65
F-Value		5.78***			15.82***			3.90**	

1. The lower the $\overline{X}$ the lower the mean income of the hunter group.

*, **, *** = $p < .025$, $p < .01$ and $p < .001$, respectively.

Table C.6. Hunter Sample by Occupation.

Category	Absolute Frequency	Relative Frequency (%)
Professional and Technical	76	14.0
Managerial	52	9.6
Contractor	1	.2
Farming	40	7.4
Tradesman	84	15.5
Transportation/Communication	13	2.4
Service Sector (N.E.S.)	36	6.6
Sales	36	6.6
Operative	39	7.2
Armed Forces	9	1.7
Clerical	11	2.0
Labourers	52	9.6
Homemaker	7	1.3
Student	45	8.3
Retired	13	2.4
Not in Labour Force	3	.6
Self-Employed	18	3.3
No Answer	8	1.5
Total	543	100.0

N.E.S. = Not elsewhere specified.

APPENDIX D

WTS REGRESSION RESULTS

The following tables present the results of the WTS models. The variables are as defined in equations 6 and 7 of Chapter VI.

Table D.1. The Willingness to Sell Hunting Rights Without Any Expenditures Adjustment Regression Results.[1]

Dependent Variable (SV_j)	Constant	C_j	Y	S_j	D_j	B_j/D_j	B_j	R^2	N
SV_{bg}	0.162 (3.779)	1.081 (.971)	-0.178 (1.200)	0.083 (.066)	1.335** (.574)	0.274** (.099)	---	.085	178
SV_{bg}	0.208 (3.065)	1.064* (.551)	-0.172 (1.154)	0.083 (.066	---	---	0.274** (.098)	.085	178
SV_{ub}	-0.081 (3.674)	-0.673 (1.033)	2.333 (1.653)	0.475** (.157)	1.143 (.725)	0.329** (.141)	---	.180	97
SV_{ub}	-2.574 (3.173)	0.394 (.653)	1.495 (1.534)	0.497** (.157)	---	---	0.317* (.141)	.163	97
SV_{wf}	-0.613 (3.116)	0.792 (.880	-0.913 (1.118)	0.271*** (.067)	1.563** (.508)	0.123 (.133)	---	.126	202
SV_{wf}	-1.925 (2.505)	1.303** (.505)	-1.222 (1.028)	0.273*** (.067)	---	---	0.137 (.132)	.123	202

1. The variables are as defined in equations (6) and (7) in Chapter VI.

*, **, *** = $p < .05$, $p < .01$ and $p < .001$ respectively.

Table D.2. The Willingness to Sell Hunting Rights With an Expenditure Adjustment Regression Results.[1]

Dependent Variable (SV_j)	Constant	C_j	Y	S_j	D_j	B_j/D_j	B_j	R^2	N
SV_{bg}	5.339*** (1.189)	0.062 (.279)	∀	0.014 (.019)	0.366* (.185)	0.054* (.028)	---	.068	123
SV_{bg}	4.772*** (.988)	0.260 (.184)	−0.055 (.343)	0.012 (.020)	---	---	0.056 (.028)	.063	123
SV_{ub}	3.522*** (.987)	0.553^{Δ} (.323)	−0.294 (.498)	0.100* (.050)	0.310^{Δ} (.179)	0.057 (.045)	---	.165	60
SV_{ub}	4.0[illegible]2*** (.[illegible]08)	0.310^{Δ} (.169)	0.051 (.415)	0.096^{Δ} (.049)	---	---	0.060 (.045)	.153	60
SV_{wf}	3.779Δ (.984)	0.355 (.252)	0.236 (.304)	0.009 (.019)	0.295* (.146)	0.045 (.037)	---	.074	126
SV_{wf}	4.003*** (.717)	[illegible]	0.288 (.277)	0.009 (.019)	---	---	0.043 (.037)	.072	126

1. The variables are as defined in equations (6) and (7) in Chapter VI. Expenditures are netted out of the WTS estimate.

∀: The F value for this variable was insufficient to warrant inclusion.

Δ, *, *** = $p < .1$, $p < .05$, and $p < .001$ respectively.

Table D.3. Hunting Activity Valuation Estimates Based on Willingness to Sell Regression Results.

Hunting Activity	Average Valuation[1]		Marginal Valuation[2]	
	Day	Bag	Day	Bag
Big Game[3]	$ 7.86	$26,475.71	$10.49	$7,254.35
Upland Bird[3]	6.05	20.63	6.92	6.55
Waterfowl[3]	4.19	3.21	6.54	.44
Big Game[4]	62.48	147,887.50	22.84	8,237.33
Upland Bird[4]	126.95	194.03	39.32	11.68
Waterfowl[4]	93.99	68.59	27.75	2.96

1. Calculated using $\overline{SV}_j/\overline{D}_j$ or $\overline{SV}_j/\overline{B}_j$ where, these values are derived from the regression sample. Geometric means are employed.

2. Calculated using $\hat{\beta}_{kj}(\overline{SV}_j/\overline{D}_j)$ or $\hat{\beta}_{kj}(\overline{SV}_j/\overline{B}_j$ where, $\hat{\beta}_{kj}$ is the estimated coefficient for D_j or B_j. Geometric means are employed.

3. Based on WTS regression results (table D.1) without any expenditures adjustment.

4. Based on WTS regression results (table D.2) with expenditures on activity j deducted (i.e., a net WTS).

APPENDIX E

REGRESSION RESULTS FOR HEDONIC MODELS

The following tables present results for each of the four alternative model forms: OLS, SUR, restricted OLS, and restricted SUR, respectively. The variables are defined below.

PD_j ≡ implicit price of a day, activity j;

PB_j ≡ implicit price of a bag, activity j;

PDO_j ≡ implicit price of a day, substitute activities for j;

PBO_j ≡ implicit price of bag, substitute activities for j;

D_j ≡ days hunting, activity j;

B_j ≡ bag, activity j;

OD_j ≡ days, substitute activities to j;

OB_j ≡ bag, substitute activities to j;

where,

j ≡ B if big game;

U if upland bird, and

W if waterfowl.

C ≡ constant,

LV7 ≡ respondent's household income,

AG ≡ age of respondent,

V6 ≡ respondent's family size, and

LV31 ≡ rating of quality of hunting.

ORDINARY LEAST SQUARES

NUMBER OF OBSERVATIONS = 229

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-4.0625346E-01	6.1718723E-01	-6.5823375E-01
PDB	5.1262148E-01	9.6361643E-02	5.3197669E+00
PDOB	-1.0163076E+00	2.1074657E-02	-4.8224159E+01
PBB	-6.0654849E-03	1.2294959E-02	-4.9333105E-01
PBOB	2.5895737E-02	1.9244456E-02	1.3456206E+00
LV7	2.1053338E-01	1.3511530E-01	1.5581757E+00
AG	2.0844704E-01	1.5491838E-01	1.3455281E+00
V6	2.5343965E-02	3.1438014E-02	8.0615668E-01

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	1.8626380E+00	6.4184396E-01	2.9020106E+00
PDB	-4.8672311E-01	9.6458203E-02	-5.0459485E+00
PDOB	-1.6152960E-02	2.1095913E-02	-7.6569144E-01
PBB	-9.6581933E-03	1.3186612E-02	-7.3242414E-01
PBOB	2.6213292E-02	1.9267515E-02	1.3604916E+00
LV7	2.2130694E-01	1.3598889E-01	1.6273898E+00
AG	2.0640424E-01	1.5509077E-01	1.3308603E+00
LV31	1.3063453E-01	1.7220615E-01	7.5859388E-01
V6	2.5158573E-02	3.1469203E-02	7.9946649E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-2.4997124E-01	3.3235283E-01	-7.5212598E-01
PDB	5.0369936E-01	9.6072441E-02	5.2429121E+00
PDOB	-1.8214791E-02	2.1065661E-02	-8.6466743E-01
PBB	[illegible]	1.2095329E-02	-2.9832780E-01
PBOB	-9.7022298E-01	1.9093393E-02	-5.0814593E+01
LV7	2.3924463E-01	1.3399403E-01	1.7854872E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-2.0373118E+00	6.0675185E-01	-3.3577348E+00
PDB	5.0560072E-01	9.5891586E-02	5.2726286E+00
PDOB	-1.6736053E-02	2.1051335E-02	-7.9501151E-01
PBB	-1.0066069E+00	1.2266917E-02	-8.2058674E+01
PBOB	2.6299315E-02	1.9222768E-02	1.3681336E+00
LV7	2.2097304E-01	1.3438719E-01	1.6443013E+00
AG	2.1261092E-01	1.5471011E-01	1.3742535E+00

SEEMINGLY UNRELATED REGRESSION

NUMBER OF OBSERVATIONS = 229

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE OD3

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	3.7609926E-01	3.3639564E-01	1.1180264E+00
PDB	5.0371721E-01	9.5958572E-02	5.2493195E+00
PDOB	-1.0182043E+00	2.1040746E-02	-4.8392026E+01
PBB	-3.6286330E-03	1.2083127E-02	-3.0030580E-01
PBOB	2.9752823E-02	1.9072436E-02	1.5599906E+00
LV7	2.3911185E-01	1.3384278E-01	1.7865129E+00
AG	1.4597571E-03	1.6492292E-02	8.8511477E-02
V6	1.7203139E-05	1.7023184E-03	1.0105711E-02

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	2.7767459E+00	3.3787400E-01	8.2182882E+00
PDB	-4.9627950E-01	9.6051937E-02	-5.1667828E+00
PDOB	-1.8203620E-02	2.1061076E-02	-8.6432528E-01
PBB	-3.6307114E-03	1.2097726E-02	-3.0011520E-01
PBOB	2.9751602E-02	1.9091245E-02	1.5583899E+00
LV7	2.3910571E-01	1.3397682E-01	1.7846797E+00
AG	1.5304087E-03	1.8291010E-02	8.3669558E-02
LV31	4.5029249E-05	8.7958819E-03	5.1193558E-03
V6	2.5869279E-05	2.3408409E-03	1.1051276E-02

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OB3

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-2.4997124E-01	3.3235289E-01	-7.5212598E-01
PDB	5.0369936E-01	9.6072441E-02	5.2429121E+00
PDOB	-1.8214791E-02	2.1065661E-02	-8.6466743E-01
PBB	-3.6083731E-03	1.2095329E-02	-2.9832780E-01
PBOB	-9.7022298E-01	1.9093393E-02	-5.0814593E+01
LV7	2.3924463E-01	1.3399403E-01	1.7854872E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.3434369E+00	3.3495887E-01	-4.0107517E+00
PDB	5.0371116E-01	9.5881688E-02	5.2534657E+00
PDOB	-1.8205816E-02	2.1024048E-02	-8.6594243E-01
PBB	-1.0036270E+00	1.2072967E-02	-8.3130103E+01
PBOB	2.9755442E-02	1.9056883E-02	1.5614013E+00
LV7	2.3913126E-01	1.3373344E-01	1.7881187E+00
AG	1.3191615E-03	1.4209199E-02	9.2838552E-02

061467 CM NEEDED

POOR PRINT
Epreuve illisible

ORDINARY LEAST SQUARES (RESTRICTED ESTIMATES) HYPOTH1

NUMBER OF OBSERVATIONS = 229

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-5.1762689E-01	2.6482[illegible]71E-01	-1.9546243E+00
PDB	5.1803953E-01	9.2474683E-02	5.6019603E+00
PDOB	-1.0158552E+00	2.0954541E-02	-4.8479002E+01
PBB	-6.2709447E-03	1.2252975E-02	-5.1178957E-01
PBOB	2.5459802E-02	1.9122065E-02	1.3314358E+00
LV7	2.2246276E-01	1.2121467E-01	1.8352791E+00
AG	2.3009853E-01	1.1070564E-01	2.0784716E+00
V6	2.6065529E-02	3.1232660E-02	8.3456002E-01

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	2.0549484E+00	3.6225922E-01	5.6725910E+00
PDB	-4.9422103E-01	9.4247734E-02	-5.2438505E+00
PDOB	-1.6811158E-02	2.1024095E-02	-7.9961387E-01
PBB	-8.2251678E-03	1.2585270E-02	-6.5355514E-01
PBOB	2.6697355E-02	1.9227042E-02	1.3885315E+00
LV7	2.0179413E-01	1.2494529E-01	1.6150600E+00
AG	1.7794219E-01	1.3383926E-01	1.3295216E+00
LV31	8.8575869E-02	1.2741018E-01	6.9520244E-01
V6	2.4247808E-02	3.1378361E-02	7.7275572E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-7.2884060E-01	1.9934324E-01	-3.6562093E+00
PDB	5.6811093E-01	8.9748150E-02	6.3300573E+00
PDOB	-1.4512232E-02	2.1114933E-02	-6.8729706E-01
PBB	-2.5036532E-03	1.2166451E-02	-2.0578337E-01
PBOB	-9.7109936E-01	1.9224316E-02	-5.0514118E+01
LV7	4.2003431E-01	8.8936631E-02	4.7225121E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-2.1987417E+00	2.6049784E-01	-8.4405372E+00
PDB	5.1334028E-01	9.2239980E-02	5.5652687E+00
PDOB	-1.6083184E-02	2.0938432E-02	-7.6811788E-01
PBB	-1.0069345E+00	1.2218788E-02	-8.2408706E+01
PBOB	2.5669781E-02	1.9107335E-02	1.3434516E+00
LV7	2.3910749E-01	1.19[illegible]087E-01	2.0012199E+00
AG	2.4490015E-01	1.092[illegible]98E-01	2.2426553E+00

SEEMINGLY UNRELATED REGRESSION (RESTRICTED ESTIMATES) HYPOTH1

NUMBER OF OBSERVATIONS = 229

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.0587062E-01	1.9955169E-01	-5.3054233E-01
PDB	5.6697452E-01	8.9094140E-02	6.3637689E+00
PDOB	-1.0145447E+00	2.0941333E-02	-4.8446999E+01
PBB	-2.5953351E-03	1.2070416E-02	-2.1501620E-01
PBOB	2.8833173E-02	1.9067365E-02	1.5121739E+00
LV7	4.1622239E-01	8.9137944E-02	4.6694198E+00
AG	5.0868285E-03	1.7384222E-02	2.9261180E-01
V6	2.3168326E-05	1.7506009E-03	1.3234499E-02

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	2.2951088E+00	2.0028571E-01	1.1459174E+01
PDB	-4.3302100E-01	8.9209354E-02	-4.8539593E+00
PDOB	-1.4544578E-02	2.0965984E-02	-6.9372264E-01
PBB	-2.5949233E-03	1.2085671E-02	-2.1471073E-01
PBOB	2.8833329E-02	1.9089996E-02	1.5103895E+00
LV7	4.1623807E-01	8.9336196E-02	4.6592321E+00
AG	5.0741855E-03	1.8480291E-02	2.7457282E-01
LV31	-6.4786464E-06	5.9652351E-03	-1.0860672E-03
V6	2.1396480E-05	2.2854605E-03	9.3619995E-03

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-7.2884060E-01	1.9934324E-01	-3.6562093E+00
PDB	5.6811093E-01	8.9748150E-02	6.3300573E+00
PDOB	-1.4512232E-02	2.1114933E-02	-6.8729706E-01
PBB	-2.5036532E-03	1.2166451E-02	-2.0578337E-01
PBOB	-9.7109936E-01	1.9224316E-02	-5.0514118E+01
LV7	4.2000431E-01	8.8936631E-02	4.7225121E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BB

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.8255718E+00	1.9917591E-01	-9.1656258E+00
PDB	5.6701805E-01	8.9022367E-02	6.3693886E+00
PDOB	-1.4543578E-02	2.0926932E-02	-6.9496811E-01
PBB	-1.0025921E+00	[illegible]	-8.3122761E+01
PBOB	2.8836174E-02	1.9054154E-02	1.5133799E+00
LV7	4.1639476E-01	8.8957712E-02	4.6808169E+00
AG	4.8866491E-03	1.6253538E-02	3.0065141E-01

065231 CM NEEDED

POOR PRINT
Epreuve illisible

ORDINARY LEAST SQUARES

NUMBER OF OBSERVATIONS = 136

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-2.7723117E+00	7.9661476E-01	-3.4801159E+00
PDU	7.3210269E-01	1.3229695E-01	5.5337834E+00
PDOU	-1.0024956E+00	2.7706669E-02	-3.6182465E+01
PBU	-1.3437594E-02	2.0006169E-02	-6.7167252E-01
PBOU	-3.3545616E-03	1.9274630E-02	-1.7404026E-01
LV7	2.5428859E-01	1.9834520E-01	1.2820506E+00
AG	8.5524963E-01	2.0159410E-01	4.2424338E+00
V6	3.7638756E-02	4.4292416E-02	8.4977880E-01

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.4514036E+00	8.2707920E-01	-1.7548545E+00
PDU	-2.6832785E-01	1.3175346E-01	-2.0365905E+00
PDOU	-2.6114418E-03	2.7592895E-02	-9.4641828E-02
PBU	-6.1008902E-03	2.0569572E-02	-2.9659782E-01
PBOU	-6.0047135E-03	1.9284050E-02	-3.1138238E-01
LV7	2.7014808E-01	1.9783887E-01	1.3654955E+00
AG	8.6031142E-01	2.0079641E-01	4.2844960E+00
LV32	-3.5028655E-01	2.4412428E-01	-1.4346698E+00
V6	3.9186578E-02	4.4123533E-02	8.8811060E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.9570912E+00	3.6906564E-01	-5.3028271E+00
PDU	6.7676420E-01	1.3925598E-01	4.8588106E+00
PDOU	-1.1328768E-03	2.9348973E-02	-3.8600219E-02
PBU	4.6767739E-03	2.0710599E-02	2.2581548E-01
PBOU	-9.9674793E-01	2.0357675E-02	-4.8961776E+01
LV7	4.1724478E-01	2.0406399E-01	2.0446762E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-3.0409910E+00	7.5098892E-01	-4.0493153E+00
PDU	7.2354883E-01	1.3177130E-01	5.4909440E+00
PDOU	-1.8010739E-03	2.7664768E-02	-6.5103525E-02
PBU	-1.0124546E+00	1.9951173E-02	-5.0746613E+01
PBOU	-2.8701831E-03	1.9245438E-02	-1.4913576E-01
LV7	2.8418230E-01	1.9499034E-01	1.4574173E+00
AG	8.2265535E-01	1.9769829E-01	4.1611658E+00

POOR PRINT
Epreuve illisible

SEEMINGLY UNRELATED REGRESSION

NUMBER OF OBSERVATIONS = 136

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.0191140E-01	4.2000264E-01	-2.4264500E-01
PDU	6.8222783E-01	1.3149397E-01	5.1882822E+00
PDOU	-1.0012119E+00	2.7694271E-02	-3.6152311E+01
PBU	2.6798569E-03	1.9596539E-02	1.3675154E-01
PBOU	2.5361981E-03	1.9216825E-02	1.3208207E-01
LV7	4.0169576E-01	1.9298371E-01	2.0823641E+00
AG	9.5867598E-02	6.9550960E-02	1.3783792E+00
V6	6.5234202E-05	3.3174827E-03	1.9663766E-02

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	8.5527657E-01	4.2787394E-01	1.9988985E+00
PDU	-3.1717458E-01	1.3096625E-01	-2.4218048E+00
PDOU	-1.2288177E-03	2.7560628E-02	-4.4553650E-02
PBU	2.5737310E-03	1.9533238E-02	1.3176161E-01
PBOU	2.4349467E-03	1.9140173E-02	1.2721655E-01
LV7	4.0010585E-01	1.9220347E-01	2.0816785E+00
AG	1.0510682E-01	7.3241499E-02	1.4350720E+00
LV32	-4.2336351E-03	3.0833979E-02	-1.3730421E-01
V6	5.3806278E-04	6.4652587E-03	8.3223704E-02

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.9570912E+00	3.6906564E-01	-5.3028271E+00
PDU	6.7676420E-01	1.3920598E-01	4.8588106E+00
PDOU	-1.1328768E-03	2.9348973E-02	-3.8600219E-02
PBU	4.6767739E-03	2.0710599E-02	2.2581548E-01
PBOU	-9.9674793E-01	2.0357675E-02	-4.8961776E+01
LV7	4.1724478E-01	2.0406399E-01	2.0446762E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-5.8980817E-01	4.1646412E-01	-1.4162281E+00
PDU	6.8214124E-01	1.3134773E-01	5.1933994E+00
PDOU	-1.2096738E-03	2.7664357E-02	-4.3726801E-02
PBU	-9.9729216E-01	1.9573089E-02	-5.0952211E+01
PBOU	2.5484289E-03	1.9195791E-02	1.3275978E-01
LV7	4.0195168E-01	1.9266474E-01	2.0862753E+00
AG	9.4549178E-02	6.8010044E-02	1.3902238E+00

061467 CM NEEDED

POOR PRINT
Epreuve illisible

ORDINARY LEAST SQUARES (RESTRICTED ESTIMATES) HYPOTH1

NUMBER OF OBSERVATIONS = 136

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-3.1120469E-01	3.6776538E-01	-8.4620441E-01
PDU	6.3518465E-01	1.3512346E-01	4.7007726E+00
PDOU	-1.0041357E+00	2.8957319E-02	-3.4676405E+01
PBU	-1.4037377E-03	2.0590800E-02	-6.8173054E-02
PBOU	-4.3284518E-03	2.0145475E-02	-2.1485976E-01
LV7	1.2185571E-02	1.9386662E-01	6.2855437E-02
AG	3.5844331E-01	1.4717987E-01	2.4354098E+00
V6	4.0543883E-03	4.5162214E-02	8.9773905E-02

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-3.5840447E-01	4.6916783E-01	-7.6391526E-01
PDU	-3.0181159E-01	1.3137496E-01	-2.2973296E+00
PDOU	-3.2592868E-03	2.7865647E-02	-1.1696433E-01
PBU	3.5032911E-03	1.9867665E-02	1.7633130E-01
PBOU	-8.3198166E-03	1.9421680E-02	-4.2837779E-01
LV7	1.9916954E-01	1.9471010E-01	1.0229030E+00
AG	6.9410784E-01	1.7344666E-01	4.0018519E+00
LV32	-6.1224272E-01	1.8263497E-01	-3.3522755E+00
V6	2.8852748E-02	4.4082825E-02	6.5451222E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.7895566E+00	2.0818564E-01	-8.5959657E+00
PDU	6.6147216E-01	1.3663556E-01	4.8411422E+00
PDOU	-1.7768351E-03	2.9359596E-02	-6.0519738E-02
PBU	5.0223599E-03	2.0725070E-02	2.4233259E-01
PBOU	-9.9794008E-01	2.0265217E-02	-4.9243986E+01
LV7	3.3322239E-01	1.3527973E-01	2.4632101E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-7.9353557E-01	3.4841921E-01	-2.2775311E+00
PDU	6.3481250E-01	1.3453958E-01	4.7184069E+00
PDOU	-4.0470196E-03	2.8528970E-02	-1.4038030E-01
PBU	-1.0013665E+00	2.0507314E-02	-4.8829724E+01
PBOU	-4.2676256E-03	2.0056518E-02	-2.1277958E-01
LV7	1.7059080E-02	1.8539391E-01	9.2015320E-02
AG	3.5780955E-01	1.4644416E-01	2.4433173E+00

POOR PRINT
Epreuve illisible

SEEMINGLY UNRELATED REGRESSION (RESTRICTED ESTIMATES) HYPOTH1

NUMBER OF OBSERVATIONS = 136

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	3.6318754E-01	2.1359961E-01	1.7003193E+00
PDU	6.6048824E-01	1.3463470E-01	4.9057803E+00
PDOU	-1.0018602E+00	2.8926086E-02	-3.4635179E+01
PBU	4.7870535E-03	2.0426056E-02	2.3436017E-01
PBOU	1.8269662E-03	1.9973026E-02	9.1471681E-02
LV7	3.2158943E-01	1.3605470E-01	2.3636774E+00
AG	1.3184620E-02	3.0938963E-02	4.2612997E-01
V6	-1.5550384E-05	3.5834940E-04	-4.3394474E-02

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	1.2159906E+00	2.3812948E-01	5.1064262E+00
PDU	-3.3658310E-01	1.2970239E-01	-2.5950416E+00
PDOU	-1.9688474E-03	2.7836910E-02	-7.0727943E-02
PBU	4.6873268E-03	1.9672502E-02	2.3826795E-01
PBOU	1.0387332E-03	1.9235748E-02	5.4000146E-02
LV7	3.1207948E-01	1.3721736E-01	2.2743448E+00
AG	6.6080264E-02	5.7095287E-02	1.1573681E+00
LV32	-4.7560286E-02	5.2072724E-02	-9.1335507E-01
V6	2.2270273E-03	1.2573202E-02	1.7712491E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBU

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.7895566E+00	2.0818564E-01	-8.5969697E+00
PDU	6.6147216E-01	1.3663556E-01	4.8[illegible]E+00
PDOU	-1.7768350E-03	2.9359596E-02	-6.05[illegible]E-02
PBU	-5.6223601E-03	2.0725078E-02	[illegible]E-01
PBOU	-9.9794008E-01	2.0265217E-02	[illegible]E+01
LV7	3.3322239E-01	1.35279[illegible]	2.4632101E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE [illegible]

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.31922[illegible]	2.1276363E-01	-6.2004126E-01
PDU	6.6039[illegible]	1.3411603E-01	4.9240315E+00
PDOU	-1.86885[illegible]	2.8814656E-02	-6.4857727E-02
PBU	-9.952[illegible]	2.0347360E-02	-4.8912322E+01
PBOU	1.8034[illegible]	1.9896076E-02	9.0643381E-02
LV7	3.20407[illegible]	1.3552620E-01	2.3641721E+00
AG	[illegible]	3.0798788E-02	4.7090110E-01

065231 CM [illegible]ED

ORDINARY LEAST SQUARES

NUMBER OF OBSERVATIONS = 221

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-4.1651527E-01	6.1271640E-01	-6.7978476E-01
PDW	4.8551571E-01	1.1004883E-01	4.4118205E+00
PDOW	-9.9034535E-01	1.5941078E-02	-6.2125367E+01
PBW	-2.2147455E-02	1.5956062E-02	-1.3880276E+00
PBOW	2.6378073E-02	1.6059765E-02	1.6424944E+00
LV7	5.2210919E-01	1.4[illegible]1296E-01	3.4827489E+00
AG	1.8634642E-01	1.4[illegible]849E-01	1.2483139E+00
V6	-2.3345869E-02	3.60[illegible]1970E-02	-6.4684387E-01

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE OW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	1.6682641E+00	6.0499866E-01	2.7574674E+00
PDW	-5.1342076E-01	1.0734525E-01	-4.7828924E+00
PDOW	1.2737079E-02	1.5575113E-02	8.1778409E-01
PBW	-1.6885657E-02	1.5638778E-02	-1.0797300E+00
PBOW	2.7010781E-02	1.5666234E-02	1.7241400E+00
LV7	5.3806936E-01	1.4630280E-01	3.6777790E+00
AG	2.6098588E-01	1.4721385E-01	1.7728351E+00
LV33	-6.4122191E-01	1.8614572E-01	-3.4447308E+00
V6	-2.6263288E-02	3.5215332E-02	-7.4579129E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.9147140E+00	3.3108647E-01	-5.7831238E+00
PDW	5.0083183E-01	1.0916293E-01	4.5879297E+00
PDOW	8.3220324E-03	1.5895613E-02	5.2354272E-01
PBW	-2.2014238E-02	1.5962300E-02	-1.3791395E+00
PBOW	-9.7274156E-01	1.6037200E-02	-6.0655322E+01
LV7	5.0415449E-01	1.4395632E-01	3.5021352E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-3.0974573E-01	5.8673335E-01	-5.2791568E-01
PDW	4.9420905E-01	1.0907658E-01	4.5308449E+00
PDOW	9.9454243E-03	1.5913071E-02	6.2498459E-01
PBW	-1.0220229E+00	1.5933205E-02	-6.4144215E+01
PBOW	2.6090807E-02	1.6031794E-02	1.6274415E+00
LV7	4.9524299E-01	1.4384856E-01	3.4428081E+00
AG	1.9781404E-01	1.4802046E-01	1.3363966E+00

POOR PRINT
Epreuve illisible

SEEMINGLY UNRELATED REGRESSION

NUMBER OF OBSERVATIONS = 221

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	1.1525692E-01	3.3464114E-01	3.4441945E-01
PDW	5.0079814E-01	1.0911503E-01	4.5896324E+00
PDOW	-9.9166879E-01	1.5888731E-02	-6.2413340E+01
PBW	-2.2014239E-02	1.5954901E-02	-1.3797791E+00
PBOW	2.7251815E-02	1.6030021E-02	1.7000486E+00
LV7	5.0409453E-01	1.4390291E-01	3.5030183E+00
AG	1.1091041E-03	1.5005484E-02	7.3913249E-02
V6	8.8614252E-06	1.5980638E-03	5.5451010E-03

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE DW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	1.8658728E+00	3.4684680E-01	5.3795301E+00
PDW	-4.9992382E-01	1.0648249E-01	-4.6948921E+00
PDOW	8.5549163E-03	1.5502405E-02	5.5184444E-01
PBW	-2.1753837E-02	1.5566962E-02	-1.3974416E+00
PBOW	2.7239576E-02	1.5637740E-02	1.7419126E+00
LV7	5.0581959E-01	1.4068795E-01	3.5953298E+00
AG	1.4304294E-02	3.6764299E-02	3.8908110E-01
LV33	-3.2557910E-02	4.2856245E-02	-7.5970048E-01
V6	-1.3251015E-03	8.2482962E-03	-1.6065154E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.9147140E+00	3.3108647E-01	-5.7831239E+00
PDW	5.0083183E-01	1.0916293E-01	4.5879297E+00
PDOW	8.3220324E-03	1.5895613E-02	5.2354272E-01
PBW	-2.2014238E-02	1.5962300E-02	-1.3791395E+00
PBOW	-9.7274156E-01	1.6037200E-02	-6.0655322E+01
LV7	5.0415449E-01	1.4395632E-01	3.5021352E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	3.3428480E-01	3.3341307E-01	1.0026146E+00
PDW	5.0079234E-01	1.0896488E-01	4.5959062E+00
PDOW	8.3317112E-03	1.5867023E-02	5.2509606E-01
PBW	-1.0220143E+00	1.5933203E-02	-6.4143679E+01
PBOW	2.7251483E-02	1.6008165E-02	1.7023490E+00
LV7	5.0410136E-01	1.4369520E-01	3.5081295E+00
AG	1.1793882E-03	1.3466215E-02	8.7581273E-02

061467 CM NEEDED

POOR PRINT
Epreuve illisible

ORDINARY LEAST SQUARES (RESTRICTED ESTIMATES) HYPOTH1

NUMBER OF OBSERVATIONS = 221

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE ODW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	9.6379980E-02	2.7139222E-01	3.5513169E-01
PDW	4.6306256E-01	1.0760575E-01	4.3033253E+00
PDOW	-9.9052844E-01	1.5972424E-02	-6.2014911E+01
PBW	-2.2864523E-02	1.5970097E-02	-1.4317085E+00
PBOW	2.5893521E-02	1.6084149E-02	1.6098782E+00
LV7	4.6380774E-01	1.3655315E-01	3.3965365E+00
AG	8.8391137E-02	1.0635854E-01	8.3106762E-01
V6	-2.7761996E-02	3.5853462E-02	-7.7431842E-01

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE OW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	9.8476408E-01	3.7726551E-01	2.6102679E+00
PDW	-4.8753216E-01	1.0634736E-01	-4.5843372E+00
PDOW	1.2134171E-02	1.5645523E-02	7.7556828E-01
PBW	-1.7443336E-02	1.5710335E-02	-1.1103096E+00
PBOW	2.7407993E-02	1.5740301E-02	1.7412623E+00
LV7	6.0179589E-01	1.4013700E-01	4.2943399E+00
AG	3.5539112E-01	1.3246990E-01	2.6828065E+00
LV33	-4.7141020E-01	1.4477864E-01	-3.2560756E+00
V6	-2.0343471E-02	3.5145588E-02	-5.7883427E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.8791711E+00	1.9325089E-01	-9.7239970E+00
PDW	4.9603364E-01	1.0295750E-01	4.8178484E+00
PDOW	8.4534971E-03	1.5865125E-02	5.3283521E-01
PBW	-2.2153637E-02	1.5928085E-02	-1.3908538E+00
PBOW	-9.7296219E-01	1.5950785E-02	-6.0997762E+01
LV7	4.9062868E-01	1.0127950E-01	4.8443040E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	2.3593698E-01	2.5089554E-01	9.4037932E-01
PDW	4.7111214E-01	1.0700216E-01	4.4028281E+00
PDOW	9.8032561E-03	1.5951733E-02	6.1455743E-01
PBW	-1.0227927E+00	1.5954879E-02	-6.4105323E+01
PBOW	2.5492657E-02	1.6060768E-02	1.5872626E+00
LV7	4.2488962E-01	1.2684800E-01	3.3495964E+00
AG	9.1495016E-02	1.0618349E-01	8.6166895E-01

SEEMINGLY UNRELATED REGRESSION (RESTRICTED ESTIMATES) HYPOTH1

NUMBER OF OBSERVATIONS = 224

EQUATION EQ2

NORMALIZED ENDOGENOUS VARIABLE OOW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	1.5427781E-01	1.9403780E-01	7.9509155E-01
PDW	4.9598999E-01	1.0314262E-01	4.8087781E+00
PDOW	-9.9154450E-01	1.5890008E-02	-6.2400503E+01
PBW	-2.2154694E-02	1.5952674E-02	-1.3887762E+00
PBOW	2.7035529E-02	1.5975954E-02	1.6922639E+00
LV7	4.9054173E-01	1.0164967E-01	4.8258072E+00
AG	1.4495566E-04	8.4083001E-03	1.7239592E-02
V6	-1.3017296E-05	1.8998490E-03	-6.8528350E-03

EQUATION EQ1

NORMALIZED ENDOGENOUS VARIABLE OW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	1.8732249E+00	2.0270556E-01	9.2411125E+00
PDW	-5.0326217E-01	1.0115998E-01	-4.9749140E+00
PDOW	8.6224550E-03	1.5548393E-02	5.5455603E-01
PBW	-2.1940872E-02	1.5609860E-02	-1.4055778E+00
PBOW	2.7052433E-02	1.5632978E-02	1.7304722E+00
LV7	4.9559091E-01	1.0174179E-01	4.8710656E+00
AG	1.6267521E-02	3.0003537E-02	5.4218677E-01
LV33	-2.1394578E-02	3.1596168E-02	-6.7712573E-01
V6	-9.3568884E-04	7.8815327E-03	-1.1872042E-01

EQUATION EQ3

NORMALIZED ENDOGENOUS VARIABLE OBW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	-1.8791711E+00	1.9325089E-01	-9.7239970E+00
PDW	4.9603365E-01	1.0295750E-01	4.8178484E+00
PDOW	8.4534971E-03	1.5865125E-02	5.3283521E-01
PBW	-2.2153637E-02	1.5928085E-02	-1.3908538E+00
PBOW	-9.7296219E-01	1.5950785E-02	-6.0997762E+01
LV7	4.9062868E-01	1.0127950E-01	4.8443040E+00

EQUATION EQ4

NORMALIZED ENDOGENOUS VARIABLE BW

VARIABLE	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
C	3.7353462E-01	1.9359510E-01	1.9294633E+00
PDW	4.9600544E-01	1.0303326E-01	4.8140324E+00
PDOW	8.4550248E-03	1.5874902E-02	5.3260327E-01
PBW	-1.0221544E+00	1.5937693E-02	-6.4134401E+01
PBOW	2.7036065E-02	1.5960695E-02	1.6939153E+00
LV7	4.9055427E-01	1.0143945E-01	4.8359317E+00
AG	1.0355858E-04	6.2436487E-03	1.6586228E-02

065231 CM NEEDED