MODELLING REGIONAL RECREATIONAL TRAVEL BEHAVIOUR IN NEWFOUNDLAND

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by

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ABSTRACT

The purpose of this study was to develop a predictive model of annual travel behaviour of moose hunters for the island of Newfoundland which could be used to investigate appropriate road access systems for this recreational activity. Roads originally constructed for natural resource development have opened up the wildland interiors of the island of Newfoundland for recreational users. Road maintenance programs continue to be carried out for the resource developers needs. Agencies responsible for recreational activities are interested in the effect which the existing quality and quantity of road conditions have on recreational travel behaviour. This thesis presents a study of regional moose hunter travel as a major representative group of this type of trip purpose.

The study showed that this travel can be modelled with conventional trip generation and trip distribution techniques. Regional travel was significantly influenced by distance between home and the recreational area. A trip choice model showed that travellers were most attracted to areas where there was a better main access by highway combined with sufficient resource access roads deteriorated to a class suitable for all-terrain vehicles. Some evidence was found that the character of the trip purpose and trip maker was changing from a subsistence activity for local, rural hunters to a sport-oriented activity for urban hunters who were more interested in a recreational experience than a successful hunt. Applications for these predictive models and implications for management of these road systems are discussed.

ACKNOWLEDGEMENTS

I would like to express sincere gratitude to Mr. Mervin Andrews (thesis supervisor) for his encouragement and guidance throughout my years of study.

I thank my wife Catherine and daughters Sarah and Jessica for their sacrifices, patience and support.

This work is dedicated to my mother Edna Flannigan.

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CHAPTER 1

INTRODUCTION

The Trans Canada Highway (T.C.H.) was completed in 1966. It was the first highway across the province of Newfoundland and it was constructed within the transportation corridor originally defined by the railway route (Figure 1). This highway connected existing roads into a system of province-wide access by automobiles. Resource developers, thereafter, undertook ambitious programs of resource road construction from points where the existing roads left off. Today the total system reaches every major area of the province (Figure 1).

Regular maintenance is being carried out on the provincial highway system by a systematic annual program. In contrast to this approach, resource access roads are maintained by resource developers on a need basis. With the introduction of wide spread funding for agricultural and forest improvement initiatives in the nineteen seventies, the original builders and new commercial users rehabilitated many abandoned resource roads and created new ones to access wildlands for new development opportunities. Very little consideration, however, has been given to road maintenance for residual users such as recreationists.

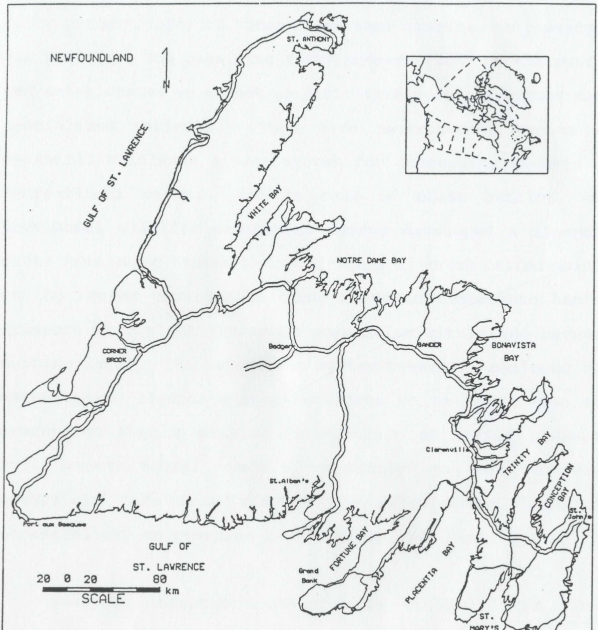

Figure 1. The Island of Newfoundland showing the Major Highway System.

The provincial resource access road system in 1988 consisted of approximately 10,000 kilometres. At that time, fifty percent (50%) of these roads were passable to passenger car traffic. The remaining fifty percent (50%) of the system was deteriorated so as not to facilitate passage without more specialized vehicles. They have nevertheless become an essential wildlands access system for increasing numbers of recreational users. In the case of moose hunting, the provincial wildlife management agency developed a licence-quota management system in 1973 (Figure 2) which relied mainly on the access provided by these roads to distribute hunter pressure throughout the moose population within and between hunting zones. The management system presently employed for establishing licence quotas continues to be based upon the assumption that a similar distribution of hunter pressure still exists today. Such a supposition may not, however, adequately take into account the deteriorated level of accessibility on resource road systems over time.

Several important consequences follow from this assumption. Firstly, resource road deterioration combined with insufficient maintenance over time may be giving rise to <u>unsatisfactory hunter distribution</u> between and within certain moose management zones. These conditions may contribute to excessive hunter pressure on some segments of a moose population resulting in unfavourable loss of animals and

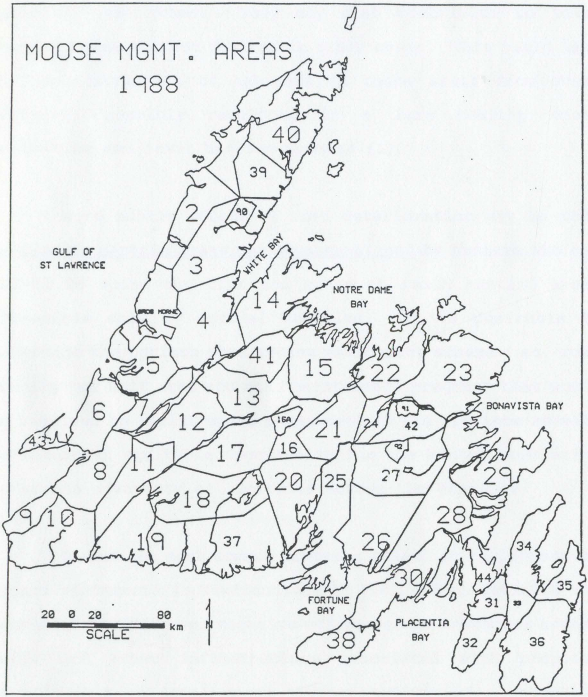

Figure 2. The 1988 Moose Management Areas for the Island of Newfoundland.

possibly lower hunting success or lower quotas in successive years in some zones. They may also contribute to lower hunting pressure than desired in other areas. This could lead to the destruction of habitats in those areas from over-browsing, possibly resulting in a less healthy moose population and lower hunting success (1).

A more subtle effect of road deterioration may be that <u>hunting in certain areas can be monopolized</u> by hunters who can afford to spend the time and money to reach hunting areas accessible only by special vehicles. It is desirable to determine the optimum road system management scheme (eg. road density per unit area and road maintenance program) that would be required to assist moose management in the province as well as insure an equitable opportunity for the hunter population to access a variety of locations across the province.

One of the most common concerns raised in environmental impact statements in Newfoundland is the need to estimate the potential positive and negative effects of new resource access roads and other infrastructure associated with proposed developments on local moose hunting activities. Potential effects could include loss or increase of employment for outfitters and other businesses. There is also a need to predict the potential effects of closing the same road systems to hunter access during and/or after operations. This control of public access may have potential as a management tool to actively manipulate hunter pressure in remote areas (2).

The three scenarios described in the previous paragraphs are current issues for resource road managers. The condition and number of resource roads has an important role in the choice of a particular hunting zone or in the movement of hunters around a zone. Under these conditions, the resource road infrastructure may affect both hunting distribution 'within' and 'between' moose management zones. The study was limited by the available resources. Therefore, it focused only on assessing the influence of the resource road system on annual moose hunter distribution <u>between</u> moose management zones on the island of Newfoundland. The 'between' (interzonal) effects could be studied with limited field observations and with the use of data generated on an annual basis by the provincial authorities.

The unique advantage of using the routine data from the "moose hunter quota system"[1] is that it makes it possible to provide an economical annual database which has continuous historical records on moose hunter behaviour as far back as 1973. According to provincial wildlife regulations, hunting must be conducted only by hunters who have received a licence

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[1] moose hunter quota system: regulatory system for allocation of hunter licences by assigning quotas for each hunting area and awarding licences by a computerized draw.

in a given year for a particular moose management zone. This regulated characteristic of moose hunting activity are very different than the rambling and uncertain behaviour of other recreational trip-makers. The fact that the hunter sets out along a predetermined route to a previously defined destination is similar to a typical home-to-work trip, therefore, this recreational activity may be conducive to conventional predictive modelling techniques. Consequently, this study was directed toward examination of this type of travel demand.

Transportation demand forecasting techniques used in conventional traffic studies were employed in this investigation. It was hoped that models could be developed to predict changes in annual hunter trip distribution. These models could account for the effect of resource road conditions on hunter trip distribution. With this predictive tool, the effects of various road conditions on changes in hunter distribution may be assessed. With the subsequent development of associated socio-economic and biological models more informed decisions might be made concerning resource access road maintenance and management in the Province of Newfoundland.

The main purpose of this study was to develop a predictive model of annual travel behaviour of moose hunters for the island of Newfoundland which could be used to evaluate the existing road access systems for this recreational activity. The importance of resource access road conditions as a factor affecting trip destination choice would be assessed. This information could materially support decisions on management of resource access road systems to sustain and enhance this recreational activity in the Province of Newfoundland.

CHAPTER 2

LITERATURE REVIEW

A review of literature was extended to the general topic of regional recreational travel demand as very limited information on hunter's travel behaviour would be found in published form. The review also concerned the subject of the influence of resource access roads or similar types on travel behaviour.

There was a lack of information on studies related to resource access roads in the literature. Therefore, letters were written to wildlife agencies in the other provinces requesting any known relevant information. Respondents could not offer knowledge of studies to model regional recreational travel demand. They did, however, offer citations for studies which related to policy on public use and also road design criteria for resource access roads or rural gravel road highways (2) (3) (4) (5).

The scope of the review was broadened from the original hunting context by considering modelling techniques for any regional scale recreational travel. This provided extensive literature for use in this study.

2.1 Regional Rural Travel Demand

Sullivan, Layton and Kanafani (6) described recreational travel models which were developed by them and others at the Institute for Transportation and Traffic Engineering, University of California, Berkeley. These models were used with others to estimate travel to and within the National Forests of the State of California, U.S.A. The estimation of this recreational traffic was approached by them as a two-stage problem answering two questions:

(1) how many visitors will be attracted to the forest from surrounding centres of population

(2) how will the visitors, upon arrival, distribute within the forest area.

Mathematical models were developed to answer these questions separately. A third model was used a quantitative variable to express the inherent attractiveness or drawing power of each National Forest which provided inputs to the other models. These models are described under the headings of 'Macro-Allocation ', 'Micro-Allocation', and 'Attraction' models.

2.1.1 Macro-Allocation Models

The purpose of these models were to estimate recreational traffic to one of the eighteen national forests from fifty eight population centres in the state. A trip generation model was developed to estimate the aggregate demand through a regression equation using population centre demographics for independent variables (7).

The trip distribution model was developed by Gyamfi (8). The model was based on the principles of systems analysis similar to methods used for a similar purpose in Ontario by Ellis (9). In this model the recreational travel system was broken down into origin components, destination components, and travel link components. They were modelled separately and aggregated for the required estimation. The model components had the following general equations specific to the State of California:

Origin components equations

$Y_i = (138.6\ P_i^{\ 0.385Di})^{\ 0.025}$ (for day trips)

$Y_i = (\ 88.3\ P_i^{\ 0.382Di})^{\ 0.137}$ (for overnight trips)

where

Y_i = total recreational demand at $_i$

P_i = population of origin zone$_i$

D_i = accessibility of origin zone$_i$ to all national forests in California, and

$D_i = A_j\ d_{ij}\ \exp\ y_i$

where

y_i = -1.90 for day trips

y_i = -1.50 for overnight trips

A_j = attraction index of the $forest_j$ and

d_{ij}= travel time from $zone_i$ to $forest_j$

Transport link components equations

$$Y_{1i} = K_1 \frac{1}{(R_{1i})} K_2 \Delta X_{1i}$$

Y_{1i} = link flow through $link_{ij}$

X_{1i} = propensity to travel across $link_{ij}$

R_{1i} = link resistance of $link_{ij}$

K_{12} K_{21}, = calibration constants.

Destination components equation

$$Y_{di} = K_3 A_{di} + (X_{di})$$

where

Y_{di} = attracted trips to $destination_{ij}$

X_{di} = potential for recreational trip attraction;

K_3 = attraction calibration constant

A_{di} = attraction index of $forest_i$

Comparison between model results and observed data showed an error of twenty six percent or less. Largest errors were associated with the low-attraction forests. The authors proposed that the prediction would improve with improved estimation of attraction indices.

2.1.2 Micro-Allocation Models

The micro-allocation models estimated the volumes of trips attracted to individual recreation areas within the forests and their distribution on the road networks within the forests (10). These trip generation models involved the use of traffic volume estimates to the forest entrances from the macro-allocation model. These input volumes were divided into various type categories and trip rates were applied to disaggregated generation estimates. Trip distribution within the forest was performed by one of the following three models: impendence-dependent opportunity (11), simple proportional (12) and the touring travel models (13).

2.1.3 Attraction Model

The third model used by these researchers was very similar to the model earlier developed by Ellis in 1969 (10). It employed the use of factor analysis to develop representative factors for a large assortment of variables which would describe various features of the individual national forest areas. The result of the model run was one measure of inherent attractiveness which could be used as a variable for both the above macro or micro-allocation modelling procedures. It is important to note that both the macro-distribution models of Gyamfi (8) and of Kanafani and Okyere (14) depend on the attraction index as a main variable in the equations.

Kanafani and Okyere (14) developed a model which described and predicted patterns of regional recreational travel in a large region without extensive travel survey information. This was contrasted to the model developed earlier by De Kalb and Sullivan (7) which required information from a special roadside survey. Both studies, however, were based on a similar hypothesis that the amount of recreational travel a recreation area attracts is affected by the accessibility of the area to potential origins and by its attractiveness relative to other recreational areas.

These researchers used actual routine data on recreational demand which was collected at each entrance to each national forest in California, U.S.A. They derived the following equations:

$$A_j = \text{sum } P_i{}^{-0.44t}{}_{ij}$$

$$T_j = 1.1393\ A_j{}^{0.93259}$$

where

T_j = the total number of recreation trips attracted to forest$_j$

A_j = the accessibility of forest$_j$ to areas of trip potential

P_i = the population of county$_i$

t_{ij}= the travel time between county$_i$ and forest$_j$.

The variables of accessibility and attractiveness were derived values from information found in 'National Recreation Survey' carried out in 1962 for the U.S. outdoor Recreation Resources Review Commission (15). They found that the attractiveness of the destination forest was not as important an explanatory variable of recreational trips to forests as the accessibility of the destination and the per capita income of populations at the points of origin. In the final analysis, accessibility alone was chosen because of the advantage of simplicity. The coefficient of determination was calculated as a test. The model explained 57% of the total variations in T_{ij}. This was considered adequate for the researchers.

Deacon, Pigman, Kaltenbach, and Dean (16) compared several trip generation and trip distribution techniques to estimate outdoor recreational travel from population centres throughout the United States to outdoor recreational areas in the State of Kentucky. Trip generation models were developed for the gravity and intervening opportunities model by the means of regression equations. Trip distribution models were developed and compared using the single equation, cross classification, gravity and intervening opportunities modelling techniques. Similarly to the macro-allocation models presented in previous studies, these models relied heavily on the delineation of reliable attraction and accessibility indices for the recreational destinations. Statistical tests showed that the cross classification model was the most accurate in predictions of trip distribution. The disadvantage in this technique was that the success of the model depended entirely on the identification of the important independent variables to the travel behaviour. One of these variables was the attractiveness index which requires a great deal of knowledge of the destination resources. The gravity model performed very well by distributing the travel according to distance between origins and destinations. The researchers noted that difficulties developed at the trip generation phase since suitable variables to predict trip productions and attractions were difficult to find. The intervening opportunities model performed less accurately than the gravity model for the same reasons. The single equation technique was the least favourable. It did not predict travel behaviour in an acceptable manner.

A recent application of modelling techniques to a regional transportation problem in Newfoundland is found in the work of Pilgrim (17). He studied regional intercity bus passenger travel demand by using ticket records and published national census data. By using ridership catchment areas to develop traffic zone boundaries, he showed that conventional methods for urban interzonal traffic estimation could be employed successfully to forecast regional interzonal travel demands. His final equations for the regional model included the following:

$$Tp = 49 + 0.20782\ DWEL.$$

$$Ta = 33 + 0.21680\ DWEL.$$

where

Tp = trips produced by a zone

Ta = trips attached by a zone

DWEL = number of dwelling units in a zone.

Statistical analysis on the predictive power of the above equations yielded a simple correlation coefficient for each equation greater than 0.9. The trip distribution model did not predict future trip interchanges satisfactorily. The author proposed that this may have been due to changes in the ridership patronage over time.

Pilgrim's work described the travel of a 'captive' ridership whose patronage was not stable over time. This may indicate that the current socio-economic status of the Newfoundland public may be such that it will select for best level of service among available travel mode options. This selectivity may extend to trip distribution of recreational travel and may indicate difficulty for representation by a trip distribution function.

2.2 Resource Access Roads

The second focus of the literature search was to obtain information on cases where resource access roads have been evaluated for their influence on travel behaviour. It became evident that a proper classification was necessary for these roads in order to complete this study.

Resource access roads in Newfoundland (or in Canada) are built according to standards established by the provincial authority (18). In the literature they are considered as a category of low-volume roads. The latter is characterized by an average daily traffic (A.D.T.) of 200 vehicles or less. Bews, Smith, and Tencha (19) developed a classification scheme for low volume roads in Canada which included the following three categories:

(1) "rural roads and roads to or within isolated communities provide access to farms, residences, and businesses or other abutting properties; traffic consists of light and medium vehicles with occasional heavy trucks"

(2) "recreational roads provide access to and within all types of recreational areas; traffic generally consists of cars, trailers, camper-truck units, and maintenance vehicles; recreational roads are further subdivided into primary roads, perimeter roads, and internal roads which essentially reflect differences in expected operating speeds; this category is similar to the classification

for the recreational roads of both Parks Canada and the American Society of State Highway and Traffic Officials"

(3) "resource development roads include all resource-related roads such as forest roads, mining roads, and roads required for energy development; traffic on these types of roads is predominantly large, heavily loaded trucks."

This classification scheme was compared to other schemes applied in other countries (20). In this review, resource access roads will be considered as low-volume roads since they are built largely as resource development roads and deteriorate to recreational road standards of varying quality over their lifetime.

Bews et al. (19) estimated that there were over 800,000 km of roads in Canada in 1987 and that approximately 490,000 km or 60 percent of these roads were rural local roads with earth or gravel surfaces. The literature on low volume roads is sparse as low priority is given to them in spite of their abundance. Studies showed an emphasis on development strategies for cost efficient expenditures for road construction and maintenance (21). To a lesser extent there were proposals for policies on public use (5), recommendations on standards and improvements of design (19), and on traffic census methodologies (22).

An important advancement in the publication of material on transportation planning and engineering of low-volume roads was noted by the availability of proceedings for international conferences on low-volume roads for 1975, 1979, 1983 and 1987 through the primary sponsorship of the Transportation Research Board of the National Research Council. The proceedings from these conferences were a valuable source to this literature search. These investigations and the work by the I.T.T.E. at Berkeley on attraction models described earlier in this chapter would be considered in the experimental design for this study.

CHAPTER 3

RESEARCH DESIGN AND DATA COLLECTION

3.1 Objectives

The main purpose of this study was to develop a predictive model of annual travel behaviour of moose hunters for the island of Newfoundland which could be used to investigate appropriate road access systems for this recreational activity. It was required that the model(s) predict travel origins, and associated traffic volumes between the forty-seven moose management areas which comprise the entire land mass of the island of Newfoundland. This capability could be useful for wildlife management officials to better integrate recreational hunting opportunities with limitations to hunter's travel demand such as type of vehicle, distance to travel from home, etc. An example of a hypothetical application is the use of these models as predictive tools of the change in the number and origin of hunters resulting when road access has deteriorated to a point where some trip-maker vehicles were no longer suitable for that new range of conditions. These models may also indicate to planners the value of the current policy in which any hunter can make an application to any area of the province by an examination of such factors as the effect of distance from home on trip choice. This has not been previously attempted in the province and there is no evidence of studies concerning this matter in other areas of Canada. Any tools developed here could be adapted for use in another province with adjustments for variation in moose management strategies, hunting area accessibility, cultural attitudes toward hunting, etc..

The following objectives were set for the study:

(1) to model the annual travel behaviour of moose hunters

(2) to assess the relative influence of resource access roads on this travel behaviour.

3.2 Conceptual Model

It was evident from the literature especially Deacon et al. (16) and Gymafi (8) on regional travel distribution that any effort to model travel behaviour would need to account for the accessibility and attractiveness of recreational areas to the recreational tripmaker. Gyamfi (8), Ellis (9) and Kanafani and Okyere (14) used on a national recreational survey and/or a roadside survey to identify important variables for their recreational traffic studies. Similarly, it was decided that this study would also require a preliminary survey to identify important influences to hunters trip choices in Newfoundland. In turn the results of the preliminary survey were used to establish study methods for the achievement of the stated objectives.

In the study hunters were asked to evaluate the relative importance of six major factors in the process of their selection of a hunting area. Cumulative totals were computed based on 6 for the highest and 1 for the lowest rating. The factors were distance from hunter's home (Factor A), suitability of access roads in a zone (Factor B), hunter's familiarity with the zone (Factor C), number of moose in the zone (Factor D), abundance of access roads in a zone (Factor E) and a factor for miscellaneous other considerations (Factor F). The survey results are illustrated by Figure 3. This chart shows the average level of importance given to these factors by the population of respondents for the base year 1988. The plotted values are derived from the median values of ratings given to the six factors for their order of importance. The most important factor was Factor C (area was well known to the hunter). This is followed closely by the influence of distance from home to the hunting area (Factor A). More moose in the hunting area (Factor D) was next in importance and was at a level slightly higher than the influence of resource roads suitable for the hunter's vehicle (Factor B). Lastly, the need for more roads (Factor E) was only higher in importance than the miscellaneous factor (Factor F). These levels of importance for factors remained the same over time as evidenced by the responses of hunters when asked for their reasons for annual choices back to 1980.

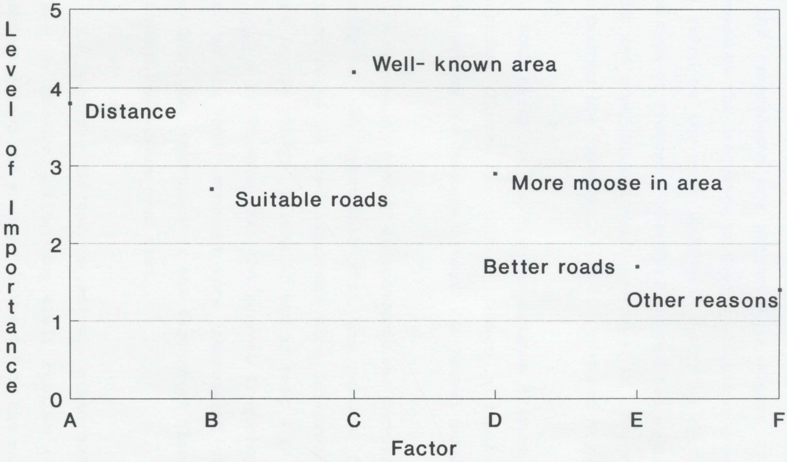

Figure 3. The Level of Importance for Hunt Area Choice Factors in 1988.

The most important factors affecting destination choice of the respondents are presented in Figure 4. The chart represents the frequency of factor selection when that factor was rated as the most important factor by the respondents. This type of frequency chart was created for each of the eight years and superimposed over each other to show any variance. The factors are labelled as in the previous figure.

Both plots for relative importance (Figure 3) and most important (Figure 4) factors showed a similar frequency distribution for hunters reasons for travel behaviour.

A chi-square test of independence was carried out for the testing of the hypothesis that the percent frequency of factors rated as most important were independent from the years in the study. Values of the X^2 test 6.24 and tabular $X^2_{0.05;40}$ = 26.51 show that the percent frequency of factors rated as the most important were independent of the years. Therefore, the importance of the factors of first choice can be considered stable over time.

The possible differences between urban and rural trip makers in factors influencing their choices could not be ascertained from the survey results due to the relatively low response from urban hunters in the survey. In addition, low

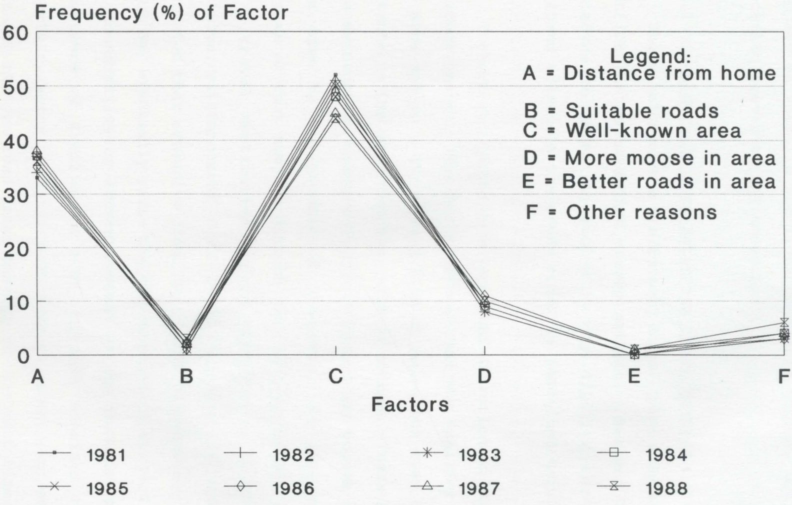

Figure 4. The Frequency of Factors when Rated as the Most Important Factor of Choice Among the Six Factors from 1981 to 1988.

response on specific questions regarding income, age, sex or education prevented any assessment.

3.2.1 Considerations to Establish Study Methods

The results of the preliminary survey gave only a partial contribution to establish survey methods. Besides this the procedure to establish quotas by the Wildlife Service has profound effect on the study which is described here.

The survey results gave important direction to the choice of study design. The survey showed that the familiarity with the area may be a stronger factor of selection even than the distance to the area from the point of origin. There has been some evidence to suggest that this factor may become stronger over time by the process of fidelity. In his review of studies on that subject Davison (23) concluded that fidelity to a travel destination became stronger as a result of positive reinforcement from past trips to an area. He indicated that exclusive fidelity to a destination may develop which may eventually cause the trip-maker to disregard changes in accessibility or attractiveness of the destination. The importance of familiarity with the area remained the most important factor in this study over an eight year period in spite of obvious road deterioration during that time (Figure 4). These observations may have an important influence on the ability of models to predict values for a horizon year. These possibilities will be considered in the following paragraphs.

Many variables could normally be considered to influence total traffic flows as demonstrated by the work of Deacon et al. (16). Some of these variables may be found in the characteristics of a destination - land use variables, and are found in models of total traffic flow to destinations. The present study dealt with a travel environment where the total traffic flow destined to each MMA was limited to the number of moose hunting licenses issued in a given year. This figure was determined from consideration of biological parameters of the local moose population. This presented a constraint to model design since the predictions for actual trips attracted to a zone was not influenced by the trip-maker demand. It was concluded that inputs on number of trips attracted for the purposes of a trip distribution model would have to be derived from exogenous sources.

The influence of access roads as a variable of attractiveness to trip-maker choice should be determined by development of a predictive model where the dependent variable would be <u>number of applicants applying to a zone</u> and independent variables would be measurements of the road system in each zone. The purpose of this model would solely be to assess the influence of access road conditions and abundance on hunters trip choice and would have no value in the prediction of actual total flow to a destination zone.

Models of total traffic flow from origins could be developed by using variables of trip maker characteristics or population demographic at the origin. The provincial licence-quota system was designed to issue the maximum number of licences which could benefit the sustained health of the moose population. The system did not regulate licence quota allocations by origin of residential hunters. The distribution of hunter licences resulted from a computerized random draw from the annual database of licence applicants. It was evident, therefore, that the total trip flow from an area could be modelled by establishment of a relationship between trips produced in the origin and some independent variable such as trip-maker or zone characteristics.

The results of the preliminary survey indicated sufficient influence of an accessibility factor (distance from home) to support the development of a travel impedance function as a trip distribution model. The continuing importance of this factor over an eight year period for the respondents (Figure 4) indicated the likely stability of this factor over time. To develop a model of this kind it was necessary to decide on whether to express the units of the travel impedance function in terms of cost, time or distance.

Regional recreational studies have regularly used cost and/or distance values. When considering the cost variable for this study, it was reasoned that there was a poor response to the hunter questionnaire regarding income and there has been characteristic difficulty in assessment of travel costs from indirect sources where cooperation cannot be assured from the trip maker.

The variable of distance could be estimated without the help of the traveller in the present study since the route options were limited. The distance was found by some researchers (7), (14) and (15) to represent very well the accessibility of an area to a trip-maker. However, it was an unsatisfactory indicator of the attractiveness of a destination.

The time variable has not traditionally been selected for recreational travel studies since it has not been considered as an important consideration to this trip-maker type. Time, as an impedance variable, may be a better representation of accessibility for the present case. Since there were various classes of roads encountered travelling to a hunting destination, hunters must be prepared to reduce speed and/or change to an ATV mode of travel. This reduction of speed alone would increase the travel time between points compared to the travel time for a constant speed implied by using the measured distance only. One severe disadvantage to the use of the time variable is the difficulty in determination of average travel speeds for each vehicle type on each category of road conditions. In this case, the resource road system would have to be classified and measured to allow the travel times to be estimated. This would be difficult to achieve with the limited road inventory methodology available for this study.

In summary, the salient results of this survey and considerations concerning the present policies of establishing quotas are presented below which formed a conceptual model for the study:

1. A model of traffic flow from each origin should be represented by a trip production equation.
2. A model of traffic flow to each destination could not be represented by a trip attraction equation because the determining factors for the trips attracted to an area set by quotas based on biological considerations, and therefore unrelated to land use variables such as resource roads systems.
3. The trip distribution model should be represented by a travel impedance function using travel time as the constraining variable. The time variable would likely give superior performance if travel speeds assigned to

and distance measurements for the various classes of road conditions between origins and destinations were sufficiently accurate to enable useable total interzonal travel times to be calculated in the present study. The influence of familiarity with the area and fidelity over time on the performance of the model(s) should need to be assessed.

4. The influence of resource roads on the actual trips attracted to a hunting area has been discussed in 2. above. Their influence as an <u>interzonal accessibility factor</u> can be assessed through the weighting of various road classes according to condition or through use of a travel time variable in the impedance function as discussed in 3. above. Either of these options would be useful to assess the influence which access roads may have on travel impedance between zone centroids.

5. The influence of resource access roads as an <u>attraction factor</u> of an MMA to the tripmaker could be examined by considering the influence of their conditions and quantity on the number of applicants choice of the MMA. A trip choice equation using regression analysis could be used to show these relationships.

3.3 Methods

Information on moose hunters has been collected in Newfoundland by the Wildlife Division for the last two decades. Records have been stored from two sources; 1) information received from completed moose licence applications and 2) a questionnaire portion of the moose hunters' licence which has been required to be returned at the end of the hunting season. This exercise has largely been geared to the need to gather information necessary to award licences in a fair manner, to allow the identification of hunters in the field by enforcement officers and to provide necessary information to support the operation of the licence-quota system. Since the introduction of the "quota" system in 1973, the hunter has been asked to provide information on kill location, kill effort and moose abundance; however, very little emphasis has been placed on moose hunter travel behaviour itself.

The information collected by this agency formed the key source for vital data to this study. The 1988 hunting season was chosen as the base year for the development of a prediction model. This year was selected since most data for independent variables which were included in the more recent application and return files of the Wildlife Division. Another reason for the selection was to allow both a hunter survey and a resource road census to be conducted to gather information on reasons for choices from the hunters directly.

3.3.1 <u>Origin and Destination Trip Information Requirements</u>

The trips which are considered in this study refer to the annual individual journeys made by hunters or hunting parties from home to the moose management area for which the hunters have received a moose hunting licence. An applicant for an individual or party licence can make up to ten choices of preferred areas to hunt either moose or caribou. The choices are ranked in order of preference and the hunter receives a licence based on his priority in the pool of total eligible applicants for that moose management area. The annual proportion of first choice licences awarded in 1988 was sixty eight percent (68%). This figure was considered lower than other years as a result of a high demand for licences in that year. The number of first choice licences sold each year has increased largely due to large increases in the annual moose licence quota. Nevertheless, hunters take a keen interest to gather reliable information on more than one area in order to make choices which are suitable to vehicle options, at reasonable distances from home, in areas well known, and where accessibility and numbers of moose are acceptable.

The 1988 application and hunter return information was used to provide the origins and destinations of hunters. The latter could be used directly as each MMA has a unique two digit identification number. The origins were developed from the postal code information in the hunter home addresses. The postal code of an individual was associated with the number for the MMA in which the trip-maker resided as closely as possible.

The number of moose management areas on the island change from year to year. To allow a prediction in a horizon year to be attempted, the moose management areas were aggregated into geographic groups which would be comparable over time. Therefore, origin - destination matrices for the trips of the 29,413 hunters sharing 15,460 licences in insular Newfoundland in 1988 were aggregated into 38 traffic zones.

The terms traffic zone will be used to represent a moose management area or aggregate of moose management areas and trip-maker for moose hunter in this text.

3.3.2 Social and Land Use Information Requirements

The data requirements to develop the trip generation model were next considered. The final product of any trip generation model using regression techniques should be a number of trip production and attraction equations to describe the trip ends or total traffic flow at traffic zones. The independent variables chosen for these equations form the critical foundation of the model(s) since the projected values for their growth to the horizon year directly affect the forecasted quantities of trip ends. McLoughlin (30) stated that the total demand for general outdoor recreation was a function of any of an array of variables including age, income, education, car ownership, and supply. He also put forward the concept of a variable called ease of enjoyment which was a function of topography, climate and accessibility.

The importance and hence the selection of any of these factors will vary by the kind of recreational trip. For example, Sullivan (10) emphasized the need to distinguish between day users and overnight campers in his studies of recreational trips to, and, within National Forests in California. Kanafani and Okyere (14) found that population of origin rather than income was more important a predictor of recreational trips generated to the National Forests of California.

By examining the moose hunter trip more closely we could determine some independent variables with a reasonable cause and effect relationship to the dependent variable - hunter trips. Newfoundland moose hunters were considered to be split between those who needed the food (subsistence food gatherers) and those who were sport hunters. Subsistence hunters were commonly taken to be rural inhabitants who hunted in a restricted area from a boat, all-terrain vehicle and two wheel drive pick-up truck. They were usually blue collar workers, largely consisting of seasonally employed fishermen in the lower income classes. The sport hunter was normally depicted as a blue or white collar worker from a larger community,town, or city. These people were not considered to restrict themselves to local hunting areas. Their mode of travel was considered to be more restricted, however, than that of the non-resident hunters who often hire guides and aircraft for their activities. Sport hunters preferred to travel to areas far from the point of origin. With these foregoing impressions on the characteristics of the moose hunting population, the available databases were examined for data useful for this study.

3.3.3 Model Building

A list of candidate variables is presented in Table 1. A selection was made with consideration of McLoughlin's (24) recommendations, availability of data and relevance to this particular recreational activity based on the author's understanding of the subject. It was felt that efforts to aggregate data from Statistics Canada and others sources would be inadvisable due to incompatibility with the main database or unknown sources of sampling error. Another important limiting factor to the use of data was that the moose management area boundaries were determined from biological

Table 1. Candidate Variables for Regression Analysis to Develop the Trip Generation Model.

No.	Variable	Source	Years	Potential Use	Form
1.	registered hunters	Wildlife	1988	trip prod. equation	number
2.	human population	Stats Canada	1986	trip prod. equation.	number
3.	moose population	Wildlife	1988	trip choice eqn.	number
4.	applicants	Wildlife	1988	trip choice eqn.	number
5.	hunting success	Wildlife	1987	trip choice eqn.	percent
6.	moose seen per day	Wildlife	1988	trip choice eqn.	mean
7.	mean days hunted	Wildlife	1988	trip choice eqn.	mean
8.	harvest effort	Wildlife	1988	trip choice eqn.	number

Variable 1 refers to the number of registered hunters in a traffic zone. Variable 2 refers to the number of humans living within 50 kilometres of a traffic zone. Variable 3 refers to the average number of moose per square kilometre of forested area within a traffic zone. Variable 4 refers to the number of applicants for a permit to carry out a hunting trip to a traffic zone. Variable 5 refers to estimated percent of licensed hunters to the traffic zone who will be successful. Variable 6 refers to the number of moose seen per day by a hunter expressed as a zonal mean number for all hunters to a traffic zone. Variable 7 refers to the days hunted expressed as a zonal mean for all successful hunters to a traffic zone. Variable 8 refers to the harvest effort expressed as total days hunted/total moose kills in a traffic zone.

Parameters which had little relevance to parameters used to aggregate land use data. Therefore, it was decided that variables such as car ownership, income and education could not be aggregated into meaningful quantities for the purpose of this study. Those sources were not pursued further.

3.3.4 Data Collection

A survey on existing land use and resource road infrastructure was carried out between 1988 and 1990 to provide data for this study. It was important that the data would be useful for the entire island and the 38 traffic zones. The survey was limited to the assessment of road conditions which were shown on the road network depicted on the 1988 moose hunter maps supplied to each licence holder. These maps are 1:250,000 Topographic Series (NTS) maps. The information was collected by the Wildlife Protection Officers who patrol the moose management areas in the province. The Officers were mailed a package which included a questionnaire, hunter maps for the appropriate MMAs and a letter of introduction. The Officers were asked to rate individual kilometres of roads in their respective management areas according to their 'passibility' to four different classes of vehicle (modes). This rating system and the questionnaire itself was tested prior to mailing and adjusted for clarification. The vehicle classes were considered to be associated with increasingly difficult passibility as illustrated in Table 2.

The information was collected and coded into quantitative variables by measuring the lengths of road sections which corresponded to one of four color codes to indicate the road classes. The road lengths for each color code were aggregated for each map block and tabulated for each traffic zone. The resulting 47 tables were input into D-BASE IV database files and aggregated into 38 traffic zones (Appendix A, Table A-1).

3.4 Trip Generation

This is the first stage of the travel demand forecasting procedure described by the U.S. Department of Transportation (25). Its purpose is to produce a forecast model for trip ends for each traffic zone within the transportation study area.

In the past and still in many cases today where demand relates very well to the progress of time, a historical trend curve will yield a satisfactory forecast. For example,this technique has application in studies in small communities or in freight movement analysis. However, where trips will vary independently of time and they relate more to other variables in a cause-effect relationship, a regression equation forms

Table 2. Road Conditions by Classes Used In Island-wide Resource Road Inventory for this Study.

ROAD CLASS	VEHICLE GROUP	ASSOCIATED CONDITION
1	all vehicles	Passable to all types
2	2 X 2 Truck 4 X 4 Truck, ATV	Passable to this group only
3	4 X 4 Truck ATV	Passable to this group only
4	ATV	Passable to this group only

Notes:

The term "2 X 2 truck" refers to a conventional pickup truck.
The term "4 X 4 truck" refers to a truck or similar vehicle with four wheel drive capability.
The term "ATV" refers to either a tracked or rubber tired all terrain vehicle.

the basis of the best model (Roads and Transportation Association of Canada, (26)).

The simple linear equation may be sufficient to model a transportation environment using one independent variable. Pilgrim (17) found that both trip production and trip attraction equations of the form $Y = A + B\ (X)$ described sufficiently the intercity bus passenger travel demand in Newfoundland where

Y = the passenger trips produced or attracted to a bus traffic zone

A = the constant

B = regression coefficient

X = dwelling units found within the traffic zone

It was considered more likely that the present problem would require a model that used a multiple regression equation. The general form of the multiple linear equation has the general form:

$$Y = a + b_1x_1 + \ldots\ldots + b_nx_n$$

where several independent variable are used in the estimation of Y. The SYSTAT software package was used to calculate the coefficients in this study.

The linear regression procedure can be used to carry out a regression analysis with a series of repetitions. At the end of each program run, the independent variable is automatically eliminated from the equation which contributes the least to the explanation of the variation in the Y values ie. having the smallest partial correlation coefficient. The resulting equation should express the optimal minimum expression of independent variables to predict the value of the dependent variable.

3.5 Trip Distribution

The second component of the travel demand forecasting procedure is trip distribution. The model so produced will describe the trip interchanges taking place between traffic zones, that is, moose management areas (MMAs) or aggregations of same. In this way the quantities of trip productions and attractions estimated in each traffic zone for a horizon year can be distributed among the other zones according to some constraining parameter usually time, cost, or distance.

The standard form of the gravity model is given as follows (U.S. Department of Transportation, 27);

$$T_{ij} = \frac{P_i \; A_j \; F_{ij} \; K_{ij}}{\sum_{j=1}^{n} (A_j \; F_{ij} \; K_{ij})}$$

where:

T_{ij} = trips produced in zone $_i$ and attracted by zone $_j$

P_i = trips produced by zone $_i$

A_j = trips attracted to zone $_j$

F_{ij} = empirically derived travel deterrence (friction) factor which expresses the average area-wide effect of spatial separation on trip interchanges between zones

K_{ij} = a specific zone to zone adjustment factor to allow for the incorporation of the effect on travel patterns of social and/or economic linkages not otherwise accounted for by the gravity model formulation.

The computation of trip interchanges from the above formula requires the following:

(1) Production of a travel time frequency distribution for all zonal pairs in the study area. This is accomplished by developing friction factors from origin (P_i) - destination (A_j) tables, commonly known as trip tables.

(2) The gravity model is calibrated by running successive iterations using revised friction factors which are suggested by the fit of the new travel time frequency distribution from 1) to the one for the base year.

Initial friction factors were set at a value of one 1 which assumes no effect on trip interchanges by the independent variable. This approach was selected rather than the use of friction factors from another community of comparable size as a first approximation to start the model iterations.

Adjustment to friction factors after the first iteration can be performed by the use of one of the following methods:

(1) application of the following formula to generate adjusted values of F:

F (adjusted) = F (used) * OD% / GM%

where

F (adjusted) = friction factor to be used in the next iteration

F (used) = friction factor used in the current run

OD% = percentage of origin-destination trips in the base year

GM% = percentage of gravity model trips from the current run

(2) by a plot of the adjusted friction factors against distance to find a "line of best fit". This plotted line could be used to select new adjusted values of F which could be used in the next iteration of the gravity model.

The second step was chosen since it allows for selection of new estimates of friction factor values from a fitted curve. This provided for more control than the first method during the iteration process and selection of friction factors that exceed the minimum adjustment criteria.

Another factor which may have some importance in the development of the gravity model for this study was the likely presence of special land use characteristics (eg. outfitting camps) which might inordinately influence the recreational trip maker (Blunden (28)). The gravity model could accommodate this potential situation by the inclusion of special factors in the equation(s).

The calibrated gravity model was next subjected to testing for validity as a predictive tool. The 1990 values of many independent variables used in model development for the base year, 1988, were known and were input into the model trip generation equations. The other variables in those equations were estimated. The resulting trip tables were inputted into the model trip distribution equation. The forecasted trip interchanges were compared to the actual values for the forecast year using the 'goodness of fit' chi-square test.

3.6 Summary

This study began with the definition of the problem. An extensive literature review was subsequently carried out and a statement of objectives was developed. A trip-maker survey was carried out on 1500 individuals of the hunter population to gather preliminary information. Analysis of these results assisted the determination of methodology and relevant variables to be used in the study design. A resource roads inventory survey for the entire island portion of the province was designed, conducted and compiled for the data requirements of the study. Other data was compiled from records and departmental reports of the provincial wildlife authority. Information from all sources was prepared and analyzed. Mathematical models were developed to describe the relationships between the variables. A flow chart of the approach and methods used in this study is shown in Figure 5.

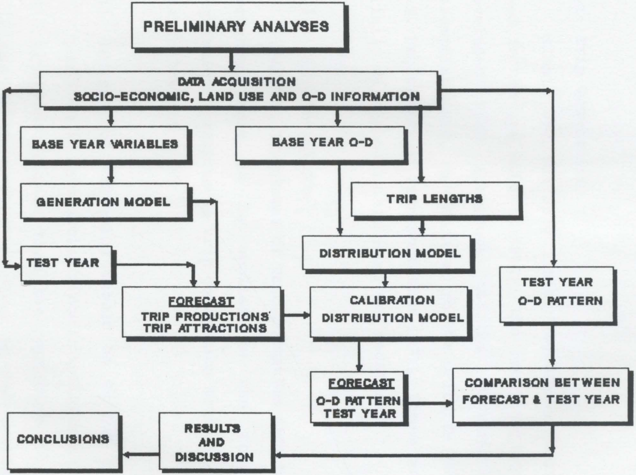

Figure 5. Flowchart For Research Methodology.

CHAPTER 4

ANALYSIS OF DATA

4.1 Trip Generation

Simple and multiple linear regression techniques were used in the analysis of data. The resulting equations were developed with adherence to the standard statistical assumptions and, in addition, to the criteria set out by the U.S. Department of Transportation (27). These parameters are briefly described in the next two sections.

4.1.1 Considerations

The U.S. Department of Transportation (27) has developed recommendations to be applied in the construction of regression equations as trip generation models. They include the following:

(1) independent variables should be as few in numbers as possible in an equation since practice has shown that the addition of more than two variables does little to improve the predictive power of the equation;

(2) independent variables should be selected which can be forecasted to a horizon year, have logical association and have some kind of causative relationship with the dependent variable;

(3) data stratification should result in sufficient observations of trip making to represent each traffic zone, zones with insufficient trip end data should be eliminated, rate data cannot be mixed with aggregate data unless the rates are aggregates themselves;

(4) traffic zones which have unique special land use characteristics may require separate treatment in analysis.

These criteria were used in this analysis and will be discussed in the appropriate parts of the chapter.

4.1.2 Statistical Assumptions of Regression Analysis

The following assumptions are mandatory for the validity of regression analysis if error terms with probability statements are calculated:

(1) the independent variable must be measured without error,

(2) for all values of the independent variable, the residuals of the dependent variable must be approximately normally distributed with a zero mean and independent of one another;

(3) the variance of the dependent variable must be equal for all values of the independent variable.

These assumptions were tested on the final candidate variables in this study.

The following information was obtained from records of the provincial wildlife authorities and were considered to be collected without error: addresses of registered hunters, addresses and licence area numbers for successful applicants, addresses and licence area choices for applicants, percent hunting success in the previous year, number of moose kill locations, human population within 50 kilometres of the MMA, moose populations, harvest effort, moose seen per day per hunter and days hunted per hunter.

Other potential independent variables to be used were complied from the resource road inventory described in Chapter 2. They include total kilometres of the following road service classes for each MMA: provincial highway, paved road, gravel road, roads passable to any type vehicle, roads passable to pickup trucks, four wheel drive vehicles and ATVs only, roads for four wheel drive vehicles and ATVs only, roads for ATVs only. Any error in measurement was considered to be evenly distributed for this survey and would not affect the effect of the independent variable on the dependent variable under study.

The first step in the analysis was to scrutinize the relationships between the dependent variable (Trips Produced) and candidate independent variables for logical association and causality. The selected variables were plotted to check for linearity with the dependent variable. Independent variables showing no linear relationship with the dependent variable were eliminated from further analysis.

The next step was to examine the independent variables for correlation with the dependent variable by developing matrices of correlation coefficients between each variable and Trips Produced (Table 3). The results showed that Registered Hunters in a traffic zone (TPRODUCE) and total kilometres of Highways in a traffic zone (HIGHWAYS) were both correlated($r = 0.947$ and $r = 0.541$ respectively) at the 0.01 level of significance to Trips Produced in a traffic zone. Unfortunately, they were collinear with one another ($r = 0.508$ significant at the 0.01 level of significance). Further testing was restricted to the Registered Hunters variable which showed the largest and most significant correlation with the dependent variable.

The above tests and criteria were repeated to select independent variables for a regression equation in which the dependent variable was number of Applicants choosing a traffic zone, labelled APPLICANTS. The purpose of this equation was to describe the degree to which resource road condition and quantity attract potential trip makers to a traffic zone per year.

Table 3. Correlation Matrix Between Trips Produced and Candidate Independent Variables.

	TPRODUCE	REGHUNT	HUMANPOP	HIGHWAYS	RDCLASS1	RDCLASS2	RDCLASS3	RDCLASS4	RDSTOTAL
TPRODUCE	1.000								
REGHUNT	0.947	1.000							
HUMANPOP	0.226	0.389	1.000						
HIGHWAYS	0.541	0.508	0.064	1.000					
RDCLASS1	0.370	0.361	-0.041	0.630	1.000				
RDCLASS2	0.165	0.242	0.201	0.249	0.645	1.000			
RDCLASS3	-0.028	0.020	-0.067	0.107	0.387	0.313	1.000		
RDCLASS4	-0.094	-0.071	0.272	0.094	0.160	0.226	0.232	1.000	
RDSTOTAL	0.231	0.284	0.231	0.547	0.812	0.574	0.516	0.584	1.000

The first step was repeated to scrutinize the relationships between the dependent variable and candidate independent variables for logical association and causality. The selected variables were plotted to check for linearity with the dependent variable. A matrix of correlation coefficients were calculated for these variables and for the dependent variable (Table 4). It comprised the dependent variable (APPLICANTS), and independent variables chosen from the resource access roads survey which reflected road condition and quantity by classes (Table 2, Chapter 3). It also included total kilometres of highways (HIGHWAYS) per zone and total kilometres of resource access roads per zone (RDSTOTAL). Other zonal variables which warranted consideration were: total number of moose licences available for the base year (LICENCES), total number of humans residing in the zone (HUMANPOP), total number of moose residing in the zone MOOSEPOP) and the percentage of a zone with forest habitat (FOREST).

The results of this analysis showed that the variables ATV and FOREST correlated significantly with APPLICANTS ($r = 0.5217$ and $r = 0.5440$ respectively) using the 0.01 level of significance. The variable LICENCES had a correlation value of $r = 0.4741$ which is significant at the 0.01 level. There was collinearity between all independent variables as

Table 4. Correlation Matrix Between the Number of Applicants Naming a Zone and Candidate Independent Variables.

	APPLICANT	HIGHWAYS	RDCLASS1	RDCLASS2	RDCLASS3	RDCLASS4	RDSTOTAL	LICENCES	MOOSEPOP	HUMANPOP	FOREST
APPLICANT	1.000										
HIGHWAYS	0.034	1.000									
RDCLASS1	0.109	0.501	1.000								
RDCLASS2	0.275	-0.027	0.285	1.000							
RDCLASS3	0.383	-0.003	0.420	0.435	1.000						
RDCLASS4	0.522	0.154	0.118	0.185	0.206	1.000					
RDSTOTAL	0.339	0.346	0.753	0.659	0.608	0.510	1.000				
LICENCES	0.474	-0.197	-0.217	-0.147	-0.070	0.408	-0.057	1.000			
MOOSEPOP	-0.266	-0.425	-0.534	-0.352	-0.281	-0.129	-0.488	0.361	1.000		
HUMANPOP	0.277	0.159	-0.001	0.086	-0.074	0.290	0.203	0.007	-0.160	1.000	
FOREST	0.544	0.216	0.383	0.461	0.410	0.115	0.425	0.044	-0.587	0.123	1.000

evident in the matrix. The correlation between LICENCES and FOREST was low (r = 0.0437) whereas between LICENCES and ATV was much larger (r = 0.4081). Since LICENCES variable least correlated with the dependent variable, it was not used in further analyses, it's inclusion would not add to the power of the prediction. Further testing was restricted to the ATV and FOREST variables which showed the largest and most significant correlations with the dependent variable.

4.1.3 Regression Equations

The regression equations were developed through the use of the multiple linear regression procedure contained in the SYSTAT software product (29). Values for Trips Produced were calculated from an origin-destination data obtained from wildlife records using a DBASE data management software package.

The Trips Produced and the selected independent variables were used as inputs to the SYSTAT regression procedure. This provided the following trip production model:

$$T_p = 108.0 + 0.26\ R$$

where

T_p = hunting trips produced by a traffic zone

R = number of registered hunters in a traffic zone

This equation explains ninety percent (90%) of the total variation of trip productions for the base year. An Analysis of Variance for this equation yielded an F ratio of 260.279 which is significant at $P < 0.001$. The graph of the regression equation and the ninety-five percent confidence intervals were plotted to examine the precision of the regression equation (Figure 6). The r^2 value for the linear relationship was 0.900. There were a total of thirty-one traffic zones which produced hunter trips. Data points for ten zones fell outside the confidence band which indicates some bias in the data. Eight of these ten were close to the band area. The values for Trips Produced for zone 6 (Corner Brook) and zone 35 (St. John's) were outliers which fell far outside the band and also away from the data group. Since there were no data points between 5,960 and 11,199 on the X axis (Registered Hunters), the assumption of a linear relationship between them beyond $x = 6000$ may be erroneous.

The data were tested for conformity to the assumptions of regression analysis. The independent variable (Registered Hunters) obtained from the Wildlife Division, was assumed to be measured without error. The dependent variable values (Trips Produced) were tested for normality using a set of class intervals. The independent variable was first divided into three classes such that the frequency of the dependent variable values were as equal as possible. The dependent

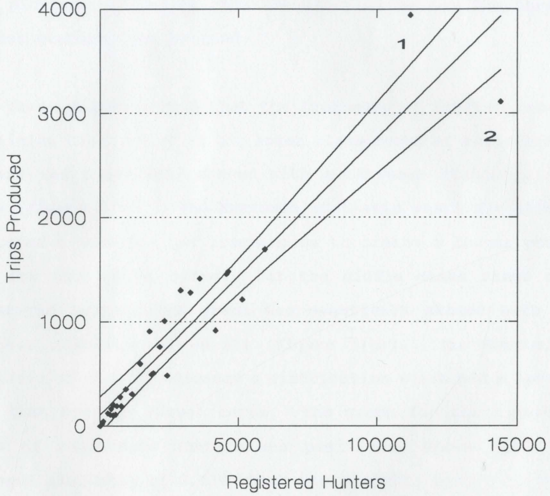

Figure 6. The 95% Confidence Band for the Mean Values of the Dependent Variable on the Regression Line with 31 Traffic Zones of Origin (St. John's (1) and Corner Brook (2) identified as outliers).

variable was divided into classes of 200 trips per class. Then, the class frequency of zones within the trip classes were plotted. Finally, the frequency curve for the three classes combined was plotted.

These graphs showed that the frequency of traffic zones containing total trips in the lower class range of registered hunters was positively skewed with a Skewness statistic of 1.306 (Figure 7(a)). The Kurtosis statistic was 1.234 which indicates a tendency for frequencies to create a larger peak than for the normal curve. For the middle class range of registered hunters the graph was negatively skewed with a Skewness statistic of -0.524 (Figure 7(b)). The Kurtosis statistic of -1.175 indicated a distribution which had a lower peak than for the normal curve. The graph for the highest class of registered hunters was positively skewed with a Skewness statistic of 0.937 which was slightly less than the distribution of the lower class (Figure 7(c)). The Kurtosis value of -0.677 indicated that the frequencies were grouped around the peak a little less than for a normal curve.

Although the curve for the higher class had the least number of frequencies, it approximated the shape of the normal distribution better than the other two classes. A plot of all frequencies together showed a positively skewed curve with a

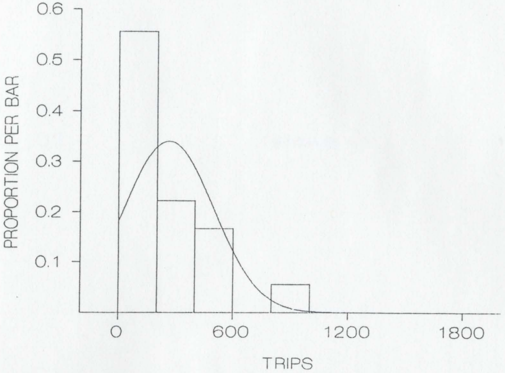

Figure 7 (a). Frequency Distribution of Dependent Variable (Trips Produced) by Lower Frequency Class of the Independent Variable (0 - 1999 Registered Hunters).

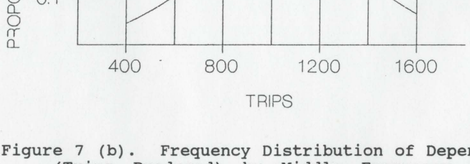

Figure 7 (b). Frequency Distribution of Dependent Variable (Trips Produced) by Middle Frequency Class of the Independent Variable (2000 - 3999 Registered Hunters).

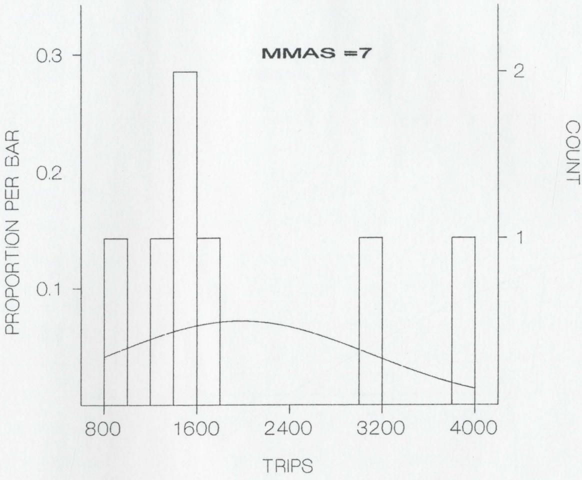

Figure 7 (c). Frequency Distribution of Dependent Variable (Trips Produced) by Upper Frequency Class of the Independent Variable (4000+ Registered Hunters).

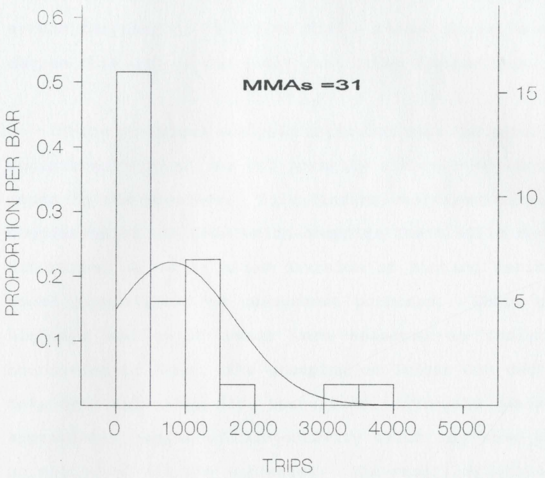

Figure 8. Frequency Distribution of Dependent Variable (Trips Produced) for All Classes of the Independent Variable (4000+ Registered Hunters).

Skewness statistic of 0.738 (Figure 8). The Kurtosis value of -1.133 indicated that the frequencies were highly grouped around the peak of the curve than a normal curve to a larger degree than any of the individual class frequencies.

These graphical analyses indicated that the population of registered hunters was not normally distributed among these zones in the province. This finding was expected since the boundaries of the MMAs which comprise the traffic zones were determined so as to allow division of hunting habitats and moose populations for management purposes. Where possible highways and major roads were selected as unmistakeable boundaries of MMAs. The grouping of origin and destination trip data into MMAs and, thereafter, aggregate zones had an appreciable degree of subjectivity which may have effected normality of all the variables. The ramifications of these facts on the normality of the population were discussed in the next Chapter.

The independence of residuals for the dependent variable was tested by a visual comparison of a plot of the standardized residuals to a normal curve. This showed a distribution where twenty-nine of the thirty-one traffic zones fell within the acceptable limits of -2 to +2. Zones 6 and 35 contain the two largest cities and populations in the province. The residuals for these zones were 3.2 and -3.3

respectively. They could not be examined against a tabulated criteria since such a test would require a sufficient sample size, normally n>50 (30).

The limited number of trip observations did not allow for the tests of normality and independence to be conclusive. Although the regression equation may have some error, evidence from the tests do not refute the validity of the equation. Distribution which is approximately normal, like this case, is acceptable for the regression analysis.

The homogeneity of variances of the dependent variable for the values of the independent variable was examined by application of the Bartlett's test (30). The dependent variable values for all thirty-one zones were grouped into three classes of the independent variable. The variances of these three classes (n = 18,6,7) were compared for homogeneity along the regression line (Appendix B, Table B-1). This test yielded a chi-square value of 26.53 which is larger than chi-square$_{(0.01,2)}$ = 9.21 and chi-square$_{(0.05,2)}$ = 5.99 indicating that at least one of the variances were not equal with the others.

It was clear from the tests of assumptions for regression that zones 6 and 35 were outliers. These determinations could be understood since these zones contain the largest human populations in the province. Also, these populations are the most urban and relatively affluent in the province. As stated in Chapter 3, an attempt was made to characterize urban and rural differences in hunting preferences by the preliminary questionnaire, however, the survey did not produce sufficient responses from urban tripmakers to reach a valid conclusion. It was generally concluded, though, that urban hunters were more sport than subsistence hunters, spend more money on a hunt and travel farther distances than rural hunters. It was apparent on this basis that these two zones and particularly the cities of St. John's in zone 35 and Corner Brook in zone 6 could be responsible for anomalous number of trips produced for numbers of registered hunters in those zones than for the other zones in the study. These special generators are treated separately in trip generation studies (Institute of Transportation Engineering (31)).

It was decided to treat zone 6 and 35 separately, and test the regression equation of the remaining 29 zones for any improvements concerning the assumptions for regression analysis. The new equation was as follows:

$$T_p = 55 + 0.293R$$

where

T_p = trips produced in a traffic zone

R = the number of registered hunters in a traffic zone

The exclusion of zone 6 and 35 from the analysis improved the reliability of the equation, however, the correlation between the dependent and independent variables was reduced slightly from 0.949 to 0.939 and the r^2 of 0.900 to 0.881. A graph of the 95% confidence band and the new regression line showed that the regression line had been pulled down slightly by the two outlier zones (Figure 9). With the elimination of those points the regression line had tipped upward and the confidence band tightened around the line. This caused two former borderline data points to be found outside the confidence band. Nevertheless, the standard error of the estimate was reduced from 289.58 to 187.49 which indicated a better fit by the new equation.

Other improvements occurred in the fit of the frequencies of the third class of the independent variable to the normal curve (Figure 10). The Bartlett's test of the homogeneity of variances was applied again, the new chi-square value was 1.737. Since the critical values of chi-square are 9.21 and 5.99 for 0.01 and 0.05 level of significance respectively, it was concluded that the variances were now homogeneous (calculated chi-square < table chi-square).

Other improvements were that the constant in the equation was reduced from 108.025 to 54.722.

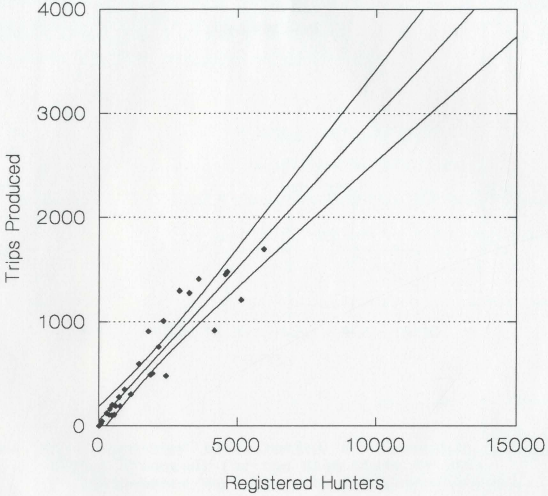

Figure 9. The 95% Confidence Band for the Mean Values of the Dependent Variable on the Regression Line with 29 Traffic Zones of Origin (St. John's and Corner Brook removed).

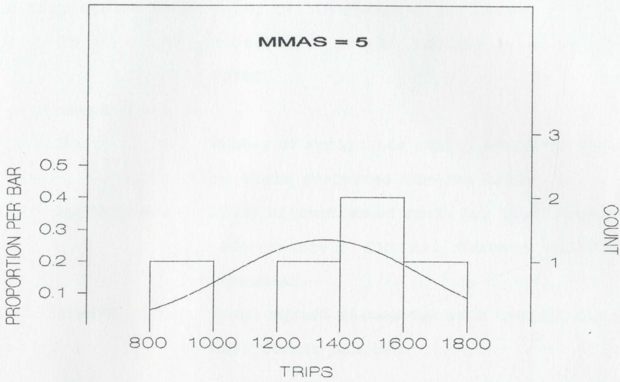

Figure 10. Frequency Distribution of Dependent Variable (Trips Produced) for the High Class of the Independent Variable with two Zones Removed.

4.1.4 Trip Choice Model

A multiple linear regression equation was developed for a trip choice model using two independent variables:

Tc = 1754.246 + 12.416 RDCLASS 4 + 41.437 FOREST

where

Tc = Number of applicants naming a traffic zone as their preferred hunting area.

RDCLASS 4 = Total kilometres of roads per traffic zone only suitable for All Terrain Vehicle operation.

FOREST = Total square kilometres of a traffic zone with forest habitat.

The calculated R^2 was 0.510 indicating an adequate fit of the regression line to the data. The standard error of the estimate was 1164.586 and the F ratio of 18.2. Since the table value of $F_{(0.01,2,35)} = 5.29$, the calculated F is significant at the 0.01 level of significance. Therefore, it was concluded that trip choices per zone were significantly influenced by the total kilometres of ATV trails and by the percent of forest habitat per zone. However, only 50% of the total variation of the dependent variable (TC) can be explained by the use of the two independent variables (RDCLASS 4 and FOREST) which means that the choice of hunting area partially depends on total kilometres of ATV and square kilometres with forest habitat. The important implications of these findings were discussed in the next chapter.

4.2 Trip Distribution

This section presents the results of the trip distribution analysis of the study.

4.2.1 Information Requirements

(1) Traffic Zone Centroids

Centroids were determined by selecting the location of each MMA which exhibited the most moose killed within a 10 X 10 square kilometre block according to records of the Wildlife Division. For large zones kill activity tended to occur away from the centre. In those zones, the centroids were the geometric centre between the identified centres of moose kill activity which ranked in the top 5% of kill areas in the previous year.

(2) Interzonal travel distances

Travel distances between zonal centroids were measured by way of the resource access roads and provincial highway network which appeared on the 1:250,000 scale hunter maps provided to hunters each year by the Wildlife Division. Some centroids were delineated in wilderness areas where kills had been made from hunting by aircraft, boat, snowmobile or all terrain vehicle. Distances in these cases were measured from the centroid to the nearest road on a 1:250,000 scale topographic map of the provincial road system. Appendix C, Table C-1 contains a matrix of these travel distances from 38 zones to 38 zones.

(3) Interzonal travel times

The interzonal travel times were found by assuming average travel speeds for each road class (Table 5), calculating travel times to traverse each distance for each road class between centroids and aggregating the individual times. The interzonal travel times were finally collated into a 38 by 38 cell matrix referred to as a Travel Time Table. This table was one of the input requirements for the trip distribution model (Appendix C, Table C-2).

Another important input to the model was the total actual trip interchanges in the 1988 base year between traffic zones. This data was arranged in a 38 by 38 matrix which showed the distribution of trip interchanges between trip origins and destinations (Appendix C, Table C-3). This table will be further referred to as the Origin - Destination (O-D) Table. As described earlier, this study defined a hunter trip as the travel by a licensed hunter for an entire season from traffic zone origin to a traffic zone destination. Therefore, several moose hunting trips to the hunting area by the licensed hunter for that year was considered as one hunting trip. The reasons for and implications of this definition will be explained in the next section on discussion of results.

Table 5. Travel Speeds for Road Classes.

ROAD CLASS	VEHICLE TYPE	TRAVEL SPEED (km/hr.)
Provincial Highways		
Trans-Canada Highway	All	90
Paved Highway	All	90
Gravel Highway	All	80
Resource Access Roads		
1	All	60
2	2x2 Truck 4x4 Truck ATV	50
3	4x4 Truck ATV	30
4	ATV	20
Unknown	Unknown	25

The O-D table (Table C-3) indicated that hunter travel was often regionalized into the Northern Peninsula, Bay Verte Peninsula, Notre Dame Bay and the Bonavista Peninsula North, Bonavista Peninsula South, Burin Peninsula and the Avalon Peninsula. It also showed that the total number of hunter trips which originated from urban areas were distributed into more distant zones than rural areas as was indicated earlier from the hunter questionnaires. Other observations were made and discussed after presentation of the outputs of the model.

Table C-4 contains the expected trip interchanges (contingency table) as determined from the O-D survey trip productions and attractions. Comparison with the actual O-D table showed that the cell values of the expected table are more evenly distributed. The reason for the deviation of the actual trips from the expected values indicates that some factors in the zones were exerting an influence on this recreational travel behaviour.

A test was carried out on the association or independence of the rows (trip productions) and columns (trip attractions). The chi-square test of independence procedure was used to obtained chi-square values between the observed and expected trip interchanges (Table C-5). Chi-square cell values for cells where expected frequencies were less than five were eliminated from further calculations. The total chi-square value for the table was much larger than the critical values at the 5% or 1% level of significance. This result gave the conclusion that the rows and columns are not independent. Characteristics of the trip maker or zones were therefore responsible for unexpected levels of trip production or attractions.

4.2.2 Calibration of the Gravity Model

A computer program was written in BASIC language which used the inputs in a gravity model. The following inputs were required to run the program; the O-D table for the base year, the Travel Time Table and a table of travel deterrence factors for the time variable. An initial assumption of this model was made that travel for this trip purpose was not affected by distance from origin. Therefore, the initial friction factors were set to the value of unity. The computer program provided for an adjustment of the friction factors after each iteration of the model in order to enable a closer convergence of the estimated trip interchanges with actual values.

The trip length frequency distribution curve for the first iteration was plotted from these data outputs against a curve of the actual trip length frequency distribution for the base year (Figure 11). A comparison showed that there was an underestimation of the shorter trips while the longer trips

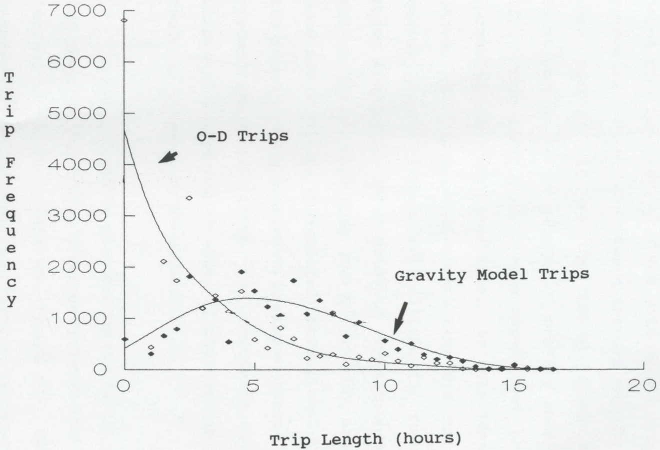

Figure 11. Trip Length (time) Frequency Distribution Comparison for Iteration 1.

were overestimated. The divergence of the curves was considered more unusual than for results of first iterations for recreational and urban trip distribution models. It was noted that the scatter of the data points around the line was excessive. Travel deterrence factors for the first iteration were plotted against the travel times to examine the relationship for violations of gravity model theory (Figure 12). The graph should have shown that travel deterrence increases with increased time. At this iteration the model showed that increasing travel time did not strongly deter travel trips. Dekalb and Sullivan (7) found this to be a major problem in their study of recreational trip behaviour and concluded that time and the gravity model could not be used for modelling unregulated recreational travel. Although the present study focused on regulated travel where trips were predetermined at least for destinations, some of the unidentified sources of model fluctuation in the Dekalb study could be evident in this scenario.

It was decided to pick new travel deterrence factors from the graph of the travel deterrence factors vs. the travel time lengths of the last iteration (Figure 12). This procedure was recommended by the U.S. Department of Transportation to adjust for the illogical relationships between the two variables resulting from the scatter of individual points by fitting

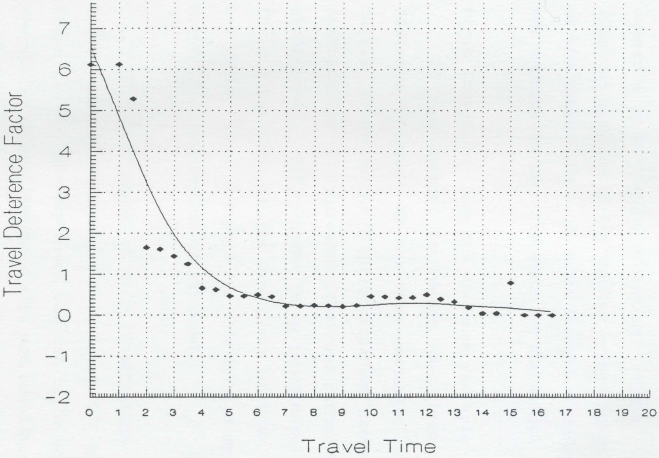

Figure 12. Plot of the Travel Deterrence Factors from Iteration 1 vs. Travel Time Including Frequency Points for 0.5 Hour Class Intervals.

a "line of best fit". The new values was used to replace the initial input values of the first iteration and the model was run again. The results of the second model showed an inflection of relationship describing the estimated trips compared to the first iteration. These results showed an improved estimate of the shorter trips with an underestimation of the longer trips. A third iteration showed that the model was increasing the divergence of the second iteration.

First iteration using the distance variable

It was decided to repeat the first iteration using distance in place of the time variable. The travel trip matrix for estimated trip interchanges showed a bias toward distribution of trips along the rows rather than the columns (Table C-6). Both column (trip production) totals and row (trip attraction) totals were close in value to those for the O-D table. This is normal for this type of mathematical model since it is production constrained.

The total number of trip interchanges for the gravity model differed with the O-D table by 593 trips. The mean trips for the gravity model was 636 trips and the O-D table was 652. These differences were not considered to be serious for the size of the population. The more important consideration was the ability of the model to replicate the actual trip distribution of the base year. The variance of the gravity model was 30586 and standard deviation was 28.63 compared to a variance of 21972 and standard deviation of 184.0 for the O-D table. This indicated that the actual trip interchanges were slightly more irregularly distributed among the zones than the gravity model estimates. The expected values (Table C-4) were more regularly distributed among the zones than either the O-D values or the gravity model values.

The differences between the corresponding cell values for the trip interchanges of the O-D table and estimated by the gravity model are presented in Table C-7. A chi-square "goodness of fit " test was also performed on the two data tables which determines the closeness of cell values and detects differences (Table C-8).

Table 6 presents the results of the chi-square "goodness of fit" test between the gravity model and the O-D table by distance classes. These values are a measure of the closeness of the values of each model iteration to the actual trips. The larger values of the chi-square correspond to the largest differences between the O-D and gravity model values. Since

Table 6: Chi-square Test Results by Distance Class for Gravity Model Iteration No. 1.

CLASS NO.	DISTANCE	TRIP DIFF. (OD-GM)	CHI^2	CLASS NO.	DISTANCE	TRIP DIFF. (OD-GM)	CHI^2
1	0-14	6428	65899.70	36	525-539	-333	228.64
2	15-29	704	8695.14	37	540-554	-138	60.08
3	30-44	423	1345.33	38	555-569	-406	308.11
4	45-59	925	4433.26	39	570-584	-191	60.90
5	60-74	1620	3865.08	40	585-599	-385	316.05
6	75-89	123	95.75	41	600-614	-97	29.59
7	90-104	1075	1667.57	42	615-629	-216	158.16
8	105-119	-9	0.30	43	630-644	-223	95.82
9	120-134	434	570.78	44	645-659	-143	131.93
10	135-149	-46	4.37	45	660-674	-374	320.08
11	150-164	115	16.83	46	675-689	-171	161.55
12	165-179	292	205.95	47	690-704	-113	86.86
13	180-194	196	91.69	48	705-719	-311	253.20
14	195-209	-22	1.54	49	720-734	-135	119.12
15	210-224	-285	169.57	50	735-749	-129	124.19
16	225-239	-311	253.20	51	750-764	4	1.33
17	240-254	0	0.00	52	765-779	-322	306.76
18	255-269	-74	8.30	53	780-794	-125	110.82
19	270-284	-398	215.81	54	795-809	-219	193.39
20	285-299	107	33.28	55	810-824	-157	125.76
21	300-314	-355	148.97	56	825-839	-239	212.34
22	315-329	-254	189.75	57	840-854	-266	223.91
23	330-344	-255	236.45	58	855-869	-177	125.32
24	345-359	-323	130.74	59	870-884	-50	46.30
25	360-374	-492	374.71	60	885-899	-111	98.57
26	375-389	-346	246.84	61	900-914	-22	20.17
27	390-404	-230	121.05	62	915-929	-26	25.04
28	405-419	-498	377.48	63	930-944	-56	56.00
29	420-434	-288	179.15	64	945-959	0	0.00
30	435-449	-270	211.92	65	960-974	0	0.00
31	450-464	-686	545.30	66	975-989	0	0.00
32	465-479	-204	106.43	67	990-1004	-89	89.00
33	480-494	-563	349.86	68	1005-1019	0	0.00
34	495-509	-570	530.88	69	1020-1034	0	0.00
35	510-524	-141	48.97	70	1035-1050	-9	9.00
						Total	91976.9

CHI^2 0.95,1 = 3.84 CHI^2 0.95,69 = 89.38
CHI^2 0.99,1 = 6.63 CHI^2 0.99,69 = 99.25

the total chi-square value was larger than the critical value at both 5% and 1% level of significance, there is a significant difference in trip interchanges of the gravity model and the actual data set.

The trip length frequency distribution curves for both the gravity model iteration no. 1 and the O-D data are presented in Figure 13. This plot is recommended by the BPR for comparison of the visual closeness of the data sets. In comparison, Table 6 shows chi-square test results by distance class for the first iteration of the gravity model to aid in the interpretation of Figure 11. The table shows statistically significant values of chi-square for larger differences between trip numbers of the data sets. These correspond to the lack of closeness between the curves. The curves did not meet the BPR criteria that they must be within + or - 3 percent. It was decided that another iteration of the gravity model was required.

Second iteration using the distance variable

The BPR procedures described in Chapter Three were used to calculate travel deterrence factors for the second iteration. The model produced trip interchanges which are presented in Table C-9. The descriptive statistics recommended by the BPR were calculated and their values were greater than those for iteration 1 and were closer to the

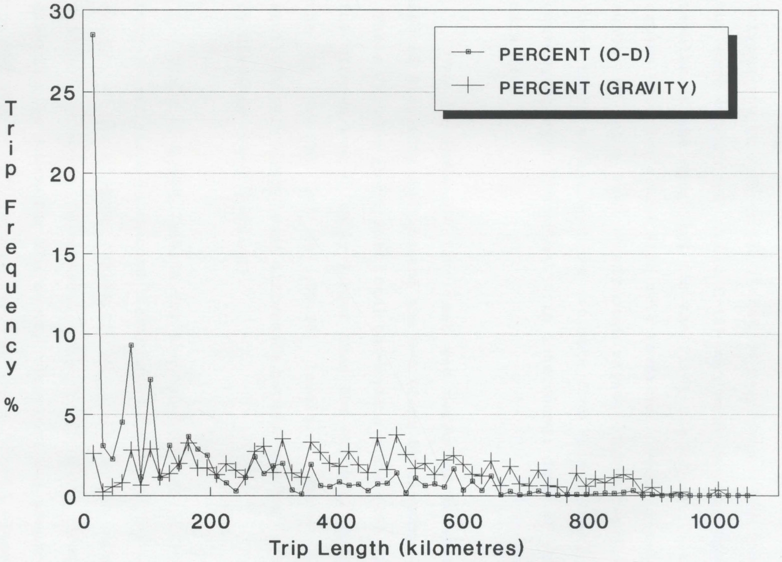

Figure 13. Trip Length (distance) Frequency Distribution Comparison for Iteration 1.

values of the O-D data set. The trip interchange differences between the gravity model iteration results and the O-D data set were calculated (Table C-10) and were smaller than the results of the same test for the first iteration. The chi-square test for these data sets revealed a reduction in the number of cells with significant values (Table C-11). The above tests showed that the estimate from this iteration was converging with the actual trip interchange data of the O-D data set.

The 'goodness of fit' test was performed between the second iteration results and the O-D trips by distance class (Table 7). The calculated total chi-square value (143.11) for the classes was slightly larger than the critical values at the 1% (99.25) and 5% (89.38) levels. There was no statistically significant difference between the two data sets by distance class (Table 7).

Table 8 showed results for the 'goodness of fit ' test between the first and second iterations. The total chi-square value for the classes (72144.12) was much larger than the critical value of chi-square. The trip length frequency distribution curve for the second iteration was prepared by the BPR method (27) (Figure 14). It shows 'visual closeness'

Table 7: Chi Square Test Results by Distance Class for Model Iteration No. 2

CLASS NO.	DISTANCE	TRIP DIFF. (OD-GM)	CHI^2	CLASS NO.	DISTANCE	TRIP DIFF. (OD-GM)	CHI^2
1	0-14	328	15.99	36	525-539	-16	1.52
2	15-29	71	7.31	37	540-554	-54	12.51
3	30-44	9	0.15	38	555-569	-1	0.01
4	45-59	-53	2.40	39	570-584	-71	10.52
5	60-74	164	12.60	40	585-599	6	0.46
6	75-89	3	0.03	41	600-614	0	0.00
7	90-104	138	11.68	42	615-629	-13	1.84
8	105-119	-25	2.16	43	630-644	-29	2.59
9	120-134	-78	7.23	44	645-659	4	2.00
10	135-149	41	4.23	45	660-674	6	0.63
11	150-164	77	7.20	46	675-689	3	1.29
12	165-179	12	0.21	47	690-704	2	0.13
13	180-194	-0	0.00	48	705-719	2	0.06
14	195-209	-15	0.73	49	720-734	-3	0.43
15	210-224	5	0.13	50	735-749	1	0.25
16	225-239	4	0.24	51	750-764	-11	4.48
17	240-254	43	7.90	52	765-779	1	0.07
18	255-269	-64	6.30	53	780-794	-0	0.00
19	270-284	19	1.14	54	795-809	0	0.00
20	285-299	-9	0.18	55	810-824	1	0.03
21	300-314	20	0.85	56	825-839	0	0.00
22	315-329	9	1.05	57	840-854	-15	3.46
23	330-344	2	0.22	58	855-869	-8	0.79
24	345-359	-25	1.25	59	870-884	1	0.33
25	360-374	7	0.33	60	885-899	-0	0.00
26	375-389	8	0.49	61	900-914	1	1.00
27	390-404	0	0.00	62	915-929	1	0.00
28	405-419	-9	0.48	63	930-944	0	0.00
29	420-434	-30	4.39	64	945-959	0	0.00
30	435-349	1	0.01	65	960-974	0	0.00
31	450-464	7	0.29	66	975-989	0	0.00
32	465-479	-12	0.72	67	990-1004	0	0.00
33	480-494	-6	0.10	68	1005-1019	0	0.00
34	495-509	5	0.68	69	1020-1034	0	0.00
35	510-524	-3	0.03	70	1035-1050	0	0.00
						Total	143.11

CHI^2 0.95,1 = 3.84   CHI^2 0.95,69 = 89.38
CHI^2 0.99,1 = 6.63   CHI^2 0.99,69 = 99.25

Table 8: Chi Square Test Results by Distance Class to Compare Gravity Model Estimates from Iteration 1 with Iteration 2.

CLASS NO.	DIST.	TRIP DIFF. (GM 1 - GM 2)	CHI^2	CLASS NO.	DIST.	TRIP DIFF. (GM 1 - GM 2)	CHI^2
1	0-14	-6100	5531.44	36	525-539	317	598.15
2	15-29	-633	580.71	37	540-554	84	30.28
3	30-44	-414	313.34	38	555-569	405	1261.73
4	45-59	-978	816.81	39	570-584	120	30.06
5	60-74	-1456	992.94	40	585-599	391	1960.06
6	75-89	-120	51.80	41	600-614	97	42.57
7	90-104	-937	538.63	42	615-629	203	447.91
8	105-119	-16	0.89	43	630-644	194	115.80
9	120-134	-512	311.34	44	645-659	147	2700.79
10	135-149	87	19.07	45	660-674	380	2533.31
11	150-164	-38	1.75	46	675-689	174	4324.49
12	165-179	-280	112.97	47	690-704	115	413.26
13	180-194	-196	62.47	48	705-719	313	1419.82
14	195-209	7	0.16	49	720-734	132	829.67
15	210-224	290	444.97	50	735-749	130	4225.87
16	225-239	315	1480.93	51	750-764	-15	8.33
17	240-254	43	7.90	52	765-779	323	6955.56
18	255-269	10	0.15	53	780-794	125	976.64
19	270-284	417	548.55	54	795-809	219	1653.90
20	285-299	-116	29.25	55	810-824	158	656.96
21	300-314	375	298.57	56	825-839	239	1904.13
22	315-329	263	898.32	57	840-854	251	969.28
23	330-344	257	3669.68	58	855-869	169	352.60
24	345-359	298	177.61	59	870-884	51	867.20
25	360-374	499	1693.90	60	885-899	111	880.11
26	375-389	354	956.61	61	900-914	23	529.17
27	390-404	230	255.56	62	915-929	27	0.00
28	405-419	489	1423.34	63	930-944	56	0.00
29	420-434	258	324.70	64	945-959	0	0.00
30	435-449	271	1006.05	65	960-974	0	0.00
31	450-464	693	2825.00	66	975-989	0	0.00
32	465-479	192	185.25	67	990-1004	89	0.00
33	480-494	557	888.96	68	1005-1019	0	0.00
34	495-509	575	8935.82	69	1020-1034	0	0.00
35	510-524	138	71.06	70	1035-1050	9	0.00
						Total	72144.12

CHI^2 0.95,1 = 3.84CHI^2 0.95,69 = 89.38
CHI^2 0.99,1 = 6.63CHI^2 0.99,69 = 99.25

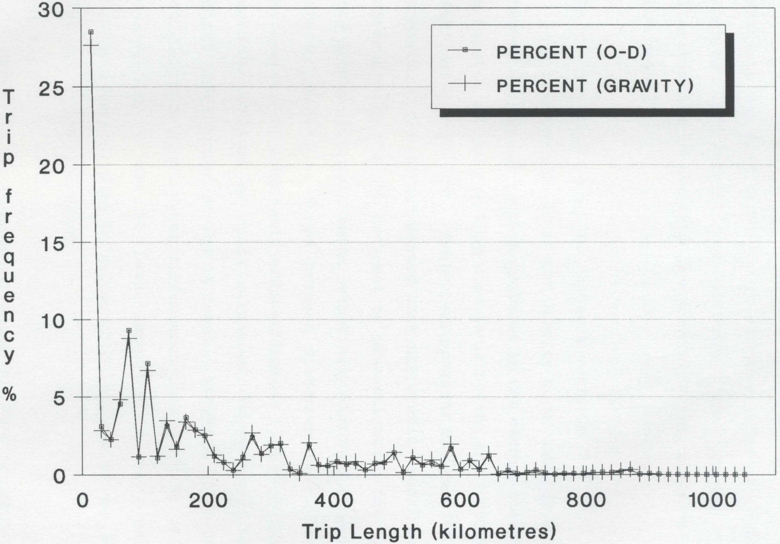

Figure 14. Trip Length (distance) Frequency Distribution Comparison for Iteration 2.

of the O-D trip data curve with the curve of the gravity model estimate for this iteration to within + or -3 percent. This contrast of results was sufficient to warrant a third iteration to investigate the possibility of a better fit by the model.

Third iteration using the distance variable

A third iteration of the gravity model was run using the travel deterrence factors produced in the second iteration as a input. The results were used to calculate the ' goodness of fit' chi-square test. Table C-12 presents the results of the analysis. The values showed that the gravity model began to diverge with the O-D data set by overestimating the trips in the middle distance classes (especially distance between 75 to 270 kilometres). Trips between distances of 570 and 584 kilometres were severely underestimated. These differences were accompanied by class values of chi-square which were highly significant at the 1% level. Nineteen of 70 distance classes had significant differences according to values of chi-square at the 1% level compared to no significant differences according to values of chi-square at the 1% level for the second iteration.

The model was considered calibrated at this point because the following criteria was evident;

1. the chi-square test results showed no significant difference by the 'goodness of fit' chi-square test for distance classes between the trip interchange data of the O-D and the second iteration of the gravity model,
2. the visual closeness of the data curves of the O-D and the second iteration including average trip lengths within + or -3 percent.

4.2.3 <u>Testing the Model</u>

The travel demand forecasting techniques had been applied to this problem to produce trip generation and trip distribution models for the base year of 1988. It remained that a test be carried out to demonstrate the forecasting ability of these models for a horizon year.

It was desirable to pick a test year for which the values of the variables of the models were known and for which the values of the dependent variable would not be outside or too far outside the range of the regression data.

Reasons were given in Chapter Three to explain why the trip attraction data would not be predicted. Actual data on trip attractions for the test year will be used in the study. The independent variable for the trip generation model was registered hunters per zone per year. The values of this variable for the test year were derived from the records of the Newfoundland Wildlife Division. The dependent variable was the trips produced in a zone in the test year. The data records containing this variable were large and take much of a given year to prepare from hunter license applications and questionnaire returns. The latest available records were the 1990 data sets. Hence, 1990 was chosen as the test year.

The final equations used to model trip generation were:

$T_p = 55 + 0.293R$ (for 36 traffic zones)

where

T_p = trips produced in a traffic zone

R = the number of registered hunters in the population of the zone of origin

The standard error of the estimate was 187.50.

The equation from the first run of the trip production regression procedure was used to develop inputs for zones 6 and 35. It was as follows:

$T_p = 108 + 0.265R$

where

T_p = trips produced by a traffic zone

A = the number of registered hunters in the population of the zone of origin

The standard error of the estimate was 289.59.

These equations were developed under the criteria recommended by the U.S. Department of Transportation and the statistical assumptions necessary for regression analysis. Values for trip productions for the test year were generated from the above equations (Table D-1). The difference in the values of these estimated trips compared to the test year actual values ranged from 0% to 3% which was acceptable under BPR procedures.

The inputs for a test of the calibrated gravity model consisted of the estimated trip productions and actual attractions per traffic zone, the trip distance table for 1990 (Table D-1), and the friction factors developed from the second iteration. The results of the test are presented in Appendix D, Tables D-3 and D-4. The OD trip interchanges for the 1990 test year are presented in Table D-2. The trip interchanges predicted in the test (Table D-3) are compared by cell differences (Table D-4) and chi-square values (Table D-5). The O-D trip interchanges were distributed unevenly among the zones. This showed an influence of stronger trip productions or attractions in certain zones. Zones 1, 6 and 35 were exceptionally strong influences on the total trips. The differences between the O-D and the estimate (Table D-4) were smaller in all cases than the differences between the O-D and the first iteration of the model calibration process. The differences between the O-D and the second iteration of the model calibration were lowest of the interchange tables. The chi-square test between the trip interchange tables of the O-D and the test results (Table D-5) showed cells with significant values at the 1% level of significance and at the 5% level. The total chi-square value by distance class (1684.30) was larger than the critical value ($\chi^2_{0.99,69}$ = 99.25) (Table 9) indicating that the model predicted trip interchange values which were not statistically a good fit to the actual trip interchanges for the test year. The individual differences between distance classes were larger for the middle distance classes similar to the problem of the third iteration, however, only six were significant by the chi-square test at the 1% level of significance. This may indicate another influence of an unaccounted factor influencing the direct effect of distance as a deterrence variable. The trip length frequency distribution graph (Figure 15) showed that the line plot of the gravity model estimates was visually close to the line plot of the actual trip frequencies for each trip length class for the test year. The differences were all within the BPR recommended $\pm$ 3 percent range with the exception of the 0-15 Kilometre trip distance class where there was slight over estimates .

The test showed clearly that the calibrated gravity model had performed well as a trip distribution model for moose hunters. It had successfully distributed the hunter trips

Table 9: Chi Square Test Results by Distance Class for Gravity Model Prediction of the Test Year.

CLASS NO.	DIST.	TRIP DIFF. (OD-GM)	CHI^2	CLASS NO.	DIST.	TRIP DIFF. (OD-GM)	CHI^2
1	0-14	1126	175.17	36	525-539	7	0.24
2	15-29	140	36.28	37	540-554	-30	4.48
3	30-44	-238	83.97	38	555-569	42	14.97
4	45-59	32	0.68	39	570-584	-110	25.21
5	60-74	520	133.11	40	585-599	30	20.53
6	75-89	-15	0.75	41	600-614	2	0.02
7	90-104	-52	1.47	42	615-629	-44	16.80
8	105-119	-71	13.43	43	630-644	56	13.04
9	120-134	-247	78.23	44	645-659	4	1.15
10	135-149	-221	110.26	45	660-674	12	3.22
11	150-164	164	36.89	46	675-689	21	92.54
12	165-179	-336	135.44	47	690-704	5	0.87
13	180-194	-175	50.47	48	705-719	-2	0.07
14	195-209	13	0.83	49	720-734	-5	1.18
15	210-224	-96	39.87	50	735-749	-3	1.56
16	225-239	97	71.00	51	750-764	-25	20.21
17	240-254	-5	0.12	52	765-779	-1	0.10
18	255-269	89	14.07	53	780-794	-6	2.79
19	270-284	-125	38.82	54	795-809	-9	2.29
20	285-299	-104	16.80	55	810-824	-5	1.26
21	300-314	-100	17.07	56	825-839	25	26.97
22	315-329	26	6.68	57	840-854	-23	12.93
23	330-344	59	150.26	58	855-869	29	13.79
24	345-359	-46	3.75	59	870-884	0	0.00
25	360-374	-20	2.18	60	885-899	-4	1.44
26	375-389	60	31.58	61	900-914	-1	1.03
27	390-404	-41	9.15	62	915-929	0	0.00
28	405-419	97	56.61	63	930-944	0	0.00
29	420-434	-96	38.79	64	945-959	0	0.00
30	435-449	-34	10.32	65	960-974	0	0.00
31	450-464	-3	0.05	66	975-989	0	0.00
32	465-479	-21	3.28	67	990-1004	0	0.00
33	480-494	15	0.60	68	1005-1019	0	0.00
34	495-509	-7	1.05	69	1020-1034	0	0.00
35	510-524	102	36.65	70	1035-1050	0	0.00
						Total	1684.30

CHI^2 0.95,1 = 3.84 CHI^2 0.95,69 = 89.38
CHI^2 0.99,1 = 6.63 CHI^2 0.99,69 = 99.25

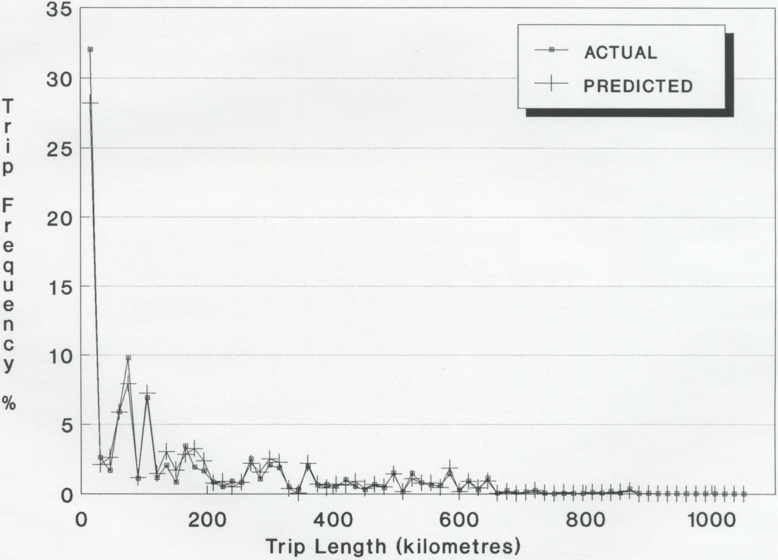

Figure 15. Trip Length (distance) Frequency Distribution Comparison for the Test Year.

among the traffic zones to emulate the actual O-D matrix for the test year.

CHAPTER 5

DISCUSSION OF RESULTS

5.1 Trip Generation

There was some difficulty to find an independent variable which met the absolute statistical requirements for regression analysis and had a sufficiently strong predictive capability of the dependent variable. Based on literature review Deacon et al. (16) found that finding an acceptable independent variable was the most difficult problem in their modelling exercise for recreational traffic in Kentucky.

The trip production equation had an independent variable which correlated with and was a good predictor of the dependent variable. All assumptions of regression analysis could not, however, be met. The trips produced for the population of registered hunters were not normally distributed and the variances were not homogeneous. There were several reasons postulated which could have contributed to this situation.

1) The origins of the tripmakers were determined by the author by developing a BASIC program which converted the postal codes of licence holders and applicants into associated MMA numbers. The postal code boundaries did not readily correspond to MMA boundaries, but more often to communities, bays or coves. As described in the previous Chapter, MMAs

were designed to allow roads and highways to be boundaries for enforcement and identification. Therefore, the tripmaker, applicant or registered hunter might live in one MMA or another with no information from the postal code to distinguish the side of the road boundary in which they resided. The author was required to use judgement on many of the more than 90,000 entries.

2) The number of MMAs have changed from year to year. For the purposes of the study, it was necessary to aggregate the MMAs into a set of traffic zones which would remain constant over a period of time. The original forty-seven MMAs of the base year were aggregated into thirty-eight traffic zones. The errors in assignment of addresses to the original MMAs may have been enhanced by this procedure.

The trip production equation was revised by removing the two zones which contained the largest number of registered hunters and trip productions. The Bartlett's tests showed that the new equation had homogeneous variances. The trip productions in the highest class of the independent variable range conformed more closely to a normal distribution (Figure 10). An important improvement was found concerning the 95% confidence band around the regression line for the 29 zones. The new equation had a slightly larger correlation coefficient ($r = 0.293$) than the former equation ($r = 0.265$). This change in association with the large reduction in the standard error of the estimate indicated that the rates of trip productions among registered hunters from traffic zones with larger and/or urban communities may be different than the rates from traffic zones with smaller and/or rural communities.

5.2 Trip Choice

The analysis in the previous chapter was designed to assess the influence of resource access roads on travel behaviour for two separate aspects. The influence as an accessibility factor was assessed in the trip distribution model and will be discussed in the next section. The influence as an attractiveness factor was assessed by constructing a trip choice model. This equation used the number of applicants naming a traffic zone as the variable expressing trip choice. A broad range of variables were selected which categorized and quantified the entire range of average road conditions in a zone. Other variables were include to assess their importance relative to resource roads as factors of attractiveness influencing trip choice. These include variables which were considered logical influences of the dependent variable such as number of available licences, known size of moose population, percentage of moose habitat.

The correlation matrix (Table 4) showed several important points.

1) Applicants were more attracted to traffic zones which had more resource access roads. The attractiveness of these roads increased with deteriorating condition.

2) The roads which were passable to ATV traffic only were more highly correlated to trip choice than any other road class examined including highways (r = 0.522). The total quantity of resource and paved road (exclusive of highways) showed a correlation value of r = 0.339 which was lower than the values for ATV and 4X4 roads (Road Class 3) or ATVs only (Road Class 4).

3) Three variables were significantly correlated to trip choice, namely the percentage of forest habitat per zone (0.544), the kilometres of roads passable to ATVs only per zone (0.522), and the number of available moose licences per zone (0.474). Surprisingly, the number of licences was the least significant and showed the least correlation with the dependent variable.

4) The estimated moose population per zone had a negative correlation with the number of applicants. This might be explained by the tendency for hunters to seek hunting areas which are not overcrowded.

These points tend to support the hypothesis that applicants were seeking a particular hunting experience more than a better chance of obtaining a licence, hunting success, quantity of roads, or the specialized equipment required to move around the hunting area. It was evident by the correlation of variables that the trip purpose was evolving or had evolved from a predominantly subsistence, or hunt-oriented activity to a broader recreational type activity. This was consistent with the results of the preliminary survey (Figure 4) in which respondents indicated that for the period 1980 to 1988 the most important factor of first choice was familiarity with the area. These results were similar to Davison's study (29) which showed that familiarity or fidelity to an recreational destination increased with increasing positive reinforcement from previous trips.

The results supported a theory that hunters preferred zones where intrazonal travel had to be carried out with a specialized equipment. The ATV may be the preferred means of this type of travel among the vehicles considered.

The trip choice model showed also that the number of applicants choosing an area was mostly dependent on the combination of the kilometres of ATV Trails and percentage of forest habitat in the traffic zone versus all the possible variables.

Based on the results of this study it is concluded that the wildlife regulatory authorities would find it profitable to give more recognition to the importance of resource access roads to hunter trip choice. The correlation and analyses give important directions for the management concerning road maintenance to enhance this recreational activity. Hunter distribution within hunting areas could be improved by assurance of fair accessibility to the various MMAs.

5.3 Trip Distribution

Evaluation of Results

There were large significant cell values of chi-square for the test of independence carried out on the O-D data set for the base year.

Results indicate that the actual number of trip interchanges between zones are much greater than the expected number. The zones which showed the largest chi-square values are evident in Table C-5. These zones have unusual characteristics which produce or attract greater passenger volumes. As discussed in the development of the trip generation model, the number of registered hunters in a zone was significantly correlated (r^2 = 0.90) to the number of trips produced in a zone. The O-D trip interchanges (Table C-3) for the base year showed zone 6 (Corner Brook), zone 35 (St. John's) and zone 1 (St. Anthony) are major producers of trips. These trip makers travel farther to hunt than hunters in other zones.

The O-D table also indicates that the majority of trip interchanges originate in these zones. Since these zones have the largest concentrations of populations, it is important to note that this recreational travel pattern may result from urban as opposed to rural travel interests.

The time variable was used initially in this modelling exercise. The results of the first iteration (Figure 10) were plotted in a trip length frequency distribution which did not meet the test of visual closeness prescribed by the BPR. The second iteration showed a closer fit for shorter trips, but divergence for the larger trips. It was decided that this behaviour of the model may be due to varying degrees of one or both of the following reasons:

(1) The time values between zone centers were calculated by estimating the road classes which make up the linkage and measuring their individual lengths. Then, travel speeds were estimated for each road class and the travel times to travel the road linkages were subsequently calculated. There was considerable subjectivity in these estimations due to the lack of field information or resource road systems in the province. Errors in road length measurement, estimation of road classes and appropriate speeds, and the large category of roads for which classification was impossible may have lead to inaccuracy

of travel time estimates. This error would likely be larger for larger travel time estimates.

(2) The trip generation exercise showed that applicant's choice was strongly correlated to the percentage of forest cover and the kilometres of ATV trails in the destination zone. Dekalb et al. (7) found that recreational travel was more influenced by characteristics of the destination (attraction factors) rather than of the accessibility to the destination from the origin (accessibility factors). This may give an explanation for the unsuitability of the variable as an important influence on hunters' travel behaviour. It may be more similar to travel behaviour of other recreational travellers (14) where travel time is not an important determinant of the travel movements.

Consequently, the trip distribution model was run with the distance variable. The first iteration of the model produced estimated trip interchanges (Table C-6) which were neither close by a graphical test (Figure 13), by comparison of all differences (Table C-7), by chi-square cell values (Table C-8) nor by chi-square values by distance classes (Table 6). These results were consistent with the test of independence for the O-D data set which pointed out the larger population areas as the major sources of production and attractions. The gravity model estimates underestimated the shorter trips and overestimating the large trips. They were distributing the trip interchanges closer to the pattern of expected values rather than the actual values.

The chi-square 'goodness of fit' test by distance class between the O-D and first gravity model estimate produced large chi-square values for shorter trips especially trips which originated and remained within the same zone. The cell values of differences and chi-squares decreased for the longer distance classes and approached the trip distribution pattern since the longer actual trips showed a pattern similar to expected values. It was easier for the model to produce values similar to the O-D if they were also close to the expected values.

The second iteration of the model yielded estimated trip interchanges with differences (Table C-10) and cell values of chi-square (Table C-11) which were closer to the actual values of the O-D data set. The chi-square values for zones which produced greater volumes of trips (zone 6, 35, 29) correspondingly decreased as this indicated the model had distributed the trips closer the pattern of the O-D than the first iteration. The 'visual closeness' criteria of the frequency curves for the O-D data and the gravity model (Figure 14) was considered adequate for model calibration. This conclusion was not consistent with the results of the more precise chi-square 'goodness of fit' test (Table 7). This test showed a chi-square of 143.11 exceeding the critical value of $x^2_{0.99.69} = 99.25$. Examination of trips by distance class (Table 7) showed larger ,though not significant individual chi-square values in the shorter trip distance classes where the gravity model underestimated the actual O-D data, e.g. Class 0-14; 328 trips. This was not unusual since the actual O-D data had shown larger numbers of trips in the shorter distance classes than expected since hunters preferred to hunt near to their homes. BPR recommendations are that trip estimates of the trip length frequency distribution must be within three percent of the actual value. The largest value was 328 which was only two percent less than the actual value. The model was considered calibrated, however, a third iteration was carried out to examine the possibility of a closer fit.

A third iteration of the model (Table C-12) showed a large increase in the differences between the O-D data and the gravity model estimate compared to the previous iteration. The model derived from the second iteration was accepted.

<u>Testing of Model</u>

Travel behaviour for a recreational purpose has often been described by models which can predict opportunistic and somewhat erratic behaviour (7). Such models as the intervening opportunities model are suitable for these purposes, but are complex and require very detailed inputs. The model of this study used readily available variables as the number of registered hunters and road distances between points. There were limitations to the accuracy of estimates from the model since many factors such as travel mode which influence the complex travel behaviour of the recreational traveller are not considered directly in this study.

The time period between the base year and test year was two years. It was not anticipated that patronage for this type of trip purpose would change during this time. The information on resource road construction showed that there were no new roads which were part of the interzonal network. There were roads constructed in most of the zones which were accounted for in the trip generation phase of the exercise. Road deterioration effects on existing roads over this time were negligible. In summary, land use characteristics were likely unchanged over the two year period.

The only significant factor for which no assessment could be made was the effect of the annual moose licence quota system on the tripmakers allowed to make the trips. The details of the quota system were discussed in Chapter Three. Any variance of the model estimate beyond measurement error may relate to the control by the system on the total number of trips and the total number of trips to individual zones.

Also, system selects each trip-maker by an eligibility criteria which favours hunters who are willing to make longer trips to more remote areas to hunt. These trip-makers would be more typically sport hunters from more affluent population centers who have many mode choices. If the quantity of this type of hunter was large for a given year, the model would be unable to estimate these trips closely. This same scenario is possible for shorter trips in varying degrees of effects on trip interchanges since the type of mode available to hunters, their economic status, etc. may influence the choice of the destination.

Lastly, the time variable proved unsuccessful for use in the model. The distance variable was successfully employed but could not account for the effects of varying levels of road conditions and mode type as accessibility factors affecting interzonal travel.

The model was run for the test year using the travel deterrence factors of the calibrated 1988 model. The total number of trips increased from 24,778 in 1988 to 26,210 in 1990. The trip interchange differences between the O-D data set and the prediction for the test year (Table D-4) and the chi-square values (Table D-5) showed that the prediction was significantly different than the actual data for the year. The most significant discrepancies were found in the cell values for the intrazonal hunting trips around major population centers. Examination of the 1990 O-D trip interchanges (Table D-2) shows that the number of hunting trips around major population centers increased slightly over the two year period. It would be impossible for the model to account for this distribution which is not controlled by travel deterrence, but rather the increase in the licensed hunting quotas for a zone. The differences in predictions of the other cell values and trips per distance class (Table 9 and Figure 14) may explained in whole or in part by this factor.

5.4 Implications for Management

The present model did not give predictions within the recommended criteria of the BPR recommendations for the test year. However, in the opinion of the author, the model is adequate to predict annual changes in travel behaviour which can be used to evaluate the effect of large changes in <u>interzonal accessibility</u> on trip interchanges over short term periods. This predict would show indicate shifts in trip-maker origins by location and numbers of hunters. It could also be used successfully to predict gross shifts in percentages of interzonal or intrazonal hunting practice due to changes to the licence quota system or annual allocations.

Resource access roads were shown in the trip generation phase of the study to be the most important factor affecting trip choice of the factors considered. This importance outstripped factors such as the number of available licences for a zone, and the hunting success for the previous year. The most important road class was the amount of ATV trails in a destination zone. This finding indicated that these hunters preferred roads which had deteriorated to a level which provided a particular degree of difficulty for <u>intrazonal accessibility</u>. This may also point to a fundamental change in this recreational activity by a shift from subsistence to sport hunting.

Surveys to determine changing socio-economic profiles of these trip makers are recommended since a change in the trip purpose could have major implications to resource road maintenance strategies. Also, the model predictions may be improved by a consideration of the dynamic effect of the licence quota system on trip interchanges. They would also be improved by the inclusion of more precise measurements of the resource road classes in the interzonal network.

A final consideration was the nature of the present trip interchanges from a management perspective. Table 10 shows the distribution of traffic zones in 1988 by the number of trips produced. The table clearly reiterates the observations described earlier in the preliminary survey and the trip interchange matrix (Table C-2). Thirty-one percent (12/38) of traffic zones produced trips of 300 kilometres or less. These traffic zones of origin were characterized very small and concentrated populations in remote locations. The largest number of trips were produced in the range of 1201 to 1500 trips. They were from zones 1 (St. Anthony), 10 (Codroy Valley), 14 (Bay Verte Peninsula), 15 (Grand Falls), 22 (Lewisporte) and 34 (Bay De Verde). These areas are characterized by good road access systems, and, relatively large and dispersed populations. There were few zones that produced large numbers of trips in the range of 1501 to 4200. They were 29 (Bonavista Peninsula), 35 (St. John's) and 6 (Corner Brook) in increasing order of trip magnitude. It was noteworthy that these were areas of singularly high populations. Nevertheless, St.John's produced less than Corner Brook even though it exceeds the population of the latter by more than three hundred percent. This table indicated that regional differences in hunting tradition exist across the island.

The distribution of traffic zones by the number of trips attracted to them is presented in Table 11. This frequency distribution is predominantly influenced by the licence quota system for this recreational activity. The trip frequency class from 301 to 600 trips had more zones in it than any other trip class. These zones were not characterized by human populations, regional geography, etc. It was evident that they had more moose habitat than other zones such as a mixture of forest and newer forest cutovers. The next largest group of zones was found in the 401 to 600 trip class. They also were characterized by relatively more moose habitat, but these zones are characterized by older cutovers and resource road infrastructure. In contrast to this, the shortest trip class had zones which have very little moose habitat and road infrastructure. They were 2 (Portland Creek), 30 (Burin Peninsula Knee), 31 (Placentia), 34 (Bay De Verde), and 38 (Burin Peninsula Foot). The largest trip class included zones 3 (Harbour Deep), 4 (Taylor's Brook) and 36 (Southern Shore). These zones were characterized by relatively accessible conditions and good habitat. It may be important that these three zones were adjacent to three of the four zones producing the most trips.

There were some possible inferences by viewing these tables together. The vast majority of these trips came from zones containing larger, more urban centers. The available

Table 10. Distribution of Traffic Zones (Moose Management Areas) by Number of Trips Productions from them in 1988.

0-300	301-600	601-900	901-1200	1201-1500	1501-1800	3001-3300	3901-4200
3 5 7 9 12 13 24 26 31 32 33 37	8 19 28 30 36 38	25	2 4 23	1 10 14 15 22 34	29	35	6
12	6	1	3	6	1	1	1

Table 11. Distribution of Traffic Zones (Moose Management Areas) by Number of Trips attracted to them in 1988.

0-300	301-600	601-900	901-1200	1201-1500	1501-1800
2 30 31 34 38	1 12 14 15 16 21 22 23 26 27 28 29 32 33 35	5 8 9 17 18 19 20 25	6 10 11 13 24	7 37	3 4 36
5	15	8	5	2	3

"trip licences" within their home zones did not meet this travel demand. An example is zone 35 (St. John's) where only 14 percent (intrazonal supply/demand ratio) of this demand would have been met if every available licence for zone 35 was given to a resident of the zone. Other areas such as zone 37 (Grey River East) have very low demands for this type of travel, but have a high availability of "trip licences". The intrazonal supply/demand ratio for zone 37 was 900 percent. Considering that the 1988 trip length frequency distribution (Figure 11) showed that greater than 25 percent of those trips were the intrazonal type, it can be concluded that intrazonal trips were characteristically made by trip-makers in zones of small,remote human populations.

It can also be concluded that interzonal trips were more often made by trip-makers from larger, urban zones. The trip interchange matrix (Table C-2) showed that these trips were distributed across the province. This conclusion supports an earlier point that the nature of this trip purpose may be changing from a subsistence activity to a sport. This is consistent with the trip choice model developed for this study which showed that hunters wanted road systems which afforded a unique type of recreational experience. This activity would not necessarily require the inclusion of a successful, effortless, or short hunt.

In a comprehensive study to propose a resource road policy in this province, Philpott (3) concluded that the lack of road maintenance for residual users may jeopardize public safety. He noted that residual users may cause significant land use conflicts or negative environmental damage. The study indicated that road closure and even road decommissioning should be considered by government to control public access. There was a recommendation that a program to implement access control measures should follow a detailed study of present and future road usage by the public.

The present study examined the resource road usage by a portion of recreational travellers in this province. The findings indicate that road closure is not generally in the best interest of the recreational user especially the hunter. Deteriorated roads provide a part of the attraction for a growth industry which should be encouraged by a more intensive resource road program.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Summary

A study was designed to develop a predictive model of annual travel behaviour of moose hunters for the island of Newfoundland which could be used to investigate appropriate road access systems for this recreational travel demand.

Previous studies of regional recreational travel demand indicated the need to separately assess the importance of these roads for intrazonal and interzonal travel. In order to develop a predictive model, it was necessary to collect information on trip interchanges. The study focused on moose hunting travel since it represented a large portion of the recreational travellers using these roads and for which adequate records existed.

The first task of the study was a user questionnaire sent to a 10% random sample of 15,000 licensed hunters in 1988. The responses were used to select methodologies and further define study parameters.

The second major effort was a province - wide resource roads inventory to meet the needs of this study. Most information was available from hunter applications and returns. An inventory of resource road conditions did not exist. A census of existing resource access roads was carried out in 1988 with the assistance of the provincial wildlife protection officers. The inventory compiled information on road class, density and condition down at the 1;250,000 scale of resolution.

The importance of resource access roads to interzonal travel by moose hunters was assessed by using the time variable as the travel deterrence factor in a trip distribution model. The time variable behaved badly and a model could not be calibrated. Although the distance variable could not assess the interzonal effects of these roads on trip distribution, it was employed successfully to predict travel behaviour of the hunters.

The importance of resource access roads to travel choice for the hunter group was examined and a trip choice model was developed.

The methods recommended by the Bureau of Public Roads (25) were followed to develop the trip generation and trip choice models. It was also used to calibrate and test the trip distribution model. Additional tests were employed as previously shown in Pilgrim (17). The chi-square 'goodness of fit' test was used to investigate the association between trip productions and attractions, and, to determine if the trip distribution model was calibrated.

6.2 Conclusions

The study was designed to develop a predictive model of annual travel behaviour of moose hunters for the island of Newfoundland which could be used to investigate appropriate road access systems for this recreational activity. This was the largest users of the public who used these roads and for whom information existed on which quantitative and predictive models could be developed.

Objective One

The first objective was to model the annual travel behaviour of moose hunters. A predictive model of annual travel behaviour was developed. It consisted of a trip generation equation for trip productions which is:

$$T_p = 108 + 0.265\ R$$

where

T_p = trips produced in a traffic zone

R = the number of registered hunters living in an traffic zone

This equation was applicable to all zones except zone 6 and 35 which were zones containing large urban populations.

The equation used for trip production estimates for these zones was:

$$T_p = 55 + 0.293\ R$$

The equation for trip attractions could not be calculated since the independent variables controlling the number of trips attracted were primarily biological parameters of the wildlife population and habitat. The values for this input to the trip distribution were derived from the actual data.

The trip distribution model consisted of a gravity model which was calibrated for the base year of 1988 according to BPR recommendations. Statistical tests showed that the function could not be calibrated better with the 1988 data for the distance variable.

The model was tested to predict trip interchanges at two years beyond the base year. The results were acceptable by the BPR recommendations, but were significantly different at the 5% and 1% level of significance by the chi-square 'goodness of fit' test. A hypothesis was presented that the model could be improved by the determination of the role of other factors in the travel deterrence function. These factors could include the effects of road resource road condition on selection of travel mode and travel speeds.

Another possibility was the effect of the moose licensing system on the pattern of trip interchanges.

Objective Two

The second objective was to examine the relative influence of resource access roads on this travel behaviour. The analysis was carried out for influences on interzonal travel and trip choice of destination.

1. Interzonal Travel

The influence of resource access roads on interzonal travel could be determined by use of travel times between zones to represent the travel impedance in the trip distribution function. This variable could include impedance from portions of the total distance containing deteriorated road conditions, poorer road type and/or reduced travel speeds. The variable proved to be very unstable, probably due to the limitations of measurement accuracy. The distance variable was then used to develop a model of travel behaviour, but the influence of resource roads on interzonal travel could not be assessed.

2. Trip Choice

The influence of resource access roads on trip choice was assessed through the development of a trip choice model using the number of moose hunter applications for a particular hunting zone as the dependent variable. Correlation analysis gave an $r^2 = 0.522$ for applicants with total road kilometres in the traffic zone and an $r^2 = 0.544$ for applicants with total square kilometres of forest habitat in a traffic zone. Other variables did not add significantly to the explanation of the variance of trip choice.

The trip choice model was:

$T_c = 1754 + 12.416$ RDCLASS + 41.437 FOREST

where

T_c	=	Number of applicants naming a traffic zone as their preferred hunting area.
RDCLASS 4	=	Total kilometres of roads per traffic zone only suitable for ALL Terrain Vehicle operation.
FOREST	=	Total square kilometres of a traffic zone with forest habitat.

The standard error of the estimate was 1164.59.

The model showed that these roads are a very important influence in the choice of an annual hunting area by the moose hunter.

The implications of these trends on resource road strategies are clear. The resource access roads in this province are a vital necessity to the recreational hunting industry in this province. These roads provide essential intrazonal and preferred intrazonal accessibility to the recreational area. This type of trip purpose is changing from a subsistence to a sporting activity. This pursuit as a sporting activity has typically more revenue potential especially with the implied preference for intrazonal travel using ATV trails. Since the number of tripmakers and the travel demand is increasing each year, there is a need to carefully consider the management of the provincial resource access roads as a system to enhance the growth of this new industry.

Further research is recommended in the following general areas:

1. Rates of resource access road deterioration under various maintenance regimes.
2. Effects of resource access road condition on travel speed for various travel modes.
3. Socio-economic profiles of recreational travellers, especially revenue generators such as sport hunters.
4. Investigation into the effect of the moose management quota system on trip interchanges in the province.

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APPENDICES

APPENDIX A

Table A1. Summary of Results From the Island-Wide Resource Road Inventory for this Study Conducted in 1988.

Traffic Zone	Class 1	Class 2	Class 3	Class 4	Roads Total	Highways
1	238	0	0	0	238	555
2	204	13	1	20	237	143
3	0	0	0	0	0	0
4	153	80	0	167	250	257
5	123	97	0	0	220	134
6	60	0	0	0	60	208
7	117	30	43	17	207	133
8	103	20	0	37	160	184
9	28	0	0	57	85	92
10	180	0	0	87	267	143
11	47	13	0	0	60	33
12	40	83	0	77	200	27
13	224	3	100	250	577	189
14	441	87	13	50	590	349
15	0	43	18	6	67	305
16	44	334	77	97	552	62
17	364	133	100	0	598	13
18	0	0	13	0	13	48
19	50	3	20	20	93	30
20	67	7	20	27	120	0
21	159	374	47	30	610	38
22	243	97	113	33	486	207
23	314	67	110	17	508	303
24	117	210	67	120	325	68
25	144	43	17	7	211	229
26	0	0	0	0	0	0
27	143	37	0	20	200	0
28	156	0	13	7	176	267
29	311	187	13	80	590	458
30	0	0	40	0	40	192
31	64	17	0	7	88	210
32	12	0	0	10	22	165
33	39	27	0	60	126	108
34	259	140	43	40	482	308
35	202	83	0	40	325	205
36	54	30	0	227	579	292
37	0	0	0	0	0	0
38	180	23	0	0	203	173

APPENDIX B

Table B-1. Bartlett's Test for Equality of Variances (38 Zones)

Registered Hunters Class	(1) df	(2) Σx^2	(3) s^2	(4) log s^2	(5) (n_i-1) logs^2	(6) $\frac{1}{n_i-1}$
0-1999	17	1,885,291.41	55077.987	4.740978083	80.596627	0.058823529
2000-3999	5	655,135.33	131,027.067	5.11736102	25.5868051	0.20
4000-10,000	6	34,732,707.00	1,244,636.286	6.0950424	36.570254	0.166
Totals	28	37,273,134.00			0.4248235	
Pooling			323,545.65	5.5099356	142.75369	

Chi-square = 2.3026 $\{[\Sigma(n_i-1)] \log s^2 - [\Sigma\ (n_i-1) \log si^2]\}$

= 2.3026 ((28) 5.5099356 - 142.75369) = (154.278 1968 - 142.75369)

= 2.3026 (11.524507)

= 26.536329

Chi-square = $_{.01\ [2]}$ = 9.21

Chi-square = $_{.05\ [2]}$ = 5.99

Calculated chi-square > critical chi values therefore the variances of the three classes are not equal.

APPENDIX C

Table C-1: Travel Distances (Kilometers) by Road Between Traffic Zone Centroids

To Zone

From Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0.5	215	224	362	353	436	426	489	526	505	508	667	592	596	699	646	589	668	532
2	215	0.5	178	151	162	174	279	478	337	316	319	403	320	895	397	335	410	523	358
3	224	178	0.5	209	145	246	32	299	336	315	318	402	319	293	395	343	409	522	361
4	362	151	209	0.5	70	151	66	178	230	209	201	290	208	177	278	226	293	406	244
5	353	162	145	70	0.5	143	69	178	232	211	194	293	233	191	294	240	337	382	356
6	436	174	246	151	143	0.5	93	73	75	105	62	112	267	242	348	291	357	399	117
7	426	279	32	66	69	93	0.5	143	201	175	143	282	195	169	275	219	285	397	163
8	489	478	299	178	178	73	143	0.5	65	39	133	102	318	293	398	342	408	448	127
9	526	337	336	230	232	75	201	65	0.5	57	142	129	376	351	456	304	80	197	136
10	505	316	315	209	211	105	175	39	57	0.5	132	438	351	325	430	393	394	506	144
11	508	319	318	201	194	62	143	133	142	132	0.5	405	318	292	399	360	408	521	91
12	667	403	402	290	293	112	282	102	129	438	405	0.5	117	212	150	85	80	185	448
13	592	320	319	208	233	267	195	318	376	351	318	117	0.5	126	111	46	120	146	388
14	596	895	293	177	191	242	169	293	351	325	292	212	126	0.5	206	149	181	294	335
15	699	397	395	278	294	348	275	398	456	430	399	150	111	206	0.5	87	153	266	442
16	646	335	343	226	240	291	219	342	304	393	360	85	46	149	87	0.5	56	169	435
17	589	410	409	293	337	357	285	408	80	394	408	80	120	181	153	56	0.5	113	498
18	668	523	522	406	382	399	397	448	197	506	521	185	146	294	266	169	113	0.5	564
19	532	358	361	244	356	117	163	127	136	144	91	448	388	335	442	435	498	564	0.5
20	1142	585	585	469	482	603	462	541	642	654	549	336	297	392	250	237	318	406	592
21	642	408	419	297	323	370	295	375	475	487	362	169	130	225	83	70	172	199	424
22	678	455	441	351	355	395	334	415	499	506	402	189	150	265	129	109	211	323	464
23	834	607	606	497	511	563	498	571	674	684	577	321	325	231	286	228	367	483	621
24	716	497	496	366	392	444	448	102	553	562	456	244	204	284	144	146	247	265	500
25	802	495	494	377	391	441	369	449	549	562	456	236	204	300	164	144	250	359	499
26	984	762	760	644	567	714	1053	784	1303	1249	732	406	477	572	307	417	477	595	762
27	740	451	450	460	477	539	466	192	644	656	129	230	301	385	259	241	304	411	562
28	848	629	502	522	525	577	503	234	748	616	511	268	354	495	167	279	361	497	554
29	882	665	663	546	562	612	538	265	783	667	136	308	410	494	259	316	415	534	659
30	952	730	511	612	562	720	1022	297	816	1180	662	374	517	540	346	384	316	563	619
31	908	690	689	572	592	725	580	311	830	692	251	350	423	516	252	360	418	534	797
32	981	758	756	644	653	765	620	351	870	735	298	415	744	581	317	425	490	603	866
33	929	574	573	595	610	744	599	329	935	804	328	455	528	621	354	379	445	554	907
34	1073	1055	922	825	838	986	840	571	1090	959	518	611	681	759	545	621	723	801	1061
35	1175	762	761	637	650	811	737	396	915	784	308	435	511	601	277	446	512	625	887
36	1073	868	867	736	750	884	743	474	988	810	421	549	563	679	355	531	548	703	964
37	856	641	639	456	467	588	389	537	638	689	552	340	330	425	219	270	304	440	625
38	1035	805	804	695	600	765	1105	373	892	838	1253	277	590	657	429	528	554	647	814

From Zone	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	1142	642	678	834	716	802	984	740	848	882	952	908	981	929	1073	1175	1073	856	1035
2	585	408	455	607	497	495	762	451	629	665	730	690	758	574	1055	762	868	641	805
3	585	419	441	606	496	494	760	450	502	663	511	689	756	573	922	761	867	639	804
4	469	297	351	497	366	377	644	460	522	546	612	572	644	595	825	637	736	456	695
5	482	323	355	511	392	391	567	477	525	562	562	592	653	610	838	650	750	467	600
6	603	370	395	563	444	441	714	539	577	612	720	725	765	744	986	811	884	588	765
7	462	295	334	498	448	369	1053	466	503	538	1022	580	620	599	840	737	743	389	1105
8	541	375	415	571	102	449	784	192	234	265	297	311	351	329	571	396	474	537	373
9	642	475	499	674	553	549	1303	644	748	783	816	830	870	935	1090	915	988	638	892
10	654	487	506	684	562	562	1249	656	616	667	1180	692	735	804	959	784	810	689	838
11	549	362	402	577	456	456	732	129	511	136	662	251	298	328	518	308	421	552	1253
12	336	169	189	321	244	236	406	230	268	308	374	350	415	455	611	435	549	340	277
13	297	130	150	325	204	204	477	301	354	410	517	423	744	528	681	511	563	330	590
14	392	225	265	231	284	300	572	385	495	494	540	516	581	621	759	601	679	425	657
15	250	83	129	286	144	164	307	259	167	259	346	252	317	354	545	277	355	219	429
16	237	70	109	228	146	144	417	241	279	316	384	360	425	379	621	446	531	270	528
17	318	172	211	367	247	250	477	304	361	415	316	418	490	445	723	512	548	304	554
18	406	199	323	483	265	359	595	411	497	534	563	534	603	554	801	625	703	440	647
19	592	424	464	621	500	499	762	562	554	659	619	797	866	907	1061	887	964	625	814
20	0.5	206	289	402	344	99	595	458	472	526	602	537	602	552	834	623	701	75	685
21	206	0.5	122	270	136	113	409	233	292	328	396	372	433	392	633	458	536	166	378
22	289	122	0.5	206	91	211	357	182	220	274	324	301	366	320	597	387	464	157	407
23	402	270	206	0.5	248	352	393	218	320	293	360	336	401	356	633	420	492	478	436
24	344	136	91	248	0.5	231	339	223	260	297	365	341	406	360	603	427	505	360	448
25	99	113	211	352	231	0.5	497	321	359	397	465	486	551	505	697	522	599	129	335
26	595	409	357	393	339	497	0.5	264	160	230	108	211	1103	166	472	297	305	773	184
27	458	233	182	218	223	321	264	0.5	143	163	263	223	304	258	492	308	403	391	281
28	472	292	220	320	260	359	160	143	0.5	93	127	159	236	190	431	257	334	789	210
29	526	328	274	293	297	397	230	163	93	0.5	181	151	223	131	418	644	321	826	264
30	602	396	324	360	365	465	108	263	127	181	0.5	224	289	242	313	323	387	785	83
31	537	372	301	336	341	486	211	223	159	151	224	0.5	49	40	282	99	245	570	307
32	602	433	366	401	406	551	1103	304	236	223	289	49	0.5	79	155	344	246	481	372
33	552	392	320	356	360	505	166	258	190	131	242	40	79	0.5	261	86	163	880	326
34	834	633	597	633	603	697	472	492	431	418	313	282	155	261	0.5	200	292	1167	396
35	623	458	387	420	427	522	297	308	257	644	323	99	344	86	200	0.5	116	957	233
36	701	536	464	492	505	599	305	403	334	321	387	245	246	163	292	116	0.5	1064	470
37	75	166	157	478	360	129	773	391	789	826	785	570	481	880	1167	957	1064	0.5	820
38	685	378	407	436	448	335	184	281	210	264	83	307	372	326	396	233	470	820	0.5

Total: +05

Table C-2: Travel Times (Hours) by Road Between Traffic Zone Centroids

From Zone \ To Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	0.5	2.6	3.0	4.4	4.4	5.2	5.5	5.7	6.1	6.2	5.9	7.8	6.9	6.9	8.2	7.5	6.9	10.2	6.7	15.5	7.9	8.0	10.0	9.1	9.8	12.7	9.2	9.8	10.0	10.7	10.2	11.2	10.6	12.0	13.3	12.9	12.0	11.8
2	2.6	0.5	2.5	2.1	2.1	2.2	3.4	5.5	4.0	4.1	3.8	4.9	3.9	10.1	4.7	3.9	4.8	8.7	4.7	7.4	4.8	5.3	7.2	6.7	5.7	10.2	6.1	7.4	7.6	8.2	7.7	8.5	6.7	11.9	8.6	10.6	9.6	9.2
3	3.0	2.5	0.5	3.1	2.0	3.1	0.6	3.6	4.0	4.1	3.8	4.9	3.9	3.4	4.7	4.1	4.8	8.7	4.8	7.4	5.4	5.2	7.2	6.7	5.7	10.2	6.1	6.0	7.6	5.8	7.7	8.4	6.7	10.4	8.6	10.6	9.6	9.2
4	4.4	2.1	3.1	0.5	1.4	2.4	1.1	2.4	2.9	3.0	2.6	3.7	2.6	2.3	3.6	2.9	3.7	7.6	3.6	6.2	4.1	4.5	6.3	5.3	4.5	9.0	6.3	6.3	6.4	7.0	6.5	7.5	7.0	9.4	7.1	9.3	7.5	8.1
5	4.4	2.1	2.0	1.4	0.5	2.2	1.3	2.6	3.0	3.2	2.7	3.7	2.9	2.6	3.9	3.2	4.3	5.3	5.0	6.6	4.6	4.6	6.7	5.8	4.8	8.3	6.4	6.5	6.6	6.6	7.1	7.6	7.4	9.7	7.8	9.6	7.4	7.3
6	5.2	2.2	3.1	2.4	2.2	0.5	1.3	1.0	1.1	1.8	0.8	1.6	3.4	3.0	4.4	3.5	4.3	7.5	2.2	7.7	4.7	4.7	7.1	6.1	5.1	9.7	7.2	6.9	7.1	8.2	8.4	8.8	8.5	11.2	9.4	10.9	9.2	8.9
7	5.5	3.4	0.6	1.1	1.3	1.3	0.5	1.7	2.4	2.5	1.9	3.6	2.5	2.1	3.6	2.7	3.5	7.4	2.6	6.2	3.9	4.1	6.6	6.2	4.2	13.5	6.3	6.1	6.2	11.5	6.7	7.1	6.9	9.5	8.5	9.3	6.9	12.6
8	5.7	5.5	3.6	2.4	2.6	1.0	1.7	0.5	0.9	1.0	2.1	1.6	3.9	3.6	4.9	4.1	4.9	7.3	2.2	7.0	4.8	5.0	7.2	2.2	5.2	10.4	3.3	3.0	3.0	3.4	3.7	4.1	4.0	6.5	4.7	6.4	7.7	4.5
9	6.1	4.0	4.0	2.9	3.0	1.1	2.4	0.9	0.5	1.2	1.9	1.9	4.6	4.2	5.5	3.7	1.3	5.2	2.3	3.1	5.9	5.7	8.3	7.2	6.2	16.2	8.2	3.7	9.0	9.2	9.5	9.9	10.8	12.3	10.5	12.0	8.8	10.3
10	6.2	4.1	4.1	3.0	3.2	1.8	2.5	1.0	1.2	0.5	2.6	5.6	4.6	4.2	5.6	5.1	5.0	8.9	2.4	8.5	6.4	6.1	8.8	7.7	6.8	16.0	8.7	7.1	7.9	13.6	3.1	8.6	9.6	11.2	9.3	9.0	9.9	10.1
11	5.9	3.8	3.8	2.6	2.7	0.8	1.9	2.1	1.9	2.6	0.5	5.0	3.9	3.5	5.1	4.5	4.9	8.9	1.9	7.1	4.1	4.7	7.3	6.3	5.3	9.9	2.6	6.2	1.9	7.5	2.9	3.6	4.1	6.0	3.8	5.9	8.0	14.4
12	7.8	4.9	4.9	3.7	3.7	1.6	3.6	1.6	1.9	5.6	5.0	0.5	1.9	2.8	2.4	1.3	1.4	4.9	6.0	4.8	2.3	2.5	4.1	4.0	2.7	6.5	3.9	3.6	3.9	4.5	4.4	5.1	5.6	7.2	5.3	7.5	5.9	3.3
13	6.9	3.9	3.9	2.6	2.9	3.4	2.5	3.9	4.6	4.6	3.9	1.9	0.5	1.8	1.9	0.8	1.3	2.3	5.5	4.3	2.2	2.0	4.4	3.5	2.5	7.1	4.6	4.1	5.0	6.0	5.1	3.7	5.3	7.8	6.1	7.5	5.7	7.0
14	6.9	10.1	3.4	2.3	2.6	3.0	2.1	3.6	4.2	4.2	3.5	2.8	1.8	0.5	2.7	1.9	2.2	6.1	1.5	5.2	3.2	3.3	3.4	4.1	3.5	8.1	5.3	6.1	5.7	6.1	6.1	5.3	7.3	3.5	6.9	8.7	6.6	7.6
15	8.2	4.7	4.7	3.6	3.9	4.4	3.6	4.9	5.5	5.6	5.1	2.4	1.9	2.7	0.5	1.5	2.2	6.2	6.1	4.0	1.3	2.1	4.2	2.9	2.3	5.4	4.2	2.6	5.5	4.2	3.4	4.1	4.6	5.6	3.7	5.6	4.5	5.3
16	7.5	3.9	4.1	2.9	3.2	3.5	2.7	4.1	3.7	5.1	4.5	1.3	0.8	1.9	1.5	0.5	1.0	4.9	5.7	3.6	1.5	1.7	3.3	2.8	1.8	6.4	3.8	3.5	3.3	4.4	4.3	5.0	4.5	7.1	5.3	7.2	5.0	6.2
17	6.9	4.8	4.8	3.7	4.3	4.3	3.5	4.9	1.3	5.0	4.9	1.4	1.8	2.2	2.2	1.0	0.5	3.9	6.5	4.0	2.8	2.8	4.9	3.9	3.1	6.9	4.2	4.5	5.0	3.7	4.9	5.3	5.3	8.3	6.1	7.3	5.3	6.6
18	10.2	8.7	8.7	7.6	5.3	7.5	7.4	7.8	5.2	8.9	8.9	4.9	2.3	6.1	6.2	4.9	3.9	0.5	9.9	8.0	3.3	6.5	9.0	4.3	7.1	11.1	8.5	8.7	9.0	9.1	9.0	9.7	9.1	12.0	10.0	11.9	9.4	10.4
19	6.7	4.7	4.8	3.6	5.0	2.2	2.6	2.2	2.3	2.4	1.9	6.0	5.5	4.5	6.1	5.7	6.5	9.9	0.5	8.0	5.9	6.1	8.2	7.3	6.3	10.8	7.7	7.2	8.2	7.6	9.7	10.4	11.1	12.6	10.7	12.5	9.3	9.9
20	15.5	7.4	7.4	6.2	6.6	7.7	6.2	7.0	8.1	8.5	7.1	4.8	4.3	5.2	4.0	3.6	4.0	8.0	8.0	0.5	3.6	4.3	5.9	5.7	2.0	9.0	6.9	6.4	6.8	7.4	6.9	7.6	7.1	10.2	7.8	9.7	3.0	8.6
21	7.9	4.8	5.4	4.1	4.6	4.7	3.9	4.8	5.9	6.4	4.1	2.8	2.2	3.2	1.8	1.5	2.8	3.3	5.9	3.6	0.5	2.1	4.0	3.1	1.9	6.6	4.2	4.1	4.4	5.0	4.9	5.4	5.1	7.6	5.8	7.5	2.0	5.0
22	8.0	5.3	5.2	4.5	4.6	4.7	4.1	5.0	5.7	6.1	4.7	2.6	2.0	3.3	2.1	1.7	2.8	6.5	6.1	4.3	2.1	0.5	3.3	2.3	3.1	5.9	3.4	3.0	3.5	3.9	3.7	4.4	4.1	7.0	4.8	6.5	3.5	5.1
23	10.0	7.2	7.2	6.3	6.7	7.1	6.6	7.2	8.3	8.8	7.3	4.1	4.4	3.4	4.2	3.3	4.9	9.0	8.2	5.9	4.0	3.3	0.5	4.4	4.6	6.6	4.1	4.6	4.1	4.6	4.6	5.3	4.9	7.7	5.3	6.9	7.7	5.7
24	9.1	6.7	6.7	5.3	5.8	6.1	6.2	2.2	7.2	7.7	6.3	4.0	3.5	4.1	2.9	2.8	3.9	4.3	7.3	5.7	3.1	2.3	4.4	0.5	3.6	5.1	4.5	4.3	4.5	5.0	5.0	5.7	5.2	7.8	5.9	7.8	6.8	6.2
25	9.8	5.7	5.7	4.5	4.8	5.1	4.2	5.2	6.2	6.8	5.3	2.7	2.5	3.5	2.3	1.8	3.1	7.1	6.3	2.0	1.9	3.1	4.6	3.6	0.5	7.2	4.6	4.4	4.6	5.3	5.7	6.4	5.8	7.8	6.0	7.8	3.2	4.0
26	12.7	10.2	10.2	9.0	8.3	9.7	13.5	10.4	16.2	16.0	9.9	6.5	7.1	8.1	5.4	6.4	6.9	11.1	10.8	9.0	6.6	5.9	6.6	5.1	7.2	0.5	5.2	3.7	4.4	2.8	4.1	14.0	3.6	6.9	5.1	4.4	12.0	3.9
27	9.2	6.1	6.1	6.3	6.4	7.2	6.3	3.3	8.2	8.7	2.6	3.9	4.6	5.3	4.2	3.8	4.2	8.5	7.7	6.9	4.2	3.4	4.1	4.5	4.6	5.2	0.5	2.9	3.0	3.9	3.7	4.7	4.1	6.2	4.6	6.5	7.2	3.6
28	9.8	7.4	6.0	6.3	6.5	6.9	6.1	3.0	8.7	7.1	6.2	3.6	4.1	6.1	2.6	3.5	4.5	8.7	7.2	6.4	4.1	3.0	4.6	4.3	4.4	3.7	2.9	0.5	1.5	1.7	1.9	3.0	2.7	5.2	3.4	5.1	10.9	3.0
29	10.0	7.6	7.6	6.4	6.6	7.1	6.2	3.0	9.0	7.9	1.9	3.9	5.0	5.7	5.5	3.8	5.0	9.0	8.2	6.8	4.4	3.5	4.1	4.5	4.6	4.4	3.0	1.5	0.5	2.2	1.3	2.8	1.8	4.9	7.5	4.8	11.1	3.4
30	10.7	8.2	5.8	7.0	6.6	8.2	11.5	3.4	9.2	13.6	7.5	4.5	6.0	6.1	4.2	4.4	3.7	9.1	7.6	7.4	5.0	3.9	4.6	5.0	5.3	2.8	3.9	1.7	2.2	0.5	2.7	3.3	2.9	3.5	3.7	5.3	10.5	1.1
31	10.2	7.7	7.7	6.5	7.1	8.4	6.7	3.7	9.5	8.1	2.9	4.4	5.1	6.1	3.4	4.3	4.9	9.0	9.7	6.9	4.9	3.7	4.6	5.0	5.7	4.1	3.7	1.9	1.8	2.7	0.5	0.7	0.8	3.4	1.3	5.8	8.2	3.8
32	11.2	8.5	8.4	7.5	7.6	8.8	7.1	4.1	9.9	8.6	3.6	5.1	8.7	6.8	4.1	5.0	5.8	9.7	10.4	7.6	5.4	4.4	5.3	5.7	6.4	14.0	4.7	3.0	2.8	3.3	0.7	0.5	1.2	2.1	4.2	4.0	7.2	4.5
33	10.6	6.7	6.7	7.0	7.4	8.5	6.9	4.0	10.8	9.6	4.1	5.6	6.3	7.3	4.6	4.5	5.3	9.1	11.1	7.1	5.1	4.1	4.9	5.2	5.8	3.6	4.1	2.7	1.8	2.3	0.8	1.2	0.5	3.2	1.3	3.0	11.6	4.2
34	12.0	11.9	10.4	9.4	9.7	11.2	9.5	6.5	12.3	11.2	6.0	7.2	7.8	8.5	6.6	7.1	8.3	12.0	12.6	10.2	7.6	7.0	7.7	7.8	7.8	6.9	6.2	5.2	4.9	3.5	3.4	2.1	3.2	0.5	2.5	4.5	14.8	4.7
35	13.3	8.6	8.6	7.1	7.8	9.4	8.5	4.7	10.5	9.3	3.8	5.3	6.1	6.9	3.7	5.3	6.1	10.0	10.7	7.8	5.3	4.8	5.3	5.9	6.0	5.1	4.6	3.4	7.5	3.7	1.3	4.2	1.3	2.5	0.5	2.5	12.5	3.0
36	12.9	10.6	10.6	9.3	9.6	10.9	9.3	6.4	12.0	9.0	5.9	7.5	7.5	8.7	5.6	7.2	7.3	11.9	12.5	9.7	7.5	6.5	6.9	7.8	7.8	4.4	6.5	5.1	4.8	5.3	5.8	4.0	3.0	4.5	2.5	0.5	14.8	6.6
37	12.0	9.6	9.6	7.5	7.4	9.2	6.9	7.7	8.8	9.9	8.0	5.9	5.7	6.6	4.5	5.0	5.3	9.4	9.3	3.0	2.0	3.5	7.7	6.8	3.2	12.0	7.2	10.9	11.1	10.5	8.2	7.2	11.6	14.8	12.5	14.8	0.5	11.1
38	11.8	9.2	9.2	8.1	7.3	8.9	12.6	4.5	10.3	10.1	14.4	3.3	7.0	7.6	5.3	6.2	6.6	10.4	9.9	8.6	5.0	5.1	5.7	6.2	4.0	3.9	3.6	3.0	3.4	1.1	3.8	4.5	4.2	4.7	3.0	6.6	11.1	0.5

Table C-3: Origin - Destination Trip Data For Base Year (1988)

To Zone

From Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	306	19	219	139	147	15	64	85	34	11	129	0	6	5	1	0	11	14	26
2	1	66	756	14	11	4	3	2	2	3	6	0	0	1	0	0	0	0	2
3	1	0	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	147	498	151	12	140	9	3	0	10	1	15	4	0	1	1	0	6
5	0	0	9	30	73	1	23	6	9	0	11	0	0	0	0	0	0	0	3
6	4	0	48	336	291	844	531	499	246	79	420	32	107	5	58	200	26	24	31
7	0	1	13	37	10	9	156	5	3	1	22	1	3	0	1	0	2	0	1
8	0	0	0	2	43	7	265	40	15	212	0	0	0	0	0	0	0	0	5
9	0	0	0	0	0	0	0	26	85	5	6	0	0	0	0	0	0	0	0
10	0	0	0	1	0	2	1	29	433	635	63	1	0	0	1	0	0	10	93
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	18	41	34	0	0	1	5	6	0
13	0	0	0	7	0	0	6	0	0	0	16	26	71	1	3	5	29	20	4
14	3	3	128	264	8	0	22	5	0	1	43	23	243	497	2	3	19	86	6
15	0	0	18	36	0	2	4	2	0	2	53	57	241	22	372	123	49	29	5
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	28	301
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	13	40	2	17	13	4	2	1	80	34	29	15	31	16	213	101	6
23	0	0	6	9	1	0	0	6	2	3	22	13	30	11	5	4	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	3
26	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	2	0	4	3	0	0	0	0	2	0	15	8	64	2	0	6	5	17	0
29	1	2	43	47	3	2	7	8	3	4	78	38	21	5	3	3	84	130	12
30	0	0	0	5	0	0	0	0	0	1	7	3	5	0	0	0	11	20	16
31	0	0	0	3	0	0	0	0	2	2	6	1	2	2	0	1	0	7	0
32	0	0	1	0	0	0	0	0	0	0	3	2	0	0	0	0	0	1	2
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	1	2	10	9	1	4	7	8	2	1	53	26	18	6	2	2	39	79	12
35	0	2	39	37	2	12	19	24	16	10	67	50	41	7	14	47	143	195	14
36	0	0	4	3	0	1	0	0	2	0	0	0	0	0	0	1	3	0	2
37	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	48
38	0	0	3	3	0	2	0	1	1	0	0	8	3	0	2	0	24	48	11
Total		95	1505	1525	744	935	1261	761	866	973	1128	365	935	583	495	413	665	815	611

From Zone	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Total
1	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	40	0	1279
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0	909
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	46
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	1009
5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	166
6	16	30	6	9	8	10	1	8	7	2	0	0	3	3	1	1	4	55	0	3945
7	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	14	0	280
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	595
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	124
10	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	28	0	1300
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	108
13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	193
14	2	3	1	0	2	2	0	0	0	0	0	0	0	0	0	0	0	47	0	1413
15	113	229	4	1	16	50	2	6	0	0	0	0	1	0	0	0	1	42	0	1480
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	352
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	77	124	304	37	110	115	2	18	0	1	0	0	0	0	0	0	0	51	0	1456
23	71	8	25	387	237	19	0	10	19	2	0	0	0	1	0	0	2	23	0	916
24	9	0	10	14	58	5	0	0	0	0	0	1	0	0	0	0	0	7	0	104
25	243	4	0	0	2	296	48	2	0	1	0	0	0	0	0	0	0	156	0	759
26	1	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	1	0	24
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	17	1	0	14	34	2	66	75	106	7	0	0	0	2	0	0	0	53	0	505
29	7	4	2	19	138	18	32	189	145	279	2	72	34	27	3	2	52	176	0	1695
30	11	0	0	2	12	7	69	1	32	0	37	4	2	0	0	0	8	52	2	307
31	0	0	0	0	3	2	0	4	1	0	0	61	70	4	1	0	7	13	0	192
32	1	0	0	0	0	0	1	0	0	0	0	5	76	10	0	2	4	2	0	110
33	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
34	18	0	1	2	81	6	13	10	1	3	0	46	93	144	208	13	230	61	0	1212
35	69	25	11	85	360	45	43	105	34	27	1	19	94	138	22	305	868	121	0	3111
36	0	1	0	0	0	2	3	0	0	0	0	0	4	7	0	1	432	16	0	482
37	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	149	0	204
38	16	0	0	1	8	42	38	27	70	1	44	2	11	2	1	0	14	52	58	493
Total	675	432	[illegible]	572	1069	626	340	455	415	323	84	212	388	338	236	324	1622	1241	60	
																		Grand Total		24778

Statisti s: Mean: 34.1 Variance: 21972 Standard Deviatio 184 Coefficient of Variation: 3.98

Table C-4: Hunter Origin-Destination Expected Cell Frequencies:(Contingency Table)

From Zone \ To Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Total
1	16	12	1	13	2	51	4	8	2	17	0	1	2	18	19	0	0	0	5	0	0	19	12	1	10	0	0	7	22	4	2	1	0	16	40	6	3	6	320
2	5	3	0	4	1	15	1	2	0	5	0	0	1	5	6	0	0	0	1	0	0	6	4	0	3	0	0	2	7	1	1	0	0	5	12	2	1	2	95
3	78	55	3	61	10	240	17	36	8	79	0	7	12	86	90	0	0	0	21	0	0	88	56	6	46	1	0	31	103	19	12	7	0	74	189	29	12	30	1506
4	79	56	3	62	10	243	17	37	8	80	0	7	12	87	91	0	0	0	22	0	0	90	56	6	47	1	0	31	104	19	12	7	0	75	192	30	13	30	1527
5	38	27	1	30	5	118	8	18	4	39	0	3	6	42	44	0	0	0	11	0	0	44	28	3	23	1	0	15	51	9	6	3	0	36	93	14	6	15	741
6	48	34	2	38	6	149	11	22	5	49	0	4	7	53	56	0	0	0	13	0	0	55	35	4	29	1	0	19	64	12	7	4	0	46	117	18	8	19	935
7	65	46	2	51	8	201	14	30	6	66	0	5	10	72	75	0	0	0	18	0	0	74	47	5	39	1	0	26	86	16	10	6	0	62	158	25	10	25	1259
8	39	28	1	31	5	121	9	18	4	40	0	3	6	43	45	0	0	0	11	0	0	45	28	3	23	1	0	16	52	9	6	3	0	37	96	15	6	15	759
9	45	32	2	35	6	138	10	21	4	45	0	4	7	49	52	0	0	0	12	0	0	51	32	4	27	1	0	18	59	11	7	4	0	42	109	17	7	17	868
10	50	36	2	40	7	155	11	23	5	51	0	4	8	56	53	0	0	0	14	0	0	57	36	4	30	1	0	20	67	12	8	4	0	48	122	19	8	19	975
11	53	41	2	48	8	180	13	27	6	59	0	5	9	64	67	0	0	0	16	0	0	66	42	5	35	1	0	23	77	14	9	5	0	55	142	22	9	22	1128
12	19	13	1	15	2	58	4	9	2	19	0	2	3	21	22	0	0	0	5	0	0	21	13	2	11	0	0	7	25	5	3	2	0	18	46	7	3	7	365
13	48	34	2	38	6	149	11	22	5	49	0	4	7	53	56	0	0	0	13	0	0	55	35	4	29	1	0	19	64	12	7	4	0	46	117	18	8	19	935
14	30	21	1	24	4	93	7	14	3	31	0	3	5	33	35	0	0	0	8	0	0	34	22	2	18	1	0	12	40	7	5	3	0	29	73	11	5	12	586
15	26	18	1	20	3	79	6	12	2	26	0	2	4	28	30	0	0	0	7	0	0	29	18	2	15	0	0	10	34	6	4	2	0	24	62	10	4	10	494
16	21	15	1	17	3	66	5	10	2	22	0	2	3	24	25	0	0	0	6	0	0	24	15	2	13	0	0	8	28	5	3	2	0	20	52	8	3	8	413
17	34	24	1	27	4	106	8	16	3	35	0	3	5	38	40	0	0	0	9	0	0	39	25	3	20	1	0	14	46	8	5	3	0	33	84	13	5	13	665
18	42	30	2	33	5	130	9	20	4	43	0	4	6	47	49	0	0	0	12	0	0	48	30	3	25	1	0	17	56	10	6	4	0	40	102	16	7	16	817
19	32	22	1	25	4	97	7	15	3	32	0	3	5	35	37	0	0	0	9	0	0	36	23	3	19	1	0	12	42	8	5	3	0	30	77	12	5	12	615
20	35	25	1	28	5	108	8	16	3	35	0	3	5	39	40	0	0	0	10	0	0	40	25	3	21	1	0	14	46	8	5	3	0	33	85	13	6	13	677
21	22	16	1	18	3	69	5	10	2	23	0	2	3	25	26	0	0	0	6	0	0	26	16	2	13	0	0	9	30	5	3	2	0	21	55	8	4	9	434
22	19	13	1	15	2	58	4	9	2	19	0	2	3	21	22	0	0	0	5	0	0	21	13	2	11	0	0	7	25	5	3	2	0	18	46	7	3	7	365
23	30	21	1	23	4	91	6	14	3	30	0	2	4	33	34	0	0	0	8	0	0	34	21	2	18	1	0	12	39	7	4	3	0	28	72	11	5	11	572
24	55	39	2	44	7	170	12	26	5	56	0	5	8	61	64	0	0	0	15	0	0	63	40	4	33	1	0	22	73	13	8	5	0	52	134	21	9	21	1068
25	32	23	1	25	4	100	7	15	3	33	0	3	5	36	37	0	0	0	9	0	0	37	23	3	19	1	0	13	43	8	5	3	0	31	79	12	5	12	627
26	18	12	1	14	2	54	4	8	2	18	0	1	3	19	20	0	0	0	5	0	0	20	13	1	10	0	0	7	23	4	3	2	0	17	43	7	3	7	341
27	23	17	1	19	3	72	5	11	2	24	0	2	4	26	27	0	0	0	6	0	0	27	17	2	14	0	0	9	31	6	4	2	0	22	57	9	4	9	455
28	21	15	1	17	3	66	5	10	2	22	0	2	3	24	25	0	0	0	6	0	0	24	15	2	13	0	0	8	28	5	3	2	0	20	52	8	3	8	413
29	17	12	1	13	2	51	4	8	2	17	0	1	3	18	19	0	0	0	5	0	0	19	12	1	10	0	0	7	22	4	3	1	0	16	41	6	3	6	324
30	4	3	0	3	1	13	1	2	0	4	0	0	1	5	5	0	0	0	1	0	0	5	3	0	3	0	0	2	6	1	1	0	0	4	11	2	1	2	84
31	11	8	0	9	1	34	2	5	1	11	0	1	2	12	13	0	0	0	3	0	0	12	8	1	6	0	0	4	15	3	2	1	0	10	27	4	2	4	212
32	20	14	1	16	3	62	4	9	2	20	0	2	3	22	23	0	0	0	6	0	0	23	14	2	12	0	0	8	27	5	3	2	0	19	49	8	3	8	390
33	17	12	1	14	2	54	4	8	2	18	0	1	3	19	20	0	0	0	5	0	0	20	12	1	10	0	0	7	23	4	3	2	0	17	42	7	3	7	338
34	12	9	0	10	2	38	3	6	1	12	0	1	2	13	14	0	0	0	3	0	0	14	9	1	7	0	0	5	16	3	2	1	0	12	30	5	2	5	238
35	17	12	1	13	2	52	4	8	2	17	0	1	3	18	19	0	0	0	5	0	0	19	12	1	10	0	0	7	22	4	3	1	0	16	41	6	3	6	325
36	84	60	3	66	11	258	18	39	8	85	0	7	13	93	97	0	0	0	23	0	0	95	60	7	50	2	0	33	111	20	13	7	0	79	204	32	13	32	1623
37	64	46	2	51	8	198	14	30	6	65	0	5	10	71	74	0	0	0	18	0	0	73	46	5	38	1	0	25	85	15	10	6	0	61	156	24	10	25	1242
38	3	2	0	2	0	10	1	1	0	3	0	0	0	3	4	0	0	0	1	0	0	4	2	0	2	0	0	1	4	1	0	0	.0	3	8	1	0	1	57
Total:	1277	906	48	1010	164	3947	283	595	124	1299	0	107	196	1412	1480	0	0	0	353	0	0	1457	918	102	762	21	0	507	1696	308	196	112	0	1215	3115	483	205	490	Grand Total: 24788

Statistics: Mean: 17.16 Variance: 819.89 Standard Deviation: 28.63 Coefficient of Variation: 1.66

Table C-5: Chi-square Cell Values for Test of Independence

From Zone	To Zone 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	16.00	12.00	1.00	13.00	2.00	51.00	4.00	8.00	2.00	17.00		1.00	2.00	18.00	19.00				5.00
2	5.00	3.00		4.00	1.00	15.00	1.00	2.00		5.00			1.00	5.00	6.00				1.00
3	78.00	55.00	3.00	61.00	10.00	240.00	17.00	36.00	8.00	79.00		7.00	12.00	86.00	90.00				21.00
4	79.00	56.00	3.00	62.00	10.00	243.00	17.00	37.00	8.00	80.00		7.00	12.00	87.00	91.00				22.00
5	38.00	27.00	1.00	30.00	5.00	118.00	8.00	18.00	4.00	39.00		3.00	6.00	42.00	44.00				11.00
6	48.00	34.00	2.00	38.00	6.00	149.00	11.00	22.00	5.00	49.00		4.00	7.00	53.00	56.00				13.00
7	65.00	46.00	2.00	51.00	8.00	201.00	14.00	30.00	6.00	66.00		5.00	10.00	72.00	75.00				18.00
8	39.00	28.00	1.00	31.00	5.00	121.00	9.00	18.00	4.00	40.00		3.00	6.00	43.00	45.00				11.00
9	45.00	32.00	2.00	35.00	6.00	138.00	10.00	21.00	4.00	45.00		4.00	7.00	49.00	52.00				12.00
10	50.00	36.00	2.00	40.00	7.00	155.00	11.00	23.00	5.00	51.00		4.00	8.00	56.00	58.00				14.00
11	58.00	41.00	2.00	46.00	8.00	180.00	13.00	27.00	6.00	59.00		5.00	9.00	64.00	67.00				16.00
12	19.00	13.00	1.00	15.00	2.00	58.00	4.00	9.00	2.00	19.00		2.00	3.00	21.00	22.00				5.00
13	48.00	34.00	2.00	38.00	6.00	149.00	11.00	22.00	5.00	49.00		4.00	7.00	53.00	56.00				13.00
14	30.00	21.00	1.00	24.00	4.00	93.00	7.00	14.00	3.00	31.00		3.00	5.00	33.00	35.00				8.00
15	26.00	18.00	1.00	20.00	3.00	79.00	6.00	12.00	2.00	26.00		2.00	4.00	28.00	30.00				7.00
16	21.00	15.00	1.00	17.00	3.00	66.00	5.00	10.00	2.00	22.00		2.00	3.00	24.00	25.00				6.00
17	34.00	24.00	1.00	27.00	4.00	106.00	8.00	16.00	3.00	35.00		3.00	5.00	38.00	40.00				9.00
18	42.00	30.00	2.00	33.00	5.00	130.00	9.00	20.00	4.00	43.00		4.00	6.00	47.00	49.00				12.00
19	32.00	22.00	1.00	25.00	4.00	97.00	7.00	15.00	3.00	32.00		3.00	5.00	35.00	37.00				9.00
20	35.00	25.00	1.00	28.00	5.00	108.00	8.00	16.00	3.00	35.00		3.00	5.00	39.00	40.00				10.00
21	22.00	16.00	1.00	18.00	3.00	69.00	5.00	10.00	2.00	23.00		2.00	3.00	25.00	26.00				6.00
22	19.00	13.00	1.00	15.00	2.00	58.00	4.00	9.00	2.00	19.00		2.00	3.00	21.00	22.00				5.00
23	30.00	21.00	1.00	23.00	4.00	91.00	6.00	14.00	3.00	30.00		2.00	4.00	33.00	34.00				8.00
24	55.00	39.00	2.00	44.00	7.00	170.00	12.00	26.00	5.00	56.00		5.00	8.00	61.00	64.00				15.00
25	32.00	23.00	1.00	25.00	4.00	100.00	7.00	15.00	3.00	33.00		3.00	5.00	36.00	37.00				9.00
26	18.00	12.00	1.00	14.00	2.00	54.00	4.00	8.00	2.00	18.00		1.00	3.00	19.00	20.00				5.00
27	23.00	17.00	1.00	19.00	3.00	72.00	5.00	11.00	2.00	24.00		2.00	4.00	26.00	27.00				6.00
28	21.00	15.00	1.00	17.00	3.00	66.00	5.00	10.00	2.00	22.00		2.00	3.00	24.00	25.00				6.00
29	17.00	12.00	1.00	13.00	2.00	51.00	4.00	8.00	2.00	17.00		1.00	3.00	18.00	19.00				5.00
30	4.00	3.00		3.00	1.00	13.00	1.00	2.00		4.00			1.00	5.00	5.00				1.00
31	11.00	8.00		9.00	1.00	34.00	2.00	5.00	1.00	11.00		1.00	2.00	12.00	13.00				3.00
32	20.00	14.00	1.00	16.00	3.00	62.00	4.00	9.00	2.00	20.00		2.00	3.00	22.00	23.00				6.00
33	17.00	12.00	1.00	14.00	2.00	54.00	4.00	8.00	2.00	18.00		1.00	3.00	19.00	20.00				5.00
34	12.00	9.00		10.00	2.00	38.00	3.00	6.00	1.00	12.00		1.00	2.00	13.00	14.00				3.00
35	17.00	12.00	1.00	13.00	2.00	52.00	4.00	8.00	2.00	17.00		1.00	3.00	18.00	19.00				5.00
36	84.00	60.00	3.00	66.00	11.00	258.00	18.00	39.00	8.00	85.00		7.00	13.00	93.00	97.00				23.00
37	64.00	46.00	2.00	51.00	8.00	198.00	14.00	30.00	6.00	65.00		5.00	10.00	71.00	74.00				18.00
38	3.00	2.00		2.00		10.00	1.00	1.00		3.00				3.00	4.00				1.00
Total:	1277	906	48	1010	164	3947	283	595	124	1299	0	107	196	1412	1480	0	0	0	353

From Zone	To Zone 20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Total
1			19.00	12.00	1.00	10.00			7.00	22.00	4.00	2.00	1.00		16.00	40.00	6.00	3.00	6.00	320
2			6.00	4.00		3.00			2.00	7.00	1.00	1.00			5.00	12.00	2.00	1.00	2.00	95
3			88.00	56.00	6.00	46.00	1.00		31.00	103.00	19.00	12.00	7.00		74.00	189.00	29.00	12.00	30.00	1506
4			90.00	56.00	6.00	47.00	1.00		31.00	104.00	19.00	12.00	7.00		75.00	192.00	30.00	13.00	30.00	1527
5			44.00	28.00	3.00	23.00	1.00		15.00	51.00	9.00	6.00	3.00		36.00	93.00	14.00	6.00	15.00	741
6			55.00	35.00	4.00	29.00	1.00		19.00	64.00	12.00	7.00	4.00		46.00	117.00	18.00	8.00	19.00	935
7			74.00	47.00	5.00	39.00	1.00		26.00	86.00	16.00	10.00	6.00		62.00	158.00	25.00	10.00	25.00	1259
8			45.00	28.00	3.00	23.00	1.00		16.00	52.00	9.00	6.00	3.00		37.00	96.00	15.00	6.00	15.00	759
9			51.00	32.00	4.00	27.00	1.00		18.00	59.00	11.00	7.00	4.00		42.00	109.00	17.00	7.00	17.00	868
10			57.00	36.00	4.00	30.00	1.00		20.00	67.00	12.00	8.00	4.00		48.00	122.00	19.00	8.00	19.00	975
11			66.00	42.00	5.00	35.00	1.00		23.00	77.00	14.00	9.00	5.00		55.00	142.00	22.00	9.00	22.00	1128
12			21.00	13.00	2.00	11.00			7.00	25.00	5.00	3.00	2.00		18.00	46.00	7.00	3.00	7.00	365
13			55.00	35.00	4.00	29.00	1.00		19.00	64.00	12.00	7.00	4.00		46.00	117.00	18.00	8.00	19.00	935
14			34.00	22.00	2.00	18.00	1.00		12.00	40.00	7.00	5.00	3.00		29.00	73.00	11.00	5.00	12.00	586
15			29.00	18.00	2.00	15.00			10.00	34.00	6.00	4.00	2.00		24.00	62.00	10.00	4.00	10.00	494
16			24.00	15.00	2.00	13.00			8.00	28.00	5.00	3.00	2.00		20.00	52.00	8.00	3.00	8.00	413
17			39.00	25.00	3.00	20.00	1.00		14.00	46.00	8.00	5.00	3.00		33.00	84.00	13.00	5.00	13.00	665
18			48.00	30.00	3.00	25.00	1.00		17.00	56.00	10.00	6.00	4.00		40.00	102.00	16.00	7.00	16.00	817
19			36.00	23.00	3.00	19.00	1.00		12.00	42.00	8.00	5.00	3.00		30.00	77.00	12.00	5.00	12.00	615
20			40.00	25.00	3.00	21.00	1.00		14.00	46.00	8.00	5.00	3.00		33.00	85.00	13.00	6.00	13.00	677
21			26.00	16.00	2.00	13.00			9.00	30.00	5.00	3.00	2.00		21.00	55.00	8.00	4.00	9.00	434
22			21.00	13.00	2.00	11.00			7.00	25.00	5.00	3.00	2.00		18.00	46.00	7.00	3.00	7.00	365
23			34.00	21.00	2.00	18.00	1.00		12.00	39.00	7.00	4.00	3.00		28.00	72.00	11.00	5.00	11.00	572
24			63.00	40.00	4.00	33.00	1.00		22.00	73.00	13.00	8.00	5.00		52.00	134.00	21.00	9.00	21.00	1068
25			37.00	23.00	3.00	19.00	1.00		13.00	43.00	8.00	5.00	3.00		31.00	79.00	12.00	5.00	12.00	627
26			20.00	13.00	1.00	10.00			7.00	23.00	4.00	3.00	2.00		17.00	43.00	7.00	3.00	7.00	341
27			27.00	17.00	2.00	14.00			9.00	31.00	6.00	4.00	2.00		22.00	57.00	9.00	4.00	9.00	455
28			24.00	15.00	2.00	13.00			8.00	28.00	5.00	3.00	2.00		20.00	52.00	8.00	3.00	8.00	413
29			19.00	12.00	1.00	10.00			7.00	22.00	4.00	3.00	1.00		16.00	41.00	6.00	3.00	6.00	324
30			5.00	3.00		3.00			2.00	6.00	1.00	1.00			4.00	11.00	2.00	1.00	2.00	84
31			12.00	8.00	1.00	6.00			4.00	15.00	3.00	2.00	1.00		10.00	27.00	4.00	2.00	4.00	212
32			23.00	14.00	2.00	12.00			8.00	27.00	5.00	3.00	2.00		19.00	49.00	8.00	3.00	8.00	390
33			20.00	12.00	1.00	10.00			7.00	23.00	4.00	3.00	2.00		17.00	42.00	7.00	3.00	7.00	338
34			14.00	9.00	1.00	7.00			5.00	16.00	3.00	2.00	1.00		12.00	30.00	5.00	2.00	5.00	238
35			19.00	12.00		10.00			7.00	22.00	4.00	3.00	1.00		16.00	41.00		3.00	6.00	318
36			95.00	60.00	7.00	50.00	2.00		33.00	111.00	20.00	13.00	7.00		79.00	204.00	32.00	13.00	32.00	1623
37			73.00	46.00	5.00	38.00	1.00		25.00	85.00	15.00	10.00	6.00		61.00	156.00	24.00	10.00	25.00	1242
38			4.00	2.00		2.00			1.00	4.00	1.00				3.00	8.00	1.00		1.00	57
Total:	0	0	1457	918	101	762	21	0	507	1696	308	196	112	0	1215	3115	477	205	490	

Grand Total: 485719.6

Table C-6: Trip Distribution by the Gravity Model Using the Distance Variable for the Base Year - Iteration 1

To Zone

From Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	16	4	77	78	38	48	65	39	44	50	58	18	48	30	25	21	34	42	31
2	11	3	55	55	27	34	46	27	31	35	41	13	34	21	18	15	24	29	22
3	0	0	2	2	1	1	2	1	1	1	2	0	1	1	0	0	1	1	1
4	12	3	61	62	30	38	51	30	35	39	45	14	38	23	20	16	27	33	24
5	2	0	10	10	4	6	8	5	5	6	7	2	6	3	3	2	4	5	4
6	50	15	239	242	118	148	200	121	137	154	179	58	148	92	78	65	106	129	97
7	3	1	17	17	8	10	14	8	9	10	12	4	10	6	5	4	7	9	6
8	7	2	36	36	17	22	30	18	20	23	27	8	22	13	11	9	15	19	14
9	1	0	7	7	3	4	6	3	4	4	5	1	4	2	2	2	3	4	3
10	16	4	78	80	39	49	66	39	45	51	59	19	49	30	25	21	34	42	32
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1	0	6	6	3	4	5	3	3	4	4	1	4	2	2	1	2	3	2
13	2	0	11	11	5	7	9	5	6	7	8	2	7	4	3	3	5	6	4
14	18	5	85	86	42	53	71	43	49	55	64	20	53	33	28	23	37	46	34
15	19	5	89	91	44	55	75	45	51	58	67	21	55	34	29	24	39	48	36
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	4	1	21	21	10	13	17	10	12	13	16	5	13	8	7	5	9	11	8
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	18	5	88	89	43	54	74	44	50	57	66	21	54	34	29	24	39	47	35
23	11	3	55	56	27	34	46	28	32	35	41	13	34	21	18	15	24	30	22
24	1	0	6	6	3	3	5	3	3	4	4	1	3	2	2	1	2	3	2
25	9	2	46	46	22	28	38	23	26	29	34	11	28	17	15	12	20	24	18
26	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	6	1	30	31	15	19	25	15	17	19	23	7	19	11	10	8	13	16	12
29	21	6	102	104	50	63	86	52	59	66	77	24	63	39	33	28	45	55	41
30	3	1	18	18	9	11	15	9	10	12	13	4	11	7	6	5	8	10	7
31	2	0	11	11	5	7	9	5	6	7	8	2	7	4	3	3	5	6	4
32	1	0	6	6	3	4	5	3	3	4	5	1	4	2	2	1	2	3	2
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	15	4	73	74	36	45	61	37	42	47	55	17	45	28	24	20	32	39	29
35	40	11	188	191	93	117	158	95	108	122	141	45	117	73	62	51	83	102	76
36	6	1	29	29	14	18	24	14	16	18	21	7	18	11	9	8	12	15	11
37	2	0	12	12	6	7	10	6	7	8	9	3	7	4	4	3	5	6	5
38	6	1	29	30	14	18	25	15	17	19	22	7	18	11	9	8	13	16	12
Total:	303	78	1488	1508	729	920	1247	746	848	957	1114	349	920	566	482	398	650	799	594

From Zone	20	21	22	23	24	25	26	27	28	29	30	31	33	34	35	36	37	38	Total
1	34	22	18	29	55	32	17	23	21	16	4	10	17	12	16	83	64	3	1262
2	24	15	13	20	39	22	12	16	15	11	3	7	12	8	11	59	45	2	859
3	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	3	2	0	27
4	27	17	14	23	43	25	13	18	16	13	3	8	13	9	13	66	50	2	959
5	4	2	2	3	7	4	2	3	2	2	0	1	2	1	2	10	8	0	149
6	107	69	57	91	170	99	54	72	66	51	13	33	53	37	51	258	197	9	3924
7	7	4	4	6	12	7	3	5	4	3	0	2	3	2	3	18	14	0	261
8	16	10	8	13	25	15	8	10	9	7	2	5	8	5	7	38	29	1	574
9	3	2	1	2	5	3	1	2	2	1	0	1	1	1	1	8	6	0	106
10	35	22	19	30	56	32	17	23	21	16	4	11	17	12	16	85	65	3	1252
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	2	1	1	2	4	2	1	1	1	1	0	0	1	1	1	7	5	0	88
13	5	3	2	4	8	4	2	3	3	2	0	1	2	1	2	12	9	0	171
14	38	24	20	32	60	35	19	25	23	18	4	12	19	13	18	92	70	3	1392
15	40	25	21	34	63	37	20	27	24	19	5	12	20	14	19	96	74	3	1461
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	9	6	5	8	15	8	4	6	5	4	1	3	4	3	4	23	17	0	334
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	39	25	21	33	62	36	19	26	24	18	4	12	19	13	19	95	72	3	1433
23	24	16	13	21	39	23	12	16	15	11	3	7	12	8	11	59	45	2	896
24	2	1	1	2	4	2	1	1	1	1	0	0	1	0	1	6	5	0	84
25	20	13	11	17	32	19	10	13	12	9	2	6	10	7	9	49	38	1	737
26	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	7
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	13	8	7	11	21	12	6	9	8	6	1	4	6	4	6	33	25	1	485
29	46	29	24	39	73	42	23	31	28	22	5	14	23	16	22	110	84	4	1675
30	8	5	4	7	13	7	4	5	5	4	1	2	4	2	4	20	15	0	291
31	5	3	2	4	8	4	2	3	3	2	0	1	2	1	2	12	9	0	171
32	3	1	1	2	4	2	1	2	1	1	0	0	1	1	1	7	5	0	91
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33	21	17	27	52	30	16	22	20	15	4	10	16	11	15	79	60	2	1191
35	84	54	45	71	134	78	42	57	52	40	10	26	42	29	40	203	155	7	3090
36	13	8	7	11	20	12	6	8	8	6	1	4	6	4	6	31	24	1	464
37	5	3	2	4	8	5	2	3	3	2	0	1	2	1	2	13	10	0	185
38	13	8	7	11	21	12	6	9	8	6	1	4	6	4	6	32	24	1	476
Total:	660	417	347	558	1055	610	323	439	400	307	71	197	322	220	308	1608	1227	48	

StatisticS: Mean: 16.75 Variance: 30586 Stand rd Deviatio 28.5 Coefficient of Variation: 1.7 Grand Total: 24185

Table C-7: Differences Between Trips of the O-D Data and the Gravity Model Using the Distance Variable for the Base Year - Iteration 1

From Zone \ To Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31,	32	33	34	35	36	37	38	Total
1	290	15	142	61	109	-33	-1	46	-10	-39	71	-18	-40	-25	-24	-21	-23	-28	-3	-34	-22	-18	-29	-55	-29	-16	-23	-21	-16	-4	-10	-20	-17	-12	-16	-83	-24	-3	17
2	-10	63	701	-41	-16	-30	-43	-25	-29	-32	-35	-13	-34	-20	-18	-15	-24	-29	-20	-24	-15	-13	-20	-39	-22	-12	-16	-15	-11	-3	-7	-14	-12	-8	-11	-59	-7	-2	20
3	1	0	42	-2	-1	-1	-2	-1	-1	-1	-2	0	-1	-1	0	0	-1	-1	-1	-1	0	0	-1	-1	-1	0	0	0	0	0	0	0	0	0	0	-3	-1	0	19
4	-12	-3	86	436	121	-26	89	-21	-32	-39	-35	-13	-23	-19	-20	-15	-26	-33	-18	-27	-17	-14	-23	-43	-25	-13	-18	-16	-13	-3	-8	-15	-13	-9	-13	-66	-39	-2	20
5	-2	0	-1	20	69	-5	15	1	4	-6	4	-2	-6	-3	-3	-2	-4	-5	-1	-4	-1	-2	-3	-7	-4	-2	-3	-2	-2	0	-1	-2	-2	-1	-2	-10	-8	0	17
6	-46	-15	-191	94	173	696	331	378	109	-75	241	-26	-41	-87	-20	135	-80	-105	-66	-91	-39	-51	-82	-162	-89	-53	-64	-59	-49	-13	-33	-58	-50	-36	-50	-254	-142	-9	21
7	-3	0	-4	20	2	-1	142	-3	-6	-9	10	-3	-7	-6	-4	-4	-5	-9	-5	-7	-4	-4	-6	-12	-7	-3	-5	-4	-3	0	-1	-4	-3	-2	-3	-18	0	0	19
8	-7	-2	-36	-34	26	-15	235	22	-5	189	-27	-8	-22	-13	-11	-9	-15	-19	-9	-16	-10	-8	-13	-25	-15	-8	-10	-9	-7	-2	-5	-9	-8	-5	-7	-38	-23	-1	21
9	-1	0	-7	-7	-3	-4	-6	23	81	1	1	-1	-4	-2	-2	-2	-3	-4	-3	-3	-2	-1	-2	-5	-3	-1	-2	-2	-1	0	-1	-1	-1	-1	-1	-8	-4	0	18
10	-16	-4	-78	-79	-39	-47	-65	-10	388	584	4	-18	-49	-30	-24	-21	-34	-32	61	-35	-21	-19	-30	-56	-30	-17	-23	-21	-16	-4	-11	-20	-17	-12	-16	-85	-37	-3	18
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	-1	0	-6	-6	-3	-4	-5	-3	-3	-4	14	40	30	-2	-2	0	3	3	-2	-1	0	-1	-1	-4	-2	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-7	-5	0	20
13	-2	0	-11	-4	-5	-7	-3	-5	-6	-7	8	24	64	-3	0	2	24	14	0	-4	-3	-2	-4	-8	-4	-2	-3	-3	-2	0	-1	-3	-2	-1	-2	-12	-5	0	22
14	-15	-2	43	178	-34	-53	-49	-38	-49	-54	-21	3	190	464	-26	-20	-18	40	-28	-36	-21	-19	-32	-58	-33	-19	-25	-23	-18	-4	-12	-22	-19	-13	-18	-92	-23	-3	21
15	-19	-5	-71	-55	-44	-53	-71	-43	-51	-56	-14	36	186	-12	343	99	10	-19	-31	73	204	-17	-33	-47	13	-18	-21	-24	-19	-5	-12	-22	-20	-14	-19	-95	-32	-3	19
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	-4	-1	-21	-21	-10	-13	-17	-8	-12	-12	-16	-5	-13	-8	-7	-5	-9	17	293	-9	-6	-5	-8	-15	-8	-4	-6	-5	-4	-1	-3	-5	-4	-3	-4	-23	3	0	18
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	-18	-5	-75	-49	-41	-37	-61	-40	-48	-56	14	13	-25	-19	2	-8	174	54	-29	38	99	283	4	48	79	-17	-8	-24	-17	-4	-12	-22	-19	-13	-19	-95	-21	-3	23
23	-11	-3	-49	-47	-26	-34	-46	-22	-30	-32	-19	0	-4	-10	-13	-11	-24	-30	-22	47	-8	12	366	198	-4	-12	-6	4	-9	-3	-7	-14	-11	-8	-11	-57	-22	-2	20
24	-1	0	-6	-6	-3	-3	-5	-3	-3	-4	-4	-1	-3	-2	-2	-1	-2	-3	-2	7	-1	9	12	54	3	-1	-1	-1	-1	0	1	-1	-1	0	-1	-6	2	0	20
25	-9	-2	-46	-44	-21	-28	-38	-23	-26	-29	-34	-11	-28	-17	-15	-12	-19	-24	-15	223	-9	-11	-17	-30	277	38	-11	-12	-8	-2	-6	-11	-10	-7	-9	-49	118	-1	22
26	0	0	-1	-1	0	1	-1	0	0	0	-1	0	0	0	0	0	0	0	0	1	0	0	0	-1	0	121	0	0	0	0	0	0	0	0	0	-1	0	0	17
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	-4	-1	-26	-28	-15	-19	-25	-15	-15	-19	-8	1	45	-9	-10	-2	-8	1	-12	4	-7	-7	3	13	-10	60	66	98	1	-1	-4	-7	-4	-4	-6	-33	28	-1	20
29	-20	-4	-59	-57	-47	-61	-79	-44	-56	-62	1	14	-42	-34	-30	-25	39	75	-29	-39	-25	-22	-20	65	-24	9	158	117	257	-3	58	8	4	-13	-20	-58	92	-4	20
30	-3	-1	-18	-13	-9	-11	-15	-9	-10	-11	-6	-1	-6	-7	-6	-5	3	10	9	3	-5	-4	-5	-1	0	65	-4	27	-4	36	2	-2	-4	-2	-4	-12	37	2	16
31	-2	0	-11	-8	-5	-7	-9	-5	-4	-5	-2	-1	-5	-2	-3	-2	-5	1	-4	-5	-3	-2	-4	-5	-2	-2	1	-2	-2	0	60	67	2	0	-2	-5	4	0	21
32	-1	0	-5	-6	-3	-4	-5	-3	-3	-4	-2	1	-4	-2	-2	-1	-2	-2	0	-2	-1	-1	-2	-4	-2	0	-2	-1	-1	0	5	75	9	-1	1	-3	-3	0	19
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
34	-14	-2	-63	-65	-35	-41	-54	-29	-40	-46	-2	9	-27	-22	-22	-18	7	40	-17	-15	-21	-16	-25	29	-24	-3	-12	-19	-12	-4	36	75	128	197	-2	151	1	-2	21
35	-40	-9	-149	-154	-91	-105	-139	-71	-92	-112	-74	5	-76	-66	-48	-4	60	93	-62	-15	-29	-34	14	226	-33	1	48	-18	-13	-9	-7	46	96	-7	265	665	-34	-7	21
36	-6	-1	-25	-26	-14	-17	-24	-14	-14	-18	-21	-7	-18	-11	-9	-7	-9	-15	-9	-13	-6	-7	-11	-20	-10	-3	-8	-8	-6	-1	-4	-3	1	-4	-5	401	-8	-1	18
37	-2	0	-12	-12	-6	-7	-10	-6	-3	-7	-9	-3	-7	-4	-4	-3	-5	-6	43	-3	-3	-2	-4	-8	-5	-2	-3	-3	-2	0	-1	-3	-2	-1	-2	-13	139	0	19
38	-6	-1	-26	-27	-14	-16	-25	-14	-16	-19	-22	1	-15	-11	-7	-8	11	32	-1	3	-8	-7	-10	-13	30	32	18	62	-5	43	-2	4	-4	-3	-6	-18	28	57	17
Total	16	17	17	17	15	15	14	15	18	16	14	16	15	17	13	15	15	16	17	15	15	17	14	14	16	17	16	15	16	13	15	16	16	16	16	14	14	12	

StatisticS: Mean: 0.41 Variance: 3573 Standard Deviatio 59.78 Coefficient of Variation: 148 Grand Total: 585

Table C-8: Chi-square Cell Values Between Origin -Destination Trip Data and Gravity Model Using Distance Variable in Base Year (1988)

To Zone (zones 1–10)

From Zone	1	2	3	4	5	6	7	8	9	10
1	5256.25	56.25	281.87	47.71	312.66	22.69	0.02	54.26	2.27	30.42
2	9.09	1323.00	8934.56	33.56	9.48	26.47	40.20	23.15	27.13	29.26
3			882.00	2.00	1.00	1.00	2.00	1.00	1.00	1.00
4	12.00	3.00	121.25	3068.08	488.03	17.79	155.31	14.70	29.26	39.00
5	2.00		0.10	40.00	1190.25	4.17	28.13	0.20	3.20	6.00
6	42.32	15.00	152.84	36.51	253.84	3273.08	547.81	1180.86	86.72	36.53
7	3.00	0.00	0.94	23.53	0.50	0.10	1440.29	1.13	4.00	8.10
8	7.00	2.00	36.00	32.11	39.76	10.23	1840.83	26.89	1.25	1553.09
9	1.00		7.00	7.00	3.00	4.00	6.00	176.33	1640.25	0.25
10	16.00	4.00	78.00	78.01	[illegible]	45.08	64.02	2.56	3345.42	6687.37
11										
12	1.00		6.00	6.00	3.00	4.00	5.00	3.00	3.00	4.00
13	2.00		11.00	1.45	5.00	7.00	1.00	5.00	6.00	7.00
14	12.50	0.80	21.75	368.42	27.52	63.00	33.82	33.58	49.00	53.02
15	19.00	5.00	58.64	33.24	44.00	51.07	67.21	41.09	51.00	54.07
16										
17										
18										
19	4.00		21.00	21.00	10.00	13.00	17.00	6.40	12.00	11.08
20		1.00								
21										
22	18.00	5.00	63.92	26.98	39.09	25.35	50.28	36.36	46.08	55.02
23	11.00	3.00	43.85	39.45	25.04	34.00	46.00	17.29	28.13	29.26
24	1.00		6.00	6.00	3.00	3.00	5.00	3.00	3.00	4.00
25	9.00	2.00	46.00	42.09	20.05	28.00	38.00	23.00	26.00	29.00
26			1.00	1.00			1.00			
27										
28	2.67	1.00	22.53	25.29	15.00	19.00	25.00	15.00	13.24	19.00
29	19.05	2.67	34.13	31.24	44.15	39.06	72.57	37.23	53.15	58.24
30	3.00	1.00	18.00	9.39	9.00	11.00	15.00	9.00	10.00	10.08
31	2.00		11.00	5.82	5.00	7.00	9.00	5.00	2.67	3.57
32	1.00		4.17	6.00	3.00	4.00	5.00	3.00	3.00	4.00
33										
34	13.07	1.00	54.37	57.09	34.03	37.38	47.80	22.73	38.10	45.02
35	40.00	7.36	118.09	124.17	89.04	94.23	122.28	53.06	78.37	102.82
36	6.00	1.00	21.55	23.31	14.00	16.06	24.00	14.00	12.25	18.00
37	2.00		12.00	12.00	6.00	7.00	10.00	6.00	1.29	6.13
38	6.00	1.00	23.31	24.30	14.00	14.22	25.00	13.07	15.06	19.00
Total:	5520.94	1435.08	11070.48	4227.73	2747.28	3301.96	4744.56	1827.89	5591.82	8923.31

To Zone (zones 11–20)

From Zone	11	12	13	14	15	16	17	18	19	20
1	66.91	18.00	33.33	20.83	23.04	21.00	15.56	18.67	0.23	34.20
2	29.88	13.00	34.00	19.05	18.00	15.00	24.00	29.00	16.18	24.00
3	2.00		1.00	1.00			1.00	1.00	1.00	1.00
4	27.22	12.07	13.92	15.70	20.00	14.06	25.04	33.00	13.50	27.00
5	2.29	2.00	6.00	3.00	3.00	2.00	4.00	5.00	0.25	4.00
6	324.47	11.66	11.36	82.27	5.13	260.38	60.38	85.47	44.91	77.39
7	8.33	2.25	4.90	6.00	3.20	4.00	3.57	9.00	4.17	7.00
8	27.00	8.00	22.00	13.00	11.00	9.00	15.00	19.00	5.79	16.00
9	0.20	1.00	4.00	2.00	2.00	2.00	3.00	4.00	3.00	3.00
10	0.27	17.05	49.00	30.00	23.04	21.00	34.00	24.38	116.28	35.00
11										
12	49.00	1600.00	225.00	2.00	2.00	0.00	4.50	3.00	2.00	0.50
13	8.00	288.00	585.14	2.25	0.00	1.33	115.20	32.67	0.00	3.20
14	6.89	0.45	681.13	6524.12	24.14	17.39	8.76	34.78	23.08	34.11
15	2.93	61.71	629.02	4.24	4056.66	408.38	2.56	7.52	28.69	133.23
16										
17										
18										
19	16.00	5.00	13.00	8.00	7.00	5.00	9.00	26.27	10731.13	9.00
20										
21										
22	2.97	8.05	11.57	10.62	0.14	2.67	776.31	62.04	24.03	37.03
23	6.80	0.00	0.47	4.76	9.39	8.07	24.00	30.00	22.00	92.04
24	4.00	1.00	3.00	2.00	2.00	1.00	2.00	3.00	2.00	24.50
25	34.00	11.00	28.00	17.00	15.00	12.00	18.05	24.00	12.50	2486.45
26	1.00									
27										
28	2.78	0.14	106.58	7.36	10.00	0.50	4.92	0.06	12.00	1.23
29	0.01	8.17	28.00	29.64	27.27	22.32	33.80	102.27	20.51	33.07
30	2.77	0.25	3.27	7.00	6.00	5.00	1.13	10.00	11.57	1.13
31	0.50	0.50	3.57	1.00	3.00	1.33	5.00	0.17	4.00	5.00
32	0.80	1.00	4.00	2.00	2.00	1.00	2.00	1.33	0.00	1.33
33										
34	0.07	4.76	16.20	17.29	20.17	16.20	1.53	41.03	9.97	6.82
35	38.84	0.56	49.37	59.67	37.16	0.31	43.37	84.79	50.58	2.68
36	21.00	7.00	18.00	11.00	9.00	6.13	6.75	15.00	7.36	13.00
37	9.00	3.00	7.00	4.00	4.00	3.00	5.00	6.00	369.80	1.80
38	22.00	0.14	12.50	11.00	5.44	8.00	9.31	64.00	0.08	0.69
Total:	739.94	2085.76	2604.34	6917.80	4348.99	888.07	1258.73	776.45	11536.64	3115.15

To Zone (zones 21–30)

From Zone	21	22	23	24	25	26	27	28	29	30
1	22.00	18.00	29.00	55.00	28.28	15.08	23.00	21.00	16.00	4.00
2	15.00	13.00	20.00	39.00	22.00	12.00	16.00	15.00	11.00	3.00
3			1.00	1.00	1.00					
4	17.00	14.00	23.00	43.00	25.00	13.00	18.00	16.00	13.00	3.00
5	0.50	2.00	3.00	7.00	4.00	2.00	3.00	2.00	2.00	
6	22.04	45.63	73.89	154.38	80.01	52.02	58.89	52.74	47.08	13.00
7	4.00	4.00	6.00	12.00	7.00	3.00	5.00	4.00	3.00	
8	10.00	8.00	13.00	25.00	15.00	3.00	10.00	9.00	7.00	2.00
9	2.00	1.00	2.00	5.00	3.00	1.00	2.00	2.00	1.00	
10	20.05	19.00	30.00	56.00	28.13	17.00	23.00	21.00	18.00	4.00
11										
12	0.00	1.00	0.50	4.00	2.00	1.00	1.00	1.00	1.00	
13	3.00	2.00	4.00	8.00	4.00	2.00	3.00	3.00	2.00	
14	18.38	15.05	32.00	56.07	31.11	19.00	25.00	23.00	18.00	4.00
15	1664.64	13.78	32.03	35.06	4.57	16.20	16.33	24.00	19.00	5.00
16										
17										
18										
19	6.00	5.00	6.00	15.00	6.00	4.00	6.00	5.00	4.00	1.00
20										
21										
22	392.04	3813.76	0.48	37.16	173.36	15.21	2.46	24.00	16.06	4.00
23	4.00	11.08	6378.86	1005.23	0.70	12.00	2.25	1.07	7.36	3.00
24	1.00	81.00	72.00	729.00	4.50	1.00	1.00	1.00	1.00	
25	6.23	11.00	17.00	28.13	4038.37	144.40	9.31	12.00	7.11	2.00
26				1.00						
27										
28	6.13	7.00	0.82	8.05	8.33	600.00	484.00	1200.50	0.17	1.00
29	21.55	20.17	10.26	57.88	13.71	3.52	805.29	488.89	3002.23	1.80
30	5.00	4.00	3.57	0.08	0.00	1056.25	3.20	145.80	4.00	1296.00
31	3.00	2.00	4.00	3.13	1.00	2.00	0.33	1.33	2.00	
32	1.00	1.00	2.00	4.00	2.00	0.00	2.00	1.00	1.00	
33										
34	21.00	15.06	23.15	16.17	19.20	0.56	6.55	18.05	9.60	4.00
35	15.57	25.69	2.76	381.16	13.96	0.02	40.42	6.23	4.23	8.10
36	6.13	7.00	11.00	20.00	8.33	1.50	8.00	8.05	6.00	1.00
37	3.00	2.00	4.00	8.00	5.00	2.00	3.00	3.00	2.00	
38	1.00	7.00	9.09	8.05	75.00	170.67	36.00	480.50	4.17	1849.00
Total:	2296.25	4172.20	6816.41	2822.53	4624.57	2174.41	1612.03	2590.12	3226.99	3208.90

To Zone (zones 31–38 and Total)

From Zone	31	32	33	34	35	36	37	38	Total
1	10.00	20.00	17.00	12.00	16.00	83.00	9.00	3.00	6715.36
2	7.00	14.00	12.00	8.00	11.00	59.00	1.09	2.00	10957.10
3						3.00	0.50		905.50
4	8.00	15.00	13.00	9.00	13.00	66.00	30.42	2.00	4489.33
5	1.00	2.00	2.00	1.00	2.00	10.00	6.00		1357.08
6	33.00	55.15	47.17	35.03	49.02	250.06	102.36	9.00	7786.98
7	0.50	4.00	3.00	2.00	3.00	18.00	0.00		1612.50
8	5.00	9.00	8.00	5.00	7.00	38.00	18.24	1.00	3893.19
9	1.00	1.00	1.00	1.00	1.00	8.00	2.57		1903.70
10	11.00	20.00	17.00	12.00	16.00	85.00	21.38	3.00	11128.73
11									0.00
12		1.00	1.00	1.00	1.00	7.00	5.00		1950.50
13	1.00	3.00	2.00	1.00	2.00	12.00	2.78		1136.03
14	12.00	22.00	19.00	13.00	18.00	92.00	7.36	3.00	8439.41
15	12.00	21.04	20.00	14.00	19.00	94.01	13.34	[illegible]	7782.95
16									3.00
17									0.00
18									0.00
19	3.00	5.00	4.00	3.00	4.00	23.00	0.53		11049.40
20									1.00
21									0.00
22	12.00	22.00	19.00	13.00	19.00	95.00	6.13	3.00	5969.17
23	7.00	14.00	10.08	8.00	11.00	55.07	10.76	2.00	3019.79
24		1.00	1.00		1.00	6.00	0.80		979.80
25	6.00	11.00	10.00	7.00	9.00	49.00	368.42	1.00	7656.10
26						1.00	0.00		6.00
27									0.00
28	4.00	7.00	2.67	4.00	6.00	33.00	31.36	[illegible]	2708.33
29	240.29	2.46	0.70	10.56	18.18	30.58	100.76	4.00	5549.42
30	2.00	1.00	4.00	2.00	4.00	7.20	91.27		2772.95
31	3600.00	1496.33	2.00	0.00	2.00	2.08	1.78		5198.11
32		5625.00	81.00	1.00	1.00	1.29	1.00		5773.72
33									0.00
34	129.60	312.50	1024.00	3528.09	0.27	288.62	0.02	2.00	5903.03
35	1.88	44.08	219.43	1.69	1755.63	2178.45	7.46	7.00	5910.53
36	4.00	1.29	0.17	4.00	4.17	5187.13	2.67	1.00	5545.78
37	1.00	3.00	2.00	1.00	2.00	13.00	1932.10		2461.11
38	1.00	2.29	2.67	2.25	6.00	10.13	32.67	3249.00	6241.59
Total:	4113.27	7735.14	1544.88	3699.62	2001.26	8805.61	2809.01	3296.00	
							Grand Total:		151804.2

Table C-9: Trip Distribution By the Gravity Model Using the Distance Variable for the Base Year- Iteration 2

To Zone (zones 1–19)

From Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	269	9	212	138	82	13	53	97	21	11	183	0	10	7	27	0	15	19	35
2	14	36	662	12	6	7	52	0	2	1	5	0	0	2	0	12	1	0	3
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
4	11	0	105	525	61	33	123	3	9	0	5	0	4	42	4	6	0	28	2
5	3	0	8	28	59	1	17	11	6	0	9	0	0	0	0	0	1	0	0
6	8	3	52	249	231	1464	399	365	205	49	421	9	63	2	27	154	19	12	23
7	1	0	8	38	12	17	113	39	1	1	7	0	3	3	5	0	10	0	0
8	9	0	25	4	29	58	148	154	27	66	56	0	1	0	0	0	0	0	3
9	0	0	4	2	3	7	1	6	46	35	6	0	0	0	0	1	0	0	0
10	2	0	10	0	0	17	10	144	330	548	50	0	0	0	0	25	0	6	87
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	3	0	0	0	0	0	0	0	0	18	41	2	1	1	7	7	2
13	0	0	0	1	0	2	3	0	0	0	3	21	63	14	12	31	22	2	0
14	3	0	119	226	8	1	65	3	1	0	27	23	233	406	11	58	20	62	5
15	13	0	15	24	0	21	109	1	2	1	49	18	231	12	327	77	48	14	2
16	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	5	0	0	4	1	6	2	5	5	65	0	7	2	1	0	9	0	13	163
20	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0
21	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	1	0	14	26	20	11	42	3	2	16	59	24	32	23	23	18	242	82	32
23	0	0	6	4	3	2	0	4	63	1	23	5	20	4	2	16	0	0	8
24	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0
25	0	0	0	1	0	2	7	0	17	0	3	9	3	6	13	0	0	4	2
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
28	0	0	4	2	0	1	0	0	1	0	7	8	24	14	0	1	2	38	0
29	4	5	46	44	4	1	6	4	4	37	83	25	20	3	1	3	47	123	11
30	0	0	2	7	1	1	0	0	0	1	12	5	4	0	0	0	3	32	24
31	0	0	0	0	0	0	0	0	2	0	5	0	0	0	0	0	0	1	0
32	0	0	1	0	2	0	2	0	0	2	0	0	0	0	0	2	0	6	0
33	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
34	0	0	3	12	1	2	7	2	2	0	39	8	17	2	14	3	29	85	11
35	0	1	38	30	53	8	18	16	23	8	49	42	51	5	11	39	141	190	13
36	0	0	3	0	0	1	1	0	1	0	6	3	0	0	0	5	1	1	3
37	1	0	0	1	0	2	4	1	2	3	1	0	1	1	2	0	0	0	2
38	0	0	15	4	0	1	5	1	1	0	0	11	4	0	11	2	25	17	3
Total:	344	54	1359	1382	579	1679	1187	859	773	845	1110	236	827	549	491	469	637	742	434

To Zone (zones 20–38 and Total)

From Zone	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	33	Total
1	0	0	1	0	0	3	0	0	2	4	0	0	0	0	0	0	0	55	0	1266
2	29	0	0	3	0	7	0	0	1	8	0	0	0	0	1	0	0	34	0	898
3	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
4	0	18	2	1	0	0	0	0	0	3	0	0	0	0	1	1	1	4	0	992
5	1	2	1	0	6	0	0	0	0	0	0	0	2	0	0	1	0	0	0	156
6	13	32	9	4	20	6	4	6	3	1	0	0	3	14	1	3	9	45	0	3928
7	0	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	4	0	266
8	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	3	0	586
9	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	116
10	0	8	4	1	0	0	0	0	0	8	0	1	12	0	0	1	0	24	0	1288
11	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	3
12	1	1	1	0	0	2	0	0	1	1	0	0	0	0	0	1	2	0	0	92
13	0	0	1	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	178
14	2	9	13	7	11	14	0	0	27	1	0	1	0	9	1	1	0	30	0	1397
15	109	228	14	3	15	34	1	32	0	0	0	0	0	0	7	3	10	38	2	1460
16	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	6
17	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	6	4	1	1	0	0	0	1	3	0	2	0	2	1	13	16	0	338
20	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
21	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
22	79	43	279	44	135	52	2	26	1	1	15	1	0	6	0	32	0	56	0	1442
23	70	19	16	251	249	22	5	10	6	6	0	19	3	16	1	11	12	22	0	899
24	1	,0	3	15	55	0	4	0	2	2	0	0	0	0	1	3	0	2	0	93
25	236	4	13	15	5	207	46	1	0	1	1	0	9	0	1	4	0	129	2	741
26	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
28	19	4	0	4	27	1	84	29	107	32	8	0	0	7	0	4	0	52	10	490
29	7	2	1	23	146	6	34	203	136	273	7	69	35	29	3	1	52	174	2	1674
30	3	0	19	2	5	9	19	16	35	7	19	8	9	0	0	0	9	27	15	294
31	1	0	0	8	3	0	0	19	0	9	1	15	61	28	6	1	9	10	0	179
32	0	0	0	0	0	2	0	0	0	1	0	22	19	14	7	2	16	0	0	98
33	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5
34	15	9	0	3	86	6	20	4	0	3	0	47	157	157	141	13	245	52	0	1195
35	68	23	68	65	324	36	35	79	29	24	0	17	93	117	23	459	822	79	0	3097
36	1	0	1	1	0	1	3	1	14	1	1	8	4	17	17	24	339	9	0	467
37	1	4	2	2	4	18	0	2	6	1	0	2	0	0	1	1	5	117	1	188
38	14	0	0	1	11	23	61	12	92	0	30	0	9	3	0	0	25	77	19	477
Total:	674	409	455	460	1104	452	322	441	464	388	85	210	419	423	214	569	1569	1061	51	24326

Table C-10: Differences Between Origin - Destination Trip Data and the Gravity Model Using Distance Variable for the Base Year - Iteration 2

From Z \ To Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Total
1	37	10	7	1	65	2	11	-12	13	0	-54	0	-2	-2	-26	0	-4	-5	-7	0	0	-1	0	0	0	1	0	-2	-4	0	0	0	0	0	0	0	-15	0	13
2	-13	30	94	2	5	-3	-49	2	0	2	1	0	0	-1	0	-12	-1	0	-1	-29	0	0	-3	0	-7	0	0	-1	-8	0	0	0	0	-1	0	0	4	0	[illegible]
3	1	0	44	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	1	0	43
4	-11	0	42	-27	90	-21	17	6	-6	0	5	1	11	-38	-4	-5	1	-28	4	0	-18	-2	-1	0	0	0	0	0	-3	0	0	0	0	-1	-1	-1	7	0	17
5	-3	0	1	2	14	0	6	-5	3	0	2	0	0	0	0	0	-1	0	3	-1	-1	-1	0	-6	0	0	0	0	0	0	0	-2	0	0	-1	0	0	0	12
6	-4	-3	-4	87	60	-620	132	134	41	30	-1	23	44	3	31	46	7	12	8	3	-2	-3	5	-12	4	-3	2	4	1	0	0	0	-11	0	-2	-5	10	0	17
7	-1	1	5	-1	-2	-8	43	-34	2	0	15	1	0	-3	-4	0	-8	0	1	0	0	-1	0	0	0	-1	0	0	0	0	1	-1	-1	0	0	0	10	0	14
8	-9	0	-25	-2	14	-51	117	-114	-12	146	-56	0	-1	0	0	0	0	0	2	0	0	0	-1	-1	0	0	0	0	0	0	0	0	0	0	-1	0	3	0	9
9	0	0	-4	-2	-3	-7	-1	20	39	-30	0	0	0	0	0	-1	0	0	0	0	0	0	-1	0	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	5
10	-2	0	-10	1	0	-15	-9	-115	103	87	13	1	0	0	1	-25	0	4	6	0	-7	-4	-1	0	2	0	0	0	-8	0	-1	-12	0	0	-1	0	4	0	12
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	-3
12	0	0	-3	0	0	0	0	0	0	0	18	23	-7	-2	-1	0	-2	-1	-2	0	0	-1	1	0	-2	0	0	-1	-1	0	0	0	0	0	-1	-2	0	0	16
13	0	0	0	6	0	-2	3	0	0	0	13	5	8	-13	-9	-26	7	18	4	1	0	-1	-1	0	0	0	0	-2	0	0	0	0	0	0	0	0	4	0	15
14	0	3	9	38	0	-1	-43	2	-1	1	16	0	10	91	-9	-55	-1	24	1	0	-6	-12	-7	-9	-12	0	0	-27	-1	0	-1	0	-9	-1	-1	0	17	0	16
15	-13	0	3	12	0	-19	-105	1	-2	1	4	39	10	10	45	46	1	15	3	4	1	-10	-2	1	16	1	-26	0	0	0	0	1	0	-7	-3	-9	4	-2	22
16	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	-1	0	0	0	0	0	-1	-1	0	0	0	0	0	-1	0	0	0	0	0	-6
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-3
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	-5	0	0	-4	-1	-6	-2	-3	-5	-64	0	-7	-2	-1	0	-9	0	15	138	0	0	-6	-4	-1	-1	0	0	0	-1	-3	0	-2	0	-2	-1	-13	4	0	14
20	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-4
21	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	-3
22	-1	0	-1	14	-18	6	-29	1	0	-15	21	10	-3	-8	8	-2	-29	19	-26	-2	81	25	-7	-25	63	0	-8	-1	0	-15	-1	0	-6	0	-32	0	-5	0	14
23	0	0	0	5	-2	-2	0	2	-61	2	-1	8	10	7	3	-12	0	0	-8	1	-11	9	136	-12	-3	-5	0	13	-4	0	-19	-3	-15	-1	-11	-10	1	0	17
24	0	0	-1	0	-3	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	8	0	7	-1	3	5	-4	0	-2	-2	0	1	0	0	-1	-3	0	5	0	11
25	0	0	0	1	1	-2	-7	0	-17	0	-3	-9	-3	-6	-13	0	1	-4	1	7	0	-13	-15	-3	89	2	1	0	0	-1	0	-9	0	-1	-4	0	27	-2	18
26	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	-1	-1	0	0	1	0	0	0	0	0	21	0	0	0	0	0	0	-1	0	0	0	1	0	21
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
28	2	0	0	1	0	-1	0	0	1	0	8	0	40	-12	0	5	3	-21	0	-2	-3	0	10	7	1	-18	46	-1	-25	-8	0	0	-5	0	-4	0	1	-10	15
29	-3	-3	-3	3	-1	1	1	4	-1	-33	-5	13	1	2	2	0	37	7	1	0	2	1	-4	-8	12	-2	-14	9	6	-5	3	-1	-2	0	1	0	2	-2	21
30	0	0	-2	-2	-1	-1	0	0	0	0	-5	-2	1	0	0	0	8	-12	-8	8	0	-19	0	7	-2	50	-15	-3	-7	18	-4	-7	0	0	0	-1	25	-13	13
31	0	0	0	3	0	0	0	0	0	2	1	1	2	2	0	1	0	6	0	-1	0	0	-8	0	2	0	-15	1	-9	-1	46	9	-24	-5	-1	-2	3	0	13
32	0	0	0	0	-2	0	-2	0	0	-2	3	2	0	0	0	-2	0	-5	2	1	0	0	0	0	-2	1	0	0	-1	0	-17	57	-4	-7	0	-12	2	0	12
33	0	0	-1	0	0	0	0	0	0	0	-1	0	0	0	0	-1	0	0	0	0	-1	0	0	0	0	-1	0	0	0	0	1	0	0	0	0	0	0	0	-4
34	1	2	7	-3	0	2	0	6	0	1	14	18	1	4	-12	-1	10	-6	1	3	-9	1	-1	-5	0	-7	6	1	0	0	-1	-64	-13	67	0	-15	9	0	17
35	0	1	1	7	-51	4	1	8	-7	2	18	8	-10	2	3	8	2	5	1	1	2	-57	20	36	9	8	26	5	3	1	2	1	21	-1	-154	46	42	0	14
36	0	0	1	3	0	0	-1	0	1	0	-6	-3	0	0	0	-4	2	-1	-1	-1	1	-1	-1	0	1	0	-1	-14	-1	-1	-8	0	-10	-17	-23	93	7	0	15
37	-1	0	0	-1	0	-2	-4	-1	2	-2	-1	0	-1	-1	-2	0	0	0	40	1	-4	-2	-2	-4	-18	0	-2	-6	-1	0	-2	0	0	-1	-1	-5	32	-1	16
38	0	0	-12	-1	0	1	-5	0	0	0	0	-3	-1	0	-9	-2	-1	31	8	2	0	0	0	-3	19	-23	15	-22	1	14	2	2	-1	1	0	-11	-25	39	16
Total	-25	41	146	143	165	-744	74	-98	93	128	18	129	108	34	4	-56	28	73	177	1	23	-91	112	-35	174	18	14	-49	-65	-1	2	-31	-85	22	-245	53	180	9	444

Table C-11: Chi-square Cell Values Between Origin - Destination Trip Data and the Gravity Model Using Distance Variable in the Base Year - Iteration 2

To Zone (columns 1–13)

From Zone	1	2	3	4	5	6	7	8	9	10	11	12	13
1	4.47	5.26	0.22	0.01	28.74	0.27	1.89	1.69	4.97	0.00	22.60		0.50
2	169.00	13.64	11.69	0.29	2.27	2.25	800.33	2.00	0.00	1.33	0.17		
3	1.00		44.00										
4			12.00	1.46	53.64	36.75	2.06	4.00	12.00		2.50	1.00	8.07
5			0.11	0.13	2.68	0.00	1.57	4.17	1.00		0.36		
6	4.00		0.33	22.53	12.37	455.45	32.81	35.98	6.83	11.39	0.00	16.53	18.09
7		1.00	1.92	0.03	0.40	7.11	11.85	231.20	1.33	0.00	10.23	1.00	0.00
8				2.00	4.56	371.57	51.66	324.90	9.60	100.55			
9								15.38	17.89	180.00	0.00		
10				1.00		112.50	31.00	456.03	24.50	11.92	2.68	1.00	
11													
12											18.00	12.90	1.44
13				5.14			1.50				10.56	0.96	0.90
14	0.00	3.00	0.63	5.47	0.00		84.05	0.80		1.00	5.95	0.00	0.41
15			0.50	4.00		180.50	2756.25	0.50		0.50	0.30	26.68	0.41
16													
17													
18													
19								4.50		4096.00			
20													
21													
22			0.08	4.90	162.00	2.12	64.69	0.25	0.00	225.00	5.51	2.94	0.31
23			0.00	2.78	4.00			0.67	1860.50	1.33	0.05	4.92	3.33
24													
25				0.50	1.00								
26						1.00							
27													
28	2.00		0.00	0.33					0.50		4.27	0.00	25.00
29	9.00	4.50	0.21	0.19	0.33	0.50	0.14	2.00	0.33	272.25	0.32	4.45	0.05
30				0.80						0.00	3.57	1.33	0.20
31				3.00					0.00	2.00	0.17	1.00	2.00
32			0.00								3.00	2.00	
33													
34	1.00	2.00	4.90	1.00	0.00	1.00	0.00	4.50	0.00	1.00	3.70	12.46	0.06
35		0.50	0.03	1.32	1300.50	1.33	0.05	2.67	3.06	0.40	4.84	1.28	2.44
36			0.25	3.00		0.00			0.50				
37									1.00	4.00			
38			48.00	0.33		0.50		0.00	0.00			1.13	0.33
Total:	190.47	29.90	124.87	60.22	1572.50	1172.85	3889.86	1091.25	1944.03	4908.68	98.79	91.59	63.55

To Zone (columns 14–26)

From Zone	14	15	16	17	18	19	20	21	22	23	24	25	26
1	0.80	676.00		1.45	1.79	1.75						0.00	1.00
2	1.00					0.50							
3													
4	361.00		25.00	1.00		2.67							
5						3.00		1.00					
6	1.80	16.57	10.58	1.88	6.00	2.05	0.56	0.13	1.50	2.78	13.00	1.60	9.00
7		16.00		32.00		1.00							
8						0.80							
9													
10		1.00			1.50	0.39		49.00				2.00	
11													
12			0.00	0.80	0.17		0.00	0.00		1.00			
13	169.00	27.00	135.20	1.69	15.20	4.00	1.00						
14	16.66	40.50	1008.33	0.05	6.70	0.17	0.00	12.00	144.00		40.50	72.00	
15	4.55	5.44	17.20	0.02	7.76	1.80	0.14	0.00	25.00	4.00	0.05	5.12	0.50
16													
17													
18													
19					8.04	63.27							
20													
21													
22	4.27	2.06	0.25	3.95	3.57	112.67	0.05	52.91	2.06	1.32	5.68	34.51	0.00
23	4.45	1.80	36.00				0.01	15.13	3.24	47.79	0.61	0.47	
24							7.11		4.90	0.07	0.16	5.00	
25				1.00		0.33	0.20				4.50	25.76	0.08
26							1.00						21.00
27								1.00					
28	72.00		4.17	1.80	25.94		0.24	9.00		7.14	1.44	0.50	4.91
29	0.80	1.33	0.00	15.30	0.38	0.08	0.00	1.00	0.50	0.84	0.46	8.00	0.13
30				5.82	7.20	4.00	5.82			0.00	4.08	0.57	36.23
31	2.00		1.00		5.14						0.00	2.00	
32					25.00	2.00	1.00						1.00
33													
34	2.67	72.00	0.50	2.56	0.46	0.08	0.50		1.00	0.50	0.31	0.00	3.77
35	0.57	0.64	1.36	0.03	0.13	0.07	0.01	0.16	236.40	4.71	3.60	1.80	1.49
36			16.00	1.33		0.50		1.00				0.50	0.00
37						44.08	0.50						
38		40.50		0.04	20.02	5.82	0.25			0.00	1.13	8.60	13.92
Total:	641.57	900.85	1255.59	71.73	136.08	251.04	18.40	142.33	418.60	70.16	80.53	169.43	93.03

To Zone (columns 27–38)

From Zone	27	28	29	30	31	32	33	34	35	36	37	38	Total
1											5.63		759.05
2											0.42		1004.89
3											1.00		46.00
4											4.45		527.61
5													14.02
6	0.50	2.29	0.50			0.00	40.33	0.00	4.00	6.25	1.82		744.49
7					1.00						7.14		323.22
8											1.50		867.13
9											0.00		213.25
10											0.57		745.20
11													0.00
12													34.31
13											4.00		377.16
14											6.15		1448.37
15	112.67					1.00				81.00	0.38		3236.30
16													0.00
17													0.00
18													0.00
19											0.80		4172.60
20													0.00
21													0.00
22	3.56		0.00								0.49		695.16
23	0.00	8.89	8.00				225.00			50.00	0.04		2279.03
24					1.00						3.57		21.81
25	0.50		0.00								4.67		39.55
26											1.00		24.00
27													1.00
28	28.21	0.01	89.29				12.50				0.02		289.27
29	1.04	0.56	0.13	12.50	0.13	0.03	0.15	0.00	0.50	0.00	0.02		339.15
30	225.00	0.28		8.76	4.00	24.50				0.13	12.02	84.50	428.81
31	56.25	1.00			34.69	1.16	144.00	25.00		0.57	0.69		231.67
32					57.80	42.75	1.60		0.00	36.00	2.00		174.15
33					1.00								1.00
34	3.60	1.00	0.00		0.02	44.04		21.58	0.00	0.98	1.33		188.52
35	6.44	0.74	0.33	1.00	0.21	0.01	3.20	0.05	77.76	2.44	14.58		1676.13
36						0.00	14.29		529.00	20.02	3.06		589.45
37											6.87		56.46
38	8.33	6.91	1.00	4.45	2.00	0.36	0.50	1.00		8.64	12.02	26.22	212.01
Total:	446.09	21.68	99.25	26.71	101.85	113.85	441.56	47.63	611.26	206.03	96.25	110.72	

Grand Total: 21810.79

Table C-12: Trips by Distance Classes and Related Chi Squares. Iteration No.3.

NO.	% O-D	% GRAVITY	RATIO	TOTAL TRIP O-D	TRIP GRAVITY	TRIP DIFF. (OD-GM)	CHI^2
1	28.47284	30.51779	0.932991	7055	7399	-344	16.00
2	3.07127	0	0	761	0	761	0.00
3	2.24393	1.82239	1.231311	556	442	114	29.50
4	4.51207	0	0	1118	0	1118	0.00
5	9.27839	7.3908	1.255397	2299	1792	507	143.51
6	1.13407	0.05785	19.60363	281	14	267	5081.74
7	7.13536	15.44692	0.461927	1768	3745	-1977	1043.75
8	1.06546	0.7521	1.416646	264	182	82	36.56
9	3.08338	4.67168	0.660015	764	1133	-369	119.99
10	1.7677	4.151	0.425849	438	1006	-568	321.03
11	3.63629	9.34336	0.389184	901	2265	-1364	821.66
12	2.8493	0.13017	21.88906	706	32	674	14412.97
13	2.48204	0.36159	6.864238	615	88	527	3171.98
14	1.17846	3.22534	0.365375	292	782	-490	307.02
15	0.78295	0.01446	54.14591	194	4	191	10350.71
16	0.28654	0.34712	0.825478	71	84	-13	2.06
17	1.11793	0.11571	9.661481	277	28	249	2209.12
18	2.365	0.99798	2.369786	586	242	344	489.18
19	1.35604	1.27278	1.065415	336	309	27	2.44
20	1.82016	3.09517	0.588064	451	750	-299	119.47
21	1.9816	1.186	1.670826	491	288	204	143.96
22	0.34708	0.47729	0.727188	86	116	-30	7.63
23	0.08072	0.01446	5.582295	20	4	17	77.61
24	1.91702	1.27278	1.506167	475	309	166	89.74
25	0.62152	0.88227	0.704455	154	214	-60	16.78
26	0.56098	1.54758	0.362488	139	375	-236	148.71
27	0.83542	0.33266	2.511332	207	81	126	197.93
28	0.6417	0.37605	1.706422	159	91	68	50.46
29	0.70627	0.36159	1.953234	175	88	87	87.00
30	0.29865	0.17356	1.720730	74	42	32	24.21
31	0.71434	1.08476	0.658523	177	263	-86	28.12
32	0.7547	1.73561	0.434832	187	421	-234	129.90
33	1.38429	1.11368	1.242987	343	270	73	19.73
34	0.16951	0.21695	0.781332	42	53	-11	2.14
35	1.0695	1.48973	0.717915	265	361	-96	25.61
36	0.61345	0.33266	1.844075	152	81	71	63.12
37	0.72242	0	0	179	0	179	0.00
38	0.52062	0.92566	0.562431	129	224	-95	40.58
39	1.64662	0.13017	12.64976	408	32	376	4490.12
40	0.33901	0.89673	0.378051	84	217	-133	81.87

Table C-12 (cont'd): Trips by Distance Classes and Related Chi Squares. Iteration No.3.

NO.	% O-D	% GRAVITY	RATIO	% TOTAL TRIP O-D	GRAVITY	TRIP DIFF. (OD-GM)	CHI^2
41	0.89192	0	0	221	0	221	0.00
42	0.31883	0	0	79	0	79	0.00
43	1.19461	0.78102	1.529551	296	189	107	60.06
44	0.04843	0	0	12	0	12	0.00
45	0.25426	0.26034	0.976645	63	63	-0	0.00
46	0.04036	0	0	10	0	10	0.00
47	0.13722	0	0	34	0	34	0.00
48	0.28654	0.11571	2.476363	71	28	43	65.74
49	0.07265	0	0	18	0	18	0.00
50	0.02018	0	0	5	0	5	0.00
51	0.06457	0.02893	2.231939	16	7	9	11.51
52	0.06457	0.1591	0.405845	16	39	-23	13.21
53	0.06457	0.10124	0.637791	16	25	-9	2.98
54	0.11704	0.05785	2.023163	29	14	15	15.99
55	0.1574	0	0	39	0	39	0.00
56	0.12108	0.01446	8.373443	30	4	27	200.24
57	0.20179	0	0	50	0	50	0.00
58	0.29462	0.17356	1.697510	73	42	31	22.72
59	0.01614	0	0	4	0	4	0.00
60	0.0565	0.01446	3.907330	14	4	11	31.41
61	0.00807	0	0	2	0	2	0.00
62	0.00404	0.02893	0.139647	1	7	-6	5.16
63	0	0	0	0	0	0	0.00
64	0	0	0	0	0	0	0.00
65	0	0	0	0	0	0	0.00
66	0	0	0	0	0	0	0.00
67	0	0	0	0	0	0	0.00
68	0	0	0	0	0	0	0.00
69	0	0	0	0	0	0	0.00
70	0	0	0	0	0	0	0.00
						Total	44832.89

CHI^2 0.95,1 = 3.84 CHI^2 0.95,69 = 89.38
CHI^2 0.99,1 = 6.63 CHI^2 0.99,69 = 99.25

APPENDIX D

Table D-1: Estimated Trip Productions and Actual Trip Attractions which were Inputs to the Trip Distribution Model in the Test Year (1990).

Traffic Zone	Estimated Trips Produced	Actual Trips Attracted
1	815	89
2	957	167
3	18	1089
4	990	1333
5	166	612
6	4345	1261
7	309	1031
8	705	1280
9	146	1227
10	1473	655
11	0	1113
12	134	369
13	236	519
14	1220	666
15	1681	762
16	0	965
17	0	1279
18	0	974
19	398	504
20	0	632
21	0	967
22	1843	733
23	1097	669
24	132	816
25	923	735
26	28	292
27	0	332
28	493	480
29	1285	327
30	359	101
31	214	234
32	135	454
33	3668	335
34	1136	201
35	3602	272
36	537	1618
37	222	977
38	519	58

Table D-2: Origin-Destination Trip Data for Test Year (1990)

From Zone \ To Zone	1	2	3	4	5	6	7	8	9	10	11	12	13'	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	TOTAL
1	37	18	63	92	146	17	68	104	49	2	116	0	3	2	1	2	6	16	8	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	815
2	0	148	673	32	6	5	3	3	4	2	13	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	957
3	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	18
4	0	0	121	449	205	13	132	14	5	0	17	6	8	2	0	1	0	4	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	990
5	0	0	4	28	90	0	15	16	4	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	166
6	0	0	35	328	109	1097	567	620	235	47	391	55	70	15	86	366	28	47	23	16	58	2	5	13	7	2	4	8	7	0	1	5	1	0	2	3	12	0	4345
7	0	0	12	45	23	9	167	5	1	1	24	3	3	0	0	0	2	1	2	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	9	0	309
8	0	0	0	0	1	73	14	366	44	3	181	1	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	705
9	0	0	0	1	1	0	0	36	100	2	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	146
10	1	0	0	3	1	2	3	50	658	582	61	0	0	1	2	0	1	0	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	1473
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	3	0	0	0	0	0	12	44	48	0	2	0	17	3	0	0	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	134
13	0	0	0	5	1	0	2	0	0	0	2	29	108	0	7	9	33	33	2	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	236
14	0	0	71	189	2	3	10	6	0	0	39	25	52	600	22	20	45	72	1	11	3	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	45	0	1220
15	0	0	10	19	1	2	1	1	2	0	19	33	87	7	543	317	50	33	0	67	423	3	0	11	11	0	3	1	1	0	0	0	0	0	0	0	31	0	1681
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	1	0	1	4	1	2	0	0	0	0	0	0	0	66	301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	398
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	4	37	2	11	8	0	2	1	35	28	24	3	44	83	297	156	2	39	259	590	25	83	47	0	34	0	1	0	0	3	0	0	0	1	33	0	1843
23	0	0	12	0	0	0	1	3	9	1	17	21	21	4	6	22	145	60	2	35	39	43	469	104	14	0	8	25	2	0	0	3	0	1	0	2	23	0	1097
24	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	6	0	0	2	35	13	64	3	0	0	0	0	0	0	0	0	0	0	0	5	0	132
25	0	0	0	1	1	0	0	0	5	0	1	1	2	1	2	3	0	1	1	254	7	1	0	0	513	32	2	0	0	0	0	0	0	0	0	0	95	0	923
26	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	28
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	2	4	2	0	0	6	2	0	7	4	8	0	2	6	23	5	0	32	19	1	10	42	4	51	60	168	3	1	0	0	0	0	0	0	31	0	493
29	0	0	29	34	5	4	13	2	10	0	36	31	30	7	14	20	93	87	6	70	30	6	21	60	19	19	111	134	272	0	0	0	4	0	0	13	100	0	1285
30	0	0	6	4	0	2	0	2	2	0	7	2	2	1	1	3	44	12	6	8	3	0	0	7	6	78	2	40	1	35	1	9	4	0	0	16	49	6	359
31	0	0	0	6	0	0	0	0	0	0	2	1	0	0	0	2	1	3	0	0	2	0	0	0	2	4	0	2	0	0	87	71	6	1	0	7	12	0	214
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	6	101	15	0	0	2	8	0	135
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3
34	1	0	8	5	1	0	2	17	0	0	39	29	10	3	7	20	109	92	4	9	14	1	2	67	7	13	3	9	1	0	84	94	110	172	10	164	29	0	1136
35	0	1	14	44	10	15	23	25	40	6	79	47	36	16	19	80	313	214	7	62	96	49	117	357	43	38	94	40	37	2	49	161	173	25	259	928	33	0	3602
36	0	0	2	1	0	0	0	0	0	0	0	7	0	0	1	5	3	6	2	4	1	0	0	0	2	2	0	1	0	0	1	2	18	2	1	452	24	0	537
37	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	50	4	1	0	0	0	9	0	0	1	1	0	0	0	0	0	0	0	152	0	222
38	0	0	8	5	1	2	1	0	1	0	0	2	0	3	3	4	62	44	6	17	6	0	4	4	48	27	10	51	1	63	3	5	2	0	0	24	60	52	519
Total:	89	167	1089	1333	612	1261	1031	1280	1227	655	1113	369	512	666	762	965	1279	974	504	632	967	733	669	816	735	292	332	480	327	101	234	454	335	201	272	1618	977	53	Grand T 26121

Statistics: Mean 18 Variance: 5543 Coefficient of V 4.1

Table D-3: : Trip Distribution by Gravity Model for Test Year (1990)

To Zone

From Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	28	18	101	90	77	13	38	100	15	6	150	0	11	8	37	0	21	20	25
2	51	116	501	12	9	11	60	1	2	1	7	0	0	5	0	35	3	0	4
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
4	34	1	63	438	72	42	113	4	9	0	5	1	6	63	7	15	0	37	2
5	8	0	4	20	60	1	14	13	5	0	8	0	0	0	0	0	1	0	0
6	22	7	29	189	252	1701	335	438	169	30	401	16	78	3	43	308	30	14	19
7	4	2	4	32	14	21	105	52	1	0	8	0	4	5	10	1	17	0	0
8	31	0	17	4	38	81	149	222	26	48	64	0	1	1	0	0	0	0	3
9	1	0	3	2	5	12	1	10	52	29	8	0	0	0	0	4	0	0	0
10	9	0	8	0	0	26	12	234	368	449	65	1	0	0	1	67	0	9	96
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	1	0	0	0	0	0	0	0	0	29	46	3	2	3	10	7	1
13	0	0	0	0	0	2	2	0	0	0	2	30	65	15	16	51	29	2	0
14	6	1	48	127	6	1	40	3	0	0	19	29	212	405	13	86	24	55	3
15	29	0	6	14	0	20	73	1	1	0	37	24	227	13	414	123	60	13	1
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	18	1	0	4	1	8	2	7	5	46	0	16	3	3	1	21	0	18	155
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	3	0	6	16	18	11	29	3	1	8	47	36	33	26	30	31	323	83	22
23	0	1	2	3	3	2	0	4	45	0	19	8	21	5	3	28	1	0	5
24	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0
25	1	2	0	0	0	2	6	0	14	0	3	16	5	9	22	0	1	5	1
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	1	1	0	1	0	0	0	0	4	9	19	12	0	2	2	30	0
29	5	6	13	17	2	1	2	2	1	11	40	22	13	2	1	3	38	76	5
30	0	0	1	4	0	1	0	0	0	0	9	7	4	0	0	0	4	31	16
31	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	1	0	0	0
32	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	3	0	5	0
33	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
34	1	1	1	6	0	2	4	2	1	0	25	9	14	2	15	4	32	69	6
35	0	2	19	21	53	8	14	18	17	4	42	67	57	6	15	72	204	208	9
36	0	0	2	0	0	1	1	0	1	0	6	6	0	0	0	13	2	2	3
37	5	1	0	1	0	2	4	1	2	2	1	0	1	3	4	0	0	0	2
38	0	0	6	2	0	1	3	1	0	0	0	15	4	0	13	4	30	16	2
Total:	256	159	837	1003	613	1971	1008	1116	736	635	974	341	824	589	647	878	835	700	380

From Zone	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	TOTAL
1	0	0	3	0	0	2	1	0	2	7	0	0	0	0	0	0	0	30	0	803
2	54	0	0	6	0	9	0	0	2	23	0	2	0	0	2	1	0	30	0	947
3	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
4	1	36	6	1	0	0	0	0	1	8	2	1	0	0	1	2	1	2	0	974
5	1	4	2	0	9	0	0	0	0	0	0	0	3	0	0	1	0	0	0	154
6	18	58	19	5	30	6	8	13	5	2	2	0	7	30	2	4	6	28	0	4327
7	0	0	3	0	0	1	2	0	0	0	0	0	2	3	0	0	0	3	0	294
8	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	1	0	2	0	693
9	0	0	0	3	0	2	0	0	0	0	0	1	0	0	0	0	0	2	0	135
10	0	21	12	2	0	1	0	0	0	21	1	4	31	0	0	2	0	20	0	1460
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1	3	3	1	1	2	0	0	2	2	0	0	0	0	0	1	1	0	0	119
13	0	0	1	2	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	221
14	2	13	20	6	12	10	0	0	30	2	0	3	0	14	1	1	0	14	0	1206
15	118	327	24	3	17	26	2	51	0	1	0	0	0	0	7	4	5	19	0	1660
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	16	6	2	1	0	0	0	4	15	0	5	0	2	2	10	12	0	384
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	91	66	504	48	169	42	3	43	2	2	45	2	0	11	0	41	0	30	0	1825
23	83	31	30	283	321	18	8	18	7	11	1	49	4	31	1	14	7	12	0	1079
24	1	0	5	17	71	0	6	0	2	4	0	1	0	1	1	4	0	1	0	118
25	331	7	29	20	8	207	92	3	1	2	6	1	18	0	1	6	0	85	0	904
26	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	17	5	0	4	26	0	105	39	105	42	18	1	0	9	0	4	0	22	0	478
29	5	2	2	15	110	3	33	205	103	274	12	102	33	31	2	1	19	56	0	1268
30	3	0	34	2	6	7	29	25	43	11	55	19	14	0	0	0	5	14	0	344
31	1	0	0	7	3	0	0	24	0	11	2	28	71	38	5	1	4	4	0	204
32	0	0	0	0	0	1	0	0	0	2	1	46	25	22	6	2	8	0	0	124
33	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5
34	13	11	0	2	86	4	25	5	0	4	0	90	192	225	117	13	117	22	0	1120
35	84	37	132	76	437	32	62	143	40	43	2	46	154	227	25	629	533	46	0	3584
36	1	2	3	2	0	1	6	2	24	4	5	29	8	44	25	42	281	7	0	523
37	3	8	5	3	8	21	0	7	11	2	3	7	0	0	2	2	4	90	0	205
38	14	0	0	1	13	17	89	18	104	1	82	1	13	5	0	0	13	37	0	505
Total:	842	633	854	517	1331	413	472	596	487	483	252	433	580	693	200	779	1014	588	0	

Statistics: Mean: 17.77 Variance: 5050.87 Standard Deviation: 71.06 Coefficient of Variation: 3.99 Grand Total: 25669

Table D-4: : Differences Between Origin - Destination Trip Data and Gravity Model for Test Year (1990)

To Zone

From Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	TOTAL
1	59	0	-38	2	69	4	30	4	34	-4	-34	0	-8	-6	-36	2	-15	-4	-17	2	0	-3	1	0	-2	-1	0	-2	-7	0	0	0	0	0	0	0	-18	0	12
2	-51	32	172	20	-3	-6	-57	2	2	1	6	0	0	-4	0	-35	-3	2	-4	-54	0	0	-6	0	-9	0	0	-2	-23	0	-2	0	0	-2	-1	0	35	0	10
3	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	3	0	15
4	-34	-1	58	11	133	-29	19	10	-4	0	12	5	2	-61	-7	-14	0	-33	4	0	-36	-6	-1	0	0	0	0	-1	-8	-2	-1	0	0	-1	-2	-1	4	0	16
5	-8	0	0	8	30	-1	1	3	-1	0	0	0	0	0	0	0	-1	0	0	-1	-4	-2	0	-9	0	0	0	0	0	0	1	-3	0	0	-1	0	0	0	12
6	-22	-7	6	139	-143	-604	232	182	116	17	-10	39	-8	12	43	58	-2	33	4	-2	0	-17	0	-17	1	-6	-9	3	5	-2	1	-2	-29	-2	-2	-3	14	0	18
7	-4	-2	8	13	9	-12	62	-47	0	1	16	3	-1	-5	-10	-1	-15	1	2	0	0	-3	1	0	-1	-2	0	0	0	0	1	-2	-3	0	0	0	6	0	15
8	-31	0	-17	-4	-37	-3	-135	144	18	-40	117	1	-1	-1	0	0	0	1	0	0	0	-1	-2	-2	0	0	0	0	0	0	0	0	0	0	-1	0	6	0	12
9	-1	0	-3	-1	-4	-12	-1	26	48	-27	-2	0	0	0	0	-4	0	0	0	0	0	0	-3	0	-2	0	0	0	0	0	-1	0	0	0	0	0	-2	0	11
10	-8	0	-8	3	1	-24	-9	-184	290	133	-4	-1	0	1	1	-67	1	0	-24	0	-21	-12	-2	0	-1	0	0	0	-21	-1	-4	-31	0	0	-2	0	7	0	13
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	-1	0	3	0	0	0	0	0	12	15	2	-3	0	-3	7	-4	-1	-1	0	-3	0	0	-2	0	0	-2	-2	0	0	0	0	0	-1	-1	0	0	15
13	0	0	0	5	1	-2	0	0	0	0	0	-1	43	-15	-9	-42	10	26	2	0	0	0	-2	2	0	0	0	-3	0	0	0	0	0	0	-1	0	1	0	15
14	-6	-1	23	62	-4	2	-30	3	0	0	20	-4	-160	195	9	-66	21	17	-2	9	-10	-19	-6	-11	-10	0	1	-30	-2	0	-3	0	-14	-1	-1	1	31	0	14
15	-29	0	4	5	1	-18	-72	0	1	0	-18	9	-140	-6	129	194	-10	25	-1	-51	96	-21	-3	-6	-15	-2	-48	1	0	0	0	0	0	-7	-4	-5	12	0	21
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	-18	-1	0	-4	0	-8	-1	-3	-4	-44	0	-16	-3	-3	-1	-21	0	48	146	0	0	-16	-6	-2	-1	0	0	0	-4	-15	0	-5	0	-2	-2	-10	10	0	14
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	-3	0	-2	21	-16	0	-21	-3	1	-7	-12	-8	-9	-23	14	52	-26	67	-20	-52	193	86	-23	-86	5	-3	-9	-2	-1	-45	-2	3	-11	0	-41	1	0	0	18
23	0	-1	10	-3	-3	-2	1	-1	-36	1	-2	13	0	-1	3	-6	144	60	-3	-48	8	13	186	-217	-4	-8	-10	18	-9	-1	-49	-1	-31	0	-14	-5	16	0	18
24	0	0	0	1	-2	1	0	0	0	0	0	0	0	0	0	1	-1	6	0	-1	2	30	-4	-7	3	-6	0	-2	-4	0	-1	0	-1	-1	-4	0	4	0	14
25	-1	-2	0	1	1	-2	-6	0	-9	0	-2	-15	-3	-8	-20	3	-1	-4	0	-77	0	-28	-20	-8	306	-60	-1	-1	-2	-6	-1	-18	0	-1	-6	0	10	0	19
26	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	-1	-1	0	0	1	0	0	0	0	0	26	0	0	0	0	0	0	-1	0	0	0	0	0	25
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	1	3	2	-1	0	6	2	0	3	-5	-11	-12	2	4	21	-25	0	15	14	1	6	16	4	-54	21	63	-39	-17	-1	0	-9	0	-4	0	9	0	15
29	-5	-6	16	17	3	3	11	0	9	-11	-4	9	17	5	13	17	55	11	1	65	28	4	6	-50	16	-14	-94	31	-2	-12	-102	-33	-27	-2	-1	-1	44	0	17
30	0	0	5	0	0	1	0	2	2	0	-2	-5	-2	1	1	3	40	-19	-10	5	3	-34	-2	1	-1	49	-23	-3	-10	-20	-18	-5	4	0	0	11	35	0	9
31	0	0	0	6	0	0	0	0	-1	0	-1	1	0	0	0	1	1	8	0	-1	2	0	-7	-3	2	4	-24	2	-11	-2	59	0	-32	-4	-1	3	8	0	10
32	0	0	0	0	-1	0	-1	0	0	-1	0	0	0	0	0	-2	0	-3	0	0	0	0	0	0	-1	0	0	0	-2	-1	-40	76	-7	-6	-2	-6	8	0	11
33	0	0	-1	0	0	0	0	0	0	0	-1	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	2	0	0	0	0	0	-2
34	0	-1	7	-1	1	-2	-2	15	-1	0	14	20	-4	1	-8	16	77	23	-2	-4	3	1	0	-19	3	-12	-2	9	-3	0	-6	-98	-115	55	-3	47	7	0	16
35	0	-1	-5	23	-43	7	9	7	23	2	37	-20	-21	10	4	8	109	6	-2	-22	59	-83	41	-80	11	-24	-49	0	-6	0	3	7	-54	0	-370	395	37	0	18
36	0	0	0	1	0	-1	-1	0	-1	0	-6	1	0	0	1	-8	1	4	-1	3	-1	-3	-2	0	1	-4	-2	-23	-4	-5	-28	-6	-26	-23	-41	171	17	0	14
37	-5	-1	0	-1	0	-2	-4	-1	1	-1	-1	0	-1	-3	-4	0	0	0	48	1	-7	-5	-3	-8	-12	0	-7	-10	-1	-3	-7	0	0	-2	-2	-4	62	0	17
38	0	0	2	3	1	1	-2	-1	1	0	0	-13	-4	3	-10	0	32	28	4	3	6	0	3	-9	31	-62	-8	-53	0	-19	2	-8	-3	0	0	11	23	0	-38
Total:	-167	8	252	330	-1	-710	23	164	491	20	139	28	-312	77	115	87	444	274	124	-210	334	-121	152	-515	322	-180	-264	-7	-156	-151	-199	-126	-358	1	-507	604	389	0	

Statistics: Mea 0.3 Variance: ### Standard Devia 35 Coefficient of Variatio 130 Grand Total: 394

Table D-5: Chi-square Cell Values Between Origin - Destination Trip Data and Gravity Model for Test Year

To Zone

From Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	TOTAL
1	124.32	0.00	14.30	0.04	61.83	1.23	23.68	0.16	77.07	2.67	7.71		5.82	4.50	35.03		10.71	0.80	11.56			3.00			2.00	1.00		2.00	7.00								10.80		407.23
2	51.00	8.83	59.05	33.33	1.00	3.27	54.15	4.00	2.00	1.00	5.14			3.20		35.00	3.00		4.00	54.00			6.00		9.00			2.00	23.00		2.00			2.00	1.00		40.83		407.81
3																1.00					1.00												1.00						3.00
4	34.00	1.00	53.40	0.28	245.68	20.02	3.19	25.00	1.78		28.80	25.00	0.67	59.06	7.00	13.07		29.43	8.00	0.00	36.00	6.00	1.00					1.00		2.00	1.00			1.00	2.00	1.00	8.00		614.38
5	8.00		0.00	3.20	15.00	1.00	0.07	0.69	0.20		0.00						1.00			1.00	4.00	2.00		9.00								3.00			1.00				49.16
6	22.00	7.00	1.24	102.23	81.15	214.47	160.67	75.63	79.62	9.63	0.25	95.06	0.82	48.00	43.00	10.92	0.13	77.79	0.84	0.22	0.00	15.21	0.00	9.63	0.17	4.50	6.23	1.80	12.50	2.00		0.57	28.03	2.00	1.00	1.50	7.00		1122.82
7	4.00	2.00	16.00	5.28	5.79	6.86	36.61	42.48	0.00		32.00		0.25	5.00	10.00	1.00	13.24					3.00			1.00	2.00						2.00	3.00				12.00		203.50
8	31.00		17.00	4.00	36.03	0.11	122.32	93.41	12.46	33.33	213.89		1.00	1.00					0.00			1.00	2.00	2.00											1.00		18.00		589.54
9	1.00		3.00	0.50	3.20	12.00	1.00	67.60	44.31	25.14	0.50					4.00							3.00		2.00						1.00						2.00		170.25
10	7.11		8.00			22.15	6.75	144.68	228.53	39.40	0.25	1.00			1.00	67.00		0.00	6.00		21.00	12.00	2.00		1.00				21.00	1.00	4.00	31.00			2.00		2.45		629.32
11																																							0.00
12			1.00									7.76	0.09	3.00	0.00	3.00	4.90	2.29	1.00	1.00	0.00	3.00	0.00	0.00	2.00			2.00	2.00						1.00	1.00			35.03
13						2.00	0.00				0.00	0.03	28.45	15.00	5.06	34.59	3.45	338.00				0.00	2.00					3.00							1.00				432.58
14	6.00	1.00	11.02	30.27	2.67	4.00	22.50	3.00			21.05	0.55	120.75	93.89	6.23	50.65	18.38	5.25	1.33	40.50	7.69	18.05	6.00	10.08	10.00			30.00	2.00		3.00		14.00	1.00	1.00		68.64		610.52
15	29.00		2.67	1.79		16.20	71.01	0.00	1.00		8.76	3.38	86.34	2.77	40.20	305.98	1.67	48.08	1.00	22.04	28.18	18.38	3.00	2.12	8.65	2.00	45.18		0.00					7.00	4.00	5.00	7.58		772.96
16																																							0.00
17																																							0.00
18																																							0.00
19	18.00	1.00		4.00	0.00	8.00	0.50	1.29	3.20	42.09		16.00	3.00	3.00	1.00	21.00		128.00	137.52			16.00	6.00	2.00	1.00				4.00	15.00		5.00		2.00	2.00	10.00	8.33		458.93
20																																							0.00
21																																							0.00
22	3.00		0.67	27.56	14.22	0.00	15.21	3.00	1.00	6.13	3.06	1.78	2.45	20.35	6.53	87.23	2.09	54.08	18.18	29.71	564.38	14.67	11.02	43.76	0.60	3.00	1.88	2.00	0.50	45.00	2.00		11.00		41.00		0.00		1037.07
23		1.00	50.00	3.00	3.00	2.00		0.25	28.80		0.21	21.13	0.00	0.20	3.00	1.29	20736.00		1.80	27.76	2.06	5.63	122.25	146.69	0.89	8.00	5.56	46.29	7.36	1.00	49.00	0.25	31.00	0.00	14.00	3.57	21.33		21344.32
24					2.00												0.50			1.00		180.00	0.94	0.69		6.00		2.00	4.00		1.00		1.00	1.00	4.00		16.00		220.13
25	1.00	2,00				2.00	6.00		5.79		1.33	14.06	1.80	7.11	18.18		1.00	3.20	0.00	17.91	0.00	27.03	20.00	8.00	452.35	39.13	0.33	1.00	2.00	6.00	1.00	18.00		1.00	6.00		1.18		664.41
26																1.00	1.00																1.00						3.00
27																																							0.00
28			1.00	9.00		1.00					2.25	2.78	6.37	12.00		8.00	220.50	20.83		13.24	39.20		9.00	9.85		27.77	11.31	37.80	36.21	16.06	1.00		9.00		4.00		3.68		501.84
29	5.00	6.00	19.69	17.00	4.50	9.00	60.50	0.00	81.00	11.00	0.40	3.68	22.23	12.50	169.00	96.33	79.61	1.59	0.20	845.00	392.00	8.00	2.40	22.73	85.33	5.94	43.10	9.33	0.01	12.00	102.00	33.00	23.52	2.00	1.00	0.05	34.57		2221.22
30			25.00	0.00		1.00					0.44	3.57	1.00				400.00	11.65	6.25	8.33		34.00	2.00	0.17	0.14	82.79	21.16	0.21	9.09	7.27	17.05	1.79				24.20	87.50		744.62
31									1.00		0.33					1.00				1.00			7.00	3.00			24.00		11.00	2.00	124.32	0.00	26.95	3.20	1.00	2.25	16.00		224.05
32					1.00		1.00			1.00						1.33		1.80							1.00				2.00	1.00	34.78	231.04	2.23	6.00	2.00	4.50			290.68
33			1.00								1.00					1.00					0.00					1.00													4.00
34	0.00	1.00	49.00	0.17		2.00	1.00	112.50	1.00		7.84	44.44	1.14	0.50	4.27	64.00	185.28	7.67	0.67	1.23	0.82		0.00	4.20	2.25	5.76	0.80		2.25		0.40	50.02	58.78	25.85	0.69	18.88	2.23		656.64
35		0.50	1.32	25.19	34.89	6.13	5.79	2.72	31.12	1.00	32.60	5.97	7.74	16.67	1.07	0.89	58.24	0.17	0.44	5.76	94.08	52.19	22.12	14.65	3.78	9.29	16.79	0.00	0.84	0.00	0.20	0.32	12.85	0.00	217.65	292.73	29.76		1005.42
36			0.00			1.00	1.00		1.00		6.00	0.17				4.92	0.50	8.00	0.33	9.00	0.50	3.00	2.00		1.00	2.67	2.00	22.04	4.00	5.00	27.03	4.50	15.36	21.16	40.02	104.06	41.29		327.56
37	5.00	1.00		1.00		2.00	4.00	1.00	0.50	0.50	1.00		1.00	3.00	4.00				1152.00	0.33	6.13	5.00	3.00	8.00	6.86		7.00	9.09	0.50	3.00	7.00			2.00	2.00	4.00	42.71		1282.62
38			0.67	4.50		1.00	1.33	1.00				11.27	4.00		7.69	0.00	34.13	49.00	8.00	0.64			9.00	6.23	56.53	43.19	3.56	27.01	0.00	4.40	4.00	4.92	1.80			9.31	14.30		307.48
Total:	349.43	32.33	335.01	272.34	511.95	338.45	598.28	578.41	601.37	172.88	374.82	257.63	294.92	310.75	362.26	814.20	21775.33	787.63	1359.13	1079.69	1197.04	427.17	241.73	302.80	647.55		188.90	198.57	151.27	122.73	381.79	385.41	240.51	77.21	350.36	482.05	496.18		
																																					Grand Total:		37342.1