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Economic Valuation Of Nontimber Resources Under a Lottery Rationing System: The Case of Moose Hunting in Newfoundland

by

Kojo Mawunyo Akabua ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Economic Valuation Of Nontimber Resources Under a Lottery Rationing System: The Case of Moose Hunting in Newfoundland** submitted by Kojo Mawunyo Akabua in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Agricultural Economics.

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Dedicated to

Theresa, the children, and to the memories of my parents-Theresa and Eusebius.

Abstract

This thesis focuses on the use of random utility models in the estimation of nonmarket values when choices may not be realized with certainty. Two non-nested probabilistic choice models were estimated and compared. One is based on the works of Rouwendal (1989) and the other on probability and expected utility theory. The latter approach was used by Boxall (1995). These models were first used independently to estimate welfare measures under counterfactual scenarios and with Count Data models to examine both site choice and trip frequency decisions within a utility-consistent two-stage expenditure framework (Hausman *et al.*, 1995). A Varying Parameter Model was also used to compute welfare measures. The models were applied to data on moose hunting in Newfoundland.

Licenses are needed to hunt moose in designated moose management areas (MMA) in Newfoundland. They are applied for and rationed out through a priority pool lottery rationing process. Site choices made at the application stage were used as revealed preference data because of the costs involved in making choices and the high degree of license utilization. The attributes postulated to determine site choice are travel cost, the probability of winning licenses at sites, the proportion of the balsam fir, white birch, black spruce and disturbed areas working groups at sites, the success rate at making a kill at sites and the alternative specific constants for remoteness and Either Sex licenses. Data provided by successful applicants who hunted were used to estimate the Count data and the Varying Parameter models.

Results show that only travel cost, success rate, balsam fir and the log of the probability of winning a permit in the Rouwendal model were significant in determining site choice. Average per trip consumer surplus for MMA6, for example, ranges from $2.47 to $23.91 depending on the model used. These welfare measures are for moose hunting only. The total expenditure of hunters during the three month hunting season was estimated at about $5.6 million.

Based on statistical test results such as rho squared values, prediction success indexes and adjusted likelihood ratio indexes, the Rouwendal choice model performed better than the Multiplicative choice model.

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CHAPTER 1

INTRODUCTION

Efficient allocation and use of forest resources requires knowledge of their values. These values, like those of many other goods and services, may be revealed through their market prices. Unfortunately, not all forest resources have well-developed markets and market prices. Timber products have well-defined markets and prices whereas non-timber products do not. This thesis estimates the value of a major non timber resource in Newfoundland.

Some aspects of forest resources may not have well-developed markets because of the difficulty in properly defining, establishing and enforcing all property rights in them. As a result, they may be nonexcludable and/or nonrival in consumption. Thus no one can be prevented from consuming them (nonexcludable) and consumption by one person does not limit the chances of others obtaining them (nonrivalry) once they have been provided. The cost of accessing them therefore may well be below prices that would ensure their efficient use. These types of resources are referred to as public goods and services. An example is national defense. They are referred to as environmental goods and services if they are, in addition, components of the natural environment such that their aggregate quantity supplied may be known but their individual or aggregate expenditures will be unknown. Examples are national parks, wilderness, wetlands, the aesthetic services provided by forests and some forms of recreational activities like hunting, hiking and birdwatching. They are also called either nonmarket, nonpriced or extramarket resources if, in addition to being nonexcludable and nonrival in consumption, they do not have well-developed markets (Freeman, 1993; Adamowicz, 1988). In forestry, the term nontimber resources is also used to refer to these goods and services.

Timber products, on the other hand, are excludable and rival in consumption. In addition, they have well developed markets and market prices. An example is wood. Few goods have all the characteristics of pure public goods. For example, access may not be totally unrestricted, such as national parks and recreational hunting or fishing grounds. These are referred to as either impure public goods, mixed goods or quasi-public or environmental goods and services (Randall, 1987; Nautiyal, 1988; Dasgupta and Heal, 1979). The classification of a resource as public, private or quasi-public may depend on the circumstance as well as the characteristics of the resource. Generally, the degree of ease with which property rights are defined, established and enforced in a resource in any circumstance determines whether the resource is private, public or quasi-public. Thus, private goods have well established property rights which are easier to enforce than public goods.

Although nonmarket or nontimber resources do not have well developed markets, they still have value. Value will be used in this thesis to mean economic value, *i.e.*, the maximum amount of money a person is willing to exchange for a nonmarket resource service or the minimum amount he/she is willing to accept in exchange if he/she should part with or do without it (Brown, 1984; Adamowicz, 1990). Until recently, the values of these resources were neglected in decision making due, probably, to the difficulty in estimation (Ciriacy Wantrup, 1952). This neglect has greatly inconvenienced many a user of these resources. Examples abound. One is the effect of clearcutting by timber companies on consumers of nontimber forest resources in British Columbia such as forest-based tourism.

The situation has changed considerably over the past two to three decades and more recognition is being given to the value of these resources. According to Walsh *et al.* (1990), perhaps the most important reason for the change has been the growing pressure from both inside and outside government for improvements in the criteria on which public expenditure decisions are made. Another reason could be the increased demand for recreational activities brought about by economic prosperity following the Second World War. This change has resulted in a corresponding increase in the demand for the provision and/or protection of recreation-related resources. Linked to this phenomenon, perhaps, is the increased awareness of the importance of the environment and the effects of its deterioration on society.

The beginning of the change toward recognition of nontimber values could be traced to US Senate Document 97 (US Water Resources Council, 1962) which established benefit-cost methods for federal agencies in planning water and related resources development (Walsh *et al.*, 1990). Supplement No.1 to this document, which was signed by President Kennedy in 1964, authorized the use of the unit day method of valuation. In 1973, the Water Resources Council revised the guidelines under President Nixon to authorize the use of the Travel Cost Method. Then in 1979, President Carter approved the use of the Contingent Valuation Method. The enactment of laws such as the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)[1] by the US Congress in 1980 gave legal backing to the use of nonmarket valuation techniques in the settlement of damages in courts of law[2] and generated interests in nonmarket valuation elsewhere.

Forests have multiple uses. They provide timber products such as saw and peeler logs, poles, pulpwood, mining props and firewood (Nautiyal, 1988). In addition, they control floods thereby conserving soil and water; they provide forage and chemicals, and are also home to wildlife, some of which are hunted for food and recreation. They also provide aesthetic services to outdoor recreationists who may use them for hiking or for

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[1] This law prohibits the release of hazardous materials into the environment.

[2] However, see Choices (1992, Spring) for arguments against its use in estimatin damages.

other recreational purposes. Thus forests jointly produce private, quasi-public and public goods and services.

Some of these goods and services may be competitive or complementary products with timber products. For example, a recreational activity such as moose hunting may or may not be disturbed by timber harvest decisions depending on how harvesting is done. Forest managers may not recognize the value of nontimber resources and may not even find it necessary to ensure the sustainability of these resources. If the users and potential users of nontimber resources perceive the actions of timber companies as detrimental to their own, conflicts may arise between both groups of users. For an efficient allocation and use of forest resources, values of both timber and nontimber resources must be known.

This thesis will focus on the forests of the Island of Newfoundland with particular reference to the Western Newfoundland Model Forest (WNMF) as a case study of the above issues. Both the Island and the WNMF contain a wide variety of forest types and ecosystems ranging from young regeneration to overmature timber. In addition, it is extensively used for hiking, skiing, big game hunting, and sportfishing. Traditional forestry management in the area has concentrated on timber production to the neglect of other users of the forest resource. As a result, conflicts between timber management and other resource uses are frequent and increasing (Western Newfoundland Model Forest Proposal, 1991). For example, forestry practices affect moose population and moose hunting.

Moose (*Alces alces*) hunting, a nontimber resource, is an important recreational activity in Newfoundland. It is so popular at established hunting fee rates that the activity is regulated. Permits are needed to hunt and these are rationed out to applicants through a lottery system. Once a license is obtained, the hunter may take any number of trips to the site but is allowed only one kill. In 1992, about 22% of the adult population of Newfoundland applied for licenses to hunt moose. If nontimber values are obtained, they could be compared with timber values in arriving at economic decisions regarding forest use. Costs and trade-offs between conflicting resource uses can then be evaluated and means of resolving conflicts investigated. Estimating the value of moose hunting is done by estimating the value of the attributes at the hunting sites as well as changes in these attributes.

The objectives of this thesis are to provide estimates of the value of moose hunting to residents on the island of Newfoundland in 1992 and to study how these values change as site attributes change. In the process, the probability of a hunter visiting each of the 52 moose hunting sites on the Island and how these probabilities change as site attributes change are estimated. Site quality changes result in changes in site choice. This response in turn results in changes in expenditure patterns at the sites. These changes will also be examined. The results will be useful to forest policy makers and forest managers in estimating the effect of policy and resource management decisions on the welfare of nontimber resource users.

My approach in this thesis will follow the suggestions of Loomis (1995). According to him, recreational choice behavior involve four simultaneous or sequential decisions. These are: whether or not to participate in the activity; which site to visit; how many trips to take to the chosen site; and how long to stay. Although the sequence is debatable, economists agree that all four decisions must be accounted for in modeling the full effect of quality changes on welfare measures.

The participation and site choice decisions will be combined and analyzed with random utility models (probabilistic choice models) that account for the fact that individuals may not obtain their choices with certainty. The standard random utility models assume they do. Using random utility models to estimate welfare under these conditions is new. Once the expected per trip welfare measures are obtained, they are multiplied by the number of trips taken to arrive at total welfare measures. As site attributes change, choice probabilities change, and with them the number of potential hunters to the sites.

Consequently, welfare measures change. Businesses in towns within moose management areas (MMAs) are eventually affected by the resulting changes in expenditure patterns of hunters. These expenditure changes resulting from quality changes will be studied using expenditure data from Condon (1993). These are survey data on the expenditures of hunters on accommodation, food, restaurants and rentals in some moose management areas.

The Varying Parameter Model (VPM) and Count Data models will be used to model trip frequency decisions of those who won licenses and hunted. The VPM was used by Smith and Desvouges (1986) to measure water quality benefits. Until now, its use in hunting studies in the literature appears nonexistent. The Truncated Poisson and Truncated Negative Binomial models, which are count data models, have been used to study frequency of visits (Grogger and Carson, 1991; Creel and Loomis, 1992). These models will be used to estimate welfare measures. The VPM and the probabilistic choice models have different structures and are not nested. Therefore their welfare measures are not comparable.

To model the length of trip decision accurately, one must have data on the incremental costs per day at the various sites (Loomis, 1995). Since these are unavailable, this decision cannot be modeled.

Finally, participation/site selection decisions will be combined with the trip frequency decisions by including the consumer surplus[3] obtained from the participation/site selection model as the price index variable in the trip frequency decision model. This approach is identical to a two-stage budgeting process (Hausman *et al.*, 1995). The price index would capture quality changes which influence the participation/site selection decision and explain the number of trips taken as well. Thus a change in site quality would change the probability of site choice as well as the frequency

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[3] Grogger and Carson, (1991) used inclusive values (their TRATE variable).

of visit. The price index would then become a policy variable. This development would enable predictions of the effect of a quality change on both the probability of choosing a site as well as the frequency of visit to the site.

In summary, there exists the issue of potential competitiveness or complementarity in production between private and nonprivate resources in forestry. The value of nontimber resources is difficult to obtain due to their peculiar characteristics, unlike the value of timber resources. As a result, nontimber resources are often neglected when they compete with timber products in forestry. This neglect is detrimental to nontimber resource users and could result in conflict with forest companies. If the values of nontimber resources are known they can be incorporated in timber harvest decisions such that the interests of other forest users may be represented. This thesis will estimate the value of a nontimber resource, moose hunting, in Newfoundland with special emphasis on the Western Newfoundland Model Forest where the potential for such a conflict currently exists.

The rest of the thesis will be organized in the following fashion. The next chapter describes the relationship between forestry and moose hunting within the Western Newfoundland Model Forest, the data for the study and the theoretical background of nontimber valuation. In Chapter 3, the Random Utility Models and their welfare measures will be described and estimated. The combined Random Utility Model and Count Data model and their welfare measures are described and estimated in Chapter 4. The Varying Parameter Model and welfare measures are described and estimated in Chapter 5. Finally, the discussion of the results and conclusion are in Chapter 6.

CHAPTER 2

BACKGROUND

Moose hunting and timber harvest are two important activities to Newfoundlanders. In 1992, the timber harvesting and processing industry generated 3,800 person years of direct employment, contributed $198 million to the local economy and accounted for 21% of the total manufacturing activity in the Province (Statistics Canada, 1994). Moose hunting, on the other hand, is a source of recreation and food. Moose were introduced to the Island in 1878 and 1904 and legal moose hunting began in 1935 (Pimlott 1953, 1959; Mercer and Manuel, 1974). Since then, the activity has become so popular that by early 1950s moose provided 80% of annual big-game harvest on the Island. As indicated earlier, licenses are now needed to hunt and these are rationed out through a lottery system because demand for licenses exceeds supply at existing fees. In 1992, about 22% of the adult population applied for these licenses.

The potential for conflict between moose hunters and timber companies arises because the areas that are mostly inhabited by moose also happen to be the areas where pulpwood production occurs. Thus, timber products and moose may be joint and either competitive or complementary products. In this chapter the relationship between moose and timber, as well as the data and methodology used for the estimation of nonmarket values will be discussed.

Moose Hunting and Forestry

The area of Newfoundland is about 111,370 square kilometers. Of this, 36% is classified as productive forest, 6% as nonproductive forest, 44% as subalpine tundra, fine barren or scrub-covered land, and 14% as water (Pimlott 1953). The productive forests on the Island are located mainly in the watersheds of five principal rivers, viz., The Humber, Exploits, Gander, Gambo and Terra Nova. However the valley of almost every river has the habitat conditions conducive to moose.

The Island has been divided into moose management areas (MMA) for management purposes. In 1992 there were 52 MMAs (Figure.1). These MMAs lie within different moose ranges. Moose ranges, according to Pimlott, can be classified into 3 general classes: the good, the marginal and the submarginal. The good moose range covers MMA2, MMA4, MMA5, MMA6, MMA7, MMA8, MMA9, MMA15, MMA15A, MMA16, MMA16A, MMA17, MMA22, MMA22A, MMA23, MMA23A, and the southern parts of MMA25, MMA29, and parts of MMA40, MMA41, MMA43, MMA45. Pulpwood is the major timber product of the island and almost the entire supply comes from this region. The marginal moose range is covered by large areas of muskeg, barrens and water. Forest cover in this range is over 80% mature. This constitutes less than 25% of the area. The dominant trees are black spruce and balsam fir, with white birch as a minor component. Moose wintering range is found throughout the area because forest cover is interspersed along lakes and rivers. This area comprises a large area of the Burin and Avalon Peninsula. The submarginal range is found in areas with elevation of 400 meters where forest cover gives way to subalpine tundra. The only moose ranges here are found along streams. These ranges are shown in Figure 2.

Moose browsing behavior in Newfoundland has been extensively documented in the literature (Pimlott, 1953, 1963; Thompson *et al.*, 1992; Thompson *et al.*, 1993; Curran, 1989). White birch (*Betula papyrifera*) and balsam fir (*Abies balsamea*) are the two species "of universal importance" that form the basis of moose diet. They are followed by fire cherry (*Prunus pennsylvanica*), mountain maple (*Acer spicatum*), mountain ash (*Sorbus spp.*) ground hemlock (*Taxus canadensis*), aspen (*Populus tremuloides*), willow (*Salix spp.*), mountain alder (*Alnus crispa*), sweet gale (*Myrica gale*), and shadbush (*Amelanchier bartramiana*). White birch is the only specie browsed throughout the year, particularly in burnt or logged areas where moose densities are low or moderate. Balsam fir is more important in areas where moose densities are high and where mature stands of timber are predominant. However, it is browsed mostly in winter when other palatable species are in short supply (Pimlott, 1963). Generally, moose do not browse on such dominant species as black spruce (*Picea mariana*), white spruce (*Picea glauca*), white pine (*Pinus strobus*) and tamarack (*Larix laricina*).

According to Pimlott (1953), balsam fir is not browsed in areas where there are no interspersed timber areas. Thus areas with mixed stands of balsam fir and white birch, interspersed with muskegs and barrens, are ideal for moose. However, these areas also happen to supply the bulk of the Island's pulpwood. There is therefore the potential for conflict between forest companies and moose hunters, particularly if the activities of the former affect moose populations and the value of moose hunting.

Another possible source of conflict relates to thinning. Forest companies thin forests to improve production. According to Thompson and Curan (1989), balsam fir twigs from thinned areas contain more protein than those from unthinned areas. Hence moose prefer to browse in thinned areas where they can obtain their required daily intake of protein. The pulpwood companies would rather prefer moose to browse in unthinned areas.

The effects of the operation of pulpwood companies on moose population and on the value of moose hunting is debatable. Moose require pockets of cleared areas within forests where they feed on successional growth. However, creation of such areas deprive them of cover. According to Pimlott (1953), the operation of pulpwood companies in Newfoundland enhance moose value because of their method of operation. During the process of pulpwood production, balsam fir, black and white spruce are utilized while white birch is left uncut (Bergerud and Manuel, 1968). This creates room for regeneration of white birch and fir seedlings and provides ideal winter feeding habitat when regeneration becomes available above snow cover about 5 years later[4]. In addition, the operating districts of timber companies are evenly distributed on the island. This gives room for the expansion of moose population. The most valuable cutover areas to moose are those that are approximately 8-10 years old and 40 to 50 hectares in size (Parker and Morton, 1978). Larger cuts probably become less available to moose in winter because of deep snow and increased distance from cover. Therefore, to the extent that moose prefer browsing in thinned and interspersed areas, timber harvesting and moose populations are complementary. However, since moose, especially the calf, also require cover during the winter months, certain types of harvesting may be unfavorable to the increase in moose populations particularly in the period immediately following harvesting.

The Western Newfoundland Model Forest

The WNMF is one of ten model forest projects approved by the Federal government under the Government of Canada's Green Plan in June 1992. As part of the Model Forest Network, its objectives are: to accelerate the implementation of sustainable development in the practice of forestry, in particular the concept of integrated resource management; to develop and apply new and innovative concepts and techniques in the management of forests; and to test and demonstrate the best sustainable forestry practices available (Forestry Canada, 1993).

The model forest covers an area of 707,060 hectares, 50% of which is productive forest land, 20% is softwood scrub, 17% is rock or soil barrens and bog, and the remainder consists of water, residential areas, rights of way or cleared land. It is bounded on the north by the Gros Morne National Park, on the east by the Buchans Plateau and Lloyd's River, on the south by the Burgeo highway, and on the west by the Gulf of St.

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[4] On the average it takes about 15 years after cutting for fir to grow beyond the reach of moose.

Lawrence. The area's balsam fir forest is the main source of raw material for two of the province's three newsprint mills[5] as well as a valuable resource for more than 35,000 residents of the area[6]. The area contains a wide variety of forest types and ecosystems ranging from young regeneration to overmature timber, bogs, fens, barrens, coastal heathlands and riparian areas. In addition, it has abundant wildlife resources including large moose and caribou (*Rangifer caribou*) populations. It also has a variety of small furbearers including the threatened Newfoundland pine marten. There are scenic natural attractions which make it a major tourist zone in the province. Hence it is extensively used for hiking, big game hunting, sportfishing, cross-country and downhill skiing.

Traditional forestry management in the area has concentrated on timber production to the neglect of other users of the forest resource. As a result, conflicts between timber management and other resource uses are frequent and increasing[7]. For example, forestry practices affect moose population and moose hunting. If the values of nontimber resources were known, then costs and trade-offs between conflicting resource uses could be evaluated and means of resolving conflicts investigated. The ensuing analytical results will be integrated into a Decision Support System.

Data

Three types of data sets used in the study are the hunting license applications data, the site attributes data and the 'returns' data which are provided by those who won licenses and hunted. These data sets, as well as how they will be used, are described below beginning with a brief description of the lottery process and the applications data.

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[5] The pulp and paper companies have either outright ownership or long term lease of over 18,000 square miles, covering three-quarters of the island's productive forests (Pimlott, 1953).

[6] The Western Newfoundland Model Forest Proposal, 1991.

[7] The Western Newfoundland Model Forest Proposal. 1991.

Lottery and License Applications Data

Moose hunting in Newfoundland is regulated, much like other provinces in Canada and states in the United States (see Nickerson, 1989). Oosenbrug *et al.* (1991) estimate the meat value of a Newfoundland moose at $1,320. With the moose hunting application fee set at $35 (Canadian), the demand for moose exceeds supply, which was estimated at about 120,000 (Oosenbrug *et al.*, 1991). A pool-based lottery system is used to ration hunting permits or licenses.

The regular hunting season begins in September and ends in December. New applicants must pass the Hunters Capability Test before applying to hunt[8]. Applications must be submitted to hunt in any one of the MMAs. In 1992, the year of our study, there were 52 MMAs[9]. One can apply for either an Individual license or a Party license in a year. The Individual license is given to only one applicant whereas the Party license is given to two applicants who apply together. In 1992, there were about 20,300 Individual and 32,500 Party applications from the island. With an adult population of about 386,400, this means that about 22% of all adult Newfoundlanders applied for moose licenses[10] in that year. An applicant is allowed 18 choices of sites (MMAs) on the application form and these must be made in order of preference. However, a license may be won to hunt in only one of them. There is also a bag limit of one moose per license per year.

The Individual and Party licenses are classified into four groups, according to age and sex of moose. These are Either Sex, Female Only, Male Only, and Calf Only. A quota system is used to distribute these licenses among MMAs based on current moose population and desired kill rate.

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[8] This test is administered only to new hunters. In 1991, the failure rate was 30% (see Hunting Guide, 1992/93, p.39).

[9] The number of MMAs change slightly from year to year for management reasons.

[10] With two people applying for a Party license, the total number of applicants is about 85,300. The population of 0-19 years group in 1991 was 182,030 out of a population of 568,474.

All applicants are ranked in a priority pool, based on their participation and/or success at previous draws. The rank of an applicant in the pool improves the longer he/she goes without a license. There are five pools for Individual license applicants and four for Party license applicants. Party license applicants in Pool 1 have the highest priority while those in Pool 4 have the lowest priority. Similarly, Individual license applicants in Pool 1 have the highest priority and those in Pool 5 have the lowest priority.

The draw is made by a computer, beginning with all the applications in Pool 1. Party applications are considered before Individual applications. For any selected application, the computer begins with the first choice of MMA and goes through each MMA listed on the application form until a license is either awarded or there are no MMAs left to consider. In most MMAs, Either Sex licenses are awarded first, followed by Male Only ones. In a few areas where there are no Either Sex licenses, Female Only licenses are awarded first, followed by Male Only and Calf Only. Calf Only licenses are not allocated in areas where Either Sex licenses are available. The status of all the MMAs are known to applicants at the time of application. Also, the lowest pool that produced a successful application in the previous year is known to the applicants. This information is included in application kits received at the time of application. Applicants could use this information to rate their chances when they choose MMAs. I used the information on the lowest pool that produced a successful application to obtain the probability of winning licenses.

If an applicant is successful at the lottery, he/she drops to the lowest priority rank in the following year's draw, whether or not he/she hunts in the year the lottery is won. One must apply yearly to improve upon one's rank. An applicant who does not want to hunt in a particular year does not choose any MMA to hunt in and states on the application form that he/she would not like to be considered for the draw. In 1992, for example, about 6,518 individual and 294 party applicants did this. Although an applicant is free to choose as many as 18 MMAs, he/she must be prepared to hunt in any MMA for which the lottery is won, otherwise he/she drops to the bottom of the pool in the following season. Given these conditions, data on choices of MMAs made on application forms become revealed preference data which can be used to estimate demand and welfare functions (Varian, 1991; Jehle, 1990). These data will be referred to as applications data.

Since hunting is restricted to the MMA for which a license is won, there are no substitution possibilities available to the applicant once a license is won. Therefore site attributes, and changes thereof, play an important role in the choice process at the application stage. Below is a diagram that summarizes the hunting decision process of a moose hunter.

Returns Data

Successful applicants are required to submit to the Wildlife Division information on how they hunted. This includes the number of days hunted as well as the number of hours per day hunted. However, the information does not explicitly state the number of trips taken. Rather, it states the length of trips in days and the dates and hours hunted per day. The number of hours hunted was only recorded for few hunters. Other pieces of information provided are the mode of transportation to hunting sites and the mode of transportation used for hunting. These data were used in estimating the number of trips taken as well as the Count Data and the Varying Parameter models.

Site Attributes Data

There has been a great deal of literature on how the factors that influence individuals' choices differ from those of researchers (Stynes *et al.*, 1985; Perdue 1987). Since it is difficult to determine precisely what influences an applicant's choice of site, the researcher postulates attributes, usually those on which he/she has available data, and uses the error term to account for the differences in explanatory factors.

Moose hunting in Newfoundland is done for recreation and food (Pimlott, 1953). Consequently, factors that influence site choice should reflect both interests. As a result, factors that relate to moose habitat and diet and for which data are available were used as attributes. Thus the proportions of MMAs covered by balsam fir, white birch, black spruce and disturbed areas working groups were used as attributes, based on the composition of moose browse discussed earlier. Although moose do not browse on black spruce, the models may be mispecified if it is excluded due to the large proportion of the island covered by it. Other attributes used are the probability of winning a license, the success rate at making a kill, moose density (only in the VPM), remoteness of a MMA, the availability of Either Sex license in a MMA, and distance traveled which was used in calculating Travel Cost.

Data on Working Groups obtained from the Inventory Statistics (1991) of Newfoundland were used to obtain the proportion of MMAs covered by balsam fir, white birch, black spruce and disturbed areas. Minor adjustments were made since Working Group data are not reported according to MMAs but according to Forest Districts of which there are 18. The map of the MMAs was superimposed on that of the Forest Districts. With the help of a hand-held digitizer, SUMMASKETCH, the proportions of the MMAs that lie within Forest Districts were obtained. These proportions were then used to apportion the attributes of the Forest Districts to the MMAs. Further, since there are no inventory data for Forest District 3, it was assumed to be quite similar to that of Forest District 1, based on the similarity in vegetation of the two areas (see Vegetation Map of Newfoundland). The ratio of the area of District 3 to that of adjacent District 1 was used to apportion attributes of District 1 to District 3.

The Wildlife Division of Newfoundland provided data on the lowest pool license awarded in the previous year for each site. These data are included in the application kit that applicants receive. This information for 1989, 1990 and 1991 was used in obtaining the probability of winning a lottery for each site. For example, the lowest license in the pool is the individual license in Pool 5. If any applicant with this license was able to win a license in 1991, then the probability of winning a license for that site was assumed to be 100%[11]. The average probability for the three years was used as the probability of winning a license for the sites. The Wildlife Division also provided data on success rates of hunters at making kills in the MMAs in the preceding years as well as on moose densities.

Ferguson and Mercer (1988) identified MMA3, MMA11, MMA19, MMA26 and MMA37 as "extremely inaccessible" to hunters based, *inter alia*, on mean distance to the nearest road and the human population within a 50km radius of each MMA. These areas are therefore classified as remote. In 1992, some MMAs were not allocated Either Sex licenses. These are MMA5, MMA7, MMA22, MMA31, MMA34 and MMA42. Since this license type is the first to be drawn, these sites may be less preferred to others. Alternative specific constants (ASC) will be used to represent remoteness and the fact that some areas were not allotted Either Sex licenses. These are factors hypothesized to play an important role in the choice process but for which no specific attributes exist. The attributes can be found in Appendix 3.

Distances were calculated from the addresses provided by applicants on the application forms. They were used in obtaining travel costs from the origin of applicants to the approximate centers of MMAs in which they applied to hunt. There is a general agreement in the literature that both travel distance and travel time costs should be included in travel cost (Shaw, 1988; Smith, Desvouges & McGivney 1983; Bockstael, Strand, Hanemann,1987). Excluding time from welfare analyses produces inaccurate estimates (McConnell, 1985). Sorg and Loomis (1984), for example, increased reported TCM values by 30% to account for the omission of travel time. Generally, the effect of the omission depends on the proportion of travel time cost in total trip cost. The higher the

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[11] The pools were described above under License Applications data.

proportion, the greater the change in welfare resulting from a change in the value of time. McCollum *et al.*(1988) also show that deer hunting benefit estimates increase from $29 per day without travel time to $46 if travel time was valued at 50% of the wage rate and $69 if valued at 100% the wage rate. Some argue that onsite time should be included as well. The literature is very clear on the importance of travel time as an important variable distinct from on-site time (Clawson, 1959; Knetsch, 1963; McConnell, 1975, 1985; Larson, 1993; Shaw, 1992). According to McConnell (1985) if the duration of visits is the same for all individuals and if they are assumed to have the same opportunity cost of time then onsite cost becomes part of the constant term. Data on onsite time in this study is not available.

Travel time[12] is assumed to be a function of the wage rate, based on the assumption that travel time and work time are traded at the margin. However, as argued by Hausman *et al.* (1995), recreational travel time may not be related to labor supply decisions. They therefore estimated the value of travel time from a model of transportation mode choice of individuals and did not assume it is any fraction of the wage rate. Due to lack of data, this procedure could not be followed in this thesis. I calculated the travel cost variable by assuming an average speed of 80km per hour. The time traveled was multiplied by the 1992 Provincial average wage rate of $12.76, adjusted by the Provincial labor participation rate of 53.6%. Both were obtained from Statistics Canada publications. The annual cost of operating a mid-sized vehicle in Newfoundland (34.6 cents per kilometer) was also used. This value was obtained from the Maritimes Branch of the Canadian Automobile Association.

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[12] The value of an individual's time is usually taken to be the wage rate or a fraction of it, usually one-third (Cesario, 1976).

Preference and Utility Theory

At the application stage, the consumer makes a choice of sites based on the site attributes. Those successful at the lottery subsequently choose the number of trips to take. These choices reveal the preferences that applicants have for the chosen site (over others) and for a specific number of trips[13] (over other trip numbers). Under assumptions of nonsatiation, transitivity, quasi-concavity and substitutability, these preference orderings can be represented by a utility function which can be maximized, subject to a given budget constraint, to obtain ordinary Marshallian demand functions (Deaton and Muellbauer, 1980; Jehle, 1991; Varian, 1992). Hanemann (1984) provides a detailed treatment of the derivation of the demand function resulting from discrete and continuous choices.

Preferences are said to be weakly separable if commodities can be separated into groups and preferences and consumption levels within one group can be described independently of preferences and consumption levels in another. Then each group can be represented by a subutility function whose elements are not affected by those of the other groups. Assume three groups - moose hunting trips, clothing, and miscellaneous. Separable preferences are represented by a utility function of the following form

$$U = f[v_H(\text{moose hunting}), v_C(\text{clothing}), v_M(\text{miscellaneous})] \tag{1}$$

where moose hunting trips, clothing, and miscellaneous are subvectors of the selected group and f(.) is a function which is increasing in all its arguments. The value of the subutility functions sum up to the total utility of the group. The subvector, moose hunting trips, for example, can then be studied independently of the others.

Basically, the quantity demanded of hunting, a nontimber resource, is determined by the same general factors that determine the demand for conventional goods: price of

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[13] The assumption is often made that hunters determine the total number of trips to take at the beginning of season. However, given the situation in Newfoundland, the number of trips to take would be based on whether or not a license is won, a kill is made, as well as whether hunting is done for food or for recreation.

the resource, income of the consumer, prices of substitutes and complements and tastes. The definitions of these factors however differ from the conventional case. For example, the definition of the 'product', *i.e.*, number of visits, may not be clear-cut (Fletcher *et al.*, 1989). A day trip is technically a different commodity from a two-day trip. Also, the value of the resource is reflected in the number of trips the consumer undertakes to its location to participate in whatever activity it generates (Kealy and Bishop, 1986; Bockstael *et al.*, 1991). If the value of an activity is to be measured, then the sole purpose of the trip must be to undertake the activity. The price of the activity is the travel cost incurred in undertaking the activity. Even if the applicant is prevented from hunting, as may result from a rationing process, the act of choosing a site based on its attributes reveals his/her preferences for the site. Using axioms of economic theory, these revealed preferences (choices) can be used to estimate demand functions and welfare measures.

Nonmarket Valuation

The estimation of nonmarket values, and changes thereof, using the Travel Cost Method are based on utility theory and on the concept of weak complementarity[14]. The weak complementarity assumption, developed by Mäler, enables demand functions for environmental resources to be implicitly defined (Mäler, 1974; Freeman, 1993). Basically this concept implies that if an environmental good or service is weakly complementary with a non-essential market good, there will not be any expenditure on the environmental good or service unless there is a change in the quantity demanded of the nonessential market good.

Individuals' well-being (welfare) depends on the consumption of private goods as well as the quantities and qualities (attributes) of nonmarket goods (and services). They

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[14] The weak complementarity assumption is not needed for CVM studies.

are assumed to have well-defined preferences among these bundles of goods. These preferences cannot be observed and are only revealed when choices are made. Choices involve substitutions or trade-offs between bundles of goods and services. The value of a chosen good or service can be inferred from these trade-offs. Thus if one of the goods involved in the trade-off has a monetary value, the revealed choice also has monetary value. Using axioms of economic theory, these revealed preferences can be used to derive demand and welfare functions from utility functions. Compensating Variation (CV) and Consumer Surplus measures, derived from estimated demand functions or from indirect utility functions, are used to measure welfare. Then, using a Kaldor-Hicks compensation test (Bishop, 1986), individual measures are aggregated to arrive at a total welfare or benefit measure. Willig (1976) has provided grounds for Marshallian demand functions to be used as substitutes for Hicksian demand functions.

Changes in the quality of nontimber resources change welfare. Such changes may result from changes in forest resource use. This latter result may affect individuals' preferences and choices as well as rates of consumption of nontimber resources, such as the number and duration of trips to hunting sites. Hence their utility and values (benefits and costs) may change. The assumption of weak complementarity enables such changes to be estimated. To estimate such quality changes, the consumption of the public or environmental goods and services must be linked directly with a private action that is measurable in monetary terms. Also, the linkage must be assumed to exist within individuals' preferences. The corresponding changes in the demand function of the private good, resulting from changes in the quality of the complimentary nonmarket resource, are used to estimate such welfare changes.

Two broad groups of methods[15] used in the literature to estimate nonmarket values and quality changes can be described as Direct and Indirect techniques (Freeman, 1993). Each approach seeks to link the services provided by the nonmarket resource with some directly observable activity or private transaction. Direct techniques comprise the Contingent Valuation Method (CVM) and its variants (Cummings *et al.*, 1986). They are used to elicit value through stated preferences of individuals by asking them directly what they would either be willing to pay for the resource or be willing to accept to do without it. Proposed by Ciriacy-Wantrup in 1947 (Ciriacy-Wantrup, 1952) and first applied by Davis (1964), CVM uses responses of individuals to hypothetical survey questions on nonmarket or environmental resources 'contingent' on there being a market for them. The values derived are therefore contingent on the nature of the resource, the context in which it would be provided and the budget constraints of the respondents. Good results from CVM studies depend on proper survey designs. Bishop and Heberlein (1990), and Mitchell and Carson (1989) are two sources which discuss survey design issues. The CVM was used by Condon (1993) to obtain estimates of nonmarket values of moose hunting in Newfoundland.

Indirect techniques, on the other hand, use behavioral data based on revealed preferences of individuals' choices to impute willingness to pay (WTP) values from demand functions. The Travel Cost Model (TCM) is perhaps the most popular indirect technique used in the literature. It originated from Hotelling (1947) who suggested it to the US National Park Service as a way of estimating the demand for recreational sites which do not have market prices like private goods and services. The cost of visiting recreational sites could be considered as proxies of their market prices. If these costs are increased up to a point where zero visits are made, the loss in the number of visits,

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[15] Mitchell and Carson [(1989), p.75] divide the methods into four groups viz., direct observed behaviour, indirect observed behaviour, direct hypothetical and indirect hypothetical.

multiplied by the increase in cost and the number of lost visitors provides a Consumer Surplus estimate of the site's value. This is what people will be willing to pay to access the site.

In its original format, individuals' data were grouped into zones around the site and travel costs to sites were calculated from these zones (McConnell, 1985). The demand for a site was then obtained by regressing the number of trips per head in each zone on the travel costs per trip (Clawson, 1959). Different specifications followed this initial attempt. For example, Knetsch (1964) used natural logs to estimate the demand curve for 12 distance zones in a study of the Kerr Reservoir in North Carolina. Later, variables describing zone characteristics as well as quality of substitute sites were incorporated (Donnelly *et al.*, 1985). Loomis (1982a) used it to study the net benefits of recreation under conditions of lottery rationing. In that study, he recommended that applications per head be used to obtain the revealed demand for hunting instead of trips per head. Using trips per head cuts off those who are willing to pay for the activity but are unsuccessful at the lottery and underestimates the WTP measures.

Unfortunately, the simple TCM cannot be used to measure the effect of quality changes on welfare measures because it is estimated using cross-section data. It treats the number of trips as continuous (across the whole number line). Other assumptions are that trips are taken at the same time, say, at the beginning of the season, which may not necessarily be the case; the assumption that utility is solely obtained at the site and not in transit; and the assumption that all recreationists spend an equal and fixed amount of time at sites. For a detailed discussion of the simple TCM see Freeman (1993), Smith (1990), Fletcher *et al.* (1990) and Ward and Loomis (1986).

Under the TCM are variant techniques designed to handle benefits from quality changes in multisite demand models. Some of these techniques are the Discrete Choice Random Utility Model (RUM), the Varying Parameter Model (VPM), also known as the

Generalized Travel Cost Model (GTCM), the Hedonic Travel Cost Model (HTCM) and Count Data Models. The Random Utility Model (RUM) is suitable for analyzing participation decisions. In the area of hunting and recreational studies, it can be used to determine site choice based on site qualities and changes in choices arising from quality changes. However, they cannot be used to estimate frequency of visits. An example is the Multinomial Logit Model (Binkley and Hanemann, 1978; Feenberg and Mills, 1980; Bockstael *et al.*, 1987). The Varying Parameter Model (Vaughan and Russell, 1982; Smith and Desvouges, 1985; Smith *et al.*, 1986) and the Count Data Models (Cameron and Travedi, 1986; Creel and Loomis, 1992) can also be used to analyze frequency of visits and changes thereof arising from quality changes. The Hedonic Travel Cost Model (Brown and Mendelsohn, 1984; Mendelsohn, 1984) attempts to reveal shadow values for site characteristics by estimating individual's demands for these characteristics. Thus although it can be used to analyze quality changes, it neither predicts behavior nor takes account of the number of trips taken by individuals. This thesis will use the RUM, the Count Data Model and the Varying Parameter Model.

In this chapter, the relationship between moose hunting and forestry in Newfoundland was discussed. Moose and timber products, particularly pulpwood, may be competitive or complementary products and the interests of timber companies and hunters may conflict or be complementary. Either way, it is necessary that the value of moose hunting be known and incorporated in timber harvest decisions. The Western Newfoundland Model Forest and the data sets that will be used in the study and their sources were also described. Finally, preference and utility theory and the theoretical background of nonmarket valuation were briefly discussed. Identification of the models that will be employed in the thesis concluded this chapter. These models and their estimation are discussed in detail in the following chapters.

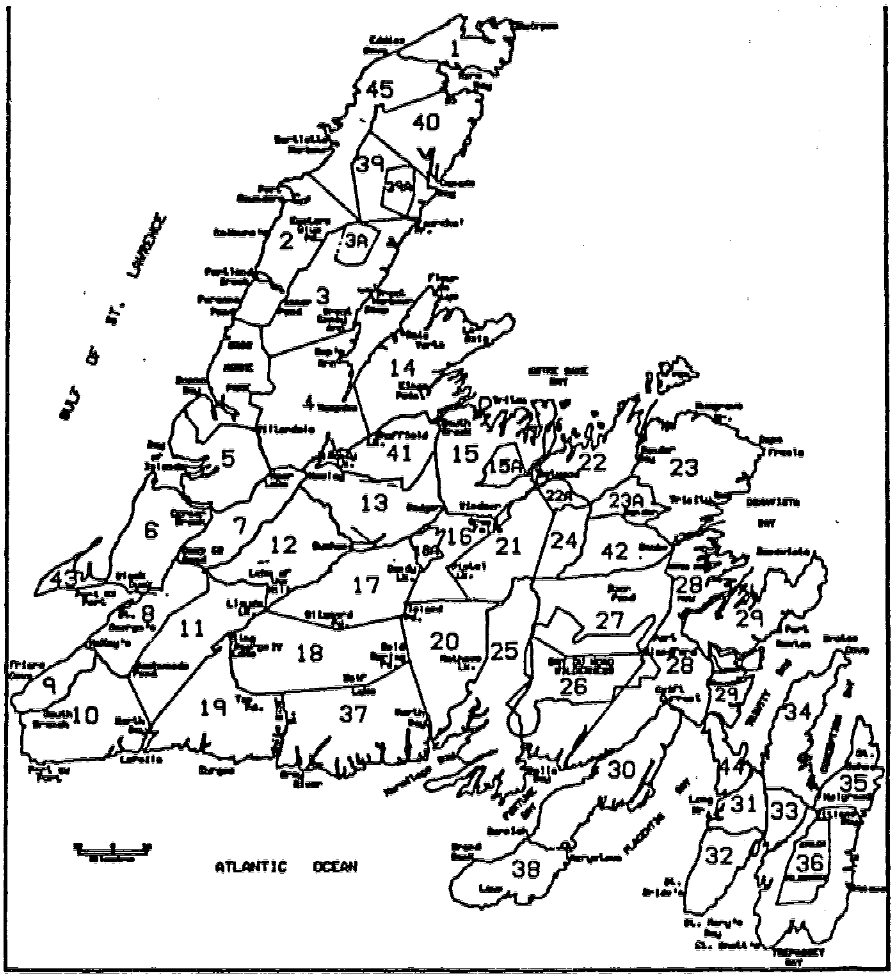

Figure 1. Moose Management Areas (from Wildlife Division, Newfoundland.)

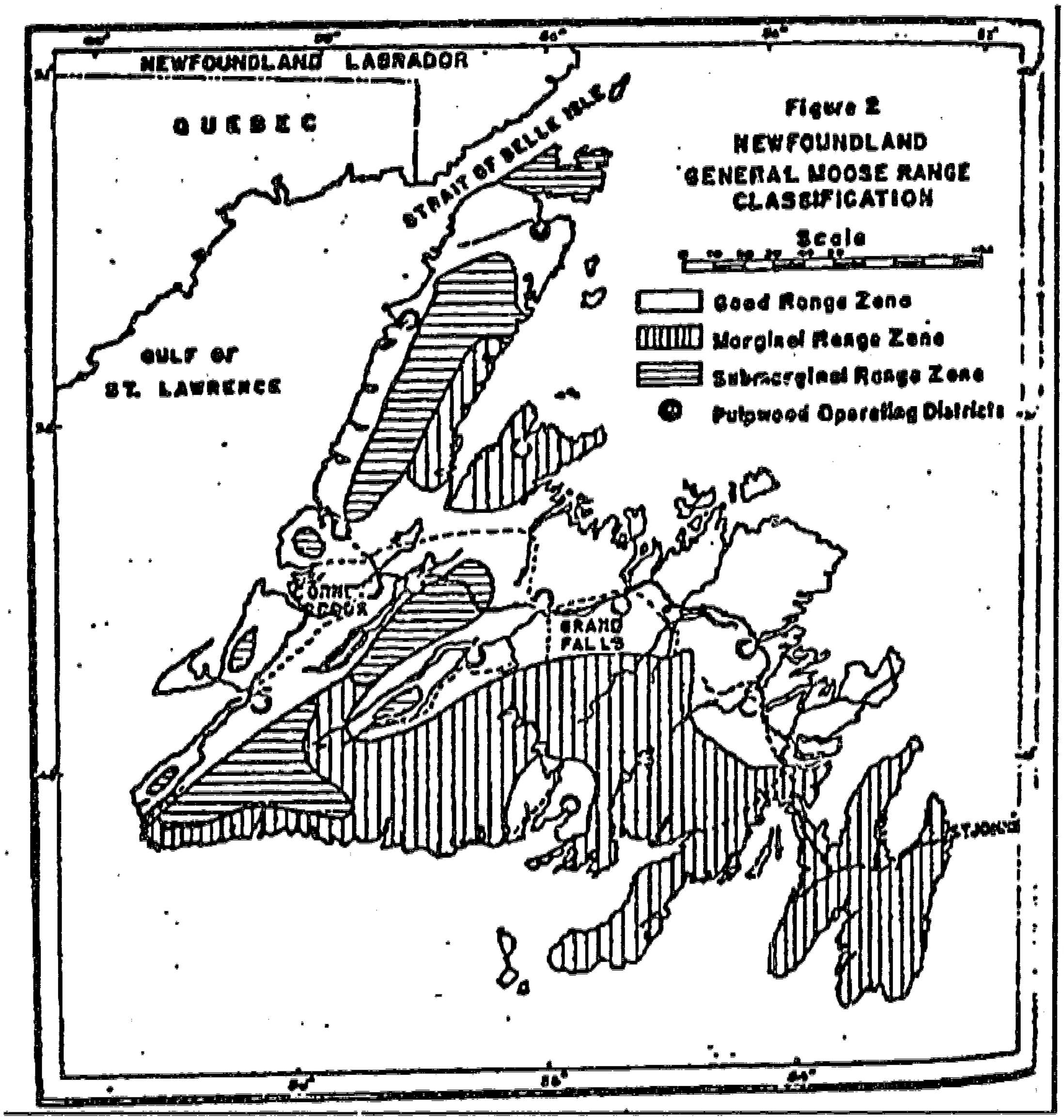

Figure 2. General Moose Range Classification (from Pimlott, 1953)

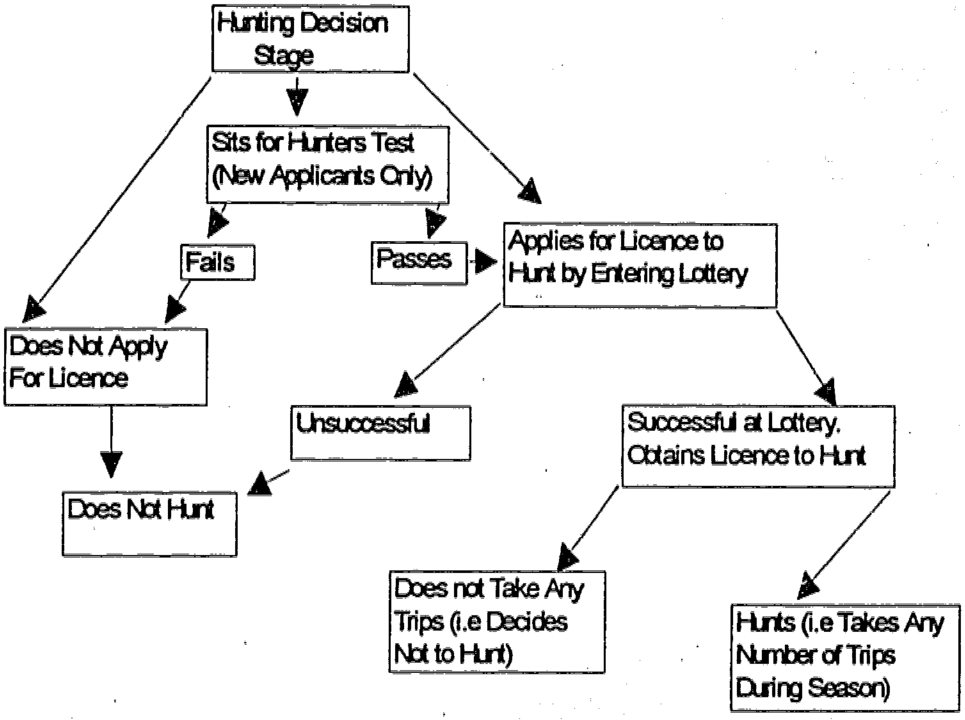

Figure 3. Decision Tree of a Moose Hunter in Newfoundland.

CHAPTER 3

THE RANDOM UTILITY MODEL.

In this chapter, the random utility model (RUM) and its theoretical foundation will be discussed. The model is designed to examine choice, based on the utility of the alternatives in the choice set, and estimate welfare with the condition that whatever choice is made will be realized with certainty. However, in certain situations, there is no certainty that choices made will be realized. An example is when rationing mechanisms are used to restrict the use of recreational sites. Under such conditions the model may need to be restructured. In what follows, the original RUM will be described first, followed by the adaptation that can be used when choices are not realized with certainty. A discussion of welfare measures will be followed by a description of the data, method of estimation and results.

The Random Utility Model

Random Utility Models date back to Thurstone (1927) but it was McFadden (1974) who rediscovered and presented them in their current form. Goods and services produce utilities (bundle of services) to their users based on their inherent attributes (Lancaster, 1966). Consumers are assumed to make choices that maximize their perceived utilities subject to budget constraints. Following Thurstone, McFadden assumed that utility is a random function because of errors in perception and measurement by analysts. Specifically, in its basic form, the utility of individual i (i = 1,...,I) for alternative j (j=1,...,J), for example, can be written as

$$U^*_{ij} = V_{ij} + e_{ij} \tag{2}$$

where V_{ij} represents the deterministic or the systematic component and e_{ij} the stochastic error term. The random or stochastic error term represents the assumption that the researcher, unlike the consumer, does not know with certainty the attributes that determine choice. The error term could therefore be due to the deterministic variation of preferences, stochastic instability of preferences, differences between perceived and realized utility values, unobserved attributes of the choice alternatives, unobserved constraints on behavior, measurement errors on the part of the researcher and irrational behavior (Rouwendal, 1989; Ben-Akiva and Lerman (1985). The consumer chooses alternative *j* if the utility to be derived from *j* is equal to, or greater than, that of any other alternative. The model is estimated by parameterizing the error term either to be normally distributed resulting in the multinomial probit model, or to have a log Weibull, Type 1 Extreme Value or Gdenenko distribution, producing the multinomial logit model. The latter is more frequently estimated because of the complexity of the probit model if the number of alternatives is greater than 3 (Maddala, 1983; Rouwendal 1989). Since the number of MMAs is 52, the multinomial probit model is not considered any further.

The deterministic portion of the utility function is assumed to be linear and additively separable, *i.e.*,

$$V_{ij} = \alpha X_j + \beta_j Z_i + \varepsilon_j \qquad (3)$$

where X_j is a vector of attributes (bundle of services) of alternative *j* and Z_i is a vector of the characteristics of the consumer and ε_j is a function of e_j above. The attributes are weighted by the parameters α and β. Whereas α is common across all the alternatives, β is indexed by the alternatives because only relative differences among attributes are relevant for choice among alternatives. Utility components that are common to all alternatives cancel out unless they are indexed by the alternative.

Assume the error terms are independently and identically distributed across consumers and assume further that they are drawn from a J-dimensional joint-distribution which has a cumulative distribution function

$$F(\varepsilon_1, \ldots, \varepsilon_J) \qquad (4)$$

with a density function $f(\varepsilon_1,\ldots,\varepsilon_J)$ which is finite valued such that the probability of having equal utility for two alternatives is zero (Börsch-Supan, 1987). A rational consumer prefers alternative *j* over *k* if the utility to be derived from *j* is greater than that of *k*, *i.e.*,

$$U^*_{ij} > U^*_{ik}\,. \tag{5}$$

Let π_{ij} represent the probability that the consumer *i* chooses *j* over the other sites. Then using Equations 2 to Equation 5, the probability that individual *i*, characterized by the deterministic utility components $V_i = (V_{i1},\ldots,V_{iJ})$, will choose alternative *j* from a set of J alternatives is given by

$$\pi_{ij} = \int_{\varepsilon_j=-\infty}^{\infty} \int_{(\varepsilon_k \mid \varepsilon_k < \varepsilon_j + V_{ij} - V_{ik}\,,\, k=1,\ldots,J,\, k \neq j)} dF(\varepsilon) \tag{6}$$

where $F(\varepsilon)$ denotes the joint distribution function of the stochastic error terms components of the utility function. This shows that only the differences between the error terms ε_j and ε_k as well as V_{ij} and V_{ik} are relevant (Börsch-Supan, 1987). Let $W_{ij} = V_{ij} - V_{ik}$ and $\eta_k = \varepsilon_j - \varepsilon_k$. Then Equation 6 above can be written as

$$\pi_{ij} = \int_{\eta_1=-\infty}^{W_{i1}} \cdots \left[\int_{\eta_j=-\infty}^{W_{ij}} \right] \cdots \int_{\eta_J=-\infty}^{W_{iJ}} dG^j(\eta)$$

$$= G^j (W_{i1},\ldots[,W_{ij}],\ldots,W_{iJ} \tag{7}$$

where the square brackets denote the terms to be excluded and $G^j(\eta)$ denotes the joint cumulative distribution function of the η_k, $k = 1,\ldots,J$, $k \neq j$. The distribution assigned to η determines whether the result is a multinomial probit model or multinomial logit model.

The Type 1 Extreme Value distribution can be written, following Maddala (1983), Hensher and Johnson (1981), and Kennedy (1993), as:

$$F(\varepsilon_j < \varepsilon) = \exp(-\exp^{-e}) \tag{8}$$

with a probability density function

$$f(\varepsilon_j) = \exp(-\varepsilon_j - \exp^{-e_j}) \tag{9}$$

and a unique mode at zero and a mean of approximately 0.577 (Amemiya, 1981). If η in Equation 7 is assumed to be distributed as Type 1 Extreme Value, the result is the conditional multinomial logit model[16] (McFadden, 1974) defined below:

$$\pi_{ij} = \frac{\exp^{V_j}}{\sum\limits_{k \in C_J}^{J} \exp^{V_k}} \quad for \quad k \in C_J \tag{10}$$

where C_j is the choice set. The probability of choosing any alternative depends on its attributes vis-à-vis the attributes of all the alternatives. McFadden (1974) has shown that Equation 10 is derived from utility maximization if and only if the error terms are independent and are distributed as log Weibull or Type 1 Extreme Value. The independent and identically distributed (i.i.d) assumption of the error term implies that the correlation between the unobserved attributes associated with each and every pair of alternatives in a choice set and across choice sets is zero (independence). Identically distributed implies that taste variation exists over the observed attributes yet it is neutral between alternatives, having the same distribution (*i.e.*, equal variance) around the mean (or representative) utility level. In practice it is difficult to distinguish the influence of taste variation from that of unobserved attributes.

The assumption of an independent disturbance (error) term is known as the Independence from Irrelevant Alternatives (IIA) assumption[17]. This makes it impossible to take into account the similarities among alternatives (Amemiya, 1981). The IIA property (or assumption) incorporates both the concepts of functional separability and separability of choices with the proviso that proportional representative utilities be preserved within

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[16] If α in Equation 3 equals zero, then choice depends only on individual characteristics. This is the multinomial logit model. When choice depends on the attributes of the alternatives as well, the model is called the conditional multinomial logit model. Amemiya refers to this as the Independent Logit model (Amemiya, 1981).

[17] According to Amemiya (1981) this weakness was first pointed out by Debreu.

and between choices (Hensher and Johnson, 1981). Functional separability (Leontief) assumes that the marginal rates of substitution among a set of variables, say in a subgroup of a two stage expenditure process, is independent of variables in other subgroups. Separability of choice assumes that the conditional probability associated with a given choice is dependent on only part of the full utility function. The assumption of IIA produces the following results: the error terms are stochastically independent across alternatives, the odds of choosing alternative *j* over alternative *k* are independent of the attributes of all other alternatives and of the number of alternatives, and the elasticity of the probability of choosing site *j* with respect to the attributes of any other alternative *k*, ($j \neq k$) is constant, *i.e.*, independent of *j*. These conditions constitute both an asset and a liability for the model. As an asset they make the computation of the probability of choosing any alternative very easy and the model can therefore be used in situations where the number of alternatives is large. To see the liability, one can calculate the odds of choosing, say, hunting site 1 over hunting site 35. The formula is

$$\pi_1 / \pi_{35} = \exp (V_1 - V_{35}) \qquad (11)$$

Notice that this does not depend on either the number of alternatives or the attributes of any other alternative. Thus if site 1 is in the north and site 35 is in the south, and distance is an important attribute to a consumer, the fact that site 36 is adjacent to site 35 will not affect the odds of choosing site 1. This assumption is restrictive.

The conditional multinomial logit model has been used in recreational, transportation and housing studies (Bockstael *et al.*, 1991; Ben-Akiva, 1985; Börsch-Supan, 1987). It can be used to estimate the welfare effects of quality changes at sites as well as the effect of adding or closing sites. It allows substitution effects to influence choices. However, its estimates are good for only "one shot" analyses, *i.e.*, for only a single choice decision at a time. It cannot be used to estimate frequency of visits. The choice alternatives in these studies are discrete in nature. Therefore econometric models that treat them as continuous will produce biased and inconsistent estimates (Maddala, 1983).

The choice probabilities, generated by stochastic utility maximization, are continuous and differentiable (Rouwendal, 1989). Since the number of applicants is large, the π_j's can be interpreted as demand functions per choice occasion. The number of consumers choosing an alternative can be forecast from the product of its choice probability and the total number of consumers. In recreational studies where licenses are required, the number of licenses to be applied for at each site can be forecast using the probability of choice in the following fashion (Loomis, 1982; Boxall, 1995):

$$Lic_j = \sum_{i=1}^{I} \pi_i(j) \qquad (12)$$

One assumption of the conditional multinomial logit model is that the choices of consumers will be realized with certainty. In other words, the model does not deal with uncertainty in the realization of choices resulting from, say, a lottery system of rationing. When a consumer is no longer certain about whether or not his/her choice of hunting site will be realized, then choices may no longer be assumed to be based solely on the utility of the sites (or alternatives). Choices may also be based on the probability of realization as well as what would happen if the choice is not realized. The MNL model therefore needs to be adjusted in such cases. The lottery system of rationing licenses in Newfoundland means that site choices may not be realized with certainty.

Random Utility Model When Choices may not be realized

The uncertainty introduced, say, by the lottery system can be explicitly modeled as an expected utility maximization problem, *i.e.*, rather than maximizing utility, the consumer is seen to be maximizing expected utility. Let ($0 < \xi_j \leq 1$) represent the probability that the applicant's choice will be realized, *i.e.*, he/she will win the lottery to hunt in the site of his/her first choice[18]. Let U_{ij}' represent the expected utility of individual i from site j as defined above (see Varian, 1992; Nickerson, 1990). Then

$$U_{ij}' = \xi_j U_j^* + (1-\xi_j)U_j^* \text{ , } j = 1,\ldots,J \tag{13}$$

where ξ_j is the probability that the choice of the jth site will be realized and U_j^* is defined in Equation 2. Define π_j' as the expected probability of choosing site j (as first choice). Then utility maximizing behavior implies that

$$\pi_{ij}' = \text{Prob}\,(U_j' > U_k');\, j = 1,\ldots,J;\ k = 1,\ldots,j\text{-}1, j\text{+}1,\ldots,J \tag{14}$$

Maintaining the additive random utility specification, this can be written as

$$U_{ij}' = V_j' + e_j' \tag{15}$$

where[19] $V_j' = \xi_j V_j + (1-\xi_j)V_j$ and $e_j' = \xi_j e_j + (1-\xi_j)e_j$. Equation 2 is similar to Equation 15.

As a result of this specification, equation 7 under uncertainty becomes

$$\pi_j = \int_{-\infty}^{\infty}\int_{-\infty}^{W_1^*}\int_{-\infty}^{W_2^*}\cdots\int_{-\infty}^{W_J^*} h(\varepsilon).d\varepsilon_J \ldots d\varepsilon_2 d\varepsilon_1 d\varepsilon_j, \quad j=1,\ldots,J$$

where $W_k^* = 1/\xi_k\,[\xi_j V_j - \xi_k V_k + (\xi_k - \xi_j)V_1 + (\xi_k - \xi_j)\varepsilon_1 + \xi_j\varepsilon_j\,]$, $k = 2,\ldots,J,\ k \neq j$ (Rouwendal, 1989). Rouwendal has pointed out that the integration of this function to produce a MNL formula equivalent to equation 10 leads to difficulties because the homogeneity properties that McFadden used to arrive at Equation 10 can no longer be applied here.

Probabilistic choice models in general relate choice probabilities directly to a set of explanatory variables. They do not have random utility interpretations. However, if they can be specified and the results found to satisfy certain compatibility or consistency requirements, the specification will also define a stochastic random utility maximization

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[18] It is possible that their first choice may not materialize but a second-best site may. This analysis concentrates only on the first choices. Some applicants actually made only one choice.

[19] Included in the choice set specifically as alternative 1 is nonparticipation. The choice set in Equation 2 is therefore smaller than the set in Equation 15.

model (McFadden, 1981; Börsch-Supan, 1987 p.18). McFadden (1981, p.205) provides the necessary and sufficient conditions for consistency of observed demands with random preference maximization, which is analogous to the strong axiom of revealed preference for the individual consumer. He however adds, "it does not provide a practical sufficient condition for consistency". The practical consistency requirements which are necessary but not sufficient are:

(i) adding up: the sum of the probabilities of choosing a site summed over all the sites in the choice set for an individual should equal unity;

(ii) translation invariance: the values of the site choice probabilities remain unchanged if a constant c is added to all the systematic portion of the indirect utility function

$$\pi_{ij}\,(v_1+c,\ldots,v_J+c) = \pi\,(v_1,\ldots,v_J), \qquad j = 1,\ldots,J;$$

(iii) symmetry: the change in the probability of choosing site *j* as a result of a change in the utility of site *k* should be equal to the change in the probability of choosing site *k* as a result of a change in the utility of site *j*. This guarantees the integrability of the probabilities of site choice and is the analogue of the Slutsky condition in continuous demand analysis;

(iv) semi-positivity:

$$\frac{\delta_{(J-1)}\pi_j(V)}{\delta V_1 \ldots [\delta V_j] \ldots \delta V_J} \geq 0$$

i.e., all mixed partials of the probability of choosing site *j* with respect to the utility of sites in the set other than *j* exists, are nonnegative and independent of the order of differentiation. (The square bracket in the denominator denotes the term to be left out). This requirement is essential for the implied distribution function to have a positive density function and for the translation invariance property to be satisfied (McFadden, 1981; Borsch-Supan).

The difference between these properties and those of conventional demand theory is that they are formulated in terms of the utility values of the alternatives instead of their prices. If these conditions are met then the estimates of the probabilistic choice model can be given a random utility maximization interpretation.

According to Rouwendal (1989), whereas the values of e_j (Equation 2) are independently and identically Weibull distributed, those of e_j' of Equation (15) are not (*i.e.*, when $0 < \xi \leq 1$). Since the expected random term does not satisfy the Weibull or Type 1 Extreme Value distribution, the basic logit model cannot be estimated (Yellott, 1977; Hensher and Johnson). In fact, Rouwendal (1989) shows that it will be difficult, if not impossible, to obtain an additive random utility model based on expected utility maximization when realization of choices is uncertain. This result is arrived at because expected utility maximization is inconsistent with the Independence of Irrelevant Alternatives (IIA) assumption. He shows that it does not make sense to assume that the error terms of the expected utility function are i.i.d since one would want that in the limit the probability density function approaches that of the error term for the existing condition (nonparticipation) when the probability of realization becomes very small. If the probability variable is used as a multiplicative term, the result may not be a logit model[20].

Rouwendal developed a generalized logit model which is a probabilistic choice model that satisfies all the compatibility conditions except that of symmetry. This property, which is analogous to the Slutsky condition in the conventional demand case, guarantees the integrability of the predicted probabilities. This shortcoming notwithstanding, he used it to estimate the choice of housing in The Netherlands (Rouwendal, 1989).

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[20] The additive specification is needed for the random term to be singled out and used for the specification

Assume that nonparticipation is included in the choice set[21] (Rouwendal; Morey *et al.*, 1993; and Adamowicz, 1994). Rouwendal argues that choice probabilities approach zero whenever the travel cost (price) to a site grows infinitely large. This result is because among the choice alternatives there exists at least one alternative whose utility is independent of price (travel cost). In our case, such an alternative may be associated with the possibility of the applicant choosing not to hunt again, *i.e.*, nonparticipation. Therefore the assumption is made, without loss of generality, that included in the choice set of each applicant is the status quo (*i.e.*, not hunting) which will be resorted to if the applicant does not win the lottery[22]. The probability of attaining this status quo, if chosen, is trivially 1.

Define π_j' as the probability that alternative j ($j > 1$) will be chosen, given that alternative 1 (non participation) is not[23]. Then the conditional choice probabilities model is given by

$$\pi_j' = \frac{g(\xi_j, V_1)\exp^{V_j}}{\sum\limits_{k \in C_J}^{J} g(\xi_k, V_1)\exp^{V_k}} \qquad j = 2, \ldots, J \tag{16}$$

This model will be referred to as the Rouwendal model. It shows g(.) as a correction factor on V_j, and suggests the requirement that $g(1, V_1) = 1$. This requirement guarantees

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[21] Making nonparticipation a choice within the participation branch of the decision tree looks awkward. This structure just gives the individual more flexibility to choose not to participate after deciding to participate.

[22] This assumption only acts as a catalyst. The utility of the status quo is not used in the analysis. See Rouwendal, 1989.

[23] The unconditional choice probabilities model is

$$\pi_i' = \frac{g(\xi_j, V_1) . \sum\limits_{j=2}^{J} \exp^{V_j} . \exp^{V_j}}{\sum\limits_{k=2}^{J} g(\xi_k, V_1) . \exp^{V_k} . \sum\limits_{k=1}^{J} \exp^{V_k}} \qquad j = 2, \ldots, J; j \neq k$$

This model will be referred to as the Rouwendal model. It shows g(.) as a correction factor on V_j, and suggests the requirement that $g(1,V_1) = 1$. This requirement guarantees that the correction factor on V_j will be zero whenever the probability of realization equals 1. Choice alternatives become less attractive as a consequence of the uncertainty and the correction is larger when the probability associated with winning a license for a site is lower. The translation invariance property ensures that V_1 does not influence the choice probabilities. Note that the inclusion of alternative 1 (non participation) in Equation 16 does not affect the probability of choosing the other sites. The results will not have a random utility interpretation unless the consistency requirements are satisfied. Without including the nonparticipation alternative, using actual number of trips to multiply per period CV bounds welfare measures neither from below nor above (Morey *et al.*, 1993).

The function g(.) can be given any specification with the proviso that in the limit

$$\xi_j \rightarrow 1 : g(.) \rightarrow 1. \qquad (17)$$

In addition, the specification must not change the original specification of the utility function. Two specifications that satisfy these conditions for a linear utility function are the simple power function of the realization probability

$$g(.) = \xi_j^{\psi} \quad ; j = 1,\ldots,J \qquad (18)$$

and the exponential function of the realization probability

$$g(.) = \exp(\psi(\xi_j - 1)) \quad ; j = 1,\ldots,J \qquad (19)$$

The expected sign of the coefficient ψ in both cases is positive. The simple power function of the realization probability (Equation 18) will be used in this thesis. Then the choice probability (Equation 16) can be written as

$$\pi_{ij}' = \frac{\exp^{V_j + \ln[g(\xi_j, V_1)]}}{\sum_{k=2}^{J} \exp^{V_k + \ln[g(\xi_k, V_1)]}} \quad j = 2,\ldots,J \qquad (20)$$

the alternatives, other than the status quo (non participation), have the same probability of realization, the model could show that applicants would make choices as they would have made under conditions of certainty. The model also satisfies a condition that is analogous to the IIA property. It states that the ratio between two choice probabilities is a function of the non-random variables that determine the expected utilities associated with these two alternatives only. For other details see Rouwendal (1989).

Boxall (1995) has approached the problem by using the probabilities as a multiplicative term with the attributes. This model will be referred to in this thesis as the 'Multiplicative model'. Its results will be compared with those of the Rouwendal model. The model is shown below:

$$\pi_{ij}' = \frac{\exp^{\xi_j V_j}}{\sum_{k \in C_J}^{J} \exp^{\xi_k V_k}} \qquad \mathit{for}\ \ k \in C_J \tag{21}$$

This model seems to be more flexible than the Rouwendal model[24]. For the sake of illustration, assume that the probability of winning permits is the same for all sites. If this probability is 1, the probabilities of site choice in both models will be equal. However, if the probability of winning permits is 0, then the probability of site choice in the Multiplicative model reduces to the proportion of the site within the choice set whereas the probability of site choice in the Rouwendal model becomes indefinite. For values between 0 and 1, the probability of site choice from the Rouwendal model is the same as if the probability of winning permits were 1. On the other hand, the probability of site choice

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[24] For the sake of illustration, Equation 20 can be written as

$$\pi_{ij}' = \frac{\xi_j \exp^{V_j}}{\sum_{k \in C_J}^{J} \xi_k \exp^{V_k}} \qquad j = 2,\ldots,J$$

the probability of site choice in the Rouwendal model becomes indefinite. For values between 0 and 1, the probability of site choice from the Rouwendal model is the same as if the probability of winning permits were 1. On the other hand, the probability of site choice from the Multiplicative model either increases or decreases for each site monotonically. From this example, one may deduce intuitively that the smaller the variance in the probabilities of winning permits, the closer the probabilities of site choice from the Rouwendal model will be to the standard RUM model. This outcome will not be the case for the Multiplicative model. These situations are unrealistic since it is improbable that the probabilities for all the sites will be equal.

Welfare Measures for the Random Utility Models

The expected Compensating Variation measure of welfare used in the literature is based on the works of Small and Rosen (1981) and Hanemann (1982). The expected per trip maximum utility formula (Small and Rosen, 1981) for the standard RUM is

$$W_i = \ln\left[\sum_{j=1} e^{V_j}\right] + 0.57722 \qquad (22)$$

where W is the welfare measure, i = 1,...I represents individuals in the sample and j=1,....J represents the choice set. If this measure is multiplied by the inverse of the absolute value of the coefficient on the implicit site price (Travel Cost), the result is an average per trip consumer surplus. The formula usually used to evaluate the average per occasion (or per trip) change in welfare due to price and quality changes is given below as

$$\mathrm{CV} = \frac{1}{\mu}\left[\ln\left(\sum_i e^{V_{i0}}\right) - \ln\left(\sum_i e^{V_{i1}}\right)\right] \qquad (23)$$

where CV is the expected Compensating Variation per choice occasion or per trip, μ is the estimated coefficient on the Travel Cost (Price) Variable which Hanemann (1982) shows to be equivalent to the marginal utility of income, V_{i0} is the level of utility at initial price or quality level in the initial state to individual *i* and V_{i1} is the level of utility in the simulated state. If income effects are assumed away, *i.e.*, if marginal utility of income is assumed constant, the above formula provides a closed form solution. Total welfare measures from quality changes for the hunting season are obtained by multiplying CV by the number of trips taken and summing over the number of successful applicants who hunted.

A problem with the welfare measure in this case is that no trips have yet been taken. An option is to use the weighted average of trips taken by those who were successful as a kind of proxy to multiply CV by to obtain total welfare measures. One may however ask whether welfare could be said to have been gained or lost when trips have yet been taken. If a large proportion of those who obtain licenses hunt, then one can use the trips taken by the successful applicants to obtain total welfare measures. Generally, the demand for licenses is very high and in 1992 only about 3% of those who obtained licenses did not hunt. Based on this low figure of people who obtained licenses but did not hunt, the above procedure for welfare determination becomes appropriate. The welfare measure is therefore ex-post.

With uncertainty in the realization of choices the above formula (Equation 23) needs to be modified. Due to the uncertainty, an alternative may be chosen simply because it has the highest probability of realization even though it may not have the highest utility. Alternatively, it may have the highest utility but the lowest probability of realization and may not be chosen for this reason. Therefore choices cannot be assumed to be exclusively explained by utility theory.

Using the probabilities as a multiplicative term of the attributes, one could define the CV measure (Boxall, 1995) as

$$CV = \frac{1}{\mu}\left[\ln\left(\sum_i e^{\xi V_{i0}}\right) - \ln\left(\sum_i e^{\xi V_{i1}}\right)\right] \tag{24}$$

Alternatively, one could design a welfare measure that would approach the standard case if the realization probabilities approach unity. One such function suggested by Rouwendal is

$$W = \ln\left[e^{x} + \sum_{j=2}^{J} \xi_j . g\left(\xi_j , V_1\right) . e^{V_j} \right] \tag{25}$$

where

$x = E(V_1 \mid V_1 \neq \max_k V_k)$

If there are no data to explain nonparticipation, x becomes zero. Then the welfare measure for participation, *i.e.*, assuming alternative 1 (nonparticipation) is not chosen, becomes[25]

$$CV = \frac{1}{\mu}\left[\ln\left(\sum_i e^{V_{i0} + \ln\xi_j + \ln g\left(\xi_j , V_1\right)} \right) - \ln\left(\sum_i e^{V_{i1} + \ln\xi_j + \ln g\left(\xi_j , V_1\right)} \right) \right] \tag{26}$$

where V_1 is ignored. Thus if the probability of realization is unity, the welfare measure collapses to the standard measure.

The models can also be used to estimate the value of a site by adding or eliminating the site or changing any of the attributes and calculating the appropriate CV values (gain or loss) for each scenario. Hence they can be used in the development of Decision Support Systems.

Distribution of Welfare Estimates (Monte Carlo)

Welfare estimates are point estimates and are random in nature. As such it is appropriate to find their distribution and the confidence intervals within which they lie. Maximum likelihood (ML) estimates asymptotically have normal distributions. This characteristic is used to simulate distributions around welfare measures obtained from

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[25] This assumes that g (.) is specified as the simple power function of the realization probability.

maximum likelihood estimates. The procedure is described in Adamowicz *et al.* (1993). A Cholesky decomposition of the variance-covariance matrix of the ML estimates, $V(\beta)$, produces the matrix m such that $mm' = V(\beta)$. The matrix m is then post-multiplied by a vector of random variables (r). Finally, a random drawing of coefficients is made to reestimate welfare measures using antithetic replications, *i.e.*, each randomly generated coefficient is used twice, in its original form and as the negative of the original ($\beta + mr$ and $\beta - mr$). The resulting estimators are symmetric bivariate normal distributions. Five hundred draws were made for each simulation. See also Krinsky and Robb (1986, 1990).

Econometrics

The dependent variable of the random utility model is discrete and categorical. It shows whether or not an alternative has been chosen and does not in itself have any value other than showing the category in which the alternative lies, viz., chosen or not chosen. Applying ordinary least squares methods will produce biased estimates (Maddala, 1983). The dependent variable can also be proportions if individuals with an identical characteristic are grouped together. The proportion of people choosing an alternative is obtained from the number of people in the group that choose the alternative out of the total for the group.

The estimates are interpreted to mean that all individuals have the same demand parameters. Heterogeneity is introduced by the inclusion of socioeconomic characteristics such as income as interaction terms. Since choices are made on the relative differences between attributes, individual socioeconomic characteristics cancel out unless they are used as interactive terms with the attributes.

Goodness of fit statistics measure the accuracy with which a model approximates the observed data. Accuracy can either be measured by the similarity between the calculated probabilities and the actual choice frequencies or by how well the model forecasts observed behavior. One such measure is the likelihood ratio index. This is analogous to the R^2 of ordinary linear regression. There are two versions; one is McFadden and the other is Cragg and Uhler (Maddala, 1991). The measure attributed to McFadden (1974) is defined as

$$\rho^2 = 1 - \frac{L^*(\hat{\beta})}{L^*(0)} \tag{27}$$

where $L^*(\beta)$ is the maximized value of the log-likelihood and $L(0)$ is the value of the log-likelihood evaluated such that the probability of choosing the *i*th alternative is exactly equal to the observed sample aggregate share of the *i*th alternative. The measure attributed to Cragg and Uhler is given by

$$\rho^2 = \frac{L_\Omega^{2/n} - L_\omega^{2/n}}{1 - L_\omega^{2/n}} \tag{28}$$

where n is the sample size, L_Ω is the maximum likelihood function when maximized with respect to all the parameters including the constant term and L_ω is the maximum likelihood function when maximized with respect to the constant term only. The ρ^2 can be improved by adjusting for degrees of freedom as shown below:

$$\bar{\rho}^2 = 1 - \frac{L^*(\hat{\beta}) / \sum_{j=1}^{J} (J_i - 1) - K}{L^*(0) / \sum_{j=1}^{J} (J_i - 1)} \tag{29}$$

where J_i is the number of alternatives available to individual i and K is the number of attributes in the model. Another type of adjusted likelihood ratio index is

$$\bar{\rho}^2 = 1 - \frac{L^*(\hat{\beta}) - K}{L^*(0)} \tag{30}$$

where the variables are as defined above. This adjusted likelihood ratio index can be used for testing non-nested hypotheses of discrete choice models (Ben-Akiva and Lerman, 1985). Assume all N observations in a sample have J alternatives. To choose between two non-nested models, the following holds asymptotically under the null hypothesis that model 1 is the true specification:

$$\Pr(\bar{\rho}_2^2 - \bar{\rho}_1^2 > z) \leq \Phi\{-[2Nz\ln J + (K_2 - K_1)]^{0.5}\}, \qquad z>0 \tag{31}$$

where $\bar{\rho}^2_l$ = the adjusted likelihood ratio index for model l = 1, 2,

K_l = the number of parameters in model l

Φ = the standard normal cumulative distribution function.

Thus if there are at least 250 observations with two or more alternatives, and if both models have the same number of parameters with the difference in the two adjusted likelihood ratio indexes of at least 0.01, then the model with the lower index is 'almost certainly incorrect' (Ben-Akiva and Lerman, 1987).

Another goodness of fit measure is the prediction success index obtained from the prediction success table. (Hensher and Johnson, 1981; Maddala, 1983). This approach is a synthesis of prediction tests. Each entry in the table, N_{jk}, gives the number of individuals who chose alternative *j* but had been predicted to choose alternative *k*. N_{jj} refers to the number of correct predictions of alternative *j*. From the table, the prediction success index for site *j* may be calculated as

$$\sigma_j = \frac{N_{jj}}{N_{.j}} - \frac{N_{.j}}{N_{..}} \tag{32}$$

where $N_{jj} / N_{.j}$ is the proportion of individuals expected to choose an alternative and who did, and $N_{.j} / N_{..}$ is the proportion which would be successfully predicted if the choice probabilities for each sampled individual were assumed to equal the predicted aggregate share. Thus if the value of σ_j equals zero, the model's prediction ability equals that of market share hypothesis for alternative *j*. Overall prediction success indexes are given by:

$$\sigma = \sum_{j=1}^{J}\left[\frac{N_{jj}}{N_{..}} - \left(\frac{N_{.j}}{N_{..}}\right)^2\right]. \tag{33}$$

where $N_{.j}/N_{..}$ is the proportion of the sample observations predicted to choose alternative *j*. This index can be normalized to have a value of 1.

Data

The data on applications for licenses and site attributes are used to estimate this model. Applicants are allowed to make up to 18 choices. Only their first choices were used in this thesis. With SAS (SAS Institute Inc., 1994), the postal codes supplied by applicants were used to obtain their towns of origin and select only applicants from the Island of Newfoundland. Those from Labrador and elsewhere were excluded. Excluded also were those who just applied to improve upon their rankings (6,518 individuals and 294 Party applicants) and those whose first choices were not moose[26]. The total number of Individual and Party applicants came to 16,447 and 25,042 respectively. The applicants were aggregated into 406 towns. Travel Costs from these towns to each of the 52 moose management areas were calculated using postal codes of applicants. The towns were later grouped into 253 to reduce the number of observations for the discrete choice model. This reduction was done by grouping nearby towns and villages together. The dependent variables are proportions of people from the towns that choose each site.

The site attributes that are postulated to determine site choice are the travel cost to the MMAs, the probability of winning a license, the proportion of the Balsam Fir, White Birch, Black Spruce and Disturbed Areas Working Groups in the MMAs, the success rate at making a kill in each of the MMAs and the Alternative Specific Constants for Remoteness and Either Sex licenses as described earlier[27].

Estimation

Parametric estimation of Discrete Choice models usually use a linear specification of the systematic or deterministic portion of the utility function. Thus

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[26] The database is for those who applied for Caribou and Black Bear licenses as well.

[27] See Appendix 3 for the definition of the attributes.

$$V = \beta' X + e \tag{34}$$

where X is the vector of attributes and e the error terms. Estimation is done by maximum likelihood techniques using the Newton (or Newton-Raphson) method (Maddala, 1983; Greene, 1993). The result is a vector of estimates, β, that are consistent, asymptotically normal and asymptotically efficient. Given r (r = 1..,R) attributes, an estimated β_r can be interpreted as an estimate of the weighting applied to attribute r in the utility function V by applicants (Hensher and Johnson, 1981).

The values of environmental amenities are believed to be positively correlated with income (Morey *et al.*, 1993). Income effects should therefore not be ignored. To this end, the assumption is made that the utility of each site is a function of travel costs, site attributes and income available to cover the period of the hunting season, *i.e.*, three months. Specifically, V was specified as[28]

$$V_j = \beta\,(Y\text{-}TC_j) + \beta\,(X_j), \qquad j = 2,\dots,53 \tag{35}$$

where Y is the income for the hunting season, TC is the travel cost and X is the vector of attributes. Individual income figures for each applicant were not available. Average incomes for the towns of origin of the applicants, obtained from Statistics Canada, were therefore used. Only one-quarter of the average income was used since this represents the approximate income available to hunters during the hunting season (Morey *et al.*, 1993).

The travel cost used is calculated as

$$TC = [\text{Distance} \times 0.346] + [(\text{Distance}/80\text{kph}) \times 12.76 \times 0.536] \tag{36}$$

The first part of the formula represents the cost of operating a vehicle in Newfoundland (34.6 cents per kilometer obtained from the Canadian Automobile Association) and the second part represents the value of time using the speed of 80km per hour. The average

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[28] The estimated coefficient on Travel Cost may be assumed to be the coefficient on income with a sign change (Bockstael *et al.*, 1991). Also the first alternative (j = 1) represents nonparticipation.

wage rate of $12.76 per hour in the Province of Newfoundland was used. This is adjusted by the Provincial labor participation rate of 53.6%.

The Rouwendal model (Equation 20) and the Multiplicative model (Equation 21) were estimated using data on the first choice of applicants. This estimation is an example of a representative agent model because the specification assumes that all applicants or households from each town have identical preferences and marginal propensities to spend on moose hunting (Deaton and Muellbauer, 1989). The dependent variable of RUM models is usually dichotomous, 1 if the site is chosen, and 0 otherwise. In this model, the dependent variables are proportions data. For each town, the proportion of applicants who select each of the sites, out of the total applicants from the town, is used as the dependent variable. LIMDEP 6 was used in the estimation. The estimates, β, are Full Information Maximum Likelihood estimates.

Welfare measures for each town were obtained from Equation 24 and Equation 26. These measures were multiplied by total number of trips[29] taken from each town to all the sites, summed and divided by the total number of trips taken to arrive at per trip welfare measures. Counterfactual changes in attributes and site closures were made to simulate quality changes and welfare measures. Monte Carlo simulations were used to obtain the means and standard deviations of these welfare measures. For each town, 500 replications of the welfare measure were done. These measures were sorted in ascending order for each town and 5% cut off from both ends. The remaining 90% was used to obtain the mean and standard deviation of the welfare measures for the towns. Two restrictions were used: the generated travel cost coefficient should be positive in accordance with the model specification and the resulting CV measure should not be greater than the average income of the town. The generated multivariate normal distributions at each stage were assumed to be so and were not tested because of the large number of replications.

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[29] The next chapter explains how the number of trips was obtained.

Results

Table 3.1 and Table 3.2 at the end of the chapter show the estimates of the Rouwendal and Multiplicative models respectively. Only the results of the individual model, *i.e.*, the model using data on choices of individual applicants, are reported since they are used for welfare estimation. The estimates from the Rouwendal model show that the coefficients of Travel Cost, the log of the probability of obtaining licenses, the success rate of making a kill at a site in the previous year and balsam fir are all significant at the 1% level. The estimates also show that the greater the travel cost from an applicant's residence to a site the smaller the chance of that site being chosen. The structure of the model is such that individual characteristics such as income cancel out during the estimation process. The greater the proportion of balsam fir at a site, the greater the chances of the site being chosen. The estimated parameters show the weight of the attributes in the utility function. Thus balsam fir has the most weight. The non-significance of the coefficient of black spruce is not surprising since the species is not known to be browsed upon by moose (Pimlott, 1953). Therefore applicants for moose licenses would not be expected to choose sites where black spruce is dominant. Indeed, Boxall *et al.* (1995) in a study of choice of water recreation routes in Nopiming Park in Manitoba (using RUM) found mature black spruce stands to have a significant and negative weight in the utility function. Black spruce is the most important pulpwood species in Canada (Vincent, 1965). According to Vincent,

> "Many foresters believe that repeated pure stands of spruce on an area lead to degradation of site quality through an accumulation of raw humus."

Since some hunters set up camps when they go hunting, sites with black spruce may not be attractive for use as camp sites. The Alternative Specific Constants representing Either Sex licenses and remoteness are not significant in site choice decisions. The likelihood ratio index of 0.483 is very high. The adjusted likelihood ratio index is 0.474. The estimates from the Multiplicative Model are similar to those of the Rouwendal Model. The Travel Cost, Success Rate and Balsam Fir attributes are all significant at the 1% level. The other attributes are not significant. This model has a likelihood ratio index of 0.45 and an adjusted likelihood ratio index of 0.441. Since the Rouwendal model and the Multiplicative model are not nested, the non-nested test (Equation 31) was used to compare them. Given that the adjusted likelihood ratio index for the Rouwendal model is greater than that of the Multiplicative model by 0.033677, the Rouwendal model can be said to be a 'more correct' specification than the Multiplicative model[30].

Welfare Measures

Welfare measures were calculated by simulating the closure of MMA5, MMA6, MMA7 and MMA12 separately and combined. These moose management areas (MMA) roughly designate the Western Newfoundland Model Forest. The closures result in welfare losses which reflect the values of the MMAs. In addition, an arbitrary 40% increase in the size of disturbed areas[31] in MMA6, and in MMA5, MMA6, MMA7, and MMA12 combined were simulated. This exercise was undertaken for illustrative purposes.

There is the concern that under conditions of lottery rationing and excess demand for licenses, closing a site may result in net loss of trips taken. This situation may arise because those who would have applied to hunt at the closed site would now move to already crowded sites with the same license quotas. However, there are sites where the possibility of winning licenses is 1 and displaced applicants can always choose to hunt in

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[30] The Multiplicative model could still predict better than the Rouwendal model.

[31] This scenario is designed to show the effect of clearcutting on moose populations and on hunting values simply for illustrative purposes. Technically, the simulation should not have been done since disturbed areas is not significant in deciding site choice. Moreover, as suggested by Dr. J.A Beck, the effect of simulating a reduction in this attribute will depend on where the cut is made as well as the size of the cut.

these areas. Also, the addition of the displaced applicants to the already existing applicants can be treated as unobserved variations in the population which can be taken care of by the random term, provided the consistency conditions are met.

Total welfare measures from a particular simulation are obtained by calculating the per trip welfare for each town, multiplying by the total number of trips originating from the town and summing over all towns. Since this procedure is conditional on the number of trips taken, per trip measures are obtained by dividing the total welfare measure by the total number of trips taken.

Table 3.3 shows the total number of trips taken from Corner Brook, Deer Lake, Pasadena and Cox's Cove to MMA5, MMA6, MMA7 and MMA12 as well as the total number of trips taken from the towns to all the sites. These towns lie within the Model Forest; Corner Brook which lies within MMA6 is situated in the center of the Model Forest. The Table shows that about 72% of all trips taken by hunters from Corner Brook, and about 98% from Cox's Cove, were to these four MMAs alone.

Welfare measures were estimated assuming minimal income effects. The average per trip welfare loss from closing the chosen sites are given in Table 3.4 and Table 3.5 for the Rouwendal and Multiplicative models respectively. These losses can also be interpreted as the values of the sites to hunters during the hunting season. These values, as stressed earlier in this thesis, are for moose hunting only. They do not represent the value of other nontimber resources at the sites. The overall provincial average per trip (or per choice occasion) loss of closing MMA5 to moose hunting for an individual of the Province is $4.12 and $3.22 from the Rouwendal and Multiplicative models respectively. The expected per trip loss to Corner Brook alone is $13.92 and $10.80 from the Rouwendal model and Multiplicative Models respectively. Also, the expected per trip loss to Cox's Cove, which lies within MMA5, is $25.05 and $20.22 from the Rouwendal and Multiplicative models respectively. These figures are higher than the Provincial average because of their proximity to the affected sites. The total welfare loss of closing MMA5 is estimated at $272,343 using the Rouwendal model. This value represents the seasonal loss to the people of Newfoundland from closing MMA5 to moose hunting. The seasonal loss to Corner Brook alone is estimated at $95,352, which is about 35% of the loss to the Province from closing MMA5. The combined loss to the four towns is about 51% of the total Provincial loss.

Closing the four MMAs to moose hunting would result in an expected per trip loss of about $57 to a reprentative hunter from Corner Brook, $61 to a reprentative hunter from Cox's Cove, $44 to a reprentative hunter from Deer Lake and $66 to a reprentative hunter from Pasadena, using the Rouwendal model. The corresponding expected per trip loss from the Multiplicative model are $44 for a reprentative hunter from Corner Brook, $46 for a reprentative hunter from Cox's Cove, $34 for a reprentative hunter from Deer Lake and $52 for a reprentative hunter from Pasadena. Overall, the closure of all the four MMAs to moose hunting would result in a Provincial seasonal welfare loss of about $1,018,000 from the Rouwendal model and $776,000 from the Multiplicative model. The total welfare loss of closing the four sites to Corner Brook alone is about $388,463.50 if the Rouwendal model is used and $304,503.70 if the Multiplicative model is used. These figures represent 38% and 39% of the total loss respectively. The total seasonal welfare loss to the other three towns as well as to the Province from closing each of the sites can found in Table 3.4 and Table 3.5. Condon (1993) estimated the net economic value of moose hunting in Newfoundland in a season to range from $122.54 to $212.90 which she described as "somewhat low". Morton *et al.* (1995) using a contingent behavior analysis estimated per trip welfare measures of moose hunting in northwestern Saskatchewan to range from $69.84 to $136.69 under various scenarios.

The estimates from these two models show that increasing the proportion of disturbed areas leads to benefits to moose hunters and not losses (see Table 3.1 and Table

3.2). Table 3.6 and Table 3.7 show the expected per trip benefits for the four towns and the Province from increasing the proportion of disturbed areas in the MMAs by 40%[32]. The expected per trip (or per choice occasion) benefit to Deer Lake and Pasadena, for example, from the Rouwendal model is 6 cents and 8 cents respectively. The corresponding per trip benefit to these towns from the Multiplicative model are 4 cents and 5 cents. The per trip benefit to Corner Brook, which lies within MMA6, is 17 cents and 12 cents from the Rouwendal model and Multiplicative model respectively. The total Provincial welfare gain from increasing disturbed areas in MMA6 by 40% is $3,865 and $2,914 from the Rouwendal and Multiplicative models respectively. The gain to Corner Brook alone is $1,181 and $856 from the Rouwendal and Multiplicative models respectively. The total Provincial benefit from increasing disturbed areas by 40% in all the four MMAs is $14,927 and $12,354 for the Rouwendal and Multiplicative models respectively. The other results can be found in Table 3.6 and Table 3.7.

Monte Carlo simulations of per trip measures were done for the values of MMA5, MMA6, MMA7, MMA12 and the combined value of MMA5, MMA6, MMA7 and MMM12 since these were the sites simulated. The results are shown in Table 3.8 and Table 3.9 below. Antithetic replications produced two means and two standard deviations representing the results from the original draws of the coefficients as well as their negatives (see discussions above). The consumer surplus per trip measures of the Rouwendal model obtained from Equation 24 and Equation 26 lie between the mean Monte Carlo per trip consumer surplus measures for MMA5, MMA7 and the combined value of MMA5, MMA6, MMA7 and MMM12. On the other hand, those of MMA6 and MMA12 are greater than the Monte Carlo measures. For the Multiplicative model, the estimated consumer surplus measures for the same MMAs are either larger or smaller than

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[32] Since disturbed areas attribute is not significantly different from zero in deciding site choice, calculation of welfare measures using this variable should strictly not have been done.

the Monte Carlo measures. None is bracketed by the Monte Carlo measures. The Monte Carlo welfare estimates need not bracket the original consumer surplus measures because of the multi-site characteristics of the RUM.

In this chapter, the standard random utility model was described. This model is used in the literature to examine choice when consumers are certain that their choices will be realized. Due to the lottery rationing system, applicants for hunting licenses are not sure whether or not their site choices will be realized. The standard RUM therefore needs to be restructured. Two models that account for this uncertainty in the realization of choices were estimated. These are the Rouwendal model and the Multiplicative model. The former model is attributed to Rouwendal and the latter, suggested by Boxall (1995), uses the probability of winning a license to hunt as a multiplicative term with the attributes in the standard RUM formula. Their welfare measures were also described. The models were used to simulate the welfare of four MMAs within the WNMF as well as changes in an attribute, disturbed areas, for purely illustrative reasons. The next chapter describes the estimation of the combined RUM and Count Data models.

TABLE 3.1

ESTIMATES OF ROUWENDAL MODEL USING INDIVIDUAL APPLICANTS

Attributes	Coefficients	T-statistics
TC+	0.01926	18.319*
Log(Prob)	1.6709	2.835*
Success Rate	3.5634	4.07*
Balsam Fir	38.967	5.237*
White Birch	7.9681	1.385
Black Spruce	-3.1048	-0.484
Disturbed Areas	1.6522	0.284
ASC (Remoteness)	-0.244	-0.626
ASC (Either Sex)	-0.1054	-0.465
Likelihood Ratio Index	0.4833	
Adjusted Likelihood Ratio Index	0.4743	

Notes: TC+ is Average Income-Travel Cost
Prob is the Probability of winning a permit
ASC is alternative specific constant
* Significant at the 1% level

TABLE 3.2

ESTIMATES OF MULTIPLICATIVE MODEL USING INDIVIDUAL APPLICANTS

Attributes	Coefficients	T-statistics
Prob x (TC+)	0.0266	17.971*
Prob x Success Rate	5.0587	4.808*
Prob x Balsam Fir	51.48	4.984*
Prob x White Birch	7.0488	0.859
Prob x Black Spruce	2.3931	0.263
Prob x Disturbed Areas	2.3395	0.289
ASC (Remoteness)	-0.1235	-0.324
ASC (Either Sex)	0.0686	0.321
Likelihood Ratio Index	0.4487	
Adjusted Likelihood Ratio Index	0.4407	

Notes:TC+ is Average Income-Travel Cost
Prob is the Probability of winning a permit
ASC is alternative specific constant
* Significant at the 1% level

TABLE 3.3

NUMBER OF TRIPS TAKEN FROM SOME TOWNS TO MMAS WITHIN THE MODEL FOREST

TOWNS	MMA5	MMA6	MMA7	MMA12	TOTAL OF MMA 5,6,7, 12	GRAND TOTAL
Corner Brook	1,954 (28.52%)	1,639 (24%)	1,302 (19%)	66 (1%)	4,961 (72.4%)	6,850
Deer Lake	776 (32.9%)	6 (0.2%)	345 (14.63%)	19 (0.8%)	1,146 (48.6%)	2,358
Pasadena	122 (11.69%)	16 (1.5%)	700 (67.11%)	9 (0.86%)	847 (81.2%)	1,043
Cox's Cove	347 (93.27%)	6 (1.6%)	12 (3.2%)	0	365 (98.11%)	372

Note: The figures in parentheses are the percentages of total trips to all 52 sites

TABLE 3.4

EXPECTED PER TRIP VALUE OF MOOSE MANAGEMENT AREAS TO THE AVERAGE HUNTER FROM SOME TOWNS WITHIN THE MODEL FOREST IN DOLLARS (ROUWENDAL MODEL)

MMA	Corner Brook	Deer Lake	Pasadena	Cox's Cove	Total CS (All Towns)	Overall Per Trip CS
MMA5	13.92 (95,352)	20.26 (47,773)	28.97 (30,226)	25.05 (9,317)	272,343	4.12
MMA6	10.34 (70,898)	3.29 (7,763)	4.40 (4,593)	7.51 (2,793)	237,457	3.60
MMA7	12.90 (88,365)	7.46 (17,591)	10.12 (10,566)	8.04 (2,992)	181,905	2.75
MMA12	1.51 (10,350)	2.74 (6,461)	1.67 (1,743)	1.49 (555)	78,123	1.18
MMAs 5,6,7,12	56.70 (388,464)	43.79 (103,257)	65.70 (68,525)	60.67 (22,569)	1,017,748	15.42

Note: Total welfare measures for the towns are in parentheses

TABLE 3.5

EXPECTED PER TRIP VALUE OF MOOSE MANAGEMENT AREAS TO THE AVERAGE HUNTER FROM SOME TOWNS WITHIN THE MODEL FOREST IN DOLLARS (MULTIPLICATIVE MODEL)

MMA	Corner Brook	Deer Lake	Pasadena	Cox's Cove	Total (All Towns)	Overall Per Trip CS
MMA5	10.80 (73,982)	16.44 (38,757)	23.21 (24,210)	20.22 (7,520)	212,911	3.22
MMA6	6.74 (46,178)	2.00 (4,731)	2.63 (2,745)	4.73 (1,759)	163,006	2.47
MMA7	11.09 (75,981)	6.07 (14,322)	8.29 (8,646)	6.14 (2,285)	147,485	2.23
MMA12	0.92 (6,291)	1.75 (4,132)	0.99 (1,035)	1.49 (333)	49,907	0.75
MMAs 5,6,7,12	44.45 (304,504)	34.53 (81,416)	52.45 (54,704)	46.32 (17,232)	776,074	11.75

Note: Total welfare measures for the towns are in parentheses

TABLE 3.6

EXPECTED PER TRIP VALUE OF INCREASING THE SIZE OF DISTURBED AREAS BY 40% IN MMA6 AND ALL OF MMAS 5,6, 7, AND 12 TO THE AVERAGE HUNTER FROM SOME TOWNS

(ROUWENDAL MODEL)

TOWNS	MMA6	MMA5,6,7,12
Corner Brook	0.17	0.76
Deer Lake	0.06	0.69
Pasadena	0.08	0.87
Cox's Cove	0.12	0.82
Total Benefit (All Towns)	3,864.50	14,927
Overall Per Trip CS	0.06	0.23

TABLE 3.7

EXPECTED PER TRIP VALUE OF INCREASING THE SIZE OF DISTURBED AREAS BY 40% IN MMA6 AND ALL OF MMAS 5,6 7,AND 12 TO THE AVERAGE HUNTER FROM SOME TOWNS (MULTIPLICATIVE MODEL)

TOWNS	MMA6	MMAS 5,6,7,12
Corner Brook	0.18	1.29
Deer Lake	0.06	1.21
Pasadena	0.07	1.45
Cox's Cove	0.13	1.36
Total Benefit (All Towns)	2.914	12.354
Overall Per Trip CS	0.04	0.19

TABLE 3.8

MEAN AND STANDARD DEVIATION OF PER TRIP WELFARE MEASURES OBTAINED FROM MONTE CARLO SIMULATIONS IN DOLLARS (ROUWENDAL MODEL)

MMA	CS Per Trip	Mean1	Std1	Mean2	Std2
Closure of MMA5	4.12	4.09	5.43	4.32	5.62
Closure of MMA6	3.60	0.80	1.32	0.79	1.34
Closure of MMA7	2.75	3.28	3.41	2.39	3.08
Closure of MMA12	1.18	0.65	0.72	0.56	0.70
Closure of MMAMF	15.42	16.82	21.80	12.38	19.02

Notes: CS Per Trip is obtained from Equations 24 and 26 and the number of trips.
MMAMF is a combination of MMA5, MMA6, MMA7 and MMA12.
Mean1 is the mean of per trip measure obtained from b + mr
Std1 is the standard deviation of the measure obtained from b + mr
Mean2 is the mean measure obtained from b - mr
Std2 is the standard deviation measure obtained from b - mr

TABLE 3.9

MEAN AND STANDARD DEVIATION OF PER TRIP WELFARE MEASURES OBTAINED FROM MONTE CARLO SIMULATIONS IN DOLLARS (MULTIPLICATIVE MODEL)

MMA	CS Per Trip	Mean1	Std1	Mean2	Std2
Closure of MMA5	3.22	3.41	4.64	4.60	5.39
Closure of MMA6	2.47	0.37	0.71	0.40	0.85
Closure of MMA7	2.23	2.98	3.48	2.82	3.54
Closure of MMA12	0.76	0.33	0.51	0.42	0.58
Closure of MMAMF	11.75	13.94	20.54	12.44	18.19

Notes: CS Per Trip is obtained from Equations 24 and 26 and the number of trips.
MMAMF is a combination of MMA5, MMA6, MMA7 and MMA12.
Mean1 is the mean of per trip measure obtained from b + mr
Std1 is the standard deviation of the measure obtained from b + mr
Mean2 is the mean measure obtained from b - mr
Std2 is the standard deviation measure obtained from b - mr

CHAPTER 4

THE RANDOM UTILITY-COUNT DATA MODEL

Recreational hunting is a process that involves many stages. These stages can be grouped into two: deciding on the number of hunting trips to take and spreading these trips among the number of sites available. Under two stage budgeting, these two stages can be linked to produce a welfare measure that is utility-consistent. The site choice decision is modeled by the RUM while the decision on the number of trips to take is modeled by count data models. This chapter will describe the theory behind the approach, the applicable models, the data used and the results. Since random utility models were described in the previous chapter, only Count data models will be described here. Finally, total expenditures made by hunters in some MMAs are calculated using survey results data from Condon (1993). Although this is not a full economic impact analysis, the results give an idea about how quality changes would affect businesses in the MMAs.

Theory

Under the weak separability assumption, consumers can allocate total expenditures in 2 stages. Utility is assumed to be maximized at each stage. At the first or higher stage, consumers allocate expenditures among a broad group of goods according to group prices (or price indexes) and total expenditure as in Equation 1. Then at the second stage, individual expenditures within the moose hunting trips subgroup would be functions of the group expenditure and the prices of commodities within the moose hunting subgroup only (*i.e.*, the different hunting sites). The subgroup indirect utility functions, which must be of the Gorman generalized polar form, produce subgroup demand functions. This is termed two-stage budgeting or branch budgeting (Hausman *et al.*, 1995; Deaton and Muellbauer, 1989).

Econometrics

The number of trips taken to hunting sites are discrete and noncategorical variables. As such, using ordinary least squares techniques to estimate the demand for trips will produce biased and inconsistent estimates (Maddala,1983). The appropriate models to use are Count data models hence their use in recreational demand studies. Examples of Count data models are the standard Poisson model, the Truncated Poisson model, the standard Negative Binomial model and the Truncated Negative Binomial model (Cameron and Trivedi, 1986; Hausman, Hall and Griliches, 1984; Grogger and Carson, 1991). Hellerstein and Mendelsohn (1990)[33] provide the theoretical reasons for using the mean of a count data model to represent its demand function and the integral under this mean to be a valid measure of welfare.

The Poisson and Negative Binomial Models belong to a family of linear exponential functions. The Poisson model assumes that the probability of taking a second trip, given that a first trip has been taken, is equal to the probability of taking the second trip, given that the first trip was not taken. The dependent variable is defined as overdispersed if its conditional mean is less than its conditional variance, resulting in a mean-variance ratio greater than unity. Thus parameter estimates will be biased if the dependent variable is overdispersed. One feature of the Poisson model is that the conditional mean and conditional variance are equal. The standard Negative Binomial model is obtained by compounding the Poisson and Gamma distributions (Cameron and Travedi, 1986). The Negative Binomial would allow for overdispersion because its conditional variance is greater than its conditional mean. Gourieroux, Monfort, and Trognon, (1984) have shown that as long as the specification of the mean is correct, linear exponential functions will be robust to misspecification. The pseudo-maximum likelihood

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[33] The resulting welfare measure is identical to the welfare measure used for the semi-log specification of the utility function in continuous demand models

estimator (PML) could be used if the mean is specified correctly and the quasi-generalized maximum likelihood (QGML) could be used if the mean and variance can be specified correctly. Thus consistent estimates of the Poisson can still be obtained with overdispersed data if conditions for PML and QGML permit. However, the standard errors will be biased downwards (see also Cameron and Travedi). Other problems of the Poisson Model include the absence of an error term, which implies that there are no omitted variables. This assumption may not be true in most cases. The model also assumes that events occur independently over time (Cameron and Trivedi). On the contrary, there may be a form of dynamic dependence between occurrence of successive events. For example, the result of a first trip may influence the probability of subsequent trips particularly when there is a bag limit in place. This form of dependence is called occurrence dependence.

Grogger and Carson (1991) developed the Truncated Poisson and Truncated Negative Binomial models for use with zero-truncated samples, *i.e.*, if the zeros are observed. (If many zeros are not expected, say if the mean number of trips is high, the estimates of the truncated and standard Poisson are not much different). They showed through Monte Carlo simulations that inconsistencies may result in parameter values if the Poisson model is applied to overdispersed truncated samples. The greater the degree of overdispersion, the greater the problems of estimation and inference. They found, *inter alia*, that as the mean of the estimated Poisson parameter (λ) increases, the inconsistency problem decreases. For $E(\lambda_i) = 3$, regression parameters are estimated with 2-10 percent bias on average for various values of the nuisance parameter, which measures the degree of overdispersion, and bias in the zero frequency estimates is reduced by a factor of two to three. The problems of estimation and inference, when truncation and overdispersion (biasedness) are not accounted for, depend to a large extent on the mean number of trips. If the mean number is large, for example 6, then truncation is less of a problem than overdispersion (since we would expect less zeros) but if the mean is small, for example 2, then truncation becomes more of a problem than overdispersion (Creel and Loomis, 1990). Grogger and Carson also found that the truncated Negative Binomial model is "essentially unbiased" compared to the standard Poisson model which showed biases of over 100% for small values of E(λ), particularly if overdispersion is large. Both the Negative Binomial and the Truncated Negative Binomial do not converge easily. See also Creel and Loomis (1991, 1992).

Count Data Models that will be examined are the standard Poisson and Negative Binomial models and their truncated forms. The Poisson model will be examined first. However, if the data exhibit overdispersion then the Negative Binomial will be used. Maximum likelihood techniques will be used to estimate these models. However, since one cannot be sure whether the specified probability distributions are the 'true' ones the method of estimation is technically 'pseudo' maximum likelihood (PML). The PML estimator is not consistent. However, if the specified distribution for the number of trips taken (the dependent variable) lies in the linear exponential family, Gourieroux, Monfort and Trognon (1984a) have shown that the PML estimator is consistent provided the mean is correctly specified. The Poisson and Negative Binomial distributions belong to the linear exponential family. Following are brief descriptions of the Count Data Models considered.

The Poisson Model

The Poisson model is used to predict the number of events that could occur within a specified time with the dependent variable taking discrete non-negative values. The model has therefore been used to estimate count data such as the number of trips taken within a hunting season. Let $T_i = 0,1,2,$ represent the random number of trips for the *i*th individual within the hunting season. The Poisson probability distribution

$$P(T_i = t_i) = \frac{\exp(-\lambda_i)\lambda_i^{t_i}}{t_i!}, t_i = 0,1,2,\ldots, i = 1,2,\ldots,n \tag{37}$$

stipulates that each realized value, t_i, is drawn from a Poisson distribution with a single mean and variance parameter λ_i. This parameter is postulated to be related to the explanatory variables X in the following fashion

$$\lambda_i = \exp(X_i\beta), \tag{38}$$

where X is a vector of exogenous variables and β is a vector of parameters to ensure its positivity (Hausman *et al.*, 1995). For a sample of I independent observations, the log-likelihood is

$$\ln L = \sum_{i=1}^{I}[-\lambda_i + t_i X_i\beta - \ln(t_i!)] \tag{39}$$

Estimation is done by maximum likelihood technique under regularity assumption that $S_{j-1}\lambda_j X'_j X_j$ is positive definite for all β. This implies that the loglikelihood function is globally concave and the estimates are unique (Yen and Adamowicz, 1993).

In some cases, such as ours, the dependent variable is truncated at zero. For example, to be able to derive the benefits of moose hunting, trips have to be taken to the hunting site. Therefore in analyzing the benefits of moose hunting, the number of trips should be greater than zero. The conditional probability for a zero-truncated Poisson model is

$$P(T_i = t_i | T_i > 0) = \frac{\exp(-\lambda_i)\lambda_i^{ti}}{t_i![1-\exp(-\lambda_i)]}, t_i = 1,2,\ldots,\ldots i = 1,2,\ldots,I \tag{40}$$

The corresponding log likelihood is

$$\ln L = \sum_{i=1}^{I}\{-\lambda_i + t_i X_i\beta - \ln(t_i!) - \ln[1-\exp(-\lambda_i)]\} \tag{41}$$

Yen and Adamowicz (1993) have shown that truncation at zero results in higher mean and lower variance than in models with untruncated data. Nevertheless, it is not suitable when there is overdispersion (heteroskedasticity) in the data. In such cases, the Negative Binomial model has been shown to be appropriate (Grogger and Carson, 1991).

The Negative Binomial Model

The Negative Binomial distribution is the result of allowing the λ parameter in the Poisson distribution to have a gamma distribution (Cameron and Travedi, 1986). The model implies that individuals have constant but unequal probabilities of taking a trip. This feature is equivalent to the 'apparent contagion' model in the biometrics literature (Xekalaki, 1983). For a sample of n observations, the Negative Binomial can be described as

$$P(t_i|X_i)=\frac{\Gamma(\frac{1}{\alpha}+t_i)}{\Gamma(\frac{1}{\alpha})\Gamma(t_i+1)}(\alpha\lambda_i)^{t_i}(1+\alpha\lambda_i)^{-(1/\alpha+t_i)},t_i=0,1,2...i=1,2,...I;\alpha>0, \qquad (42)$$

where Γ(.) indicates the gamma function, t_i is the number of trips taken, λ_i is the conditional mean of t_i, $\lambda_i(1+\alpha\lambda_i)$ its conditional variance and $1/\alpha$ is the index or precision parameter whose inverse is the nuisance or overdispersion parameter. The variance is clearly greater than the mean and the variance-mean ratio is an increasing function of $X_i\beta$. The log likelihood function is

$$\ln L=\sum_{i=1}^{n}[\ln\Gamma(\frac{1}{\alpha}+t_i)-\ln\Gamma(t_i+1)-\ln\Gamma(\frac{1}{\alpha})+t_i\ln\alpha+t_iX_i\beta-(\frac{1}{\alpha}+t_i)\ln(1+\alpha\lambda_i)] \qquad (43)$$

The Negative Binomial belongs to the linear exponential family if the precision parameter is defined.

The conditional Truncated Negative Binomial distribution, with truncation at zero, can be written as

$$P(T_i=t_i|T_i>0)=\frac{\Gamma(\frac{1}{\alpha}+t_i)}{\Gamma(\frac{1}{\alpha})\,\Gamma(t_i+1)}\;\frac{(\alpha\lambda_i)^{t_i}\,(1+\alpha\lambda_i)^{-((\frac{1}{\alpha})+t_i)}}{1-(1+\alpha\lambda_i)^{-(1/\alpha)}},\quad t_i=1,2,...;i=1,2,...I,\alpha>0 \qquad (44)$$

This is the Negbin II model employed by Creel and Loomis (1990) and Grogger and Carson (1991). It has a variance-mean ratio linear in the mean. According to Grogger and

Carson (1991) this is the case most likely to be encountered in practice. Its log-likelihood function may be written as

$$\ln L = \sum_{i=1}^{n} \{\ln\Gamma(\frac{1}{\alpha}+t_i) - \ln\Gamma(t_i+1) - \ln\Gamma(\frac{1}{\alpha}) + t_i \ln(\alpha) + t_i X_i \beta$$
$$-(\frac{1}{\alpha}+t_i)\ln(1+\alpha\lambda_i) - \ln[1-(1+\alpha\lambda_i)^{-(1/\alpha)}]\} \qquad (45)$$

where X is the vector of regressors.

The conditional mean and variance are given by

$$E(T_i|X_i, T_i > 0) = \frac{\lambda_i}{1-(1+\alpha\lambda_i)^{-(\frac{1}{\alpha})}} \qquad (46)$$

and

$$\text{var}(T_i|X_i, T_i > 0) = \frac{E(T_i|X_i, T_i > 0}{F_{NB}(0)^{\alpha}}\{1-[F_{NB}(0)]^{1+\alpha} E(T_i|X_i, T_i > 0)\} \qquad (47)$$

where $F_{NB}(0) = (1 + \alpha\lambda_i)^{-(1/}\alpha)$ is the standard negative Binomial Function evaluated at zero.

The Negative Binomial distribution nests the Poisson. When $\alpha = 0$, the Negative Binomial model degenerates to the Poisson. Therefore tests of overdispersion are based on whether or not $\alpha = 0$. Several test procedures have been developed to test for the presence of overdispersion. Gurmu's score test (Gurmu, 1991) can be used when the Poisson is estimated. Alternatively, if the Negative Binomial is estimated a one-sided Wald test can be applied to the asymptotic t statistic of the estimated α parameter. When both the Negative Binomial and the Poisson are estimated by maximum likelihood a likelihood ratio could be used to test the significance of the α parameter. If the tests show overdispersion, then the Negative Binomial should be used. However if they show underdispersion, then the binomial (not discussed here) or the truncated Poisson is the appropriate model to use. Greater flexibility of the Negative Binomial can be achieved by treating the precision parameter as a random variable with a beta distribution to produce the random effects Negative Binomial model (Hausman *et al.*, 1984).

Data

The returns data set was used to obtain the number of hunters. Unfortunately, there were problems with these data. Mistakes at the data entering stage rendered some of the data unusable. Since information on the number of days hunted is important in calculating the number of trips taken, those who did not state this information were omitted. Thus the total number of successful applicants recovered is 18,810, made up of 8,995 individual licenses and 9,815 Party licenses.

In addition, the returns data neither have the towns of origin of the applicants nor their postal codes to enable distances and travel costs to be calculated. Their MCP[34] numbers were therefore used to trace their towns of origin and their choices from the applications database. The MCP number is common to both data sets. In the process, only 6,238 Individuals and 8,136 Party applicants who hunted could be matched, giving a total of 14,374.

The returns data have no information on the number of trips taken. Distances traveled by individuals per trip as well as the number of days traveled per trip were obtained from Condon (1993). These are survey responses of moose hunters in Newfoundland in 1992 and were used to estimate the number of trips taken to the sites. A regression analysis was used to obtain the relationship between distance traveled and days per trip. The results were fed into a GAUSS (Aptech, 1995) program to obtain the number of trips taken. The results were rounded up to the nearest integer. The estimates can be found in Appendix 4.

The explanatory variables used to determine the number of trips are income, the mode of traveling to hunting sites, viz., Motor Vehicle, ATV and Walking, and whether or not a kill has been made (Kill). These data are part of the returns data. The modes of traveling are dummy variables with 1 representing mode used and zero otherwise. The

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[34] These are Provincial Health Insurance Numbers.

number of trips taken could also depend on the satisfaction of the order of choice of site won. 'Satisfaction indexes' representing three levels of satisfaction for sites won in the lottery were therefore developed. Satis1 is a dummy variable representing whether a person's first choice was won. It has a value of 1 if the first choice was won and zero otherwise. Satis2 and Satis3 are similarly defined for the second and third site choices. Finally, the per trip consumer surplus estimate obtained from the second stage is used as the price index.

Estimation

At the first stage of the process, the individual decides on the site to hunt in if he/she wins the lottery. This choice decision, which is based on the site attributes, will be modeled by the probabilistic choice models (random utility model) used in Chapter 3. At the second stage, he/she decides on the number of trips to take to the chosen or desired site. The Negative Binomial model was used to model this decision process. The two stages are linked by a price index which is obtained from the first stage and used in the second stage as a shift and policy variable to determine the demand for trips. Theoretically, this price index represents the price for a composite consumption commodity - hunting trips. In this case, it is the consumer surplus measure from the first stage choice model with its sign reversed, *i.e.* the inclusive value divided by the travel cost parameter. The procedure is therefore utility consistent and allows for exact welfare measurement (Hausman *et al.*, 1995).

A sample of 767 individuals and party applicants was drawn out of a population of 14,374 successful applicants and used for this model. The first stage was estimated first. The random utility models (Equation 20 and Equation 21) were estimated using only the first choice of the applicants. The site attributes are the same as those used in Chapter 3.

The party applicants had double the weight of the individual applicants in the estimation process since two people apply for this license. Consumer surplus measures were obtained using Equation 24 and Equation 26. Each of these measures, with reversed signs, become the price index in the second stage trips demand models[35].

The trips data were tested for overdispersion using the t-test. The results show that the overdispersion parameter was significantly different from zero at the 5% level of significance. As a result, and also to account for zero truncation of the data, the Truncated Negative Binomial model is used to estimate the number of trips at the first stage. Using this model, the demand for trips is given by

$$E(T_i|T_i > 0) = \frac{\exp(X_i\,\beta)}{1-(1+\alpha(X_i\,\beta))^{-\left(\frac{1}{\alpha}\right)}} \qquad (48)$$

where T_i is the number of trips taken, X is the variables explaining the number of trips taken including the price index from the second stage, β is the coefficients vector and α is the overdispersion parameter. The denominator of Equation 46 accounts for the truncation at zero (Hausman *et al.*, 1995; Grogger and Carson, 1991). The trip measure used was obtained from the regression of number of days hunted per trip on distance as described earlier. LIMDEP 6 (Greene, 1995) was used in estimating both models.

Welfare Measures

Welfare measures are usually obtained by integrating under a demand curve. With count data models, the estimated demand function is a probability distribution of trips (Hellerstein and Mendelsohn, 1993). The expectation of this distribution yields an expected response (number of trips) at every Travel Cost. A measure of the expected consumer surplus is obtained by integrating under this expected response.

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[35] Two models are used, the Rouwendal model and the Multiplicative model.

Assuming small income effects, point estimates of total consumers' surplus resulting from quality changes is given by

$$\Delta CS_i = \int_{P_i^N}^{P_i} \frac{\exp(X_i\beta + \mu P)}{1-(1+\alpha(X_i\beta+\mu P))^{(-1/\alpha)}} dP \tag{49}$$

where CS is the consumer surplus, P^O and P^N are the before and after quality change price indexes respectively, X is the variables affecting the demand for trips, μ is the coefficient on the travel cost parameter from the second stage probabilistic choice model (Hausman *et al.*, 1995). The above formula reduces to

$$\Delta CS_i = \frac{1}{\mu\alpha^2}\left\{\begin{array}{l}\left[\alpha^2 \exp(\mu P_i^O + X_i\beta) - \ln(1+\alpha\mu P_i^O + \alpha X_i\beta)\right] \\ -\left[\alpha^2 \exp(\mu P_i^N + X_i\beta) - \ln(1+\alpha\mu P_i^N + \alpha X_i\beta)\right]\end{array}\right\} \tag{50}$$

Quality changes lead to changes in the price index which is the price of trips. One difference between the welfare measure here and the measure from the random utility model Equation 24 and Equation 26 is that the measure in Equation 50 takes into account factors that influence both site choice and participation as well as their effects on the number of trips taken.

Results

The estimated coefficients of the first stage models (the Rouwendal and Multiplicative models) are reported in Table 4.1 and Table 4.2 respectively at the end of the chapter. The results of the Rouwendal model show that the coefficients of all the attributes are significant at the 5% level with the exception of those of black spruce, disturbed areas and the alternative specific constant for Either Sex licenses. Remote sites[36] are less preferred to the other sites. The results of the Multiplicative model are similar,

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[36] These are MMA3, MMA11, MMA19, MMA26 and MMA37.

except that no alternative specific constant is significant. Some of the possible reasons behind the non significance of the coefficient of black spruce in the utility function has been explained in Chapter 3.

On the whole, the normalized overall prediction success index for the Rouwendal model is about 20%. This result means that the model is able to predict 20% of the choices made correctly. The corresponding index for the Multiplicative model is about 19%. The success index is an appropriate goodness-of-fit measure because it weighs the overall percentage of choices correctly predicted for each alternative by the aggregate share of correctly predicted choices over the total number of observations for each alternative (Hensher and Johnson, 1981). Therefore the Rouwendal model predicts slightly better than the Multiplicative model. The rho-square value for the Rouwendal model is also slightly better than that of the Multiplicative model.

Expected per trip consumer surplus for each of the hunters in the sample was estimated using Equation 24 and Equation 26. These consumer surpluses, with reversed signs, were used in the second stage as price indexes to estimate Truncated Negative Binomial Models to explain the demand for sites, *i.e.*, the number of trips taken. The estimates from the Rouwendal and Multiplicative models are found in Table 4.3.

The estimates from both models show that the price indexes significantly determine trip choice at the 1% level. In the Rouwendal Model, the estimates show that the use of ATV users take more trips. Survey responses from Condon (1993) show that this is indeed the preferred mode of transportation and hunting since most hunters do not hunt far away from their homes. Also, the number of trips taken decreases with kill. This decrease may be due to the bag limit which restricts further trips to strictly nonconsumptive ones after a kill is made. Although it is legal to take further hunting trips after a kill, it is illegal to make another kill. Obtaining either the first or second choices in the lottery process increases the number of trips taken. However, obtaining the third choice does not[37]. Thus hunters may not be very enthusiastic to take many trips if they fail to obtain either their first or second choices. Income is not significant at the 5% level in either model. It is significant however at the 10% level in the Multiplicative model and negatively relates to the number of trips taken in both models. The insignificance and negative relation of income to recreational trips has been explained in the literature to mean that richer people prefer other forms of recreation. See for example Grogger and Carson (1991) and Gomez and Ozuna (1993). The estimates from the Multiplicative model are similar to those of the Rouwendal model.

The average 'price index' for the Rouwendal and Multiplicative models are \$175.77 and \$185.07 respectively. Given the coefficient of the price index, *i.e.*, 0.0079073 and 0.012241, the implied price elasticities[38] of demand for trips for the Rouwendal and Multiplicative Models are -1.39 and -2.26 respectively. Thus the Multiplicative model is more 'price' elastic than the Rouwendal model. Welfare measures resulting from quality changes may therefore be less pronounced if the Rouwendal model is used than if the Multiplicative model is used.

Welfare Measures

Welfare measures were obtained by applying weights to the number of trips taken by those in the sample to bring this number up to that of the population. Table 4.4 shows the average per trip changes in welfare values for the scenarios from the first stage probabilistic choice models. Beside them are the total welfare measures they generated. The difference between the total and per trip welfare measures here and those of the choice model in Chapter 3 may be due to the difference in the type of data used as dependent variable. The models in Chapter 3 use the proportion of applicants, out of the

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[37] Obtaining Fourth and Fifth choices were also not found to be significant in determining number of trips taken.

[38] Implied price elasticity = coefficient x average CS.

total from a town, choosing a site as the dependent variable whereas the models in this chapter use either 1 or 0 to represent whether or not an individual chooses a site.

There are substantial differences between the welfare measures generated at the second stage using the price indexes obtained from the Rouwendal model and the Multiplicative model. Welfare measures resulting from quality changes at the first stage do not account for the effect these changes have on the number of trips taken. This accounting is done at the second stage with the count data model. As such, they are larger than measures at the first stage (Hausman *et al.*, 1995). Table 4.5 reports the welfare effects of the scenarios at the second stage. The original number of trips taken was used in the calculation of these welfare measures rather than the predicted number of trips because of the insignificant change in the number of trips taken resulting from the scenarios. The second stage results show that the total loss in consumer surplus from closing MMA5 is about $1,800,000 and $792,000 from the Rouwendal and Multiplicative models respectively. These values respectively compare with $238,000 and $196,000 if the first stage choice models alone were used (Table 4.4). On the whole the values obtained from the Multiplicative model are less than those obtained from the Rouwendal model. It should also be pointed out that whereas the differences in the welfare estimates at the first stage of both models are not that different, the estimates at the second stage of the two models show substantial differences. For example, the per trip loss in consumer surplus from closing MMA5 using the second stage model with the Rouwendal price index is about $28 compared to about $4 loss from the first stage Rouwendal choice model, a 700% difference. On the other hand, the per trip loss in consumer surplus from the same scenario using the second stage model with the Multiplicative price index is about $12 compared to about $3 loss from the first stage Multiplicative choice model, a 400% difference. Thus the proportional increase in second stage welfare measures using the Rouwendal model's price index is more pronounced than the second stage measures using the Multiplicative model's price index.

Expenditure Analysis

Condon (1993) has data on the expenditures incurred by 1,254 Newfoundland moose hunters during moose hunting trips in the fall of 1992. These expenditures were made on transportation (including oil, gas, repairs, bus *etc.*), accommodation (hotels, motels, lodges *etc.*), campsite fees, food (*i.e.*, groceries plus alcohol), restaurants, rentals of boats, airplanes *etc.*, and equipments purchased specifically for moose hunting.

These data show that most hunters did not incur any expenditures on accommodation, restaurants and rentals. This result is not surprising since the returns data (in this study) show that most trips were day trips. Also, most hunters resided in their camps during hunting trips. Of the 1,254 hunters surveyed, 98.4% did not make any expenses on campsite entrance fees, 95.8% did not make any expenses on accommodation, 98% did not make any expenses on rentals, 78.9% did not make any expenses on restaurants, 43.7% did not make any expenses on equipment, 20% did not spend any amount on transportation, and 18% did not make any expenses on food.

One could break down the expenditures into moose management areas to examine changes in expenditure patterns due to quality changes. Unfortunately, one cannot determine from the available data whether the expenditures were made by hunters either in their places of origin, on the way to the MMAs or in the MMAs where they hunted. For example, MMAs where expenditures on transportation (oil, gas and repairs) and food were made would be difficult to trace. It is therefore not feasible under the circumstances to examine the effect of quality changes on expenditure patterns in MMAs. However, one can examine changes in aggregate expenditures made at sites resulting from quality changes. Changes in aggregate expenditures for the Province at large resulting from such changes should remain unchanged.

To arrive at total expenditures the assumption was made that each hunter took an average of 5 trips during the hunting season. This number was based on the distribution of both the survey data in Condon (1993) and the returns data used in this study[39]. The mean number of trips was used with the mean of total expenditures incurred during the season to arrive at per trip expenditures. Per trip expenditures were then used to multiply the total number of trips ending in the MMA to obtain total expenditures. Since these results were based on sample data, the total expenditures were weighted to bring the final expenditure figures up to that of the population. The aggregate expenditures incurred on moose hunting by residents of the Island, using original trips taken, was estimated at $5,580,898.

The predicted number of trips generated by the Truncated Negative Binomial model above were used to obtain the predicted aggregate expenditures and changes in predicted expenditures under the various scenarios. The predicted aggregate expenditures under the Rouwendal and Multiplicative models, as well as changes in the predicted aggregate expenditures generated by some of the scenarios are reported in Table 4.6. The results show that the predicted aggregate expenditures on moose hunting under the Rouwendal model and the Multiplicative model are about $3.2 million and $2.7 million respectively.

Quality changes in the MMAs change the number of hunters applying to hunt in the affected MMAs. Hence the number of trips taken to them change. All things being equal, revenues to businesses within these MMAs change as the number of successful hunters change. Thus in addition to their effect on the value of moose hunting (to moose

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[39] The mean number of trips taken in a season was estimated at 5.05 by Condon (1993) and 4.85 from the Returns data in this study.

hunters), quality changes also affect businesses in the moose management areas directly. The changes in predicted aggregate expenditures under the scenarios are also given in Table 4.6. The results from both models show that the loss in aggregate expenditures from closing all four MMAs (*i.e.*, MMA5, MMA6, MMA7, and MMA12) is larger than the loss from closing each of them separately. The change in predicted aggregate expenditures from closing MMA5 is estimated at about $166,000. This change is relatively small because of the flexibility of choice provided under the Random Utility Model. If a site is closed[40], hunters would hunt in substitute adjacent sites and there would be negligible change in aggregate expenditures at the sites.

In summary, this chapter describes the use of a random utility model cum count data model to estimate welfare measures based on the two-stage budgeting approach. A sample of hunters who succeeded in winning licenses was obtained and their choices traced. The Rouwendal and Multiplicative random utility models were used in the first stage to estimate consumer surplus measures. Only the first choice of applicants was used. These consumer surplus measures were then used as price indexes in the second stage to estimate a count data model to examine the demand for trips. Utility-consistent welfare measures were estimated. The per trip welfare measures for the scenarios from the second stage models are larger than those from the first stage choice models. The proportional increases are larger with the Rouwendal models than with the Multiplicative models. Finally, total expenditures made by hunters in some MMAs were calculated. The results show that in aggregate, moose hunters spent an estimated $5.6 million in 1992 on accommodation, food, campsite fees, equipment, restaurants, transportation and rentals.

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[40] The assumption is that any site closure would be made known to hunters at the time they are applying for licenses.

TABLE 4.1

ESTIMATES OF FIRST STAGE RANDOM UTILITY MODEL

(ROUWENDAL MODEL)

Attribute	Coefficient	T-statistics
TC^+	0.0188	30.745*
Log(Prob)	2.5395	6.957*
Success Rate	3.6551	7.67*
Balsam Fir	25.556	6.411*
White Birch	8.4671	2.72*
Black Spruce	-1.4343	-0.399
Disturbed Areas	4.9059	1.559
ASC (Remoteness)	-0.6532	-2.267*
ASC (Either Sex)	-0.1037	-0.817
Likelihood Ratio Index	0.4480	
Adjusted Likelihood Ratio Index	0.4450	
Prediction Success Index	0.2044	

Notes: TC^+ is Average Income-Travel Cost
Prob is the probability of winning a permit
ASC is alternative specific constant
* = Significant at the 5% level

TABLE 4.2

ESTIMATES OF FIRST STAGE RANDOM UTILITY MODEL

(MULTIPLICATIVE MODEL)

Attribute	Coefficient	T-statistics
Prob*(TC^+)	0.0253	30.442*
Prob*Success Rate	5.7647	9.587*
Prob*Balsam Fir	34.849	6.388*
Prob*White Birch	10.666	2.377*
Prob*Black Spruce	1.1014	0.216
Prob*Disturbed Areas	5.8171	1.324
ASC (Remoteness)	-0.428	-1.495
ASC (Either Sex)	-0.0188	-0.151
Likelihood Ratio Index	0.4486	
Adjusted Likelihood Index	0.4219	
Prediction Success Index	0.1857	

Notes: TC^+ is Travel Cost
Prob is the probability of winning a permit
ASC is alternative specific constant
* = Significant at the 5% level

TABLE 4.3

COEFFICIENT ESTIMATES OF TRUNCATED NEGATIVE BINOMIAL MODELS FOR NUMBER OF TRIPS

Attributes	Rouwendal Model	Multiplicative Model
Intercept	-0.3414 (-0.684)	-1.3081 (-2.293)*
Price Index	-0.0079073 (-8.035)*	-0.0122 (-7.877)*
Trip by Motor Vehicle	0.1183 (0.937)	0.1179 (0.935)
Trip by ATV	0.2913 (2.132)*	0.2860 (2.104)*
Trip by Walk	0.1263 (1.097)	0.1229 (1.074)
Income	-0.00005 (-1.611)	-0.00006 (-1.796)
Kill	-0.8691 (-5.172)*	-0.8678 (-5.175)*
Satis1	0.8989 (4.441)*	0.8844 (4.388)*
Satis2	0.8996 (3.893)*	0.8945 (3.882)*
Satis3	0.0559 (0.209)	0.0402 (0.150)
Alpha	2.289 (5.279)*	2.2874 (5.291)*
Loglikelihood Ratio	2456.5	2457.1
Number of Observations	767	767

Notes: Alpha is the Overdispersion parameter.
Asymptotic T-Statistics are in parenthesis
* = Significant at the 5% level

TABLE 4.4

EXPECTED PER TRIP WELFARE MEASURES OF SCENARIOS WITH FIRST STAGE RANDOM UTILITY MODELS IN DOLLARS

SCENARIOS	ROUWENDAL	MULTIPLICATIVE
Closure of MMA5	3.66 (237,849.46)	3.02 (196,433.68)
Closure of MMA6	3.83 (248,975.40)	2.80 (182,139.33)
Closure of MMA7	2.75 (178,723.33)	1.98 (129,049.10)
Closure of MMA12	1.12 (73,171.40)	0.71 (46,187.90)
Closure of MMA5,6,7,12	14.88 (966,541.09)	15.14 (983,510.81)
Increasing Disturbed Areas in MMA6 by 40%	0.19 (12,141.03)	0.13 (8,146.97)
Increasing Disturbed Areas in MMA5,6,7,12 by 40%	0.66 (42,844.48)	0.46 (29,915.75)

Note: Total welfare measures are in parentheses.

TABLE 4.5

ESTIMATED TOTAL WELFARE MEASURES OF SCENARIOS WITH SECOND STAGE TRUNCATED NEGATIVE BINOMIAL MODELS IN DOLLARS

SCENARIOS	ROUWENDAL	MULTIPLICATIVE
Closure of MMA5	27.71 (1,799,911.8)	12.19 (791,811.03)
Closure of MMA6	23.91 (1,552,669.6)	9.32 (604,910.63)
Closure of MMA7	20.54 (1,333,787.4)	8.06 (523,367.43)
Closure of MMA12	8.46 (549,163.17)	2.92 (189,613.48)
Closure of MMA5,6,7,12	80.49 (5,226,410.5)	32.40 (2,104,020.1)
Increasing Disturbed Areas in MMA6 by 40%	1.33 (86,472.61)	0.48 (31,021.03)
Increasing Disturbed Areas in MMA5,6,7,12 by 40%	5.34 (347,043.44)	2.02 (131,468.71)

Note: Total welfare measures are in parentheses.

TABLE 4.6

PREDICTED AGGREGATE EXPENDITURE OF HUNTERS DURING 1992 HUNTING SEASON IN DOLLARS

SCENARIOS	ROUWENDAL	MULTIPLICATIVE
Aggregate Expenditure	3,155,791.85	2,697,350.43
Change in Aggregate Hunting Expenditure from closing MMA5	165,513.71	166,467.69
Change in Aggregate Hunting Expenditure from closing MMA6	150,550.97	167,553.03
Change in Aggregate Hunting Expenditure from closing MMA7	136,920.11	125,602.62
Change in Aggregate Hunting Expenditure from closing MMA12	100,362.15	86,526.62
Change in Aggregate Hunting Expenditure from closing MMA5,6,7,12	389,627.02	375,259.61

CHAPTER 5

THE VARYING PARAMETER MODEL

One assumption of the classical linear regression model is that estimated parameters are constant. Thus in a cross-section study, the assumption of constant parameters means that all individuals in the sample have exactly the same parameters. There are however occasions when parameters may not be constant. Assume an econometric model (say, a demand function) is estimated from some problem of maximization (say, of utility) or minimization (say, of expenditure) which involves policy variables. Usually, such a model is estimated with the policy variables as direct explanatory variables in an additive fashion. However, consumers take policy variables into account as they go through the process of maximization or minimization. As such, the policy variables should enter the model not in an additive fashion but as determinants of the parameters[41] (Maddala, 1977). The estimation therefore requires a two stage procedure. This reasoning underlies Varying Parameter models. The Lucas critique (1976) may also be cited as an example to support Varying Parameter models. Whereas the Rouwendal and Multiplicative random utility models are based on choice decisions under uncertainty conditions, VPM is based on quantity decisions under certainty conditions. For different specifications of models that are based on Varying Parameters see Kmenta (1986), Maddala (1977), and Fomby *et al.* (1988). In this chapter, the Varying Parameter model as used in the recreational literature will be described and applied to moose hunting in Newfoundland.

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[41] The parameters may vary over time or across cross sectional units. The latter variation is implied here.

Theory

The Varying Parameter Model (VPM), also known as the Generalized Travel Cost Model (GTCM), can be used to estimate quality changes as well as site values for both single and multiple sites (Vaughan and Russell, 1982; Smith *et al.*, 1983; Smith and Desvouges, 1985; Smith *et al.*, 1986). As factors cause site attributes to change, consumers change the number of trips they take across sites in order to maximize utility. Varying Parameter Models (Maddala, 1977) are therefore appropriate for studying the demand for recreational trips. Unfortunately, the model does not take account of substitute sites when used as a multi-site model. This handicap is however not a problem here. Indeed the model is very appropriate for this study because of the restriction that hunting can only be undertaken in the MMA for which a license is won. There is therefore no opportunity to move to a substitute site as a result of quality changes.

The VPM is based on the household production function. It assumes constant returns to scale. It also assumes that all sites are perfect substitutes of one another and that only one site will ultimately be selected (Smith and Desvouges, 1986). The VPM relates the estimated parameters of site demand functions to their attributes in a two-step estimation procedure, although a pooled one can also be estimated if the number of observations for each site is not sufficient to estimate separate demand functions. The first stage estimates the number of trips as a function of Travel Cost and socioeconomic variables of the individual, if available. The estimated parameters are then used as dependent variables in a second stage regression on the quality variables. Specifically, at the first stage the following models are estimated,

$$T_{ij} = f_i\,(TC_{ij}\,, Y_i\,, S_i\,; \beta_j\,) + e_{ij}, \tag{51}$$

where T_{ij} is the number of trips taken to the jth site by the ith individual, TC_{ij} is the travel cost of the ith individual to the jth site. The travel cost includes the cost of vehicle operation as well as time. Y_i is ith individual's income, S_i is a vector of the socioeconomic variables of the individual, β_j is a vector of estimated demand parameters for the *j*th site and e_{ij} represents the stochastic error term. Onsite time is ignored because the model assumes that all trips have an equal amount of onsite time.

At the second stage the demand parameters for each site, viz., the intercept, travel cost and income parameters are regressed on the site characteristics as shown below

$$\beta_{jk} = g_i(\bar{c}_k; \gamma_{jk}) \tag{52}$$

where β_{jk} represents parameter k from the β_j vector, $\bar{c}_k$ is a vector of the site characteristics and γ_{jk} is a parameter vector. If only the intercept in the system of equations is assumed to vary with quality variables, *i.e.*, the coefficients across equations are constrained to be equal, then the result is the pooled demand function model. Modeling the effects of quality variables on number of trips taken in a season represents a cross section analysis. Cross-section data do not permit changes in site attributes over a season. It is therefore difficult to examine the influence of site attributes on the number of trips taken during a season. This problem is solved by regressing the demand parameters on the site attributes such that attributes across sites are allowed to influence variations in the number of trips taken (see Equation 52 above). One problem of the model is that it is difficult to separate the effects of the different site attributes from the effects of travel cost on the number of trips taken (Freeman, 1993).

There are other estimation problems. The model does not account for substitution effects. This omission is not a problem with this study because of the licensing restrictions. Once a license is won for a site, hunters are not allowed to hunt elsewhere. Corner solution problems will arise if zero trips are included in the data. Other problems include censoring and truncation of data, the functional forms to be used for f(.) and g(.) above, and how to handle the error terms that arise from the first stage in the second stage as well as the specification of the error structure at the second stage if a combined model is estimated. Maximum likelihood techniques have been used by Smith and Desvouges

(1985) for the first stage and generalized least squares for the second stage. In this thesis, the Truncated Poisson and Truncated Negative Binomial models will be used for the first stage and the OLS will be used for the second stage.

To value quality changes, hypothetical changes in the attribute of interest are used to create counterfactual changes in the demand parameters. These changes affect the demand for trips. Hence welfare measures change. The Marshallian or Hicksian approaches can be used to derive the individual's value of a quality change (Smith and Desvousges, 1986).

Welfare Measures

Site quality and travel cost changes affect the number of trips taken. Hence they affect welfare. This scenario can be seen in the diagram below. In Figure 4, assume there is an increase in the value of an attribute of a site such that the demand for the site increases from Q1 to Q2. All things being equal, there will be an increase in the number of trips (quantity demanded) from A to B at the same travel cost of C. The change in welfare in this case is the area ABED. In certain cases, increased attractiveness of a site may not increase the number of trips taken. This situation may be the case if there is a bag limit and trips may not be taken after a kill has been made. Under such conditions, increasing quality variables that increase game populations for example may actually decrease the number of trips taken due to the increase in the chances of making a kill with fewer trips (see also Loomis, 1995). Although there is a bag limit in Newfoundland, nonconsumptive trips can be taken after a kill. The data however suggest that the majority of hunters in 1992 did not do so.

With demand models, the product of the inverse of the coefficient of the Travel Cost variable, which represents the marginal cost of the trip, and the number of trips taken represents the total consumer surplus. Using this concept, the per trip consumer surplus measure for each MMA is obtained from Count Data models as follows

$$CS_j = -\frac{1}{\hat{\beta}_{TC_j}} \tag{53}$$

where $\hat{\beta}_{TC}$ is the estimated travel cost (price) coefficient. To obtain the total consumer surplus for each MMA in the first stage, Equation 53 is multiplied by the observed number of trips taken to the MMA. These are Marshallian welfare measures. The effects of quality changes on welfare are estimated from the second stage. The estimated demand parameters from the first stage are used as dependent variables in models where the site attributes and other factors, which are believed to influence trip taking, are used as explanatory variables. The predicted demand functions from counterfactual changes in site attributes are then used to estimate per trip welfare measures resulting from the quality changes for each site.

Using Figure 4 at the end of the chapter, the effect of a quality change on welfare is represented by the area ABED. Specifically,

$$\mathrm{W} = \frac{\hat{T}_1}{\hat{\beta}_{TC1}} - \frac{\hat{T}_0}{\hat{\beta}_{TC0}} \tag{54}$$

where W represents change in welfare, $\hat{T}_0$ and $\hat{T}_1$ are predicted number of trips before and after the quality change respectively[42], and $\hat{\beta}_{TC0}$ and $\hat{\beta}_{TC1}$ are the estimated travel cost coefficients before and after the quality change. The predicted post change number of trips taken, $\hat{T}_1$, and the corresponding travel cost coefficient, $\hat{\beta}_{TC1}$, are obtained under the counterfactual scenarios. The pre- and post-change predicted values of the estimated demand parameters, β_j, are used to estimate the old and new predicted number of trips in the first stage, $\hat{T}_0$ and $\hat{T}_1$.

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[42] $T = \alpha + \beta\text{Travel Cost} + \gamma\text{ Income}$. T is estimated as count data. Welfare therefore is T/β which is similar to the measure from the continuous semi-log model.

Data

The total number of successful applicants, both Individual and Party applicants, who hunted were arranged into the MMAs in which they hunted. For each MMA, the number of trips taken by those who hunted there was obtained as described in the earlier chapters. There are no zero trips, hence there is no corner solution problem. The distance traveled by each hunter from his/her town of origin to the hunting site (MMA) was calculated. This distance was used in obtaining their travel costs. The process was repeated for the 52 MMAs. One quarter of the average incomes of their towns of origin, which represents income for the duration of the hunting season, was also calculated and used as their individual incomes. The attributes that are postulated to affect the demand parameters at the second stage are balsam fir, white birch, black spruce and disturbed areas working groups, the success rate at making a kill at the site and moose density.

Estimation

The Truncated Poisson and Truncated Negative Binomial models are used to estimate number of trips as a function of Travel Cost and Income for each of the 52 MMAs. The Truncated Poisson model is used when data for a site are not overdispersed. The income used is one quarter of the average income of the towns of origin of the hunters. Specifically, the model estimated at the first stage is

$$T_{ij} = f(TC_{ij}, Y_i; \beta_j) \tag{55}$$

where T_{ij} is the number of trips taken by individual i to site j, TC_{ij} is the travel cost incurred, Y_i is the average income for the town of origin of individual i and β_j is the vector of parameter estimates for MMA_j, including the intercept. What is estimated is the distribution of trips from which the hunter draws. Unlike in continuous models, random and unobservable factors in count data models are not assumed to affect demand in an additive or multiplicative fashion (Hellerstein and Mendelsohn, 1993). The random factors that are specified in the Truncated Negative Binomial model are incorporated in a parametric fashion rather than as residuals.

At the second stage, the estimated travel cost demand parameters- the intercept, the coefficients of the travel cost and average income parameters- are regressed on the site attributes. Specifically, the estimated models are of the form:

$$\hat{\beta}_{jk} = g_k(\bar{c}_k; \gamma_{jk})\ j = 1,\ldots,52;\ k = 1, 2, 3. \qquad (56)$$

where $\hat{\beta}_{jk}$ represents the estimated demand parameters from the first stage, $\bar{c}_k$ is the vector of site attributes and γ_{jk} is the parameter vector. Thus three models were estimated. The explanatory variables used in each model are balsam fir, white birch, black spruce, disturbed areas, success rate and moose density. These equations are estimated with the ordinary least squares technique. The predicted values of the three dependent variables are then used to estimate welfare measures.

To use the model to estimate the welfare effects of quality changes, the estimated Intercept, Travel Cost and Income parameters for the 52 sites are regressed on attributes that are believed to influence the number of trips taken. The coefficients are used to generate a new set of predicted Intercept, Travel Cost and Income parameters which arise as a result of the simulated quality change. These predicted values are used in the first stage model to predict new trips taken using either the conditional means of the Truncated Negative Binomial model or the Truncated Poisson model, depending on the model producing the original estimates in the first stage. The difference between the two demand 'curves' then represents the welfare effect of the quality change. This measure is shown in Equation 54 above.

Results

The inverse of the coefficients of the Travel Cost parameter from the first stage for each site produce the per trip Marshallian Consumer Surplus measure for that site. The signs of the Travel Cost parameters estimates are all negative as expected, except those of MMA38 and MMA43 (Appendix 6). Whereas the sign for MMA43 may be due to insufficient number of observations, no explanation can be readily suggested for the sign of the estimate for MMA38. The estimates for MMA1 are from the untruncated Negative Binomial model because neither the Truncated Poisson nor the Truncated Negative Binomial estimates produced any meaningful results. The overall average per trip Consumer Surplus[43] for the 52 MMAs is about $110. The estimates as well as the Marshallian welfare measures for some MMAs are reported in Table 5.1 at the end of the chapter. See Appendix 6 for the welfare measures for all the MMAs.

The OLS estimates from the second stage are reported in Table 5.2. The columns represent the demand estimates from the first stage whereas the rows are the attributes which are postulated to explain the demand estimates. The results show that the only attribute significant (at the 5% level) in explaining the intercept is success rate. Also, black spruce, success rate and moose density are significant in explaining travel cost. None of the attributes significantly explains changes in the income parameter at the 5% level of significance. The estimates show that black spruce and moose density are negatively and significantly related to travel cost whereas success rate positively and significantly relates to it. Thus an increase in the proportion of black spruce would cause a decrease in travel cost parameter thereby leading to an increase in the number of trips taken by the representative hunter. Similarly, an increase in the success rate at making a kill leads to an increase in the travel cost parameter and decreases the number of trips taken. On the other

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[43] These results are not comparable with the previous results because the models are structurally different. The VPM uses only returns data.

hand, an increase in moose density leads to a decrease in the travel cost parameter and an increase in the number of trips taken. An explanation for this result may be that hunters, assured of making a kill before the end of the hunting season due to the high density of moose, take more trips until they find the best moose.

A 20% increase in the proportion of black spruce and a 20% increase in success rate in Central Newfoundland, *i.e.*, in MMA 25, MMA26 and MMA27, were simulated. These sites were randomly chosen. Changing the attributes in a moose management area has no welfare effect on other sites because unlike the RUM, the VPM does not allow for substitution of sites resulting from quality changes. The per trip welfare gain for increasing black spruce in MMA25, MMA26 and MMA27 by 20% are $16.95, $3.01 and $8.16 respectively (Table 5.3). An increase in black spruce leads to a decrease in travel cost which in turn leads to an increase in the number of trips taken. A 20% decrease however results in a per trip welfare decrease of $19.60, $3.54 and $10.50 respectively. This result is contrary to the welfare results obtained from simulations using black spruce in the previous RUM-based models. On the other hand, increasing success rate leads to an increase in travel cost which in turn leads to a decrease in number of trips taken. Thus increasing success rate in the same MMAs by 20% results in a decrease in welfare of $33.72, $9.28 and an increase of $4.78 in MMA25, MMA26 and MMA27 respectively (Table 5.3). The increase in welfare in MMA27 resulting from an increase in success rate is surprising. A decrease in success rate of 20% in the same MMAs results in a per trip increase in welfare of $31.47, $6.99, and $1.29 respectively.

To sum up, the Varying Parameter model as used in the recreational literature was described and used to estimate Marshallian welfare measures for the 52 MMAs. The average per trip welfare measure was estimated at around $110. The model was also used to estimate the per trip welfare measures of increasing the proportion of Black Spruce and Success Rate in Central Newfoundland, *i.e.*, in MMA25, MMA26 and MMA27. Due to their effects on the number of trips taken, increasing the proportion of black spruce results in welfare gains whereas increasing the success rate at making a kill results in welfare loss.

TABLE 5.1

ESTIMATES AND CONSUMER SURPLUS MEASURES FROM TRUNCATED POISSON AND TRUNCATED NEGATIVE BINOMIAL MODELS FOR SOME MMAS.

MMA	AREA	Intercept	Travel Cost Parameter	Income Parameter	Alpha	N	LR Stats	Total Trips to site	CS
MMA5	Trout	2.289	-0.009	0.003	1.066	481	2031.7	3,946	107.03
	River	(6.706)	(-4.232)	(1.092)	(7.984)				
MMA6	Corner	1.441	-0.009	0.719	0.719	491	1083.2	3,180	115.43
	Brook	(3.322)	(-3.312)	(7.683)	(7.683)				
MMA7	South	3.046	-0.008	-0.008	0.604	346	1032.8	2,720	125.41
	Brook	(4.996)	(-6.686)	(-1.316)	(7.352)				
MMA8	St.	1.643	-0.007	0.005	0.907	508	1502.3	3,412	151.92
	George	(6.263)	(-5.728)	(1.649)	(7.524)				
MMA11	Dash-woods	2.232	-0.012	0.007	0.831	371	1369.1	1,757	81.68
		(6.835)	(-12.834)	(2.089)	(5.653)				
MMA12	Buchans	2.753	-0.013	-0.001	0.923	127	636.7	627	75.52
		(4.576)	(-7.076)	(-0.126)	(2.813)				
MMA25	Bay	3.174	-0.014	-0.006	1.642	343	1426.1	1,486	70.53
	D'Espoir	(7.434)	(-9.866)	(-1.143)	(3.794)				
MMA26	Jubilee	1.784	-0.014	0.008		142	477.20	350	70.78
	Lake	(5.916)	(-7.596)	(1.825)					
MMA27	Terra	1.987	-0.019	0.001	1.308	193	555.10	581	52.81
	Nova	(2.514)	(-9.848)	(0.956)	(2.473)				
Average									109.87
St. Dev									78.07

Notes: T-Statistics are in parentheses
Alpha is the overdispersion paramcter
N is the total number who hunted in each MMA
LR is the Loglikelihood Ratio
Average is Average Consumers Surplus Per Trip
CS is Consumer Surplus

TABLE 5.2

SECOND STAGE OLS ESTIMATES FROM SITE DEMAND ESTIMATES.

Attributes	Intercept Parameter	Travel Cost Parameter	Income Parameter
Intercept	5.775	-0.01761	-0.02989
	(4.309)*	(-3.389)*	(-2.022)*
Balsam Fir	-14.745	0.035419	0.17278
	(-0.9245)	(0.5727)	(0.9821)
Black Spruce	16.338	-0.1234	-0.12056
	(1.092)	(-2.111)*	(-0.7248)
White Birch	-5.2022	0.08275	0.01984
	(-0.3546)	(1.455)	(0.1226)
Disturbed Areas	2.032	-0.0655	0.05404
	(0.1309)	(-1.088)	(0.3155)
Moose Density	0.08399	-0.00116	-0.0003
	(0.5679)	(-2.028)*	(-0.1855)
Success Rate	-4.6287	0.01423	0.0334
	(-2.834)*	(2.248)*	(1.854)
R^2	0.1742	0.2438	0.0889

Notes: T-Statistics are in parentheses

* = Significant at the 5% level

TABLE 5.3

PER TRIP WELFARE MEASURES OF A 20% CHANGE IN BLACK SPRUCE AND SUCCESS RATE IN MMA 25, MMA26, AND MMA27.

MMA	Total Number of Trips	Average Quarterly Income ($)	Average Travel Cost ($)	Per Trip CS of Increase in Black Spruce	Per Trip CS of Decrease in Black Spruce	Per Trip CS of Increase in Success Rate	Per Trip CS of Decrease in Success Rate
MMA25	1486	8740.25	173.47	16.95	-19.60	-33.72	31.47
MMA26	350	8728.75	337.26	3.01	-3.54	-9.28	6.99
MMA27	581	9567.00	167.77	8.16	-10.50	4.78	1.29

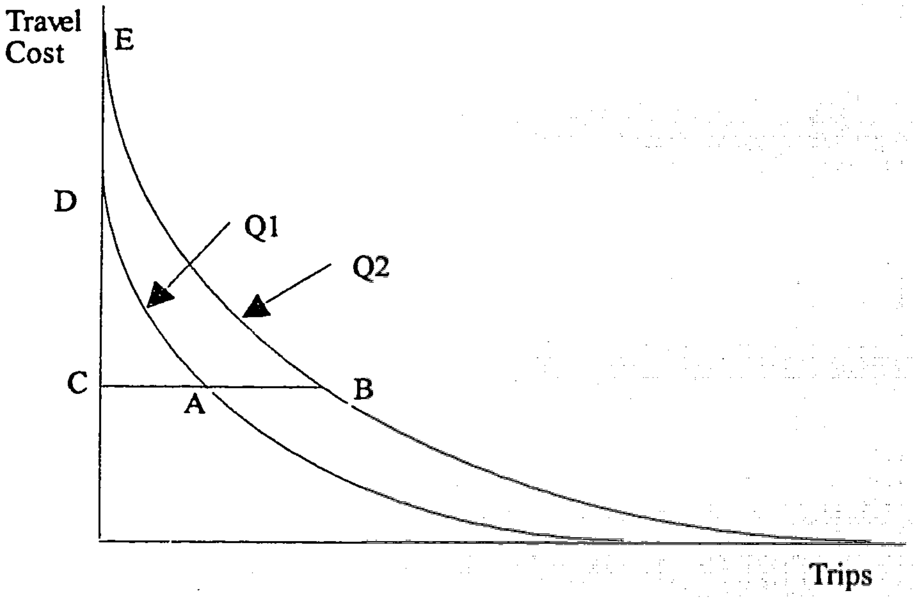

Figure 4. The Effect of Quality Change on the Demand for Sites

CHAPTER 6

DISCUSSIONS AND CONCLUSION

This thesis is about welfare estimation of nontimber resources in Newfoundland. Uncertain, lottery-rationed choice data of those who applied for and obtained hunting permits to hunt moose in Newfoundland in 1992 were used. Due to the lottery process, some of these applicants did not obtain licenses to hunt. Out of those who obtained licenses, only 3% did not hunt. Those who hunted provided data, *inter alia*, on when and where they hunted. This information was used to estimate the number of trips they took during the hunting season.

Three different types of models were estimated. In the first model, two specifications of the random utility model that account for uncertainty in the realization of choices were used to estimate site choice. The first specification is attributed to Rouwendal (1989) and the other is based on probability and expected utility theory (Boxall, 1995). The former model is referred to as the Rouwendal model and the latter as the Multiplicative model. They are not nested. Given that 97% of those who obtained licenses hunted in 1992, lottery-rationed data on site choice of applicants were used as revealed preference data. The total number of people who applied to hunt were grouped into towns of origin. The dependent variables are proportions of people from towns who chose sites as their first choices out of the total number from the towns. The site attributes that are postulated to determine site choice are the travel cost to the MMAs, the probability of winning a license, the proportion of the balsam fir, white birch, black spruce and disturbed areas working groups in the MMAs, the success rate at making a kill in each of the MMAs and the alternative specific constants for remoteness and Either Sex licenses. The probabilities of site choice, based on site attributes, were determined. Only travel cost, success rate at making a kill in a MMA and balsam fir are significant in determining site choice in both specifications at the 5% level. The log of the probability of winning a hunting permit is also significant in the Rouwendal model. Black spruce, disturbed areas and the alternative specific constants representing Either Sex licenses and remoteness are not significant in either specification. The Rouwendal model is a more preferred specification than the Multiplicative model, based on the adjusted likelihood ratio index. Changes in welfare measures of the hunting sites were calculated for the towns by simulating counterfactual scenarios and using the total trips taken by successful applicants. For example, the per trip welfare measures of MMA5, MMA6, and MMA7 to a representative resident of Corner Brook from the Rouwendal model were estimated at \$13.92, \$10.34, and \$12.90 respectively. The corresponding values from the Multiplicative models are \$10.80, \$ 6.74, \$11.09.

The second model estimated is a combination of the RUM and Count data models. This model (Hausman *et al.*, 1995) is utility-consistent and allows for exact welfare measurement. It was used to examine both site choice and trip frequency decisions in the framework of the two-stage expenditure approach. A sample of individuals was drawn from the data of successful applicants and their first choices were used to examine site choice using the Rouwendal and Multiplicative models. The dependent variables are zero-one variables. The attributes were the same as in the previous model. Again, the Rouwendal model represents a 'more correct' specification, using the adjusted likelihood ratio index. The consumer surplus measures obtained from the first stage are used as the price indexes to estimate Count data models of number of trips taken at the second stage. It was found, *inter alia*, that more trips are taken if people use ATVs than if they use other means of transportation and if they are satisfied with the sites they are allotted. Specifically, more trips are likely to be taken if the first or second choice is won than if any order of site choice was won. Winning third, fourth or fifth choices did not significantly affect frequency of trips taken. Income also did not significantly explain the number of trips taken. Welfare measures from site quality changes using both models at the first stage are not that different. Both models also show increases of second stage utility consistent welfare measures over first stage welfare measures as expected since they account for the effect of quality changes on trip frequency as well as on site choice (Hausman *et al.*, 1995). However, the proportional increases in second stage welfare measures with the price index from the Rouwendal model are more pronounced than with the price index from the Multiplicative model. This difference could be due to the structural differences between the two models. Further research is therefore needed to explain the differences.

The total number of successful hunters was used with the mean total expenditures of moose hunters obtained from Condon (1993) to examine the aggregate expenditures made by moose hunters. The object of this analysis was to examine the effect of quality changes on expenditures made in the MMAs. However, the available data were not suitable for this analysis. The data could not be used to apportion expenditures to the MMAs in which they were made. The sample data used in the Truncated Negative Binomial model was used for this analysis. Based on information from Condon (1993) and the trips data, it was assumed that each hunter took 5 trips during the hunting season. The weighted total expenditure of hunters during the three month hunting season was estimated at about $5.6 million. Although changes in expenditure in MMAs resulting from quality changes could not be analyzed, changes in aggregate expenditure resulting from quality changes were analyzed. These changes were small because of the large number of sites available for hunters to choose from. Closing one site therefore does not affect aggregate hunting expenditures in the sites very much. Changes in aggregate expenditures for the Province at large resulting from such closures should remain unchanged.

In the final part of the thesis, the Varying Parameter Model was used to estimate the demand for trips as well as the Marshallian welfare of the hunting sites. This model, unlike the RUM, does not account for substitution effects with quality changes. However, it is suitable for moose hunting in Newfoundland because of the restriction that once a license is won for a site, hunters can not hunt elsewhere. The model used the Truncated Negative Binomial Model and the Truncated Poisson model to estimate trip demand functions for the 52 MMAs. Welfare measures were estimated for the 52 MMAs. The average per trip consumer surplus for a MMA was estimated at about $110. Per trip welfare changes were calculated for MMA25, MMA26 and MMA27 by simulating changes in two attributes - black spruce and success rate. The results show that increasing the proportion of black spruce results in welfare gains whereas increasing the success rate at making a kill results in welfare loss because such increases lead to increases in travel cost which cause less trips to be taken. These results are contrary to those obtained with the Random Utility models.

A summary of the main average per trip welfare measures from the models can be found in Table 6.1 below. Generally, the average per trip welfare measures from the Rouwendal model are larger than the measures from the Multiplicative model for all the scenarios. The welfare measures reported here are for moose hunting only. They exclude the effect of the bag limit imposed on hunters. In light of the findings of Creel and Loomis (1991) it would be interesting to see how accounting for the bag limit would affect these results. It would also be interesting to study the values of other nontimber resources on the Island such as hiking, other big game hunting, sportfishing, and cross-country and downhill skiing should the appropriate data be available. The aggregate values of these activities would then give a rough estimate of the value of nontimber resources of the Island which could be compared with the gains from timber resources to arrive at decisions involving forest resource use.

A PC-based Decision Support Tool was designed for the sponsors of this project, Canadian Forest Service, Newfoundland, using the estimates from the Rouwendal model. This tool can be used to obtain estimates of per trip consumer surplus measures arising from closure of hunting sites or changes in site attributes. A copy of this software does not accompany this thesis.

Due to the sensitive nature of the results from studies involving the environment, the importance of good and accurate data for such studies can not be overstated. Currently, working groups are based on Forest Districts. A proper designation of the working groups into MMAs may produce more precise measurement of attributes and probably better results than have been produced in this thesis. GIS techniques can also be used to obtain more precise measurement of these attributes. It is therefore recommended that efforts be made to obtain GIS-based attributes and the models reestimated.

In order to expand the usefulness of the results of these studies for policy makers, it is recommended that the Wildlife Division undertake measures to obtain data on expenditures incurred by successful applicants, particularly in areas that they were incurred, without compromising anonymity. Input-Output as well as General Equilibrium analyses could then be done to study changes in expenditure patterns resulting from attribute changes. If possible these data should be broken down into where the expenditures were incurred. Also the way of recording the time spent hunting should be improved so that on time costs can be included in travel costs.

The substitution characteristics of the standard RUM imply that attribute changes result in small changes in number of trips taken and welfare measures. With lottery rationing and excess demand for trips, the concern is that welfare measures particularly from site closures may not be small. This concern need further research, particular in situations where there are no sites where applicants can go to with certainty.

Finally, if the appropriate data are found, then nested forms of the random utility model may produce better results since they do not have the IIA problem.

TABLE 6.1

SUMMARY OF MAIN PER TRIP CONSUMER SURPLUS MEASURES OF SCENARIOS IN DOLLARS

Scenarios	Site Choice Models		Two Stage Models				
	Rouwendal[a]	Multiplicative[a]	Rouwendal		Multiplicative		Varying Parameter Model[d]
			First Stage[b]	Used in Second Stage[c]	First Stage[b]	Used in Second Stage[c]	
Closure of MMA5	4.12	3.22	3.66	27.71	3.02	12.19	NA[h]
Closure of MMA6	3.60	2.47	3.83	23.91	2.80	9.32	NA
Closure of MMA7	2.75	2.23	2.75	20.54	1.98	8.06	NA
Closure of MMA12	1.18	0.76	1.12	8.46	0.71	2.92	NA
Closure of MMAMF[e]	15.42	11.75	14.88	80.49	15.14	32.40	NA
Increasing BS[f] in MMA25 by 20%	NA	NA	NA	NA	NA	NA	16.95
Increasing BS in MMA26 by 20%	NA	NA	NA	NA	NA	NA	3.01
Increasing BS in MMA27 by 20%	NA	NA	NA	NA	NA	NA	8.16
Decreasing BS in MMA25 by 20%	NA	NA	NA	NA	NA	NA	-19.60
Decreasing BS in MMA26 by 20%	NA	NA	NA	NA	NA	NA	-3.54
Decreasing BS in MMA27 by 20%	NA	NA	NA	NA	NA	NA	-10.50
Increasing SR[g] in MMA25 by 20%	NA	NA	NA	NA	NA	NA	-33.72
Increasing SR in MMA26 by 20%	NA	NA	NA	NA	NA	NA	-9.28

Scenarios	Site Choice Models		Two Stage Models				
	Rouwendal[a]	Multiplicative[a]	Rouwendal		Multiplicative		Varying Parameter Model[d]
			First Stage[b]	Used in Second Stage[c]	First Stage[b]	Used in Second Stage[c]	
Increasing SR in MMA27 by 20%	NA	NA	NA	NA	NA	NA	4.78
Decreasing SR in MMA25 by 20%	NA	NA	NA	NA	NA	NA	31.47
Decreasing SR in MMA26 by 20%	NA	NA	NA	NA	NA	NA	6.99
Decreasing SR in MMA27 by 20%	NA	NA	NA	NA	NA	NA	1.29

Notes: a: Entire data set used. Data grouped into towns. Dependent variable is proportions data.
b: Sample of 767 successful applicants used. Micro data with zero-one dependent variable.
c: Reversed sign of consumer surplus from first stage used as price index variable.
Dependent variable is count data, i.e., number of trips taken.
d: Dependent variable is count data. Whole data set of successful applicants who hunted used.
e: MMAMF is MMA5, MMA6, MMA7, and MMA12 combined.
f: BS is Black Spruce.
g: SR is Success Rate.
h: NA is Not Applicable

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APPENDIXES

APPENDIX 1

DATA USED IN ESTIMATING PROBABILISTIC CHOICE MODELS

MMA	Probability of winning License	Balsam Fir	Black Spruce	White Birch	Disturbed Areas	Success Rate	ASC for Remoteness	ASC for Either Sex Licenses
MMA1	0.4444	0.0224	0.0025	0.0001	0.0041	0.98	0	0
MMA2	0.7037	0.0372	0.0059	0.0038	0.017	0.886	0	0
MMA3	0.8519	0.0454	0.0211	0.0078	0.014	0.644	1	0
MMA3A	0.8519	0.007	0.0011	0.0007	0.0032	0.827	0	0
MMA4	0.7778	0.037	0.0263	0.0085	0.0071	0.684	0	0
MMA5	0.7778	0.0412	0.0093	0.0469	0.0382	0.817	0	1
MMA6	0.7778	0.0297	0.0067	0.0339	0.0276	0.805	0	0
MMA7	0.8148	0.0355	0.008	0.0404	0.0329	0.603	0	1
MMA8	0.7778	0.0135	0.0025	0.0113	0.0206	0.784	0	0
MMA9	0.8148	0.0056	0.001	0.0047	0.0086	0.75	0	0
MMA10	0.7778	0.0225	0.0042	0.0188	0.0344	0.796	1	0
MMA11	0.7778	0.0222	0.0051	0.0152	0.0308	0.716	0	0
MMA12	0.7778	0.0326	0.035	0.0549	0.0283	0.636	0	0
MMA13	0.7407	0.0287	0.0438	0.0495	0.0225	0.847	0	0
MMA14	0.7037	0.0502	0.0708	0.0716	0.0843	0.882	0	0
MMA15	0.7037	0.0358	0.0717	0.0525	0.0763	0.88	0	0
MMA15A	0.7037	0.0051	0.0139	0.0078	0.0137	0.904	0	0
MMA16	0.7778	0.0041	0.0186	0.0146	0.0257	0.642	0	0
MMA16A	0.8148	0.0013	0.0062	0.006	0.0099	0.722	1	0
MMA17	0.7778	0.0245	0.0438	0.0589	0.021	0.749	0	0
MMA18	0.8148	0.0277	0.0108	0.013	0.0332	0.581	0	0
MMA19	0.7778	0.0264	0.0056	0.0196	0.038	0.668	0	0
MMA20	0.8148	0.0088	0.0204	0.0073	0.0189	0.684	0	0
MMA21	0.7778	0.008	0.037	0.036	0.0596	0.742	0	0
MMA22	0.6296	0.0103	0.0675	0.1143	0.0379	0.935	0	1
MMA22A	0.6296	0.0013	0.0062	0.006	0.0099	0.733	1	0
MMA23	0.6667	0.0078	0.1135	0.1103	0.0342	0.842	0	0
MMA23A	0.6667	0.0019	0.0219	0.0245	0.0078	0.949	0	0
MMA24	0.7407	0.0036	0.016	0.0068	0.0149	0.7	0	0
MMA25	0.7778	0.0105	0.0211	0.007	0.0195	0.822	0	0
MMA26	0.7778	0.0185	0.0164	0.0057	0.0138	0.642	0	0
MMA27	0.5926	0.0111	0.0497	0.0268	0.0384	0.738	0	0
MMA28	0.5926	0.039	0.0787	0.0499	0.0255	0.854	0	0
MMA29	0.5185	0.0226	0.0395	0.0102	0.0097	0.932	0	0
MMA30	0.4444	0.0266	0.0033	0.0014	0.0029	0.814	0	0
MMA31	0.6296	0.008	0.001	0.0004	0.0009	0.803	0	1
MMA32	0.5556	0.013	0.0016	0.0007	0.0014	0.843	1	0
MMA33	0.5926	0.007	0.0009	0.0004	0.0008	0.646	0	0
MMA34	0.4074	0.02	0.0025	0.0011	0.0022	0.948	0	1
MMA35	0.5185	0.015	0.0019	0.0008	0.0016	0.672	0	0
MMA36	0.5926	0.033	0.0041	0.0018	0.0036	0.493	0	0
MMA37	0.963	0.0175	0.012	0.0098	0.0232	0.545	0	0
MMA38	0.2963	0.02	0.0025	0.0011	0.0022	0.87	0	0

MMA	Probability of winning License	Balsam Fir	Black Spruce	White Birch	Disturbed Areas	Success Rate	ASC for Remoteness	ASC for Either Sex Licenses
MMA39	0.8519	0.0217	0.0029	0.0011	0.0067	0.492	0	0
MMA39A	0.8148	0.0075	0.001	0.0003	0.0022	0.893	0	0
MMA40	0.7037	0.0305	0.0035	0.0002	0.0056	0.944	0	0
MMA41	0.7778	0.0193	0.0197	0.0146	0.0164	0.844	0	0
MMA42	0.7037	0.0065	0.0289	0.0132	0.0257	0.81	0	1
MMA43	0.5556	0.0045	0.0008	0.0038	0.0069	1	0	0
MMA44	0.3704	0.004	0.0005	0.0002	0.0004	0.963	0	0
MMA45	0.7778	0.0438	0.006	0.0025	0.0143	0.754	0	0
MMA47	0.5926	0.0029	0.0051	0.0013	0.0013	0.914	0	0

APPENDIX 2

DATA USED IN ESTIMATING VARYING PARAMETER MODEL

MMA	AREA	Average Income of Hunters	Average Travel Cost	Balsam Fir	Black Spruce	White Birch	Disturbed Areas	Success Rate	Density
MMA1	St. Anthony	39676.00	76.75	0.0224	0.0025	0.0001	0.0041	0.98	0.38
MMA2	Portland Creek	37304.00	94.06	0.0372	0.0059	0.0038	0.017	0.886	2.14
MMA3	Harbour Deep	35645.00	270.54	0.0454	0.0211	0.0078	0.014	0.644	1.6
MMA3A	Harbour Deep	35641.00	157.93	0.007	0.0011	0.0007	0.0032	0.827	1.62
MMA4	Taylor's Brook	36705.00	143.57	0.037	0.0263	0.0085	0.0071	0.684	0.4
MMA5	Trout River	37586.00	74.90	0.0412	0.0093	0.0469	0.0382	0.817	1.72
MMA6	Corner Brook	40147.00	60.85	0.0297	0.0067	0.0339	0.0276	0.805	2.4
MMA7	South Brook	40590.00	57.51	0.0355	0.008	0.0404	0.0329	0.603	0.74
MMA8	St. George	36172.00	64.91	0.0135	0.0025	0.0113	0.0206	0.784	2.16
MMA9	Anguille Mtns	35774.00	147.10	0.0056	0.001	0.0047	0.0086	0.75	3.44
MMA10	Port au Basques	35033.00	64.15	0.0225	0.0042	0.0188	0.0344	0.796	1.04
MMA11	Dashwoods	36919.00	199.43	0.0222	0.0051	0.0152	0.0308	0.716	0.79
MMA12	Buchans	34243.00	168.91	0.0326	0.035	0.0549	0.0283	0.636	0.33
MMA13	Gaff Topsails	35951.00	145.01	0.0287	0.0438	0.0495	0.0225	0.847	0.29
MMA14	Baie Verte	36315.00	86.08	0.0502	0.0708	0.0716	0.0843	0.882	0.33
MMA15	Twin Lakes	35021.00	114.46	0.0358	0.0717	0.0525	0.0763	0.88	1.04
MMA15A	Twin Lakes	36421.00	114.68	0.0051	0.0139	0.0078	0.0137	0.904	1.04
MMA16	Sandy Badger	38188.00	157.44	0.0041	0.0186	0.0146	0.0257	0.642	1.08
MMA16A	Sandy Badger	38851.00	193.12	0.0013	0.0062	0.006	0.0099	0.722	3.6
MMA17	Millertown	36759.00	329.32	0.0245	0.0438	0.0589	0.021	0.749	0.54
MMA18	Granite Lake	36627.00	407.48	0.0277	0.0108	0.013	0.0332	0.581	0.38
MMA19	Grey River W.	31872.00	68.55	0.0264	0.0056	0.0196	0.038	0.668	0.8
MMA20	Round Pond	34468.00	248.35	0.0088	0.0204	0.0073	0.0189	0.684	0.62
MMA21	Rattling Brook	35357.00	124.26	0.008	0.037	0.036	0.0596	0.742	0.94
MMA22	Lewisporte	33187.00	68.98	0.0103	0.0675	0.1143	0.0379	0.935	3.74
MMA22A	Lewisporte	33883.00	82.42	0.0013	0.0062	0.006	0.0099	0.733	3.74
MMA23	Bonavista N.	34332.00	75.77	0.0078	0.1135	0.1103	0.0342	0.842	2.02
MMA23A	Bonavista N	42113.00	49.36	0.0019	0.0219	0.0245	0.0078	0.949	2.02
MMA24	N.West Gander	39292.00	174.60	0.0036	0.016	0.0068	0.0149	0.7	1.7
MMA25	Bay D'Espoir	34961.00	173.47	0.0105	0.0211	0.007	0.0195	0.822	0.62
MMA26	Jubilee Lake	34915.00	337.26	0.0185	0.0164	0.0057	0.0138	0.642	0.68
MMA27	Terra Nova	38268.00	167.77	0.0111	0.0497	0.0268	0.0384	0.738	3.4
MMA28	Black River	36205.00	94.22	0.039	0.0787	0.0499	0.0255	0.854	0.72
MMA29	Bonavista Pen.	34872.00	90.34	0.0226	0.0395	0.0102	0.0097	0.932	1.52
MMA30	Burin Pen.Knee	35247.00	82.90	0.0266	0.0033	0.0014	0.0029	0.814	0.22
MMA31	Placentia	35845.00	42.06	0.008	0.001	0.0004	0.0009	0.803	0.82
MMA32	Cape Shore	36724.00	105.14	0.013	0.0016	0.0007	0.0014	0.843	1.02
MMA33	Salmonier	39355.00	61.86	0.007	0.0009	0.0004	0.0008	0.646	2.1
MMA34	Bay de Verde	35232.00	39.59	0.02	0.0025	0.0011	0.0022	0.948	1.2
MMA35	St. John's	44414.00	30.06	0.015	0.0019	0.0008	0.0016	0.672	0.4
MMA36	Southern Shore	41712.00	85.20	0.033	0.0041	0.0018	0.0036	0.493	1.6
MMA37	Grey River East	34478.00	325.84	0.0175	0.012	0.0098	0.0232	0.545	0.21
MMA38	Burin Pen. Foot	35117.00	41.32	0.02	0.0025	0.0011	0.0022	0.87	0.16
MMA39	Cloud River	39120.00	173.49	0.0217	0.0029	0.0011	0.0067	0.492	0.08
MMA39A	Cloud River	35500.00	64.44	0.0075	0.001	0.0003	0.0022	0.893	1.12
MMA40	Conche	37915.00	134.78	0.0305	0.0035	0.0002	0.0056	0.944	8.12
MMA41	Sheffield Lake	35565.00	120.13	0.0193	0.0197	0.0146	0.0164	0.844	0.43
MMA42	Gambo	36548.00	156.03	0.0065	0.0289	0.0132	0.0257	0.81	1.96

MMA	AREA	Average Income of Hunters	Average Travel Cost	Balsam Fir	Black Spruce	White Birch	Disturbed Areas	Success Rate	Density
MMA43	Port Au Port	28247.00	44.37	0.0045	0.0008	0.0038	0.0069	1	1.1
MMA44	Bellevue	35174.00	56.63	0.004	0.0005	0.0002	0.0004	0.963	0.76
MMA45	Ten Mile Lake	38723.00	91.09	0.0438	0.006	0.0025	0.0143	0.754	2.68
MMA47	Random Island	40579.00	86.95	0.0029	0.0051	0.0013	0.0013	0.914	1.12

APPENDIX 3

DEFINITION OF ATTRIBUTES

Attributes	Definitions
Balsam Fir	Proportion of MMA with 40-100% of the total merchantable basal area covered by Balsam Fir.
Black Spruce	Proportion of MMA with 40-100% of the total merchantable basal area covered by Black Spruce.
Disturbed Areas	Proportion of MMA disturbed by fire, logging, insects, wind or disease
White Birch	Proportion of MMA with 40-100% of the total merchantable basal area covered by White Birch
Moose Density	Number of moose per sq. km.
Success Rate	Success Rate of making a kill in previous year
Probability	The probability of obtaining a hunting permit or license
ASC Remoteness	Alternative Specific Constant for sites that are considered Remote
ASC Either Sex	Alternative Specific Constant for sites with Either Sex Licenses

APPENDIX 4

Converting Number of Days Hunted into Number of Trips taken

The number of days hunted per trip, obtained from Condon (1993), was regressed on distance dummy variables only. The estimates are reported below. D1 represents distance of less than 100 kilometres traveled, D2 represents distance greater than 100 but less than 150 kilometres, D3 represents distances greater than 150 but less than 200 kilometres, D4 represents distances greater than 200 but less than 250 kilometres, D5 represents distances greater than 250 but less than 300 kilometres, D6 represents distances greater than 300 but less than 350 kilometres, D7 represents distances greater than 350 but less than 400 kilometers, D8 represents distances greater than 400 but less than 450, D9 represents distances greater than 450 but less than 500 kilometres and D10 represents distances greater than 500. D1 is used as the base, *i.e.*, the intercept. The regression estimates, with t-statistics in parentheses, are

$$
\begin{array}{l}
\text{Days/Trip} = 1.7109\mathbf{D1} + 0.3475\mathbf{D2} + 1.9934\mathbf{D3} + 1.7822\mathbf{D4} + 3.004\mathbf{D5} + 2.9891\mathbf{D6} \\
\qquad\qquad\quad (37.8) \qquad (2.153) \qquad (14.19) \qquad (11.37) \qquad (23.09) \qquad (12.54) \\
\qquad\qquad + 2.6814\mathbf{D7} + 2.178\mathbf{D8} + 3.8927\mathbf{D9} + 3.448\mathbf{D10} \\
\qquad\qquad\quad (16.22) \qquad (9.971) \qquad (21.87) \qquad (19.04)
\end{array}
$$

$$R^2 = 0.357$$

APPENDIX 5

TOTAL EXPENDITURE MADE IN MMAS BY HUNTERS

MMA	Area	Individual Hunters	Party Hunters	Total No. of Hunters	Mean Total Expenditure
MMA1	St. Anthony	21	13	34	103
MMA2	Portland Creek	78	349	427	331.94
MMA3	Harbour Deep	268	174	442	490.26
MMA3A	Harbour Deep	33	46	79	650.5
MMA4	Taylor's Brook	129	433	562	262.91
MMA5	Trout River	116	401	517	549.74
MMA6	Corner Brook	173	349	522	354.42
MMA7	South Brook	86	282	368	429.84
MMA8	St. George	149	392	541	571.15
MMA9	Anguille Mtns	11	320	331	875.7
MMA10	Port au Basques	75	341	416	823.34
MMA11	Dashwoods	15	376	391	351.156
MMA12	Buchans	45	112	157	567.1
MMA13	Gaff Topsails	80	158	238	593.88
MMA14	Baie Verte	195	223	418	397.42
MMA15	Twin Lakes	274	239	513	246.21
MMA15A	Twin Lakes	82	19	101	271.66
MMA16	Sandy Badger	138	307	445	582.91
MMA16A	Sandy Badger	34	165	199	699.24
MMA17	Millertown	245	371	616	591.36
MMA18	Granite Lake	118	235	353	617.43
MMA19	Grey River West	16	165	181	566.59
MMA20	Round Pond	11	182	193	517.6
MMA21	Rattling Brook	147	188	335	351.77
MMA22	Lewisporte	227	136	363	212.65
MMA22A	Lewisporte	136	22	158	218.64
MMA23	Bonavista North	252	71	323	28.62
MMA23A	Bonavista North	61	54	115	351.5
MMA24	N.West Gander	178	147	325	610.84
MMA25	Bay D'Espoir	167	189	356	426
MMA26	Jubilee Lake	45	106	151	327.88
MMA27	Terra Nova	146	56	202	434.29
MMA28	Black River	229	124	353	418.52
MMA29	Bonavista Penin.	293	125	418	173.2
MMA30	Burin Penin.Knee	67	39	106	209.25
MMA31	Placentia	115	57	172	213.5
MMA32	Cape Shore	149	87	236	305.22
MMA33	Salmonier	116	98	214	251.22
MMA34	Bay de Verde	259	22	281	358.49
MMA35	St. John's	115	66	181	203.67
MMA36	Southern Shore	517	185	702	486.44

MMA	Area	Individual Hunters	Party Hunters	Total No. of Hunters	Mean Total Expenditure
MMA37	Grey River East	100	97	197	1065.13
MMA38	Burin Penin. Foot	50	4	54	107.75
MMA39	Cloud River	46	72	118	294.85
MMA39A	Cloud River	39	48	87	N/A
MMA40	Conche	125	142	267	388.03
MMA41	Sheffield Lake	87	184	271	292.6
MMA42	Gambo	75	92	167	372.66
MMA43	Port Au Port	4	8	12	88
MMA44	Bellevue	30	1	31	274.66
MMA45	Ten Mile Lake	40	49	89	404.88
MMA47	Random Island	31	15	46	54
Sum				14,374	

Note: N/A=Not Available

APPENDIX 6
ESTIMATES AND CONSUMER SURPLUS MEASURES FROM THE VARYING PARAMETER MODEL

MMA	AREA	Intercept	Travel Cost Parameter	Income Parameter	Alpha	N	LR Stats	Total Trips	Consumer Surplus
MMA1	St.	0.249	-0.003	0.014	0.567	33	17.06	142	287.274
	Anthony	(0.177)	(-0.454)	(1.064)	(2.407)				
MMA2	Portland	2.3	-0.01	-0.002	1.00	409	1198.2	2164	97.437
	Creek	(4.275)	(-11.438)	(-0.381)	(6.141)				
MMA3	Harbour	4.321	-0.012	-0.024	1.16	362	797.2	903	85.397
	Deep	(4.138)	(-12.9)	(-2.129)	(3.422)				
MMA3A	Harbour	-1.72	-0.011	0.024	N/A	69	79.33	96	87.283
	Deep	(-0.861)	(-2.585)	(1.057)					
MMA4	Taylor's	2.055	-0.013	0.011	1.032	538	2360.9	3298	75.041
	Brook	(5.593)	(-13.327)	(2.716)	(7.295)				
MMA5	Trout	2.289	-0.009	0.003	1.066	481	2031.7	3946	107.033
	River	(6.706)	(-4.232)	(1.092)	(7.984)				
MMA6	Corner	1.441	-0.009	0.719	0.719	491	1083.2	3180	115.433
	Brook	(3.322)	(-3.312)	(7.683)	(7.683)				
MMA7	South	3.046	-0.008	-0.008	0.604	346	1032.8	2720	125.412
	Brook	(4.996)	(-6.686)	(-1.316)	(7.352)				
MMA8	St. George	1.643 (6.263)	-0.007 (-5.728)	0.005 (1.649)	0.907 (7.524)	508	1502.3	3412	151.925
MMA9	Anguille	2.323	-0.007	0.002	1.056	316	1308.8	2197	134.758
	Mtns	(3.654)	(-8.395)	(0.288)	(5.632)				
MMA10	Port au	-0.339	-0.008	0.03	0.94	388	1390	2859	120.475
	Basques	(-0.429)	(-4.141)	(3.147)	(7.107)				
MMA11	Dash-	2.232	-0.012	0.007	0.831	371	1369.1	1757	81.679
	woods	(6.835)	(-12.834)	(2.089)	(5.653)				
MMA12	Buchans	2.753	-0.013	-0.001	0.923	127	636.7	627	75.523
		(4.576)	(-7.076)	(-0.126)	(2.813)				
MMA13	Gaff	0.398	-0.011	0.022	1.209	227	846.9	1117	92.928
	Topsails	(0.858)	(-10.067)	(4.356)	(4.122)				
MMA14	Baie	2.252	-0.01	-0.002	1.34	398	1322	2268	101.067
	Verte	(4.622)	(-7.779)	(-0.381)	(5.392)				

MMA	AREA	Intercept	Travel Cost Parameter	Income Parameter	Alpha	N	LR Stats	Total Trips	Consumer Surplus
MMA15	Twin	1.519	-0.012	0.008	1.389	478	1193.4	2133	85.135
	Lakes	(3.7)	(-8.369)	(1.961)	(5.186)				
MMA15A	Twin	4.408	-0.015	-0.241	N/A	95	67.55	262	66.671
	Lakes	(3.366)	(-4.073)	(-2.123)					
MMA16	Sandy	2.762	-0.013	0	0.979	413	2120.3	2296	74.828
	Badger	(5.494)	(-13.285)	(0.107)	(6.155)				
MMA16A	Sandy	4.365	-0.015	-0.015	0.812	186	798.9	838	68.549
	Badger	(7.321)	(-9.267)	(-2.739)	(3.978)				
MMA17	Miller-town	2.895	-0.014	0	1.145	591	1032.9	965	69.334
		(4.195)	(-15.429)	(0.039)	(2.743)				
MMA18	Granite	2.173	-0.006	-0.012	N/A	328	423.6	398	172.888
	Lake	(3.241)	(-5.862)	(-1.563)					
MMA19	Grey	3.71	-0.013	-0.019	N/A	169	584.9	1093	79.397
	River W.	(2.112)	(-3.617)	(-0.832)					
MMA20	Round	4.437	-0.012	-0.022	0.989	180	885.3	689	84.818
	Pond	(6.864)	(-10.145)	(-2.801)	(2.914)				
MMA21	Rattling	3.343	-0.013	-0.01	1.024	320	1358.7	1704	76.581
	Brook	(5.83)	(-10.768)	(-1.621)	(5.218)				
MMA22	Lewis-porte	2.859	-0.009	-0.014	0.755	350	436	1444	115.424
		(7.707)	(-5.557)	(-3.406)	(5.106)				
MMA22A	Lewis-porte	3.527	-0.013	-0.021	0.88	147	211.1	503	76.587
		(4.843)	(-5.068)	(-2.669)	(2.518)				
MMA23	Bonavista	2.644	-0.009	-0.007	1.05	310	805.6	1713	115.884
	North	(10.425)	(-4.832)	(-2.318)	(5.329)				
MMA23A	Bonavista	2.544	-0.011	-0.01	1.0[illegible]	110	188	447	90.621
	North	(1.995)	(-2.003)	(-0.936)	([illegible]3)				
MMA24	N.West	3.451	-0.012	-0.011	0.714	302	966.8	1201	85.005
	Gander	(8.958)	(-14.493)	(2.765)	(4.258)				
MMA25	Bay D'	3.174	-0.014	-0.006	1.642	343	1426.1	1486	70.532
	Espoir	(7.434)	(-9.866)	(-1.143)	(3.794)				
MMA26	Jubilee	1.784	-0.014	0.008	N/A	142	477.2	350	70.776
	Lake	(5.916)	(-7.596)	(1.825)					

MMA	AREA	Intercept	Travel Cost Parameter	Income Parameter	Alpha	N	LR Stats	Total Trips	Consumer Surplus
MMA27	Terra	1.987	-0.019	0.001	1.308	193	555.1	581	52.809
	Nova	(2.514)	(-9.848)	(0.956)	(2.473)				
MMA28	Black	2.34	-0.01	-0.005	1.115	342	629.4	1434	101.479
	River	(7.72)	(-7.141)	(-1.436)	(4.889)				
MMA29	Bonavista	2.893	-0.013	-0.011	1.913	391	1181.5	1851	79.962
	Pen.	(5.923)	(-7.035)	(-1.682)	(3.781)				
MMA30	Burin Pe.	1.877	-0.006	0.003	N/A	98	35.74	560	165.959
	Knee.	(5.762)	(-4.986)	(0.892)					
MMA31	Placentia	1.56	-0.004	0.001	0.896	156	320.5	816	222.514
		(2.677)	(-1.295)	(0.144)	(4.383)				
MMA32	Cape	2.22	-0.014	0	0.582	221	339.9	760	72.59
	Shore	(5.685)	(-7.002)	(0.031)	(4.14)				
MMA33	Salmonier	3.304	-0.002	-0.016	1.211	191	584.7	1231	492.393
		(5.005)	(-0.324)	(-1.795)	(4.248)				
MMA34	Bay de	2.453	-0.008	-0.012	0.926	261	314.1	1061	127.574
	Verde	(3.785)	(-2.128)	(-1.497)	(4.349)				
MMA35	St. John's	3.974	-0.01	-0.018	1.2636	167	544.7	1168	97.409
		(2.751)	(-1.623)	(-1.485)	(3.755)				
MMA36	Southern	2.139	-0.009	0	1.451	630	1722	3653	107.358
	Shore	(5.736)	(-5.32)	(0.162)	(6.468)				
MMA37	Grey	4.493	-0.01	-0.03	0.526	169	433.6	414	105.188
	River E.	(3.855)	(-9.071)	(-1.908)	(2.28)				
MMA38	Burin Pe.	1.97	0.01	-0.012	N/A	51	13.66	206	-104.864
	Foot	(3.159)	(3.411)	(-1.581)					
MMA39	Cloud	0.236	-0.008	0.019	0.783	107	237.1	421	122.85
	River	(0.26)	(-2.752)	(2.182)	(2.851)				
MMA39A	Cloud	2.808	-0.009	-0.019	N/A	79	28.18	174	109.083
	River	(1.573)	(-1.544)	(-0.987)					
MMA40	Conche	0.731	-0.014	0.014	1.355	256	606.9	930	71.736
		(1.338)	(-10.406)	(2.489)	(3.396)				
MMA41	Sheffield	1.035	-0.01	0.012	0.678	260	514.8	1064	97.201
	Lake	(1.917)	(-8.461)	(1.989)	(4.71)				
MMA42	Gambo	2.445	-0.014	0.002	0.732	158	538.3	637	72.453
		-4.664	(-9.619)	(0.275)	(2.951)				

MMA	AREA	Intercept	Travel Cost Parameter	Income Parameter	Alpha	N	LR Stats	Total Trips	Consumer Surplus
MMA43	Port Au	-3.071	0.018	0.052	N/A	12	13.68	55	-56.098
	Port	(-1.055)	(0.73)	(2.004)					
MMA44	Bellevue	2.35	-0.007	-0.01	N/A	29	14.49	99	146.908
		(1.751)	(-1.751)	(-0.572)					
MMA45	Ten Mile	2.594	-0.005	-0.004	0.53	83	196.9	584	187.751
	Lake	(3.667)	(-4.628)	(-0.545)	(3.129)				
MMA47	Random	1.819	-0.013	-0.002		44	36.91	111	74.289
	Island	(1.431)	(-3.779)	(-0.169)					
Average*									109.866

<u>Notes</u>: T-Statistics are in parentheses
Alpha is the overdispersion parameter
N is the total number who hunted in each MMA
LR is the Loglikelihood Ratio
Average* is Average Consumers Surplus Per Trip