Nested Logit Models for Motorized and Non-Motorized Modes

By

Nadeem Hasan Siddiqui *B. Eng.*

N.E.D. University of Engineering and Technology

Karachi, Pakistan

A Thesis Submitted to the

Faculty of Graduate Studies and Research

in Partial Fulfillment of the Requirements

for the Degree of

Master of Engineering

Department of Civil and Environmental Engineering

Carleton University, Ottawa, Ontario

The Master of Engineering in Civil and Environmental Engineering Program is a joint program with the University of Ottawa, administered by Ottawa-Carleton Institute for Civil Engineering

The undersigned hereby recommend to
the Faculty of Graduate Studies and Research
the acceptance of the thesis

"Nested Logit Models for Motorized and Non-Motorized Modes"

By

Nadeem Hasan Siddiqui *B. Eng.*
Carleton University, 1999

in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering

Dr. A. M. Khan, Thesis Supervisor

for Dr. J. L. Humar, Chairman
Department of Civil and Environmental Engineering

Department of Civil and Environmental Engineering
Faculty of Engineering
Carleton University
November 1999

ABSTRACT

For the last fifty years, the development of the North American transportation system has focused on providing for travel by motorized modes. Today, many people have no choice but to use a car or bus for even the shortest trips. Walking and bicycling share many attributes that warrant paying them much more serious and substantive consideration as real modes of transportation than they have typically been accorded. Both modes are available to nearly everyone, regardless of age or, in most cases, income and nearly everyone walks for at least some part of every trip. They are energy efficient and environmentally friendly. A shift in short trips away from motor vehicle travel and towards these non-motorized modes can help to alleviate the increase in traffic congestion that many of our urban areas are experiencing.

Many transportation planning agencies of North America are in the process of updating their models, by including walk and bike modes as integral parts of their travel demand modeling process, to make them more sensitive to significant factors affecting travel behaviour that have gone ignored in the past. This study was done; in collaboration of Regional Municipality of Ottawa Carleton (which has actively involved in the promotion of non-motorized modes), to model the non-motorized (walk and bike) modes along with the traditional motorized (auto and transit) modes. Nested multinomial modal split models were developed for simulating p.m. peak period *Home Based Work, Home Based School* and *Other Trip Purposes* for the National Capital Region.

Modal and individual characteristics considered important in mode choice were identified and tested using sensitivity analysis. The results indicate that travel cost, travel time and vehicle ownership are important factors in motorized modes whereas travel time, gender, number of bikes and population density are significant variables in non-motorized modes.

It is expected that transportation planning agencies of other regions would greatly benefit from this comprehensive study for integrating motorized and non-motorized modes in their transportation modeling process.

ACKNOWLEDGEMENTS

I would like to extend my sincere appreciation to Dr. A. M. Khan, Carleton University for his invaluable help, advice and encouragement. His support and guidance during this research provided much needed assistance.

The Regional Municipality of Ottawa-Carleton (RMOC) provided transportation data and research facilities. For this, I am really thankful to Mr. Don Stephens, Manager, RMOC. I would like to extend my deepest gratitude and appreciation to Mr. Mark Campbell, P.Eng. at RMOC for his invaluable help, guidance and much needed feedback, without which this thesis would not have been possible.

I would also like to thank Dr. Louis Shallal, Director, Geomatics of RMOC and Mr. Mohammad Tayyaran, Ph.D. student of Carleton University for their valuable contribution and suggestions at different stages of this research.

Special thanks to my parents, brothers and sisters for their continued support, encouragement and prayers in the pursuance of this degree.

Last but not least, I would like to offer my sincere gratitude and appreciation to my beloved wife Ghazala and my children Adil and Maheen, who provided all the strength and support I needed and who shared all the hopes and disappointments during this extensive research work.

And above all I surrender myself to my God who bestowed yet another glory in my life.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CBD	Central Business District
CUO	Communauté urbane de l'outaouais
GTA	Greater Toronto Area
HBPSS	Home Based Post Secondary School Trips
HBSS	Home Based Secondary School Trips
HBW	Home Based Work Trip
HOV	High-Occupancy Vehicles
IVTT	In-vehicle-travel-time
LH	Leave Home Trip
MTO	Ministry of Transportation, Ontario
MTQ	Ministère des Transports Québec
NCR	National Capital Region
NHB	Non-Home Based Trip
OD Survey	1995 Origin-Destination Survey
OHB	Other Home Based Trip
OVTT	Out-of-vehicle-travel-time
RMOC	Regional Municipality of Ottawa-Carleton
ROC	Region of Ottawa-Carleton
SOV	Single Occupant Vehicle
STO	Société de transport de l'otaouais
TRANS	Joint Technical Committee on Transportation Systems Planning
TSP	Time Series Processor
UTA	Urban Transit Area
SPSS	Statistical Package For Social Sciences

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND:

In the past, transportation planning in North America has mainly been concerned with developing motorized oriented transportation systems. Consequently, the travel demand models developed to simulate travel demand focused on auto and transit. Modeling for pedestrians and bicycles has historically been a low priority because they have a relatively low number of users on a macro scale and they were not perceived by decision-makers as key requirements (Replogle, 1995). However, recent desires to improve the environment and achieve sustainable transportation through environmentally friendly transportation modes are becoming an increasingly prevalent public goal in communities across North America (Stein, 1996). As a result, there is now a need to include the non-motorized modes within the transportation planning process.

The motorized transportation of people and goods presents unique challenges for sustainable development. It causes or contributes to climate change, depletion of the ozone layer, spread of toxic organic and inorganic substances, local and regional air pollution including ground level ozone (smog), acid rain, noise, depletion of oil and other natural resources, and damage to the landscape and soil (Environment Canada, 1997). Worldwide, motorized transportation is responsible for up to 20% of the emissions from human activities that are resulting in climate change (Katz, 1995). A shift in short trips away from motor vehicle travel and towards these non-motorized modes can help to alleviate the increases in traffic congestion that many of our urban areas are experiencing. These non-polluting modes can also bring air quality benefits by the elimination of vehicle trips (in terms of "cold start" emissions) over the vehicle miles of travel, which is saved (Replogle, 1993).

Recent rapid growth in computing capabilities, public awareness about environment, and the US Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 have combined with decades of modeling experience to spark a series of travel model enhancement projects. The urban travel demand models can now be made more sensitive to travel by including walk and bike modes. Some regional planning agencies of the United States have made advances in this area recently, but they are still in their infancy (Stein, 1996). In Canada, according to Khan (1997), "There is a need to investigate opportunities for enhancing the role of non-motorized means for travel. Also, constraints (e.g., weather) have to be studied." It is therefore, necessary now to treat non-motorized modes as a major component of the overall urban transportation planning process. To achieve this, a more refined tool that accurately reflects the modal choice process is needed.

1.2 RESEARCH OBJECTIVES:

The primary objective of this study is to develop modal split models for an urban area that can be used to simulate the behavior of individuals towards motorized and non-motorized modes for various trip purposes. Furthermore, the models developed should be capable of predicting the impact of changes in the transportation system on these choices and using the models, study the behavior of individuals that influence their decisions to travel, particularly by non-motorized modes.

1.3 RESEARCH SCOPE:

This study investigates the causal relationships underlying a person's choice of selecting a transportation mode to use for a specific trip and reports on the development of a tool which can be used to estimate the sensitivity of the modal choice process to a variety of transportation policies. The style of model used is the Disaggregate Nested Logit Model. The trip purposes that will be considered are Home Based Work, Home Based School and Other, within the Ottawa-Hull area during the P.M. peak period. The modes selected are auto, transit, bike and walk.

1.4 RESEARCH APPROACH:

The approach adopted in this study to develop tools capable of fulfilling the above requirements is known as "Disaggregate Behavioral Analysis". Although it has been used successfully elsewhere (Sobel, 1980, Daly, 1978) there have been relatively few attempts to use this technique in Canada that includes the walk and bike modes. Disaggregate Behavioral Analysis is based on the assumption that travel behavior originates with the decisions of the individual, and that a better understanding of the total behaviour of the population can be achieved through an improved understanding of individual behavior (Ben-Akiva and Lerman, 1985). The disaggregate approach assumes that an individual faces certain choices in his travel decisions. These choices offer the individual different combinations of favourable and unfavourable conditions. The traveler chooses from all the modes of transportation available, the one he considers most beneficial or desirable, given traveler's taste, the attributes of the alternatives and the socio-economic characteristics that affect choice (Horowitz and Koppleman, 1986).

The Ottawa-Hull area was selected as the study area. In 1995, an Origin Destination Survey was carried out collecting much of the data required for developing a logit model. Trips reported in the survey by the modes under study during the afternoon peak period provided the foundation of the data for the model development. Trips were then grouped into three trip purposes, home based work, home based school and other.

A separate modal split model was developed for each of these trip purposes for the modes auto, transit, bike and walk. Together, trips made by these modes represent approximately 90% (Trans, 1997) of the total travel in the PM peak period. The remaining 10% are primarily made by taxis, school buses and commercial traffic.

As the characteristics of walk and bike modes are quite different from motorized modes, these modes couldn't be modelled with auto and transit at the same level. A nested structure was therefore adapted to model walk and bike modes in the lower level nest. At

the higher level, these modes were grouped together as non-motorized modes having the composite utility of the lower level nest. It was then modeled along with auto and transit at the higher level. This type of model is referred to as a Nested Logit Model and will further be explained in Chapter 2.

Once the models were developed, sensitivity analysis was carried out to determine the travel behavior of motorized as well as non-motorized users. Conclusions were then drawn on modal attributes and socio-economic factors that influence the shift of persons from motorized to non-motorized modes.

1.5 RESEARCH METHODOLOGY:

The methodology adopted to achieve the thesis objectives appears in Figure 1.1. A brief overview of the overall methodology is presented here to clarify the study procedure and the interrelationships among various steps. The detailed procedure for each step is described in the following chapters.

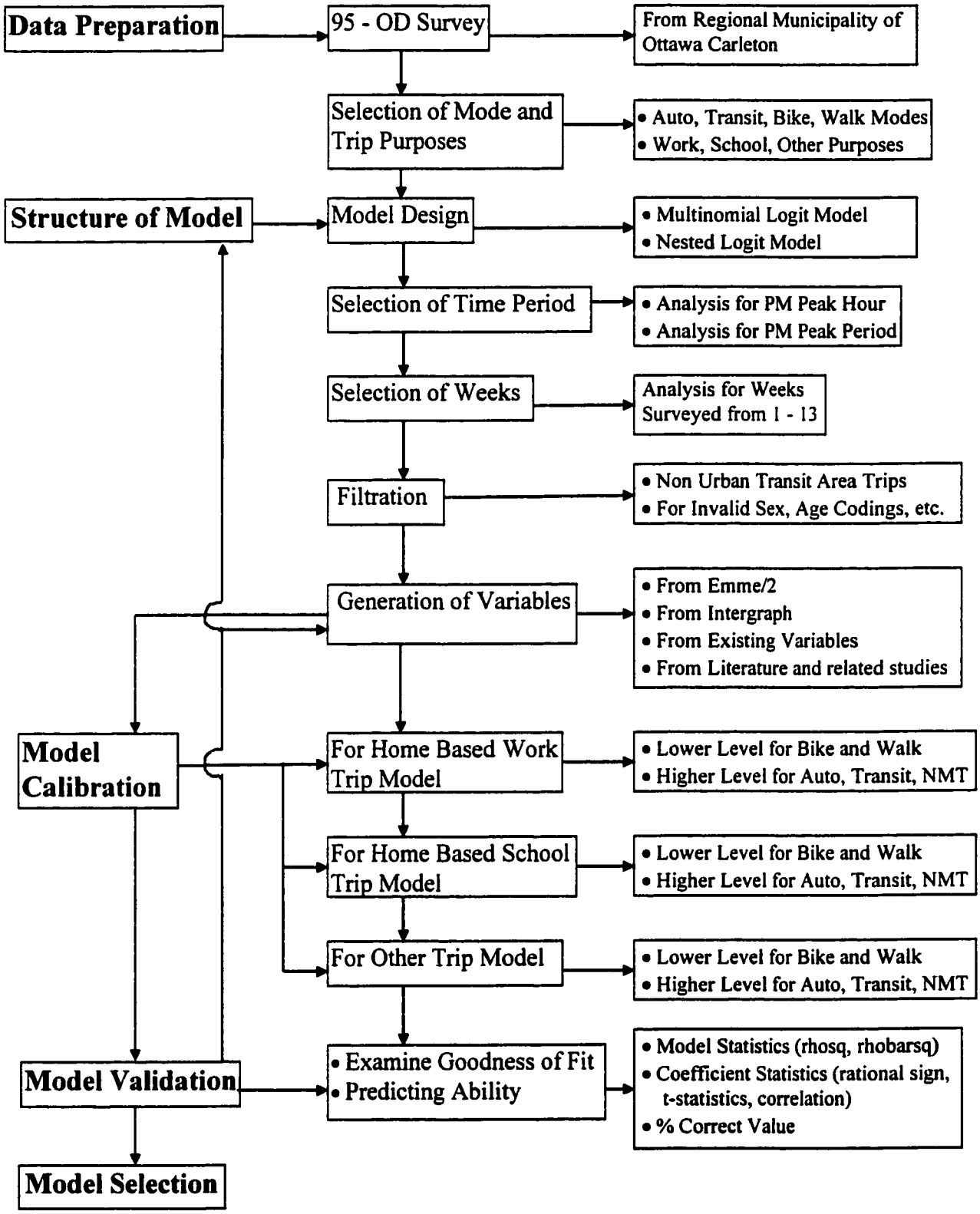


Figure 1.1: Research Methodology Flow Chart

1.5.1 Data Preparation:

The primary source of data in this project was the National Capital Region's 95 Origin Destination Survey. The survey area comprised of the Regional Municipality of Ottawa-Carleton (RMOC), Communauté urbaine de l'Outaouais (CUO) and the Municipalité régionale de Comté des Collines-de-l'Outaouais (MRC). This area is referred to as the National Capital Region (NCR) (Trans, 1996).

The first step in the data preparation was selecting trips made by auto, transit, walk and bike from the 1995 OD survey. As the characteristics of walk and bike modes are quite different from motorized modes, these modes couldn't be modeled with auto and transit at the same level. A nested structure was therefore adapted to model walk and bike modes in the lower level nest. At the higher level, these modes were grouped together as non-motorized modes.

The next stage is the selection of the following trip purposes:

- Work to Home
- School to Home
- Other, consisting of shopping (market), personal business, entertainment/social, daycare, facilitate passenger (pick up/drop off) and other

The trip purposes are categorized in these groups since people making these trips have unique trip making characteristics. Work trips are generally long trips made repeatedly each day using the same mode and to/from the same trip ends. The same applies to school trips. The remaining discretionary trip types are grouped together in the "Other" category.

The time period for the trips was then selected by analyzing different peak hours and peak periods. Typically, the highest levels of travel occur over several hours in both the morning and afternoon. These travel periods are referred to as the A.M. and P.M. peak

periods. The majority of travel in the A.M. peak period involves travel to and from work and school. The P.M. peak period demands are typically larger, as travel during this time period consists, not only of travel from work and school to home, but also includes many "Other" trips. Due to constraints in the number of samples available to build the bike component of the logit model, it was necessary to build the model from the P.M. peak period from 3:30 - 5:59 PM. An analysis was done in the selection of P.M. peak period over the P.M. peak hour as discussed in Chapter 3.

Selection of weeks was done to select only those weeks having a proper representation of all the modes. This was done considering the fact that some modes especially the bike mode is not feasible during certain time of the year, especially from November onwards, due to weather constraints.

Once a sample size was determined it was then filtered for geographic areas which are out of scope of this study, coding errors and omissions in the location of trip ends, sex and age, as well as other records when the person did not have a bike available for making a trip.

After the trips are filtered and sample size is determined, the next stage was the generation of variables. For each trip selected, additional transportation level of service information was estimated and added to the existing information in the selected sample size. Some of this information was obtained from tables of travel times (in minutes) for interzonal trips (trip within different zones) using the EMME/2 model. For transit-related variables, it was considered necessary to estimate such variables as fare, total travel time, in-vehicle travel time, out-of-vehicle travel time, number of transfers, access and egress and waiting time. For auto mode, the generated variables were auto cost comprised of parking cost and running cost, travel time and number of vehicles per household. Similarly, it was assumed that people who drive alone in their vehicles take less time to travel to their place of work than people who participate in a shared ride to get to work. The values selected in these cases depended on the past experience and relevant studies.

For non-motorized walk and bike modes, travel times and travel distances could not be estimated directly from the EMME/2 model. As such a methodology was developed using the Geographic Information System (GIS) "Intergraph" software. Using this technique travel times and travel distances for walk and bike modes were found as well as times and distances for both auto and transit modes for intrazonal trips (trips within same zone). A detailed description of this procedure has been provided in Appendix-B.

1.5.2 Model Calibration:

A computer software package called Time Series Processor (TSP), a product of TSP International, USA, was used to apply the statistical procedures required to develop the models. TSP is a general-purpose econometric and statistical data processing and estimation software that includes the maximum likelihood technique to estimate logit coefficients.

In order to have some appreciation of the procedure that the computer program employs and of the model structure, a brief explanation is presented here. For a more detailed technical explanation, Appendix-A and the bibliography should be consulted.

It has been described earlier that the disaggregate approach assumes that the individual is the basic decision-making unit and when faced with several alternatives he will choose the mode most desirable. The desirability or attractiveness, referred to as the utility, of each mode depends on its level of service (e.g., cost, travel time), the individual's socio-economic characteristics (e.g., auto and bike availability, age) and his tastes or attitudes (e.g., how he values privacy, comfort). The function of the TSP software is to estimate the relative importance or weight the user attaches to each level of service or socio-economic variable in his decision about what mode of travel to choose. The higher the weight assigned to a variable, the greater the influence of that variable in the mode choice decision.

As the values of the variables change, the utility or attractiveness of each mode also changes. For example, if the cost of fuel increases then driving becomes less attractive. However, since people can only choose between taking or not taking a particular mode (i.e., a discrete choice) it is not possible to measure the effect of all possible changes in the level of service and socio-economic variables included in the model. For example, the increase in fuel cost may or may not be enough to persuade users to switch to other modes. To overcome this, the model measures the probability of taking a mode based on the attractiveness of that mode in relation to other modes available. If a mode becomes more attractive, the probability of a person taking it should increase. The mathematical formulation of the model can be expressed as:

$$\text{Probability of choosing mode i} = \frac{e^{(\text{mean utility of ith mode})}}{e^{(\text{mean utility of first mode})} + \ldots + e^{(\text{mean utility of last mode})}}$$

In the model calibration stage, the planner tests alternative sets of variables by simply specifying the variables to be included in the equations required by the computer program. For each specification, the program estimates the weight for each variable and tabulates required statistical parameters. Once acceptable results are fixed, this specification becomes the instrument (i.e., the model) used to estimate the impact of different transportation policies.

1.5.3 Model Validation and Selection:

The objective of this step is to determine the quality of the calibrated models in terms of their ability to predict the travel behavior. Two procedures were used at the disaggregate level to validate the model developed in the calibration stage. Briefly, the first procedure validate the results at the macro level where the total number of predicted trips are compared with the total number of observed trips for each mode. In the second procedure, the developed models are validated at the micro level where the total number of correctly predicted trips is compared with the total number of observed trips for each mode. A

description and the results of these procedures are presented in the model developing chapters from 4 - 6. Based on the validation results the models will then be selected for different trip purposes.

1.6 THESIS ORGANIZATION:

Chapter 2 explains the discrete or disaggregate choice modeling formulated on the concept of random utility. The most used models, the Multinomial Logit Model and Nested Logit Model are then introduced, with special emphasis on the Nested Logit Model.

Chapter 3 describes the data collection stage required for developing the models. It explains the selection of motorized and non-motorized transportation modes and the structural form of the model, selection of trip purposes to be used in the model and the analysis for the PM peak hour and PM peak periods. Filtration process for the selection of sample size is then presented. Finally the chapter deals with the generation of variables and explains the methodology developed to generate variables for non-motorized modes using Geographic Information System - Intergraph.

Chapters 4 to 6 describe the models calibration stage. Chapter 4 first explains the problems faced in calibration with the form of the model selected earlier and selection of a revised structure. Development of *Home Based Work Trip Model* for both lower and higher levels is then detailed. The developed model along with its validation and sensitivity analysis is also presented. Chapter 5 and 6 describes the calibration and validation of *Home Based School Trip Model* and *Other Trip Model* respectively along with their sensitivity analyses.

Conclusions and recommendations can be found in Chapter 7, followed by references and appendices. Appendix-A contains an introduction to the Time Series Processor (TSP), a statistical software, employed in the thesis for the development of nested and non-nested

multinomial logit model. Appendix-B shows the list of generated variables and explains the generation of variables. Appendix-C includes all the SPSS macros used to build the variables, sample size, trip purposes, time period and other related works. Finally, Appendix-D contains the TSP outputs of the developed models.

CHAPTER 2

MODE CHOICE MODEL TECHNIQUES

2.1 MODE CHOICE MODELS:

The importance of mode choice in transportation policy and decision making has lead to a variety of methods for predicting and analyzing the effects of policy measures on traveler's mode choice. Two well-known and frequently used methods are the *Regression* and *Aggregate Modal Split Modeling* methods (Domencich and McFadden, 1975). Both of these methods have serious defects that greatly restrict their practical usefulness. For example, the method of regression cannot analyze accurately the effects of making several changes simultaneously (e.g., of increasing both the fare and the schedule frequency of the transit or of adding a new route to the system) (Brand, 1973). Aggregate mode split models can be exceedingly costly and cumbersome to develop. Moreover, they are subject to serious biases and prediction errors owing to their reliance on aggregate travel data rather than records of individual trips (Ben_Akiva and Lerman, 1985). For example, aggregate data sets often are obtained by computing average values of demographic characteristics and travel behavior of individuals living in the same geographical area (usually a traffic zone or district). The use of such average values discards information about differences among individuals within the same district or zone. The loss of such information, which is expensive to collect, is a waste of resources. The range of policy questions that can be treated with aggregate models is quite limited. For example, it usually is not possible to carry out multimodal analysis with these models (e.g., analyses in which it is necessary to predict the use of several different modes such as auto driver, auto passenger, transit, walk and bike) (NCR, 1983).

As such, estimation of models from these methods often yield parameter estimates that do not correctly reflect the relations that influence travel behavior (Brand, 1973). Such incorrect estimation will lead to an improper understanding of travel behavior and may

result in the design and selection of transportation alternatives that are not effective in meeting public objectives.

This study deals with a third class of mode choice models, called *Discrete or Disaggregate Choice Models,* that have substantial practical advantages over other available methods for predicting the consequences of transportation policy measures that affect mode choice. Disaggregate models achieve a higher degree of policy sensitivity than either regression or aggregate mode split models. Disaggregate models can treat multimodal problems without difficulty. Moreover, disaggregate models avoid the biases inherent in aggregate models, and they are much more efficient than aggregate models in terms of data and computational requirements (Manski, 1977). Disaggregate models can be developed using data from only 1000-3000 households – less then one tenth the number required by aggregate models, thereby conserving planning resources (Horowitz, Koppelman and Lerman, 1986).

2.2 DISAGGREGATE CHOICE MODELS:

The basic idea underlying disaggregate choice models is that travel is the result of choices made by individuals or collective decision-making units such as households. For example, an individual preparing to travel to work must choose whether to drive alone, take a bus, travel in a carpool, etc. the individual also must choose when to leave home and, depending on the chosen mode, may have to choose which route to use. The objective of these models is to model and predict the outcomes of these choices by individuals (or, if appropriate, by collective decision-making units such as households). Measures of aggregate travel, such as bus ridership, are obtained by adding up the choices of individuals. To model the outcomes of individuals' choices, it is necessary to:

1. Identify the decisions (e.g., choice of mode) that must be made and the options (e.g., auto, transit, bike and walk) or alternative outcomes, that are available to the individual.

2. Identify variables likely to affect the choices of interest. It is particularly important to identify policy variables – i.e., variables whose values may be changed through deliberate policy decisions – since much practical travel demand modeling is concerned with predicting the consequences of changing the values of these variables. Travel time and travel cost are examples of policy variables relevant to mode choice.

3. Develop a mathematical formula that describes the dependence of choices on the relevant variables.

According to Ben-Akiva and Lerman (1985), analyzing the choice of an individual requires the knowledge of what has been chosen, and also of what has *not* been chosen. Therefore, analysis must be made about options, or alternatives, that were considered by the individual to perform the choice. The set containing these alternatives, called the choice set, must be characterized. A discrete choice set contains a finite number of alternatives that can be explicitly listed and the corresponding choice models are called *Discrete or Disaggregate Choice Models.* Most disaggregate choice models have been formulated from the concept of random utility, which assumes that individuals' evaluation of available alternatives and their attributes can be conceptually described by utility functions and that the choice process can be conceptually described as the selection of the alternative that has the greatest utility (Manski, 1977).

Random utility models assume that the decision-maker has a perfect discrimination capability. In this context, however, the analyst is supposed to have incomplete information and, therefore, uncertainty must be taken into account (McFadden, 1974). So in practice the utility functions (U) of alternative a are typically represented by a deterministic portion (V) and a random or stochastic portion (ϵ), capturing the uncertainty

$$U_a = V_a + \epsilon_a \tag{2.1}$$

Manski (1977) identifies four different sources of uncertainty or randomness:

1. Unobserved Alternative Attributes
2. Unobserved Individual Attributes
3. Measurement Errors
4. Proxy or Instrumental Variables

Random utility models are the most used discrete choice models for transportation applications (Stopher and Kaltenbach, 1981). They have three different families of models depending upon the functional form of the error term distribution.

1) Linear Model
2) Probit Model
3) Logit Model

However, one of the most widely used models in practical applications is the Logistic Probability Unit or Logit Model and was selected for this modeling work.

2.3 LOGIT MODEL:

Logit models were first introduced in the context of binary choice models (Sobel, 1980). Their generalization to more than two alternatives are referred to as *Multinomial Logit Models.* There are three basic types of logit models, depending on whether the data or coefficients are *chooser-specific* or *choice-specific. 'Multinomial Logit Model'* has chooser-specific data where coefficients vary over the choices. *'Conditional Logit Model'* has choice-specific data where coefficients are equal for all choices. *'Mixed Logit Model'* involves both types of data and coefficients.

2.3.1 Multinomial Logit Model:

The multinomial logit model has been widely used to model both urban and intercity mode choices (Westin and Manski, 1979 and Hensher, 1991). The multinomial logit

model is widely used because its mathematical form is simpler than that of alternative models, making it easier to estimate and interpret (Koppelman and Forinash, 1994).

Here the probability 'P_i' that a given individual will choose alternative *i* from the set of 'J' possibilities is given by the equation:

$$P_i = \frac{e^{V_i}}{\sum_{1}^{J} e^{V_j}} \qquad (2.2)$$

where 'V_i' is the deterministic portion of the utility function of alternative 'i' (Ben-Akiva & Lerman, 1985 and Horowitz, Koppelman & Lerman, 1986).

Here a separate coefficient for each regressor is estimated for all but one of the choices. Let the dependent variable be denoted as "Y" and independent or explanatory variable as "X". Y can be 0/1 or 1/2 or any integral values -- if Y takes on more than 2 values, the model is multinomial logit. The names of the coefficients are determined by appending the values of Y for each choice to the names of the explanatory variables. The coefficients are normalized by setting the coefficients for the lowest choice to 0. If Y is 0/1, the coefficients C_1, X_{11}, X_{21}, ..., X_{K1} would be estimated, with C_0, X_{10}, X_{20}, ..., X_{K0} normalized to zero. If Y is 1/2/3, the coefficients and C_2, X_{12}, X_{22}, ..., X_{K2} and C_3, X_{13}, X_{23}, ..., X_{K3} would be estimated, with C_1, X_{11}, X_{21}, ..., X_{K1} normalized to zero.

2.3.2 Conditional Logit Model:

Conditional logit models may have a variable number of choices per chooser, since the data varies for each choice, and the coefficients are fixed across choices. When setting up data for this model, one observation for each choice is used, instead of one observation per chooser. An additional variable, either case number, or number of choices, is used to

keep the observations for each chooser together. It should be noted that the constant *C* is not a conditional variable since it doesn't vary across choices.

Here the regressors change across the choices, and a single coefficient is estimated for each set of regressors. For example the conditional variables X1, X2, Z1, Z2 correspond to the two choices. The coefficients X and Z would be estimated. '*C*' is not allowed as a conditional variable (since it does not vary across choices, it is not identified). For a choice-specific set of dummies, *C* is used as a multinomial variable in mixed logit.

2.3.3 Mixed Logit Model:

Here the variables are both conditional (choice specific) and multinomial (chooser specific). For example, if Y takes on the values 1, 2 and 3 for the multinomial variables X_A X_B X_C and conditional variables Z_A, Z_B the coefficients Z_A, Z_B, X_{A2}, X_{B2}, X_{C2}, X_{A3}, X_{B3}, X_{C3} would be estimated, with X_{A1}, X_{B1}, X_{C1} normalized to zero.

Consider the following model of three choices with multinomial variable X having coefficients b_1, b_2, b_3 and conditional variables Z_1, Z_2, Z_3 having coefficient g. The utilities of the three choices would then become:

$$V_1 = X^* b_1 + Z_1{}^*g \tag{2.3}$$

$$V_2 = X^* b_2 + Z_2{}^*g + c_2 \tag{2.4}$$

$$V_3 = X^* b_3 + Z_3{}^*g + c_3 \tag{2.5}$$

The latent values V_1, V_2, V3 are not observed, but the chosen alternative is the one with the highest value. If alternate 2 is chosen, for example, we know that $V_2 > V_1$ and $V_2 > V_3$. The observed choice probabilities have the form:

$$\text{Prob}(i) = \exp(Xb_i + Z_i g + c_i) / \sum_J (\exp(Xb_J + Z_J g + c_J)) \tag{2.6}$$

2.3.4 Property of Independence from Irrelevant Alternatives (IIA):

An important property of the multinomial logit model is the Independence from Irrelevant Alternatives (IIA). According to Train (1986), this property can be stated as follows:

The ratio of the probabilities of any two alternatives is independent from the choice set.

That is, for any choice sets S and T such that $S \subseteq T \subseteq C$, for any alternative a_1 and a_2 in S, we have,

$$\frac{P_S(a_1)}{P_S(a_2)} = \frac{P_T(a_1)}{P_T(a_2)} \tag{2.7}$$

Ben-Akiva and Lerman (1985) propose an equivalent definition:

The ratio of the chosen probabilities of any two alternatives is entirely unaffected by the systematic utilities of any other alternatives.

This result can be proved as follows:

Suppose for the given attributes the utilities of available modes are:

Utility for dr.alone = 0.250
Utility for sh. ride = 0.184
Utility for transit = 0.092

Then according to the multinomial logit model, the probability of each mode can be calculated using Equation 2.2:

$$P_{dr.alone} = 0.250/(0.250+0.184+0.092)$$
$$= 0.250/0.526 = 47.5\%$$

$P_{sh.\,ride} = 0.184/0.526 = 35.0\%$

$P_{transit} = 0.092/0.526 = 17.5\%$

Note that the probabilities for shared ride and transit are in 2:1 ratio. Now if utility of any mode is changed because of some changes in its attributes, say because of the increase in 'parking cost', utility for drive alone is decreased from 0.250 to 0.150. Then according to logit model the new probabilities will become

$P_{dr.alone} = 0.150/(0.150+0.184+0.092)$

$= 0.150/0.426$

$= 35.2\%$ i.e. decreased by 12.3%

$P_{sh.\,ride} = 0.184/0.426$

$= 43.2\%$ i.e. increased by 8.2%

$P_{transit} = 0.092/0.426$

$= 21.6\%$ i.e. increased by 4.1%

That is the decrease of 12.3% of drive alone modal share will be distributed in the remaining two modes in the same proportion (2:1)

$$\frac{P_{sh.\,ride}}{P_{transit}} = \frac{35.0}{17.0} = \frac{43.2}{21.6} = \frac{2}{1}$$

2.3.5 Limitations of Multinomial Logit Model:

The IIA property of multinomial logit models is a limitation for some practical applications because it restricts the relative probability of choosing between any pair of unchanged modes to be unchanged due to changes in other modes of travel. This restriction implies that the introduction of any new mode or the improvement of any existing mode will affect all other modes proportionally. This can be well illustrated by the famous red bus/blue bus conundrum of Ben-Akiva (1985) in the modal choice context.

Consider a travel system composed of two modes ---- automobile and a bus service with red buses, in which both modes have equal market shares i.e.,

$$(P_{auto}) = (P_{red\ bus}) = 1/2$$

Now suppose that half of the bus fleet is purchased by another company, but that the only change visible to the ridership is that these buses are painted blue. If the system is now regarded as three-mode system, described by a MNL model, then IIA implies that

$$(P_{auto}) = (P_{red\ bus}) = (P_{blue\ bus}) = 1/3$$

This increase in total public transport share from 1/2 to 2/3 due to a purely cosmetic change is clearly unrealistic. As noted by Williams (1979), if the MNL is first applied to autos and buses, and then separately to the red and blue buses, the intuitively correct probabilities 1/2, 1/4, 1/4 will be obtained.

Clearly, the problem is that the MNL model applies only to distinct or identifiable modes. Only in this case can the basic assumption of independent stochastic utility components be justified.

Thus, the IIA property can be regarded as a major advantage of the MNL when a new, distinct, travel mode is to be evaluated (Daly, 1987). However, this property also highlights a major weakness of the model, in that groupings of similar modes cannot be adequately modeled (Hensher, 1986). In real terms, this means that a transport system consisting of two transit modes (bus and rail), and three automobile modes (auto driver, auto-passenger and car-pool) may not be well explained by a multinomial logit model. Such mis-representation of choice behavior will result in incorrect estimated models and incorrect predictions of mode share and diversion from existing modes. The Nested Logit Model, presented in the next section, greatly overcomes this limitation of the multinomial logit model.

2.4 NESTED LOGIT MODEL:

The Nested logit model has been reported in the literature for several years, but awareness of its properties and even existence seems to be very slight (Westin & Manski, 1979 and Spear, 1999). First derived by Ben-Akiva (1973), nested logit model is an extension of the multinomial logit model designed to capture correlation among alternatives. The nested logit and multinomial logit models can each be depicted by a tree structure that represents all the alternatives. The multinomial logit model treats all alternatives equally, whereas the nested logit model includes intermediate branches that group alternatives (Figure 2.1). The grouping of alternatives indicates the degree of sensitivity among alternatives. Alternatives in a common nest show the same degree of increased sensitivity compared to alternatives not in the nest. The differences in structure can result in dramatically different mode ridership projections and diversions than those obtained by the multinomial logit model in cases where the nested logit model is significantly different from the multinomial logit model (Spear, 1999 and May, 1984).

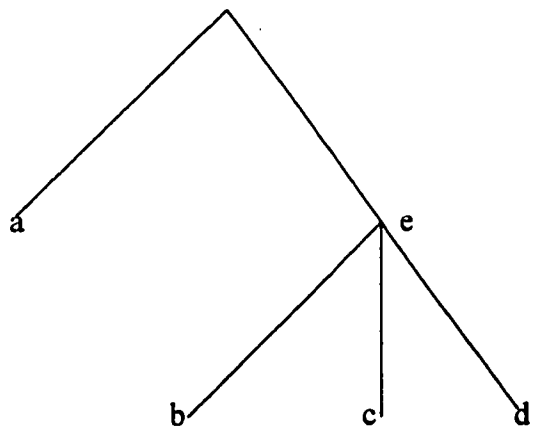


FIGURE 2.1: Four-Mode Nested Choice Structure

2.4.1 Estimation of the Nested Logit Model:

Estimation of the nested logit model has been most generally undertaken by maximum likelihood techniques (Daly, 1987 and Hensher, 1986). This method first estimates parameters for the lowest nest(s) and then estimates parameters for successively higher nests based on the computation of the log sum values (Ben-Akiva and Lerman, 1985).

To best present the nested MNL structure, it is useful to first re-examine the simple MNL model to highlight their differences. Figure 2.2 illustrates the simple MNL model, where the alternatives have been identified as auto, transit, bike, and walk.

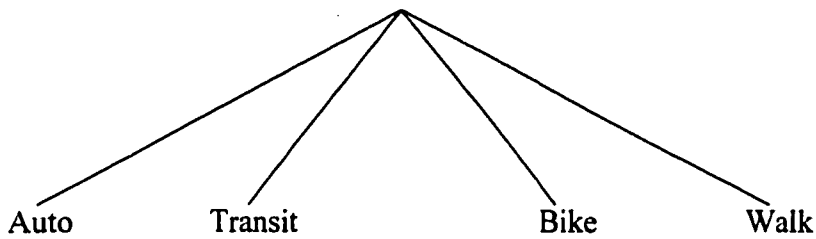


FIGURE 2.2: Four-Mode Simple Multinomial Logit Model

Conceptually, each alternative is evaluated by individuals according to utility functions U_{auto}, $U_{transit}$, U_{bike} and U_{walk} ; furthermore, individuals are conceptualized as selecting the alternative that has the greatest value of utility according to the following equation

$$P_i = \frac{e^{V_i}}{\sum_j e^{V_j}} \qquad (2.2)$$

If there are reasons to believe that the alternatives are not completely independent, one can postulate that a particular nested structure applies or, alternatively, one can test the validity of all possible nested structures as well as the simple (MNL) structure. Figure 2.3 shows one nested structure that seems to be a likely candidate for testing.

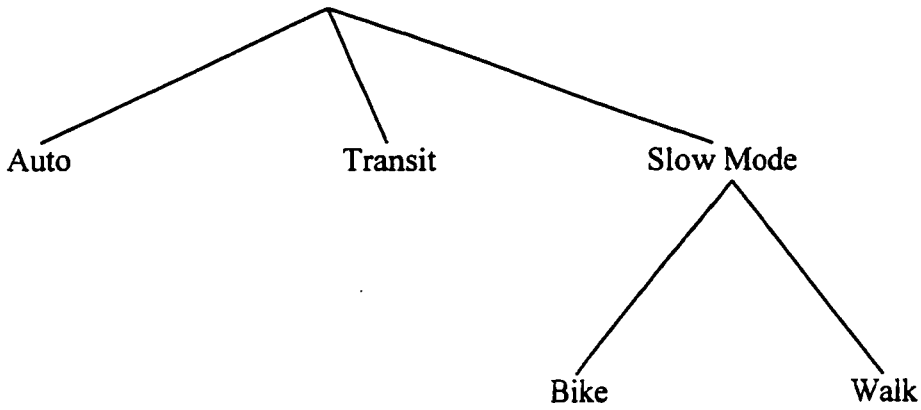


FIGURE 2.3: Four-Mode Nested Logit Model

In this situation, each individual is again conceptually assumed to evaluate each of the alternatives that has the same utility function as specified by the simple MNL model. However, there is also a composite utility of the nest, which in this case represents non-motorized or slow mode. This composite utility is also called *Inclusive Value* or *Accessibility* in the literature (Sobel, 1980).

The composite utility includes the expected value of the maximum utility of the members of the nest, given by Sobel (1980), as:

$$I_{b,w} = E[\max(U_i)] = \ln \sum_{n=1}^{J} e^{V_j} \tag{2.8}$$

where $I_{b,w}$ is the expected maximum utility of the members of the nest, J is the number of available alternatives in the nest, and all other symbols are as defined previously.

The nest's composite utility is then written as:

$$V_{b,w} = \theta I_{b,w} + gW_{b,w} = \theta (\ln \sum_{n=1}^{J} e^{V_j}) + gW_{b,w} \tag{2.9}$$

where 'θ' is an estimated coefficient, 'g' is a vector of estimated coefficients, and '$W_{b,w}$' is a vector of attributes common to all members of the nest.

The nested MNL model shown in Figure 2.3 can be estimated by using standard logit estimation software in two stages: First a simple binary logit model between bike and walk is estimated; the results allow the calculation of the expected maximum utility of the nest $I_{b,w}$ according to Equation 2.8. This value is then entered as a typical independent variable that has the $W_{b,w}$ variables and the characteristics of automobile and transit to estimate a second-level multinomial logit model for the automobile, transit and non-motorized modes.

For prediction, the first or lower-level logit model yields P (b | b, w) and P (w | b, w), the conditional probabilities of the bike or walk given that the choice is constrained to non-motorized or slow mode. The second or higher-level model yields P (b, w), P (a) and P(t), the marginal probabilities of non-motorized auto and transit modes, respectively.

To calculate bike and walk mode probabilities, the following Equations are invoked:

$$P_b = P(b \mid b, w) \,.\, P(b, w) \tag{2.10}$$

$$P_w = P(w \mid b, w) \,.\, P(b, w) \tag{2.11}$$

The choice probabilities for auto (P_a) and transit (P_t) are given directly by the second-level logit model (Sobel, 1980).

2.4.2 Structural Form of the Nested Logit Model:

It is now clear that the analyst must decide on the structure of the model a priori. Obviously the number of structural alternatives increases much faster than the number of choice alternatives, as can be seen in Figure 2.4.

Alternatives | Possible Nested Structures

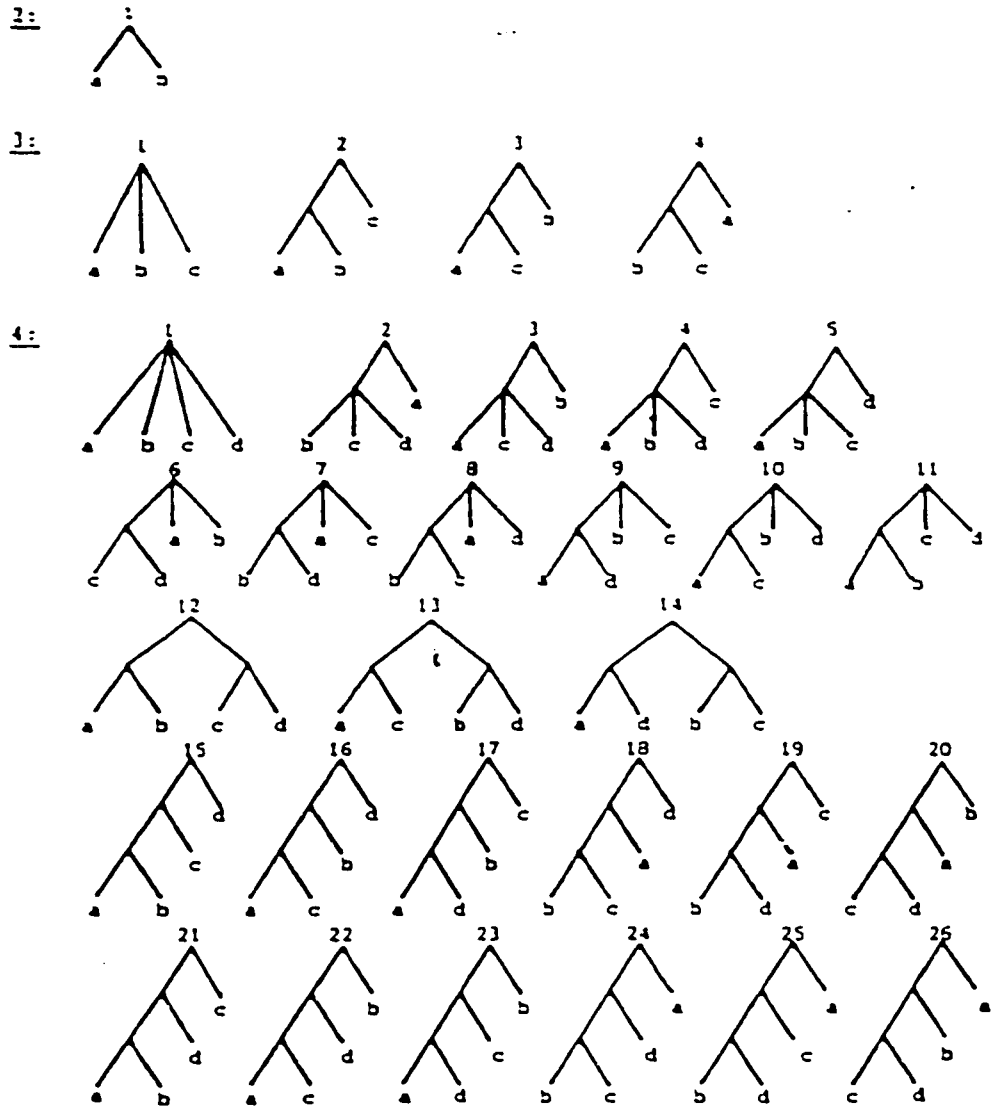


FIGURE 2.4: Nested MNL Sructural Alternatives

Furthermore, the selected structure may interact with the desirable variable specification, so that, when a satisfactory set of variables is tested in the context of one structure, it may prove to be unsatisfactory when imbedded in another structure. This, of course, would considerably increase the complexity of searching for the best model for a given choice context.

2.4.3 Technique for Testing the Appropriateness of the Nest:

A critically important feature of the model concerns acceptable values of θ, the coefficient of the expected maximum utility or inclusive value of the nest. It has been proven by Williams and Ortuzar (1979) that θ must satisfy

$$0 < \theta \leq 1 \tag{2.12}$$

and that, if $\theta \leq 0$ or $\theta > 1$, pathological forecasts may result. If $\theta < 0$, then improving the utility of one member of a nest (say, V_b) can decrease the choice probability of selection P_b of that alternative. If $\theta = 0$, then an improvement in the utility of one or both members of a nest will not change the choice probability of the nest. If $\theta > 1$, then improving the utility of one member of the nest (say, V_b) will not only improve its choice probability P_b but may also improve the choice probability of other members of the nest (here, P_w). If $\theta = 1$, then the choice probability calculations yield algebraically equivalent results to those of the simple MNL model.

These properties suggest a technique by which an analyst can statistically test whether particular structures can be rejected and whether the IIA property is appropriate for the situation that is being examined (Koppelman and Forninash, 1994). Each feasible structure (after pre-screening to eliminate theoretically unreasonable structures) can be estimated in turn. The tested structure is rejected if θ does not satisfy the constraint $0 < \theta \leq 1$, and if θ is not very different from 1, its nest and structure can be evolved into a less-general form. If all θ's equal 1, then the IIA property cannot be rejected (alternatives

cannot be empirically indicated to be interdependent) and the simple MNL model is likely to be appropriate.

Finally it should be noted that Nested Logit Models are designed to capture choice problems where *alternatives within each nest are correlated.* No correlation *across nests* can be captured by the Nested Logit Model (Hensher, 1986). When alternatives cannot be partitioned into well separated nests to reflect their correlation, Nested Logit Models are not applicable.

2.5 GOODNESS-OF-FIT MEASURES:

Maximum likelihood estimation is probably the most general and straight -forward procedure for finding estimators. As per McFadden (1974), " a maximum likelihood estimator is the value of the parameters for which the observed sample is most likely to have occurred." Goodness-of-fit measures for logit models depend on the values of the logarithm of the models' likelihood function when the coefficients assume various values. In general, the value of the likelihood function (L) is given by

$$L = \prod_{ij} P_{ij}^{N_{ij}} \tag{2.13}$$

where P_{ij} is the probability that j would choose alternative i, and N_{ij} equals 1 if individual j was observed to choose alternative i, 0 otherwise (Sobel, 1980). P_{ij} is found from Equation 2.2.

L (0):

L (0) is the value of the log likelihood function when all the parameters are zero. In binary choice models it is the log likelihood of the most naïve possible model, that is, one in which the choice probabilities are ½ for each of the two alternatives. L (0) corresponds to an initial state of information that all alternatives are equally likely. Because of the way in which it is defined, L (0) is a large negative number.

L(C):

L(C) is the value of the log likelihood function when only an alternative – specific constant is included. This corresponds to the log likelihood for another naïve model in which the choice probability for each alternative simply equals their market share. For example, 30 out of 50 observations chose auto and 20 chose transit, then for the naïve model P (auto) = 0.60 and P (transit) = 0.40. L (C) will be greater than or equal to L (0).

L (C) corresponds to a second initial state of information that alternatives are as likely to be chosen by any individual as are their aggregate market shares (Tardiff, 1976).

$$L(C) = \sum_{i=1}^{N} X_i \, [\ln(X_i / Y_i)] \qquad (2.14)$$

where X_i equals the number of observations in the estimation data set that have selected alternative i, and Y_i equals the total number of observations in the estimation data set that had alternative i available.

L (β):

L (β), is the value of the log likelihood function at its maximum i.e., with all the variables. It is a smaller negative number [a value of 0 for L (β) would indicate a perfect model]. L (β) corresponds to a final state of information about the likelihood of alternatives when the information in V is fully known (Ortuzar, 1994).

$$\text{Typically, } L(0) \leq L(C) \leq L(\beta) \qquad (2.15)$$

-2 (L (0) – L(β)):

-2 (L(0) – L(β)), is a statistic used to test the null hypothesis that all the parameters are zero. It is asymptotically (large samples) distributed as chi - squared with K degrees of freedom (Tardiff, 1976).

-2(L(C) – L(β)):

-2(L(C) – L(β)), is another statistic used to test the null hypothesis that all the parameters other than the alternative - specific constant are all zero. It is asymptotically distributed as chi-squared with K-1 degrees of freedom.

Rho Square:

As the dependent - variable observations of logit models are discrete or qualitative (e.g., auto, transit), a coefficient of determination (R^2) cannot be calculated as is done in regression analysis. Statistics similar to R^2 are constructed from the values of L given above and are called ρ^2 (Tardiff, 1976 and McFadden, 1974). It is a goodness of fit index that measures the fraction of an initial log likelihood value explained by the model. In particular,

$$\rho^2 = 1 - [L(\beta) / L(0)] \tag{2.16}$$

Rhobar Square:

Rhobar Square is another informal goodness of fit measure, which is similar to Rho Square but corrected for the number of parameters estimated. It is defined as:

$$\bar{\rho}^2 = 1 - [(L(\beta) - K) / L(0)] \tag{2.17}$$

The value of ρ^2 lies between 0 and 1, where 0 means 'no fit' and 1 refers to as 'perfect fit'. Although its meaning is clear in the limits (0 and 1) it does not have an intuitive interpretation for intermediate values. In fact, values around 0.4 may be excellent fits (Ortuzar and Willumsen, 1994). It has been shown that the minimum values of ρ^2 in the above equation vary with the proportion of individuals choosing each alternative. Taking a simple binary case, Table 2.1 shows the minimum values of ρ^2 for different proportions choosing option 1 (Ortuzar and Willumsen, 1994). It can be seen that ρ^2 is only appropriate when both options are chosen in the same proportion.

Table 2.1: Minimum ρ^2 for Various Relative Frequencies

Sample proportion selecting the first alternative	Minimum value of ρ^2
0.50	0.00
0.60	0.03
0.70	0.12
0.80	0.28
0.90	0.53
0.95	0.71

These values mean, for example, that a model estimated with a 0.9/0.1 sample yielding a ρ^2 value of 0.55, would be undoubtedly much weaker than a model yielding a value of 0.25 from a sample with an equal split. Fortunately, there is a simple adjustment that allows us to solve this difficulty; it consists of calculating the index with respect to the market share model (Ortuzar, 1994):

$$\rho_c^2 = 1 - [L(\beta) / L(C)] \tag{2.18}$$

Its statistic also lies between 0 and 1, although the corrected (ρ_c^2) allows comparisons between models estimated with observation sets that have different market shares.

In the case of Nested logit model, measures equivalent to ρ^2 suggested by McFadden (1974) and the ρ_c^2 suggested by Tardiff (1976) takes the form shown below:

$$\rho^2 = 1 - \{[L_1(\beta) + L_2(\beta) + ...+L_j(\beta)] / [L_1(0) + L_2(0) + ... + L_j(0)]\} \tag{2.19}$$

$$\rho_c^2 = 1 - \{[L_1(\beta) + L_2(\beta) + ...+L_j(\beta)] / [L_1(C) + L_2(C) + ... + L_j(C)]\} \tag{2.20}$$

where the subscripts 1 to j refer to the MNL models at each level.

Coefficient Sign:

The sign of the coefficient must be logical. For example, since cost is a deterrent to travel its sign should be negative.

Coefficient Value:

The value of the coefficient should be reasonably similar to that estimated for the same variable in other studies. The assumption here is that individual travel behaviour is relatively consistent regardless of the area in which an individual lives.

T-Statistics:

T-Statistics increase with confidence in the statistical significance of the sign and magnitude of a coefficient. A t-statistic of greater than 1.65 or less than -1.65 indicates significance at more than the 95 percent confidence level. Similarly, a t-statistic of greater than 2.3 or less than 2.3 indicates significance at more than the 99 percent confidence level. It is generally desirable to include in the utility equations of a logit model those variable coefficients with a t-statistic of 1.65 or greater. Depending on the circumstances, however, it may be desirable to include a particular variable despite an unsatisfactory t-statistic. For example, a variable which is known to have a strong influence on travel behaviour, or which is important to the future functionality of the model (vis-à-vis forecasting), may be supported in a model despite having a seemingly low t-statistic.

Correlation Coefficient:

Logit model estimation software provides a table of Correlations between each pair of variables specified in the model. A correlation between a pair of variables greater than 0.8 indicates that a particular effect is being accounted for twice, and that the model should be re-specified.

Constant:

In a three- mode logit model, two of the modes should include a constant expression, in addition to any variables, which are found to be descriptive. This constant will account for the utility effects of miscellaneous factors not included in the model specification due to difficulties in measurement or prediction. The constant should be included in the model regardless of its magnitude or t-statistic. In theory, the value of the constant should be zero. However, because it is impossible to explicitly address all actual decision-making factors in a model, the constant will always have some value. While it is desirable to attempt to minimize the value of a constant, a constant of the same approximate magnitude as the dummy variable coefficients found in the utility equations would be acceptable. For certain modes, such as walk and bike, the significant likelihood that important variables are missing will mean that the constant expression may be somewhat larger than would be ideally desired.

CHAPTER 3

DATABANK PREPARATION

3.1 OVERVIEW:

In this chapter, the urban area selected for the study is presented. This is followed by a description of the principal data source from which the models were developed. Once the data source was established, the next task was to select modes, trip purpose and filter out invalid cases to have the appropriate data sample for the model building process. An analysis was then carried out to review the number of remaining cases in order to select the time period with adequate sample size to build the model. Additional variables were then added to the OD Survey data such as time, cost and distance for the selected modes and for the selected trip purposes using other data sources such as Emme/2 and Intergraph and demographic data from the Planning Department of the RMOC and CUO. The model building process was then started and the models were developed as outlined in Chapters 4 to 6.

3.2 SELECTION OF STUDY AREA:

Upon the theory review, it is clear that logit models are the most desirable to study the behavior of motorized and non-motorized travelers in an urban area. The area selected for building the model is the National Capital Region (NCR), comprised of the Regional Municipality of Ottawa-Carleton (RMOC), Communauté urbaine de l'Outaouais (CUO) and the Municipalité régionale de Comté des Collines-de-l'Outaouais (MRC). The area comprises a total of 22 local municipalities consisting of 11 municipalities from Ontario and 11 municipalities from Quebec province, as shown in Exhibit 3.1. This region was selected due to availability of the data from the 1995 OD Survey for building the logit models. Furthermore, the area has well established bike and walking facilities in the urban areas that provided an adequate sample of trips by these modes for the model building process. The region is categorized into four broader areas as follows:

1) Core:

Refers to Ottawa and Hull inner districts, commonly referred to as the central areas, as shown in Exhibit 3.1A. These districts consist of high density office, commercial and residential developments. The density of households is greater than 1500 hhlds per sq km.

2) Urban:

This area excludes the core. In Ottawa-Carleton it includes land within the greenbelt and for Quebec it includes Aylmer, Hull and the western component of Gatineau. The area is composed of older residential, commercial and office developments. Residential developments consist of a mix of single and multi family units. Office developments are usually mid-density; commercial centres may be in form of large malls as Bayshore or single story strip developments as along Merivale road. The area has extensive transit coverage with attractive bicycle paths and sidewalks. The density of households is between 500 and 1500 per square kilometer (Trans, 1997).

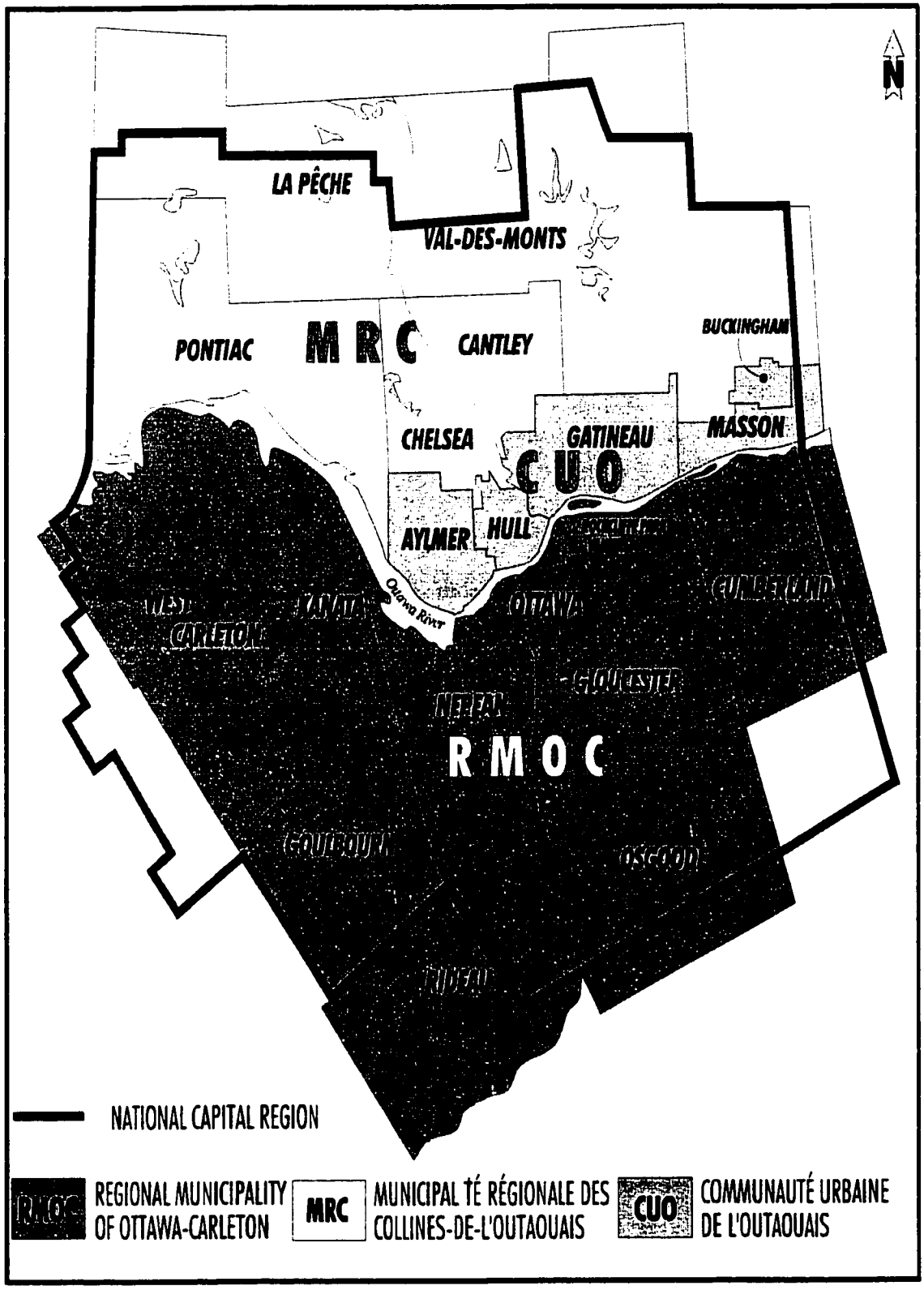
3) Suburban:

Consists of post 1970 residential developments located outside the urban area such as Orleans, Kanata and parts of Gatineau. The suburbs contain a high proportion of families with children and limited office space. Major activity centres are usually located near large malls where the majority of shopping activities take place. Transit service is not as extensive as in the urban areas. However, transit commuter service is available to major employment centres in the core and urban areas. Attractive bike and walking facilities are usually in place. The density of households is under 500 per sq kilometer (Trans, 1997).

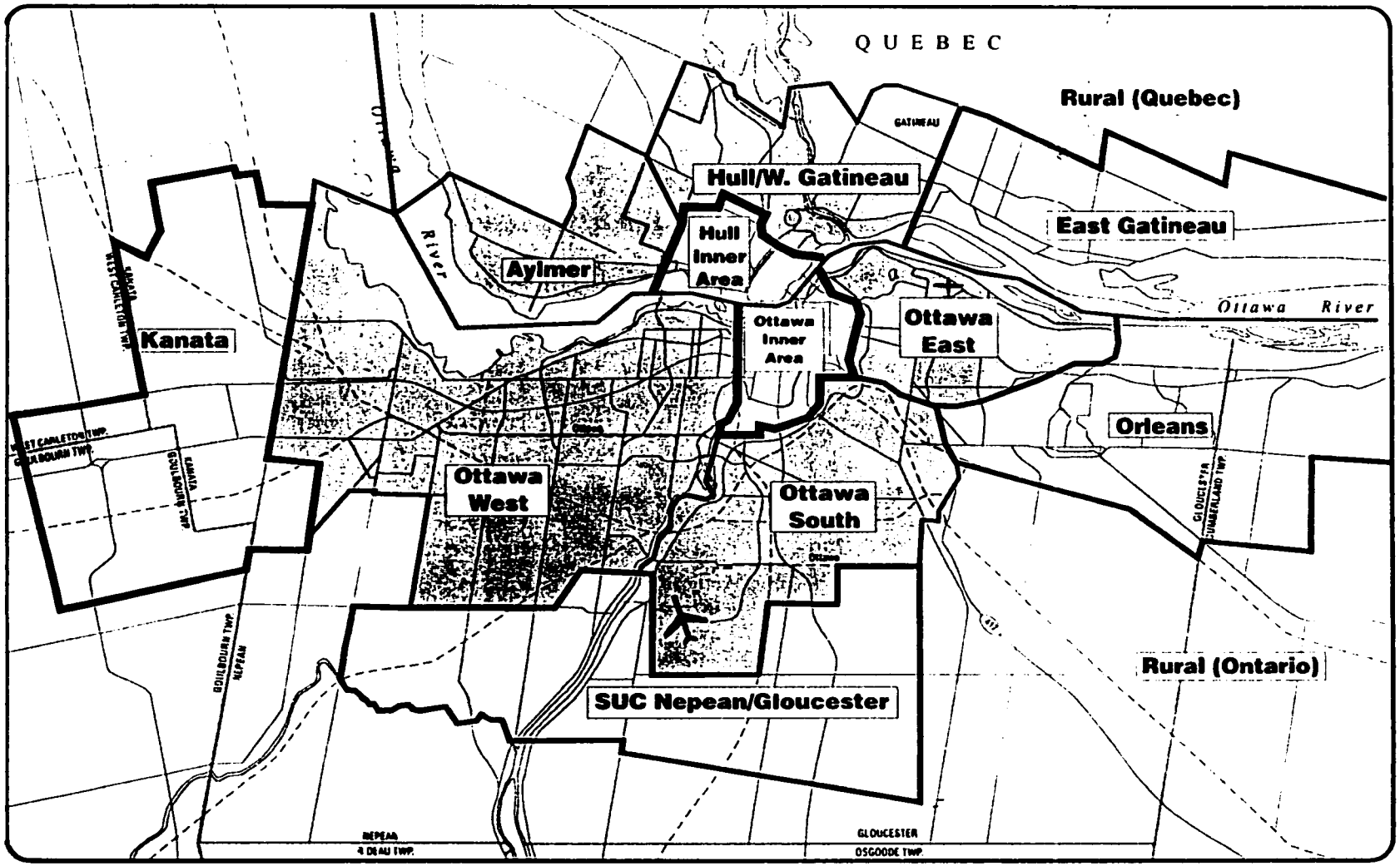
4) Rural:

This area is located outside the greenbelt and excludes suburban areas. The land is sparsely populated and has limited, if any, transit service. The population is frequently centred in small towns such as Richmond and Chelsea. Bicycles share the road with motorized vehicles since limited bike facilities are in place. Sidewalks are usually located in town centres fronting commercial buildings. The density of households varies from 1 hh per sq km in agricultural areas to 500 hhold per sq km in town centres (Trans, 1997).

EXHIBIT 3.1: Study Area

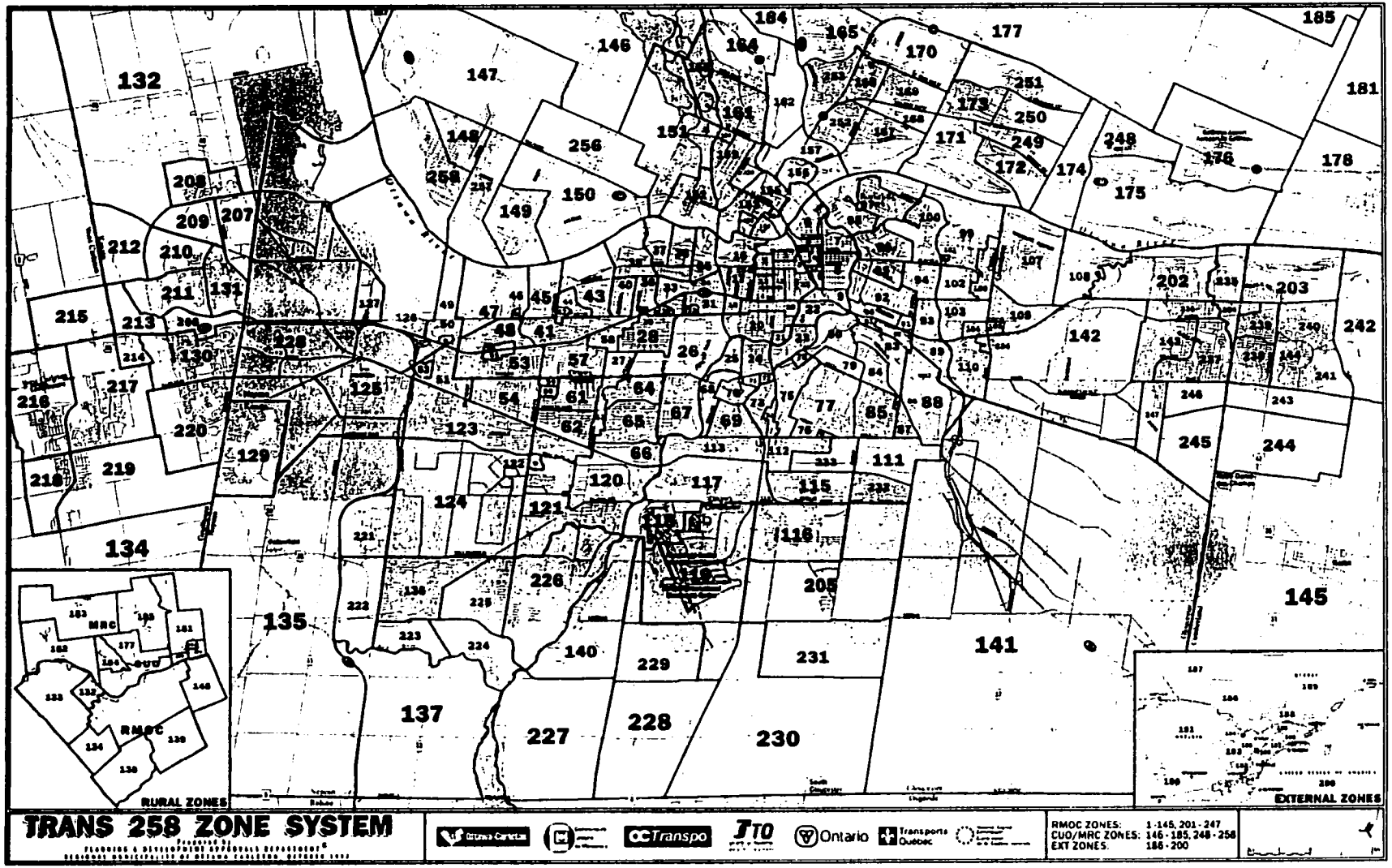


Source: Design and Administration Report, TRANS, 1996.



URBAN
SUBURBAN
CORE
RURAL

Exhibit 3.1A- Geographic Area Definitions



TRANS 258 Traffic Zones

3.2.1 The Regional Transportation Network:

A brief description of the various components of the Region's transportation network is as follows:

a) Road System:

Private vehicles, commercial traffic and public transit all make use of the Regional Road System. The Region's roadway system consists of 1,106 km of roadway (2676 lane km) which are currently designated as Regional Roads. This represents about one quarter of the roadway infrastructure within the regional boundaries. The remaining roads are under the jurisdiction of either the Province of Ontario (Provincial Highway), the National Capital Commission (Parkways), or local municipalities (local and collector roadways). The automobile is used for approximately two thirds of the weekday travel by residents of the Region. This rate varies for different areas in the region, it is highest (83%) in rural areas and lowest (48%) in the central area. In the suburban areas, the frequency is in the 67% to 74% range. The automobile is used for a variety of trip purposes ranging from shopping and leisure trips (80% by auto) to school trips where only one quarter of the trips are by auto. The rate of usage increases further from the built up areas, from a low of 43% in the central area to a high of 93% in rural areas (RMOC, 1996).

b) Transit Network:

The transit system in the RMOC is comprised of the Transitway, with its bus-only rapid transit service, major transit stations and park and ride facilities, bus-only lanes on several Regional roads, a few exclusive transit roadways, and for the most part, shared lanes with other vehicular traffic. In fact, 85% of transit operates on roads other than the Transitway. OC Transpo is responsible for transit service within the RMOC. It carries 76 million passengers over 48 million km with service comprised of 70 all day routes and 64 peak period only routes. These routes are designed to provide service within 400 meters of 955 of homes and jobs in the urban transit area. The area serviced by OC Transpo, referred to as the Urban Transit area (UTA) consists of those lands designated as the urban area within Ottawa Carleton. When considering all the weekday trips made in the Region,

19% of these trips involve transit. Approximately half of these trips are to and from work, while 215 are education related, and the remaining for shopping or leisure. The highest transit use relates to travel to, from and within the Central Ottawa and the older suburbs inside the greenbelt areas where 21% to 23% of the daily trips are made by transit. Transit share in the suburban areas ranges from 12% to 22% (RMOC Master Plan, 1996).

c) Cycling Network:

The current Regional Official Plan identifies a *Cycling and Pedestrian Policy*, which recognizes bicycles as a form of transportation used for a variety of trip purposes on existing and proposed Regional Roads, and in Transitway corridors where appropriate. Presently, the cycling network in the RMOC is comprised mainly of unsigned routes, regional roads, local municipal collector roads and local roads. There are some recreational pathways; however, the system of pathways is discontinuous, requiring cyclists to travel on routes shared by other vehicular traffic in many instances.

d) Pedestrian System:

The pedestrian system in the region is comprised of sidewalks and crosswalks along many Regional roads, as well as recreational pathways. One purpose of the system is to provide good quality and safe access to public transit by reducing the number of potential pedestrian-vehicle conflicts while providing safe walkways for recreation, shopping and other purposes.

3.3 SELECTION OF DATA SOURCE:

The primary data source in this project was the 95 Origin Destination Survey, which was carried out by TRANS, a joint technical sub-committee on transportation systems planning. TRANS staff consists of representatives from the National Capital Commission (NCC), the Regional Municipality of Ottawa Carleton (RMOC), the Communaute Urbaine de l'Outaouais (CUO), OC Transpo, the Societe de Transport de l'Outaouais (STO), the Ministere des Transports Quebec (MTQ) and the Ministry of Transportation Ontario (MTO).

The Survey was conducted between September 6th and December 14th, 1995 during which 21000 households were interviewed by telephone (TRANS, 1996). A respondent in each household was asked to provide all the information for that household including the details of the trips made by each person on the preceding weekday. Trips for persons under 10 years of age were excluded from the survey primarily due to security concerns respondents would have in providing detailed information for this group. Expansion factors were then assigned to the data for each household thus expanding the data to represent the total population of the NCR. The sampling rate was approximately 5% in urban areas and 20% in rural areas (TRANS, 1997).

The information collected for each household was divided into 3 basic categories, household data, person data and trip data as shown in Exhibit 3.2. Information was collected for a total of 145,507 trips representing travel during a typical 24-hour weekday.

EXHIBIT 3.2: SAMPLE OF DATA COLLECTED IN 1995 OD S

Household Data	Person Data	Trip Data
Location	Gender	Origin location
Dwelling Type	Age	Destination location
Number of persons	Driver's License	Trip Purpose
Number of autos	Employment Status	Start time
Number of bicycles	Place of employment	Mode of travel
	Pay to park at work	Number of auto occupants
	Student status	Access mode to transit
	School location	Egress mode from transit

Source: Database Validation and Users Guide, TRANS, 1996.

3.4 SELECTION OF MODES:

Selection of modes was carried out to define the modes to be included in the model that would consist of motorized as well as non-motorized modes. The motorized modes were consisted of auto and transit whereas non-motorized modes were comprised of bike and walk. During the literature review it was found that for the development of urban transportation models, there were a variety of definitions that could be used to describe the auto mode:

- auto persons mode (consisting of the driver as well as the passengers)
- auto vehicle mode and a separate mode for auto passenger
- Single occupant drivers mode and a separate mode for shared ride auto users

There are advantages and disadvantages of defining the auto mode in each of the above groups. The database developed in the earlier stages could be used to study each auto mode definition. Initially the definitions used for the motorized modes were the same as was taken in the 1986 TRANS model (RMOC, 1994), in which auto mode was divided into single occupancy driver (SOV) and shared ride. However soon it was realized, during the model building process, that branching of auto into these modes would not be

possible without addressing the problem of linking of trips, as explained further in Chapter 4. The linking of trips problem for auto mode was itself a complete work requiring a detailed study. As this study was primarily concerned with developing of models for the non-motorized modes along with traditional motorized modes, going back to the data preparation stage and developing of new variables to address the linking of trips problem was not considered appropriate at the final stages of model building process. It was then decided to move on with the modeling process with an aggregated definition of auto mode that included both auto driver and shared ride. This auto mode was called as *auto person mode* and the models were then developed for auto person, transit, walk and bike modes.

3.5 SELECTION OF TRIP PURPOSES:

The method of selecting trip purposes was to group trips into categories where the trip makers have predictable travel behavior patterns. The travel demand model developed by TRANS in 1986 and in 1993 (Delcan, 1993) for the PM peak hour includes the following trip purposes:

- Work to Home
- School to Home
- Other, consisting of other to home, non-home based and leave home trips.

It was decided at the onset of this research that the modal split models developed from this research should attempt to follow the same general style as the 1993 TRANS model (TRANS, 1993). This decision was based on the fact that the TRANS model successfully applies the logit model for the work to home and school to home trip purposes for motorized modes. Furthermore, by using these trip purposes for this research, it would be possible for TRANS to consider using some or all of the logit models obtained from this research into the TRANS model.

3.6 SELECTION OF TRIPS BY WEEK SURVEYED:

A concern for the development of the model containing non-motorized modes was that the sample should be based on a time period during which these modes are frequently used. Non motorized modes tend to be used more frequently during non-winter conditions. For this reason, it was decided to analyze the impact of the week surveyed on mode choice, particularly on walk and bike modes, with the intention of selecting only those weeks where all modes are used like a typical autumn week.

Analysis was carried out to ensure that all neighborhoods were surveyed in a random manner each week, thereby not biasing a sample that may contain a range of weeks surveyed to build the modal split models. The results shown in Exhibit 3.3 indicate that throughout the survey, each area was surveyed in the same proportion each week.

Exhibit 3.3- Households Surveyed by Location and Week Interviewed

Area	Survey Week Number																Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Ottawa	1,433	1,769	1,962	2,422	1,989	2,727	3,045	3,292	3,330	2,817	3,411	3,231	3,309	3,463	0	0	38,200
Vanier	36	63	107	98	63	96	139	110	157	136	199	172	158	117	0	0	1,651
Rockciffe Park	9	17	18	9		29	2	26	4	16	35	10		40	0	0	215
Nepean	601	619	912	803	757	1,137	898	1,208	1,339	872	1,171	998	966	1,157	0	0	13,438
Kanata	264	300	351	315	312	522	554	615	599	498	642	361	299	420	0	0	6,052
Gloucester	612	644	660	852	665	862	1,145	1,062	1,172	1,275	1,284	695	755	1,088	0	0	12,771
Cumberland	363	398	482	495	418	544	604	435	493	552	545	1,222	546	478	0	0	7,575
West Carleton	353	374	348	492	452	408	596	634	510	473	791	457	462	676	0	0	7,026
Goulbourn	222	294	256	225	256	372	390	339	468	353	478	250	275	425	0	0	4,603
Rideau	248	187	234	290	303	328	294	367	341	440	426	348	344	382	0	0	4,532
Osgoode	223	363	294	383	446	452	650	643	524	506	459	452	237	627	0	0	6,259
Hull	260	277	213	539	499	504	691	575	724	648	792	880	696	381	0	0	7,679
Aylmer	243	56	89	280	275	407	551	162	491	377	377	426	315	167	0	0	4,216
Gatineau	298	410	540	755	783	1,009	1,103	873	1,217	951	1,260	838	875	476	0	0	11,388
Angers-Masson	27	18	29	41	73	59	111	48	61	61	84	44	22	23	0	0	701
Buckingham	41	75	20	127	63	84	74	82	150	131	123	93	99	20	0	0	1,182
Pontiac	105	53	96	109	156	149	172	121	121	159	230	348	184	164	0	0	2,167
La Peche	64	90	110	232	158	197	268	202	243	215	240	362	250	190	0	0	2,821
Val-des-Monts	80	112	21	63	182	184	293	177	227	253	155	313	172	168	0	0	2,400
L'Ange Gardien & notre-Dame_de-la-Sal	2	8	12	0	2	33	10	16	23	16	61	16	2	0	0	26	227
Chelsea	98	65	24	181	218	246	257	210	298	167	280	373	323	193	0	0	2,933
Cantley	32	10	30	87	59	82	43	46	73	81	74	28	69	24	0	0	738
Total	5,614	6,202	6,808	8,798	8,129	10,431	11,890	11,243	12,565	10,997	13,117	11,917	10,358	10,679	0	26	138,774

Exhibit 3.4 indicates that bike trips dropped substantially from week 9 onwards while the portion of walk trips remained relatively constant. Since the primary purpose of the model was to explain the behaviour of walk and bike users, the data collected from week 0 to 8 was only used for the model development with the remaining data excluded. This filtration resulted in a model reflective of autumn conditions rather than a mix of autumn and winter conditions, if the entire survey were used.

Exhibit 3.4: Trips by Mode by Week Surveyed

Survey Week No.	Week date	Mode					Total
		SOV	Sh_Ride	Transit	Bike	Walk	
0	Sept 4 - 8	498	251	128	41	119	1,037
1	Sept 11 -15	613	234	144	40	146	1,177
2	Sept 18 - 22	662	274	159	44	162	1,301
3	Sept 25 - 29	829	396	180	60	203	1,668
4	Oct 2 - 6	838	346	203	35	172	1,594
5	Oct 9 - 13	993	432	236	74	209	1,944
6	Oct 16 - 20	1,143	490	269	63	264	2,229
7	Oct 23 - 27	1,170	476	276	37	258	2,217
8	Oct 30 - Nov 3	1,313	556	305	32	265	2,471
9	Nov 6 - 10	1,075	486	262	9	235	2,067
10	Nov 13 - 17	1,336	590	330	10	247	2,513
11	Nov 20 - 24	1,124	494	317	9	263	2,207
12	Nov 27 - Dec 1	965	451	309	7	257	1,989
13	Dec 4 - 8	1,084	.408	295	3	228	2,018
14	Dec 11 - 15	0	0	0	0	0	0
15	Jan 14 - 19	0	1	1	0	0	2
	Total	13,643	5,885	3,414	464	3,028	26,434

Exhibit 3.5: Peak Period (3:30 - 5:59) Trips by Mode and Purpose

Mode	Trip Purpose						
	HBW	LH	NHB	OH	HBSS	HBPSS	Total
SOV	3,396	1,099	2,092	1,331	27	111	8,056
Sh.Ride	254	596	1,030	1,544	12	16	3,452
Transit	982	108	242	171	262	133	1,898
Bike	127	83	41	78	74	22	425
Walk	284	343	337	408	360	64	1,796
Total	5,043	2,229	3,742	3,532	735	346	15,627

Note: Trips include survey weeks 0 to 8.

Exhibit 3.5 shows the number of cases by mode and purpose, which includes weeks 0 to 8 for the PM peak period that was used to develop the modal split models.

3.7 FILTERING PROCESS:

A filtering process was carried out to eliminate trip records that were not suitable for building the modal split models. The description of the filtering process is as follows:

3.7.1 Zero Co-ordinate Distances Trips:

During the study, it was found that there were cases where the survey contained the same Universal Meridian Distance (UTM) x-y coordinates for both the trip origin and destination. This implied that the trip length is zero. These trips were not considered as valid trips for this study and were therefore excluded.

3.7.2 Non-UTA Trips:

Once it was decided that the proposed logit model would include the transit mode, it was necessary to remove trips that were made outside the Urban Transit Area (UTA), the area where transit service did not exist. This was done because the theory of the logit model requires that the individual selecting the mode of travel must have all the modes available to them within that choice set. Since transit service was only available inside the UTA, trips with both trip ends within the UTA were included in the study. It was also found that the number of non-motorized trips, especially the bike mode, were almost non-existent outside the UTA, indicating the need to have the model based only on urban transit area.

3.7.3 Trips with Miscoded Zones:

It was also found from data base queries that some of the trips had invalid zone numbers. These trips could not be allocated to any specific zone and were excluded.

3.7.4 Records with Undefined Gender and Age:

Cases reported in the variable *gender* other than "M" or "F" were excluded. Similarly there were some cases where people refused to give their age. As *age* and *gender* were considered important descriptive variables in the building of non-motorized modes, cases with undefined age or sex parameters were excluded from the data set.

3.7.5 Records with Undefined School or Employment Zones:

Records where the location of the student's school or a worker's primary workplace was not recorded were also excluded from the databank.

3.7.6 Households with Zero Bikes:

The basic assumption in the MNL model is that every trip maker has considered all modes available to them. If any one or more modes are not available to the individual then those cases should be eliminated from the data file. Keeping this in mind the cases that have no bikes in the household were excluded presuming that bike mode was not available as a mode of travel to these trip makers. It should however be noted that cases having zero autos in the household were not excluded from the file since they could share a ride

3.8 SELECTION OF TIME PERIOD:

An analysis was carried out to determine the number of cases by mode and trip purpose for the PM peak hour and PM peak period. This was necessary in order to ensure that an adequate number of records were available to build the model. It was found that the key factor limiting the model structure was the number of cases of the bicycle mode. This mode was required in the model and had the smallest number of cases for the time interval under investigation.

3.8.1 PM Peak Hour Analysis:

It would be most desirable to have the model based on the PM peak hour since the design of any transportation facility in an urban area is based on its peak hour. Analysis of the peak hour was done for single occupant vehicles (SOV), shared ride, transit, bike, and walk modes by quantifying the number of cases for 15-minute intervals between 1500-1800 hours, as shown in Exhibit 3.6.

Exhibit 3.6: One Hour Trip Frequency by Mode

Time Interval	Mode					Total
	SOV	Sh.Ride	Transit	Bike	Walk	
1500-1559	4,034	1,669	1,468	204	**1,925**	9,300
1501-1600	5,089	1,900	**1,725**	**246**	1,851	10,811
1515-1614	5,130	1,959	1,662	233	1,806	10,790
1516-1615	5,321	2,060	1,620	224	1,665	10,890
1530-1629	5,350	2,131	1,599	221	1,590	10,891
1531-1630	5,913	2,327	1,571	206	1,237	11,254
1545-1644	5,938	2,363	1,567	207	1,191	11,266
1546-1645	6,068	2,449	1,541	208	1,144	11,410
1600-1659	6,113	2,494	1,549	208	1,135	11,499
1601-1700	6,226	2,610	1,488	189	1,084	11,597
1615-1714	**6,255**	2,650	1,485	187	1,050	**11,627**
1616-1715	6,247	2,673	1,471	183	1,041	11,615
1630-1729	6,219	2,662	1,445	178	1,036	11,540
1631-1730	5,768	**2,683**	1,263	173	1,017	10,904
1645-1744	5,761	2,634	1,250	173	1,026	10,844
1646-1745	5,638	2,618	1,221	168	1,006	10,651
1700-1759	5,580	2,589	1,186	173	1,001	10,529
1701-1800	4,611	2,478	844	147	870	8,950

As the results indicate, the modes have the following PM peak hours:

- SOV 6255 cases during 1615-1714
- Sh_Ride 2683 cases during 1631-1730
- SOV + Sh_Ride 8,920 cases during 1616-1715
- Transit 1725 cases during 1501-1600
- Bike 246 cases during 1501-1600
- Total Trips 11,627 cases during 1615-1714

The selection of a PM peak hour would govern the number of cases available to build the model and also the modal choice. As Exhibit 3.7 illustrates, modal share varies significantly depending upon which peak hour is selected.

If we wanted to build a PM peak hour model that gave the highest possible bike and transit mode split, the model would be built using the cases contained in the 1501 - 1600 time interval. This would give a bike modal choice of 2.3 percent compared to only 1.6 percent for the 1616 to 1715 time interval. For both the 1501 - 1600 and 1500 - 1559 time intervals, there are over 100 cases for the school trip purposes with the remaining trip purposes having in the order of 20 to 50 cases.

The limiting factor for the style of the model was the number of bicycle trips, see Exhibit 3.7. For the 1501 - 1600 time interval, the number of bike cases was 246. If this time interval was used, it might be possible to have at most two trip purposes aggregated such that a minimum of 100 cases was contained in each trip purpose definition. However, for the purpose of developing a logit model, it is desirable to have at least 100 trip records per mode per trip purpose (Ortuzar and Williumsen, 1994). If the 1616 - 1715 time interval was used, only 183 bicycle cases were available, implying that all the trip purposes would have to be grouped into one to build the model with a bike mode.

EXHIBIT 3.7: Trip Frequency by Mode and Purpose for 3 one Hour Intervals

Time	Mode	Trip Purpose						
Interval		HBW	LH	HBO	NHB	HBSS	HBPSS	Total
1616 - 1715	SOV	2,839	720	899	1,705	24	60	**6,247**
	Sh - Ride	244	400	1,251	760	8	10	**2,673**
	Transit	925	69	130	177	77	93	**1,471**
	Bike	77	27	40	21	9	9	**183**
	Walk	269	215	264	207	47	39	**1,041**
	Total	**4,354**	**1,431**	**2,584**	**2,870**	**165**	**211**	**11,615**
1501 - 1600	SOV	1,873	728	832	1,512	45	99	**5,089**
	Sh - Ride	164	252	801	658	14	11	**1,900**
	transit	572	86	144	248	540	135	**1,725**
	Bike	36	41	28	30	104	7	**246**
	Walk	154	274	260	279	821	63	**1,851**
	Total	**2,799**	**1,381**	**2,065**	**2,727**	**1,524**	**315**	**10,811**
1500 - 1559	SOV	1,091	779	771	1,255	55	83	**4,034**
	Sh - Ride	111	251	699	585	14	9	**1,669**
	transit	332	100	138	200	594	104	**1,468**
	Bike	18	22	19	29	113	3	**204**
	Walk	96	274	245	294	960	56	**1,925**
	Total	**1,648**	**1,426**	**1,872**	**2,363**	**1,736**	**255**	**9,300**

Note:
HBW = Home based work trips
LH = Leave home trips
HBO = Home based other trips
NHB = Non home based trips
HBSS = Home based secondary school trips
HBPSS = Home based post secondary school trips

One of the main requirements of the proposed model was to provide insight into the travel behavior of individuals. If the model was built on a sample heavily reliant on school trips, then its explanatory usefulness would be limited. School trips are for the most part made by young people who do not have a driver's license and are therefore captive users of walk, bike, transit or share a ride. They also make a large portion of their school trips outside the time when auto oriented traffic is highest. It is most desirable to build the model on a sample that contains adequate trips for the work to home, school to home and other trip purpose definition.

From this peak hour analysis, it appeared that a modal split model could not be developed from a peak hour data set, with the desired explanatory capabilities, as the number of

cases for the bike mode were inadequate for the three trip purposes. With this fact established, the next task was to review the possibilities of developing a PM peak period model.

3.8.2 PM Peak Period Analysis:

Exhibit 3.8 illustrates the number of trips by mode and purpose for the PM peak period from 3:30 to 5:59. By using this broader time interval, adequate cases were available to develop the model that included the bike mode and all the desired trip purposes.

Exhibit 3.8: Peak Period (3:30 - 5:59) Trips by Mode and Purpose

	Trip Purpose						
Mode	**HBW**	**LH**	**NHB**	**OH**	**HBSS**	**HBPSS**	**Total**
SOV	5,750	1,803	3,720	2,247	65	186	**13,771**
Sh.Ride	473	1,024	1,740	2,673	17	29	**5,956**
Transit	1,774	204	447	327	442	260	**3,454**
Bike	142	87	55	87	80	23	**474**
Walk	524	586	533	668	628	117	**3,056**
Total	**8,663**	**3,704**	**6,495**	**6,002**	**1,232**	**615**	**26,711**

Based on the above time period analysis, it was therefore decided to build the models based on PM peak period. Peak Hour Factors (PHF) would then be used to convert them to peak hour trips to be used in the subsequent model assignment stages using EMME/2.

3.9 DEVELOPMENT OF ADDITIONAL VARIABLES:

Once the sample of trip records was obtained from the 1995 OD Survey for building the logit models, the next stage was to develop additional variables to the records. This was necessary since the 1995 OD survey did not capture all of the information required to build the modal split logit models.

To build logit models, it is necessary to have information describing the attributes of the mode used for making the trip as well as the attributes of all the modes within the choice set along with the attributes of the trip maker. For having this, some variables can be created by manipulating variables already in the databank into a format more appropriate for building the model while some are created outside the databank from other sources.

Probabilistic choice models generally and logit models in particular make it possible to develop useful choice models that do not include all the variables that influence the choice being modeled (Train, 1986). This is an important property as the variables, which influence the mode choice, are not all known to the analysts. It is also not possible to measure all known variables in practice. This does not imply, however, that a model based on any subset of the influential variables will be useful. On the contrary, there are certain types of variables that must be included to obtain a useful model as described below.

3.9.1 Policy Variables:

One of the most important uses of the choice models is predicting the effects of policy measures. For example, a transportation planner may want to predict what changes will occur to mode choice if bus fare changes or if bus travel becomes faster. Such questions can be answered only if the model includes policy variables such as transit fare and travel time. By including these policy variables in the model, we can predict the effect of changes in travel time and cost on the total travel demand for each of the available modes. For example if parking cost is increased by changing the parking policy, people

will switch to other modes such as transit, walking and cycling because they find auto travel too expensive. Similarly, if transit travel time increases, people will try to find an alternative travel mode, which requires less time.

In our modeling exercise, travel cost and travel time are the policy variables. Travel cost includes fuel cost and parking cost. Travel time is the time taken to travel from the trip origin to the trip destination.

3.9.2 Socio-Economic Variables:

Often, it is important to predict the effects of policy measures on different groups in the population. For example, it may be important to know whether increasing bus fares will be particularly burdensome to students, females, and unemployed travelers or whether a certain improvement in transit service will succeed in attracting members of multi-car households to transit. A model can answer questions such as these only if it includes Socio – economic variables such as income, number of automobiles per household, number of persons per household, etc. If the income of a family is high and there are several automobiles, then members of the household are more likely to drive then to take transit. On the contrary, if the family income is low and there are no vehicles in the home then family members will likely use transit. It is important to identify the variables that affect mode choice and also demographic and socio-economic characteristics of the various population groups in order to make the model more useful and reliable.

In our proposed model, variables such as employment, age cohorts, sex, and automobiles owned would serve this purpose.

3.9.3 Other Variables:

There are certain variables which are unique and do not fall into any category mentioned above but they do affect mode choice. They influence the policy variables and other socio-economic variables. Such variables should be included in the model or else the

model will give incorrect predictions. An example of this type of variable is the CBD flag. The CBD flag identifies where high employment density occurs in the NCR. It also identifies a key location where a high proportion of auto users will likely pay for parking for the work to home trip purpose. The CBD flag is also an indicator of an area where finding a person to share a ride is highly probable. As such, this variable should be included in the model so that the model predicts travel characteristics correctly.

3.10 DEVELOPED VARIABLES:

Based on the attributes discussed in the previous section the developed variables and their rationale is given below:

3.10.1 Transit Fare:

Since the cost of travel was not collected in the survey, a method was developed to estimate this variable. Transit fares for 1995 were estimated by developing a fare matrix system, see Exhibit 3.10. Areas were identified where regular and premium transit serviced specific geographic areas in the National Capital Region. The transit fare required to travel between the areas in the matrix is a function of cash fares and monthly passes, taking into account the dual OC Transpo and STO fare structure for regular and express service.

Exhibit 3.10: Transit Fare Matrix

	Origin Area	Destination Area								
Area No.	Description	1	2	3	4	5	6	7	8	9
1	RMOC inner UTA	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.73	3.1
2	RMOC outer UTA West& South	1.35	1.35	1.73	1.35	3.1	3.1	1.35	1.73	3.1
3	RMOC outer UTA -east	1.35	1.73	1.35	3.1	3.1	3.1	1.35	1.73	3.1
4	RMOC Stitsville	1.35	1.35	1.73	1.35	3.1	3.1	1.35	1.73	3.1
5	RMOC Richmond	1.35	1.35	1.73	3.1	1.35	3.1	1.35	1.73	3.1
6	RMOC Rockland	1.35	1.73	1.73	3.1	3.1	1.35	1.35	1.73	3.1
7	CUO West of Gatineau River	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.73	3.1
8	CUO East of Gatineau River	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.35	3.1
9	CUO, Rural East Quebec	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	1.35

area no.	emme2 traffic zones in areas
1	1-45, 57-104, 106, 110-122, 201, 232-234
2	46-56, 123-133, 135-138, 140, 206 - 215, 220-231
3	105, 107-109, 139, 141 -144, 202-205, 235-247
4	216-219
5	134
6	145
7	146-164, 182-184, 254-258
8	165-177, 248-253
9	178 - 180

Concept: The high fares of $1.73 are for accessing green express buses. It is assumed that the green fare of $1.73 is for outbound trips, while inbound trips have the regular fare of $1.35. For across region service as from Orleans to area 2, the $1.73 fare is assumed, since they would have to go to the central area and then transfer to a green route to complete their trip.

emme2 zones assumed outside of the UTA for 1995 are:
132, 133, 135, 137 - 141, 146, 147, 177, 181-185, 186-200, 212-215, 227-230

3.10.2 Auto Cost:

Auto costs for auto work trips consisted of an operating cost assumed to be the cost of fuel consumed and a parking cost. Fuel consumption costs were based on averages across Canada as reported by Canadian Automobile Association for 1995. For the model calibration, 5 cents per kilometer was used as the fuel cost based on an average fuel consumption rate of 9.2 litres /100km and a fuel price of 55 cents/litre. The parking cost was estimated by contacting major parking suppliers and finding out what the monthly cost was for parking all day. This amount was divided by 20 to get a daily rate. It was then multiplied by the proportion of auto drivers who paid for parking at the work place as recorded from the 1995 OD survey. This factoring process was necessary in order to be consistent with the approach used to aggregate this variable to a zonal level if the models were later used to estimate travel demand on a zonal level. The auto cost was then divided by auto occupancy as reported by the auto driver, giving the desired auto cost. If auto occupancy was not available, it was estimated based on analysis of vehicle occupancy rates.

3.10.3 Travel Time and Trip Distance:

The EMME2 model was used to assign observed PM peak hour travel demand onto the auto and transit networks to estimate mode attributes such as time and travel cost. In-vehicle travel times of the trip for auto and transit modes were obtained using the assignment results of EMME2. These are the times in minutes to go from the trip origin to the trip destination. Out-of-vehicle travel time was also estimated. Transit out-of-vehicle travel time was assumed to include the time to walk to the bus stop, wait for the bus, access the bus, transfer if necessary to another bus, egress the bus and then travel to the destination. For the auto mode, out-of-vehicle travel time was assumed zero. Travel times for the non-motorized modes were developed from the standard speeds of these modes within the urban transit area. For details see Appendix –B.

For short trips under 2 km in length, the database was adjusted to provide a more appropriate estimate of trip time, distance and cost. This was necessary since the source used to obtain trip length and travel time was the assignment results from the EMME2 model. The EMME2 model software tends to under estimate trip lengths and times for short trips, less than 2 km. This is because the model uses centroid connectors to load trips onto the network. This implies that all trips travel the same distance within a zone to access the road and transit network. Although this approach is satisfactory for simulating auto and transit travel demand whose trip lengths average over 10km, it was a cause for concern for walk and bike trips whose average trip lengths were around 1 to 2 km in length.

To overcome this under-estimation of distances for short trips as well as to estimate the trip distances of non-motorized modes, a method was derived based on Geographic Information System – Intergraph. Here factors were developed to convert a straight-line distance using the UTM coordinates to a distance likely traveled by car, transit, walk and bike modes. For a detailed description of this method please refer Appendix-B. Once the corrected distance was estimated, appropriate estimates of travel time and cost were developed for all the modes.

3.10.4 Vehicles Per Household:

Number of vehicles per household was recorded in the survey. This variable was re-coded to take on three values: 0 for a trip maker with no vehicles in the household, 1 when there was one vehicle in their household, and 2 when there was more than 1 vehicle in the household.

3.10.5 Other Variables:

Several other variables were also developed using the TRANS 1995 Survey data. Referred to as dummy variables, and based on geographic location of a trip's origin or destination zone, they reflected potentially significant differences in transportation

service that may not be fully captured by more tangible service attributes such as travel time or cost. For this study a "Province" variable was developed to distinguish between residents by province. If the person resided in Ontario, the variable had a value of 1, if they lived in Quebec, the value was 0. Another variable developed was CBD flag whose value was 1 when the trip was made to CBD (traffic zones 1 to 16, 201, 153, 154, 155, 254, 255), 0 otherwise. For a complete list of the generated variables, refer Appendix - B.

3.11 SELECTION OF MODELING SOFTWARE:

Once the form of the model has been decided, modes have been chosen and the data has been selected the next task was to select a software that would run a multinomial logit model. The software that was available in RMOC was *Statistical Package for Social Sciences* (SPSS) version 7.1. However this software has major limitations as it could do only binary logit modeling work. As our work involved multinomial logit modeling for four or five modes we needed a software compatible to our modeling needs. There were several good packages available out there like Ulogit and Umodel etc. Time Series Processor (TSP) is one of the software used for multinomial logit work. This software was available from Carleton University and was thus selected for our modeling work. A brief description of this software and guidelines to its use is provided in Appendix A.

CHAPTER 4

HOME BASED WORK TRIP MODEL

4.1 OVERVIEW:

The first model developed was for the home based work trip purpose. Work trips represent the dominant trip purpose in the P.M. peak period (Exhibit 3.5) and as such it is the most important model in terms of policy implications. Quite a few models have been developed in the past for this type of trip purpose but very few attempts are made to develop it with non-motorized modes (Stein, 1996). By developing a nested logit model for motorized and non-motorized modes the policy makers and analysts have now a powerful and policy sensitive tool for comprehensive transportation planning, especially in promoting the environmentally friendly modes.

4.2 STRUCTURE OF THE MODEL:

The first attempt was made to build a nested logit model with single occupant vehicle, shared ride, transit, walk and bike modes (Figure 4.1). The lower level nest consisted of walk and bike modes in one group and single occupant vehicle and shared ride modes in the second group. The upper level nest consisted of auto, transit and non-motorized modes.

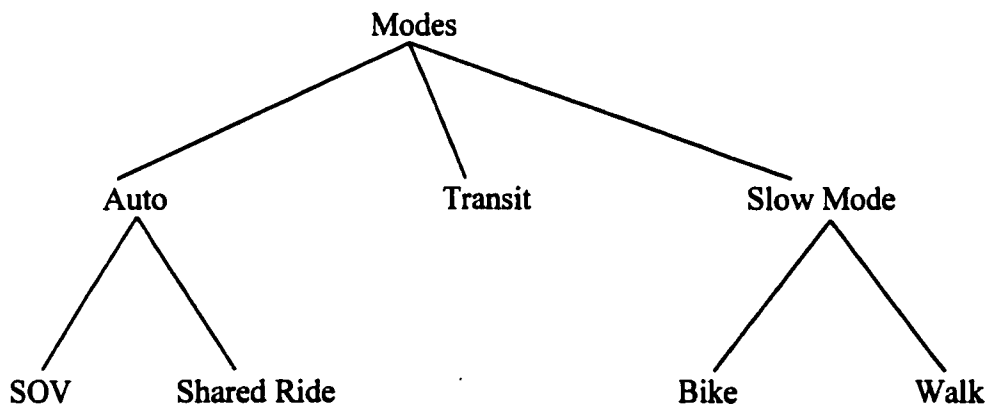


FIGURE 4.1: Structure - I for HBW Trip Model

However, the developed model (not shown) provided poor simulation results. It was found that the model had difficulty distinguishing between the SOV and shared ride modes. Part of this difficulty was related to the fact that the only person who reported car occupancy in the survey was the auto driver and not the auto passenger. As a result, average car occupancies had to be used to estimate travel cost for those auto users who were passengers. Another problem in distinguishing the auto user between the SOV and shared ride mode was the inaccurate description of the linked trips in the OD survey. In a linked trip the person is reported to have made more than one trip in the OD survey where in reality he is making just one trip. An example of this is a car driver who picks up a passenger on his way to work and then drops him at his office before going to his work place. In the survey, his movements were recorded as three "Other trips" (from 'home to serve passenger', from 'serve passenger to serve passenger' and from 'serve passenger to work') rather than one 'home based work' trip as shown in Figure 4.2.

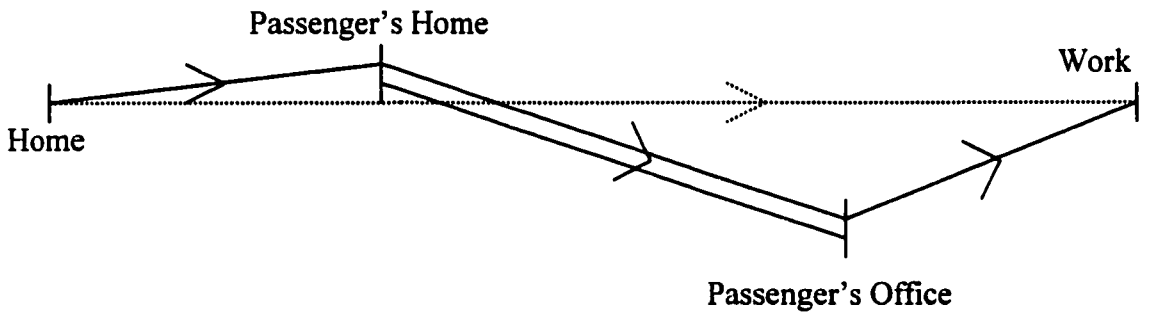


FIGURE 4.2: An Example of Linking of Trip

Ist trip (sov): Home - Passenger's Home (Home based other trip)

2nd trip (sh. ride): Passenger's Home - Passenger's Office (Non-home based trip)

3rd trip (sov): Passenger's Office - Work (Other trip)

Significant efforts were required to go back to the survey and link these trips together with the goal of improving the model's ability to distinguish between SOV and shared

ride. However, as the main purpose of this thesis was to develop a satisfactory nested logit model for non-motorized modes (walk and bike) along with the motorized modes (auto and transit) that would analyze the mode change from non-motorized to motorized, it was felt that separating the auto mode between SOV and shared ride would serve no advantage of distinguishing between motorized and non-motorized modes. This additional work was not a priority and therefore was not carried out. The definition of auto mode was then re-defined as the auto person mode that included both SOV and shared ride users and the model structure selected is as shown in Figure 4.3.

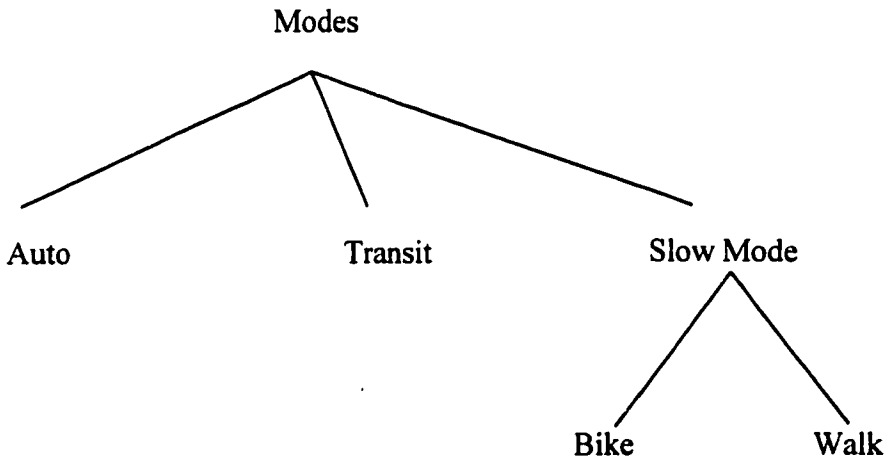


FIGURE 4.3: Revised Structure of HBW Trip Model

4.3 LOWER LEVEL MODEL:

The model for walk and bike modes was developed first, being in the lower level nest of the nested logit model. The higher level model was then developed using the inclusive value of the lower nest. The upper level model included auto, transit and slow modes.

4.3.1 Selected Variables:

The lower level model consisted of walk and bike modes. The number of cases for these two modes in the home based work trip model was 306. Out of this bike and walk cases were 119 and 187 respectively. The first mode considered was bike and so the coefficients of bike mode were normalized to zero. The variables selected for this model were *time, gender, age* and *number of bikes in the household.* It may be noted that variable '*time*' was taken as a conditional variable that allowed us to have separate time variables, *time1* and *time2* for the two modes. On the other hand *gender, age* and *number of bikes* were all multinomial variables having same values for each mode for each case. It has already been explained that conditional variables have the same coefficients for every mode whereas multinomial variables have separate coefficients for each mode (see Chapter 2 and Appendix-A for details). However as mode 'bike' (being mode 1) was normalized to zero so the TSP output gave coefficient values only for the walk mode with respect to the bike mode, along with the coefficient of the conditional variable (time).

4.3.2 Expected Signs for the Coefficients:

Values for the variable *time* were taken in minutes, *age* in years and *number of bikes per household* in numbers. '*Gender*' was coded as 0/1 with 1 for female and 0 for male. The expected signs for the coefficients of these variables are discussed below:

1) Time:

The coefficient of time was always expected to have a negative sign since increasing travel time makes the mode less attractive.

2) Gender:

By analyzing the 1995 OD Survey and searching the related literature about the socio-economic characteristics of people living in North America, it was established that women were less likely to go on work trip using bike mode as compared to males. As gender has been coded as 1 for female and 0 for male, it was expected that we would get a positive sign for the walk mode with respect to bike.

3) Age:

Age plays an important role in the selection of bike mode especially for the work trips. As age goes up, people become less energetic and are forced to shift from bike to walk mode. Therefore, age was expected to have a positive sign for the walk mode, which meant that when age increases people were more likely to use walk mode as compared to bike mode.

4) Number of Bikes:

Just like number of autos for auto mode, total number of bikes in the household was an important variable in the selection of bike mode. As such this variable was expected to have a negative sign for the walk mode as more number of bike meant person was more likely to take bike than to go on foot keeping all other variables fixed.

4.3.3 Developed Lower Level Model For The Home Based Work Trip Purpose:

Table 4.1 shows the results of the developed model for the home based work trip purpose for walk and bike modes.

TABLE 4.1: Lower Level Model for Home Based Work Trip Purpose

Mode	Time	Gender	Number of Bikes	Age	Constant
Bike	-0.0268 (-6.18)				
Walk	* -0.0268 ** (-6.18)	1.0963 (3.47)	-0.4789 (-3.55)	0.0056 (0.39)	1.6614 (3.39)

Travel Time --- total time of the trip from origin to destination in minutes

Gender --- coded as 1 for female and 0 for male

Number of Bikes --- total number of bikes in household

Age --- age of person in years

* --- coefficient

** --- t-statistic

Summary Statistics:

Number of modes	= 2
Number of bike trips	= 119 (38.89%)
Number of walk trips	= 187 (61.11%)
Total number of trips	= 306 (100.00%)
Rhosq	= 0.3322
Rhobarsq	= 0.3086
Adjusted Rhosq	= 0.3073
Adjusted Rhobarsq	= 0.2828

4.3.4 Validation:

For validating the results two different approaches were used.

- Macro Validation
- Micro Validation

The first was the macro validation of the model in which the modal split as given by the developed model was calculated and compared with the actual modal share. This would give the modal split accuracy of the model as a whole. This validation was important in presence of the borderline cases (cases whose modal probabilities are very close to each other) and as such were likely to be predicted wrong. However, they would be adjusted equally when total number of predicted cases were compared with the total number of observed cases.

The second approach was the micro validation in which the modal result of every case was compared with the selected mode. This would give the predicting ability of the model at the micro level and its percent correct (right) value.

TABLE 4.2: Macro Validation

Mode	Number of Observed trips	Number of Predicted trips	Error	Percent Predictibility
Bike	119	110	-9	92.44%
Walk	187	196	+9	
Total	306	306	9	

From Table 4.2, it can be seen that the developed model is underestimating just 9 bike trips or in other words 9 walk trips are overestimated giving an overall predicting ability of 92.44% for the model.

TABLE 4.3: Micro Validation

Mode	Number of Observed trips	Number of trips Correctly Predicted	Percent Correct Value
Bike	119	84	70.59%
Walk	187	161	86.10%
Overall	306	245	80.07%

From Table 4.3, it can be seen that the percent correct value for bike mode is 70.59% whereas for walk mode it is 86.10%. This shows that the model is distinguishing the two modes properly and in correct proportions. The overall percent correct value of 80.07% of the model shows the quality and predicting ability of the model.

4.3.5 Goodness of Fit Measures:

The goodness of fit measures provide the analyst important statistical tools to measure the quality of the developed model with respect to the sample data. According to Ortuzar and Willumsen (1994), the goodness of fit measures like *'rho-sqared'* and *'rhobar-squared'* are appropriate only for samples with equal share. When the split of modal share in the selected data set is unbalanced these measures should be corrected for their market shares. For such samples, they propose goodness of fit measures, known as, *'Corrected rhosquared'* and *'Corrected rhobarsquared'* as has been explained in Chapter-2. They have also given a table for the minimum excepted values of *rhosquare* with unequal market share datasets, as shown below in Table 4.3a.

TABLE 4.3a: Minimum p^2 for Various Relative Frequencies

Sample proportion selecting the first alternative	Minimum value of $p\ 2$
0.50	0.00
0.60	0.03
0.70	0.12
0.80	0.28
0.90	0.53
0.95	0.71

Source: Ortuzar and Willumsen, 1994

In our data set the modal split for walk and bike trips were 61.11% and 38.89% respectively, for which the excepted *rhosquared* value is 0.03. The developed model has a *corrected rhobarsquared* value equal to 0.2828, which is significantly higher than the minimum excepted value. This shows the quality of the model in statistical sense as well.

4.3.6 Correlation Matrix:

The correlation matrices for the developed home based work trip model for non-motorized modes are shown in Tables 4.4 and 4.5.

TABLE 4.4: Correlation Matrix for Bike Mode

	CHOICE	TIME1
CHOICE	1.0000	
TIME1	-0.4924	1.0000

TABLE 4.5: Correlation Matrix for Walk Mode

	CHOICE	TIME2	SEX_R	NUM_BIK	AGE
CHOICE	1.0000				
TIME2	-0.4892	1.0000			
SEX_R	-0.2985	0.1926	1.0000		
NUM_BIK	-0.3458	0.2692	0.1401	1.0000	
AGE	-0.0812	0.0930	0.1484	0.1401	1.0000

The correlation values between each pair of variables are shown in Tables 4.4 and 4.5. Whereas a lower correlation value is always desirable researchers believe that a value greater than 0.8 shows that a particular effect is being accounted for twice and only one of the two variables should be included in the model (Tardiff 1976). It can be seen from the correlation tables that there is no problem of multi-colinearity among independent variables in each of the two models. All the independent variables are having little correlation and as such the estimated coefficients of the variables are not biased.

4.3.7 Discussion on Model Results:

It can be seen that all the variables have signs as per expectations and except *age* all other variables are significant at 99.5% level. Even though age is not proving to be a significant variable and has a very low coefficient estimate, it was retained in the model as it is taking care of the effects of some other variables like health and physical condition of the person for which we do not have any information. In other words it is behaving as a proxy for some factors.

Time has come out to be the most significant among all the variables with t-statistic equal to -6.18 showing that even in non-motorized modes time is the most important factor in the selection of modes. In the absence of any cost considerations in these environment friendly modes people conceive the value of time as the decisive factor keeping all other factors same. It's estimated coefficient of 0.027 is significant considering this estimate is only for one minute of change in time.

Gender, as expected, has been proved to be an important variable in the selection of the bike mode with a t-statistic equal to 3.47 and coefficient of 1.096. As gender is a dummy variable with female = 1 and male =0, its positive sign indicates that females prefer to walking over cycling compared to men for the work trips. This finding is also in accordance with the travel characteristics of the region (TRANS, 1997), which shows that, percentage of female using the walk mode is more than males for the work trips.

'Number of bikes' in the household is also proving an important variable in the selection of bike mode with t-statistic equal to -3.55 and estimated coefficient -0.479. This result is as per expectations since a higher number of bike means the person is more likely to use bike as his/her transportation mode as against walking provided all other factors remain unchanged. Initially it was thought that *'number of bikes per person'* might be a better variable than simply *'number of bikes per household'*. The results (not shown), however, negated the idea. This proved that in work trips the benefit of addition of every bike goes mostly to the person who is capable of making the trip and is not equally divided among all the members. On the other hand *'number of bikes per person'* could prove more significant than *'number of bikes per household'* in non-work trips, where each person in the house hold is benefited equally with the addition of every bike (since each member of the household is capable of making that trip).

Lastly, the *Constant* has also come out to be a significant factor with t-statistic equal to 3.39 and a high value of 1.661 for the estimated coefficient. This proves that there are some important factors and characteristics in the selection of non-motorized modes, which are not explained by the model. The effect of those unknown and unexplained factors have therefore been incorporated in the value of the constant. The possible omitted variables are health of the person, physique, type of job she/he is doing e.g., government, wholesale, private etc., availability of bikeway and safety considerations. All these factors are potential variables in the detailed explanation of this model for which we have no information available in the 1995 OD survey.

4.3.8 Sensitivity Analysis:

Sensitivity analysis is an important tool that not only provides a better understanding of the model but also determines the effect of policy changes on the travel behaviour. As the model was based on dissaggregate mode choice, the evaluation of level of service and individual and household attributes provided an improved understanding of the traveled

choices. This type of analysis is especially useful in evaluating the impacts of policies on different market segments and interest groups. Table 4.5a shows the results of the analysis carried out for each variable.

TABLE 4.5a: Sensitivity Analysis

Variable	% Change in walk mode choice
Bike time (increased by 10%)	0.66%
Walk time (increased by 10%)	-3.59%
Male rather than female	-12.42%
Bike Per Household (increased by 1bike/household)	-14.05%
Age +10years	0.66%

The first variable analyzed was time. It was found that when bike time was increased by 10% there was only a 0.66% increase in walk mode share. However with a 10% increase in walk time, walk mode decreased by 3.59%. This shows that in non-motorized modes walk time is more important as compared to bike time. This is quite a logical result as normally a person would walk up to a certain time (or distance) and as that limit is approached he switches to another mode. However with the bike mode one can travel comparatively longer distances with less effort.

The sensitivity analysis for variable *Gender* shows that as compared with female, if male were the sex, walk mode share decreased by 12.42%. This shows that women prefer to walk while men prefer to use the bike mode for home based work trips.

The analysis for *Bikes per household* shows that walk mode share decreased by nearly 14% with the increase of 1 bike per household. This is an expected result, which confirms that availability of bikes to a person plays an important role in the selection of bike mode.

The sensitivity analysis for variable *Age* shows that walk mode choice increased by 0.66% by an increase of 10 years in age. Although its positive sign is quite logical, an increment of just 0.66% shows that age is not proving an important variable in the selection of non-motorized mode for home based work trips.

4.4 HIGHER LEVEL MODEL:

The higher level model included auto, transit and non-motorized (walk and bike) modes. An inclusive value of the lower level nest was calculated and used as an independent variable in the higher level model, as has been explained in Chapter 2. This inclusive value or composite utility of the members of the nest, $I_{b,w}$, was found for each and every case using the expression:

$$I_{b,w} = \ln \sum_{n=1}^{J} e^{v_j}$$

where, J is the number of available alternatives in the nest, which in this case were walk and bike.

$$\therefore \; I_{b,w} = \ln (e^{v_b} + e^{v_w})$$

This value was then entered as a typical independent variable that had the $W_{b,w}$ variables (attributes common to all members of the nest) and the characteristics of automobile and transit to estimate a second-level (or higher level) multinomial logit model for automobile, transit and non-motorized modes.

4.4.1 Selected Variables:

The variables selected in the formation of this model were *cost, time, inclusive value, vehicle per household, province, license* and *income. Cost, time* and *inclusive value* were considered as conditional variables while the rest were taken as multinomial variables. The number of cases available for developing the higher model was 4274. Out of this,

auto person, transit and non-motorized trips were 2952, 937 and 385 respectively. The first mode considered was auto person and so the coefficients of auto person mode were normalized to zero.

4.4.2 Expected Signs for the Coefficients:

Values for the variable *time* were taken in minutes and *cost* in cents whereas *vehicles per household, province,* and *license* were considered as dummy variables. The expected signs for the coefficients of these variables are discussed below:

1) Cost:

Travel cost is the most important variable in selecting the motorized modes and is therefore a key policy variable. This variable determines the effects of policy measures that could change the modal split of motorized and non-motorized modes. For example, this variable will predict the increase in transit ridership because of any increase in fuel or parking cost or the loss in transit ridership due to fare increase or decrease in its level of service. As the operating costs are quite different for transit, auto and non-motorized modes, this variable was taken as a conditional variable. *Cost1* was the cost for auto that included fuel and parking cost. *Cost2* was the transit cost, which included transit fare. *Cost* for non-motorized modes was assumed to be zero (however to avoid a zero value in the conditional variable for NMM, a token of 10 cents was taken in *Cost3*). As *Cost* is always a disutility in the selection of any mode, the expected sign for the coefficient for cost variable was negative.

2) Time:

Time is another important policy variable that has major impact on the mode split. The time taken in the variable was the total travel time from the trip origin to trip destination. For auto and transit modes, travel time was determined using EMME/2 model. For non-motorized modes, travel time was estimated outside of EMME/2, using GIS software 'Intergraph', as has been detailed in Appendix-B. Again, time was considered as a

conditional variable having different times for different modes. *Time1* was the in-vehicle travel time for auto from trip origin to trip destination. Out-of-vehicle travel time for auto was assumed to be zero. *Time2* was the transit travel time that included both in-vehicle and out-of-vehicle time. The out-of-vehicle transit time included the access time required to walk to the bus stop, waiting time at the bus stop, boarding time, transfer time and egress time. *Time3* was the travel time for non-motorized modes that was taken as the average of the walk and bike mode times (because of very little difference between the two times). Being a disutility of the mode, the expected sign for the time variable was negative.

3) Inclusive Value: (Inc_val)

This variable was taken as a conditional variable by making the values of auto and transit equal to zero. As explained earlier in Chapter 2, to have a feasible structure of the nested model, the coefficient of the *inclusive value* of that nest 'θ' must satisfy the condition $0 < \theta \leq 1$. Considering the condition its expected sign would be positive.

4) Vehicles Per Household: (Veh_hh_)

This has always been an important variable in the modal split modeling work. It was found from the data queries that the modal characteristic changes drastically when the person has 0, 1 or 2 cars per household. However, there was very little difference in the travel behaviour for persons having two or two plus cars per household. It was therefore decided to code this variable into three categories as 0, 1, and 2 (or 2+). Being a multinomial variable, the expected sign of *vehicle ownership* for transit and non-motorized modes (auto being normalized to zero) would be negative.

5) Province:

The survey area comprised of both Ontario and Quebec provinces. A dummy variable called *'Province'* was therefore created to capture the effect of location. 1 was coded for

Ontario and 0 for Quebec. National Capital Region is served by two transit agencies. OC Transpo operates in Ontario whereas STO is responsible for providing transit system in Quebec. The bus frequencies of the two agencies as well as the infrastructure of the transit system are quite different in the two areas. Considering the fact that Ontario side has a better Transitway and Bikeway system, the expected sign for this variable was positive.

6) License: (Lic_r)

License has also been one of the key variables in the selection of auto mode. A person with a driving license is more likely to use a car, if it is available. On the other hand the presence of an auto will have no effect on a person without a license. As the variable was coded as '1' for license and '0' for no-license, its expected sign was negative for both transit and NMM. It should be noted that *'number of vehicles per licensed person'* could be a better choice than *'vehicle per household'* and *'license'*. But because of the unavailability of information for the whole household, it was decided to take these two variables.

4.4.3 Developed Higher Level Model For The Home Based Work Trip Purpose:

Table 4.6 shows the results of the developed model for the home based work trip purpose for auto person, transit and non-motorized modes.

TABLE 4.6: Higher Level Model for Home Based Work Trip Purpose

Mode	Cost	Travel Time	Inclusive Value	Number of Veh. Per Household	Province	License	Constant
Auto-Person	-0.6704 (-31.56)	-0.0497 (-24.11)					
Transit	-0.6704 (-31.56)	-0.0497 (-24.11)		-1.4679 (-14.71)	0.751 (+5.58)	-2.2388 (-10.55)	0.9849 (+5.19)
Non-Motorized	* -0.6704 ** (-31.56)	-0.0497 (-24.11)	0.7706 (+8.17)	-1.3204 (-10.93)	0.8376 (+4.74)	-1.6395 (-6.35)	-1.1793 (-3.58)

Auto cost	---	cost for parking and fuel consumption in cents
Transit cost	---	transit fare in cents
Non-motorized cost	---	taken as zero
Travel time	---	total time of the trip from origin to destination in min
Inclusive value	---	expected maximum utility of the lower level nest consisting of walk and bike modes
Vehicles per household	---	coded as 0 for no veh/hh, 1 for 1 veh/hh, 2 for more than 1 veh/hh
Province	---	coded as 0 for Quebec and 1 for Ontario
License	---	coded as 0 for no license and 1 for license
*	---	coefficient
**	---	t-statistic

Summary Statistics:

Number of modes	= 3
Number of auto person trips	= 2952 (69.07%)
Number of transit trips	= 937 (21.92%)
Number of non-motorized trips	= 385 (9.01%)
Total number of trips	= 4274 (100.00%)
Rhosq	= 0.6124
Rhobarsq	= 0.6109
Adjusted Rhosq	= 0.475
Adjusted Rhobarsq	= 0.473

4.4.4 Statistics for Overall Model:

The statistical measures for the overall nested logit model, equivalent to ρ^2 as suggested by McFadden (1974) and the ρ_c^2 as suggested by Tardiff (1976) was calculated from:

$$\rho^2 = 1 - \{[L_1(\beta) + L_2(\beta) + \ldots\ldots + L_j(\beta)] / [L_1(0) + L_2(0) + \ldots\ldots + L_j(0)]\}$$

$$\rho_c^2 = 1 - \{[L_1(\beta) + L_2(\beta) + \ldots\ldots + L_j(\beta)] / [L_1(C) + L_2(C) + \ldots\ldots + L_j(C)]\}$$

where the subscripts 1 to j refer to the MNL models at each level. Thus,

$$\rho\ overall^2 = 1 - \{L_{lower}(\beta) + L_{higher}(\beta)\} / \{L_{lower}(0) + L_{higher}(0)\}$$

$$= 1 - \{-1820.19 - 141.65\} / \{-4695.47 - 212.10\}$$

$$= 0.600$$

$$\rho_c\ overall^2 = 1 - \{L_{lower}(\beta) + L_{higher}(\beta)\} / \{L_{lower}(C) + L_{higher}(C)\}$$

$$= 1 - \{-1820.19 - 141.65\} / \{-3467.03 - 204.48\}$$

$$= 0.466$$

4.4.5 Validation:

The macro and micro validations of the model are shown in Table 4.7 and Table 4.8 respectively.

TABLE 4.7: Macro Validation

Mode	Number of Observed trips	Number of Predicted trips	Error	Percent Predictibility
Auto person	2952	3219	+267	93.75%
Transit	937	807	-130	
Non-motorized	385	248	-137	
Total	4274	4274	267	

From Table 4.7, which is at the macro level, it can be seen that the developed model is overestimating 267 auto person trips whereas transit and non-motorized trips are underestimated by 130 and 137 trips respectively giving an overall predicting ability of 93.75% for the model. Considering the complexity of the model and limitations of data, a predicting ability of 93.75% is excellent.

TABLE 4.8: Micro Validation

Mode	Number of Observed trips	Number of trips Correctly Predicted	Percent Correct Value
Auto person	2952	2813	95.29%
Transit	937	666	71.08%
Non-motorized	385	165	42.86%
Overall	4274	3644	85.26%

From Table 4.8, which is at the micro level, it can be seen that the percent correct value for auto person and transit modes are 95.29% and 71.08% respectively. A value of 42.86% for non-motorized mode seems to be low but considering its modal share of just 9.01% in the total sample and the non-availability of some vital factors like safety, availability of bikeways, and health conditions etc., it is quite acceptable. The overall percent correct value of 85.26%, for a logit model having three modes, is considered a very good result.

4.4.6 Goodness of Fit Measures:

The goodness of fit measures provide the analyst important statistical tools to measure the quality of the developed model with respect to the sample data. As discussed in lower level model, these measures are appropriate only for samples with equal market shares and should be corrected with respect to their market shares. The corrected measures known as, *'Corrected rhosquared'* and *'Corrected rhobarsquared'* were therefore calculated and compared with the minimum excepted values provided in Table 4.3a.

In our data set the modal split for auto, transit and non-motorized trips were 69.07%, 21.92% and 9.01% respectively, for which the minimum excepted *rhosquared* value is 0.12. The developed model has a *corrected rhobarsquared* value equal to 0.473, which is significantly higher than the minimum excepted value. This shows the quality of the model in statistical sense as well.

4.4.7 Correlation Matrix:

The correlation matrices for the developed higher level model for home based work trip purpose are shown in Tables 4.9, 4.10 and 4.11.

TABLE 4.9: Correlation Matrix for Auto Person Mode

	CHOICE	COST1	TIME1
CHOICE	1.00000		
COST1	0.37115	1.00000	
TIME1	-0.21476	0.46866	1.00000

TABLE 4.10: Correlation Matrix for Transit Mode

	CHOICE	COST2	TIME2	VEH_HH_R	PROVINCE	LIC_R
CHOICE	1.00000					
COST2	-0.16433	1.00000				
TIME2	-0.27299	0.75314	1.00000			
VEH_HH_R	-0.36133	0.19746	0.21791	1.00000		
PROVINCE	0.11876	0.12061	-0.04571	-0.01682	1.00000	
LIC_R	-0.20240	0.08541	0.11309	0.25598	-0.01700	1.00000

TABLE 4.11: Correlation Matrix for Non-Motorized Mode

	CHOICE	COST3	TIME3	INC_VAL3	VEH_HH_R	PROVINCE	LIC_R
CHOICE	1.00000						
COST3	0.00000	1.00000					
TIME3	-0.22302	0.00000	1.00000				
INC_VAL3	-0.00797	0.00000	0.18534	1.00000			
VEH_HH_R	-0.36133	0.00000	0.19134	0.11560	1.00000		
PROVINCE	0.11876	0.00000	0.01726	0.02228	-0.01682	1.00000	
LIC_R	-0.20240	0.00000	0.10244	0.11146	0.25598	-0.01700	1.00000

The correlation values between each pair of variables are shown in Tables 4.9, 4.10 and 4.11. Whereas a lower correlation value is always desirable researchers believe that a value greater than 0.8 shows that a particular effect is being accounted for twice and only one of the two variables should be included in the model (Tardiff 1976). It can be seen from the correlation tables that there is no problem of multi-colinearity among independent variables in each of the two models. All the independent variables are having little correlation and as such the estimated coefficients of the variables are not biased.

4.4.8 Discussion on Results:

It can be seen that all the variables have correct expected signs and are significant at 99% level. *Cost* and *time* are the most significant variables with t-statistics equal to –31.56 and –24.11 respectively. Their coefficient values of 0.67 and 0.05 are also quite high considering that their units are in cents and minutes.

The coefficient of *inclusive value* is 0.77, which is in between the required limits of 0 and 1. Thus the appropriateness of the lower level nest was established. Its t-statistic of 8.17 proves its significance.

Vehicle per household is highly significant for both transit and non-motorized modes with t-statistics equal to -14.71 and –10.93 respectively and estimated values of -1.47 and -1.32 respectively. This shows that number of vehicle has a profound negative impact on both transit and non-motorized modes in the mode choice selection.

Coefficient of *Province* has a positive sign for both the modes having t-statistics equal to 5.58 and 4.74 for transit and non-motorized modes respectively. This shows that not only the transit system but the walk and bike facilities are also better in Ontario side giving transit and NMM a better chance of selection when the trip starts in Ontario.

License has a negative sign and high t-statistic values of –10.55 and –6.35 for transit and slow modes respectively. These are quite expected results as with the availability of license, the probability of selecting transit or non-motorized modes are greatly reduced.

4.4.9 Sensitivity Analysis:

Sensitivity analysis shows the changes in modal share of the auto person, transit and non-motorized modes. The results of the sensitivity analysis carried out for each variable are shown in Table 4.12.

TABLE 4.12: Sensitivity Analysis

Variable	% Change in auto person mode	% Change in transit mode	% Change in non-motorized mode
Auto cost +10%	-1.22%	1.03%	0.19%
Transit fare +10%	0.63%	-0.82%	0.19%
Auto time +10%	-0.36%	0.33%	0.03%
Transit time +10%	0.93%	-1.10%	0.17%
Non-motorized time +10%	0.21%	0.68%	-0.89%
Veh/hh from 0 to 1	0.68%	-0.40%	-0.28%
Veh/hh from 1 to 2+	4.42%	-3.70%	-0.72%
Ontario rather than Quebec resident	-1.06%	0.73%	0.33%
License from no to yes	1.94%	-1.64%	-0.30%

The first variable analyzed was *'Cost'*. It was found that an increase of 10% in *auto cost* would decrease the auto person mode by 1.22%. This decrease in auto mode was absorbed by transit and non-motorized modes by 1.03% and 0.19% respectively. That is, 90% of people leaving the auto person mode would choose transit and 10% would select non-motorized modes for their work trips.

On the other hand when *transit fare* was increased by 10%, there would be a loss of just 0.82% of transit mode share, which was compensated by an increase of 0.63% in auto and 0.19% in slow modes. That is, from the total change in transit mode, more than 70% would switch to auto and 30% to non-motorized modes. By looking at the 70-30% split

now as against to 90-10% split in the case of auto cost, it is clear that transit is closely related to non-motorized modes than auto. It can also be seen from the analysis of cost variable that people are really sensitive to the changes in auto cost (decreased by 1.22%) but are less concerned with the changes in transit fare (decreased by 0.82%).

The second variable analyzed was *'Travel time'*. Its sensitivity analysis was done for every mode, that is auto, transit and non-motorized modes, as shown in Table 4.10. It can be seen that the effect of a 10% increase in travel time was greatest in the case of transit, which was decreased by 1.10% whereas the decrease in auto and NMM because of their respective time increments were 0.36% and 0.89% respectively. This shows that as far as time is concerned, transit users are nearly three times as sensitive as are auto users.

Thus by looking at the two highly significant variables *'cost and time'*, we find that people perceive them differently in different modes. Whereas *'cost'* was found to be highly significant in auto, it was *'time'* which was more significant in the case of transit. For non-motorized modes, although *cost* had no direct effect on it but travel time was proved to be an important variable in the selection of these modes for the home based work trips.

The next variable analyzed was *'vehicles per household'*. As there were three different categories for this variable (0, 1, and 2), it was found reasonable to test its sensitivity under different categories. First it was analyzed when the number of vehicles per household would increase from 0 to 1 and in the second case when vehicles per household would increase from 1 to 2+. It was interesting to note that the auto modal share didn't change much when the number of vehicles was changed from 0 to 1 (caused an increment of just 0.68% in auto mode), but modal share increased appreciably (+4.42%) when the category was changed from 1 to 2. It should also be noted that the increase in auto share (+0.68%) resulting from the increase in vehicle per household from 0 to 1 would cause a loss in the other two modes nearly in the same proportion (-0.40% and -0.28%). However the increase in auto share (+4.42%) resulting from the increase in vehicle per household from 1 to 2 would cause a loss in the other two modes in 5:1 ratio

(-3.70% and –0.72%). This shows that people using non-motorized modes will switch initially to auto mode but would show less sensitivity when vehicles would increase from 1 to 2+, as compared to transit. This proves that people who are using walk and bike modes are using it not because of unavailability of auto. There are some other factors like age, health, and exercise etc., which play an important role in the selection of these non-motorized modes and which make these modes quite unique to conventional motorized modes where all these factors have very little role in the selection of a mode.

The next two variables were dummy variables. The impact of *province* on the selected modes revealed that Quebec residents use auto mode more than Ontario residents, whereas transit and non-motorized modes are in greater use in Ontario. As mentioned previously, this could be due to the size of the metropolitan area and the transit and walk and bike facilities.

Availability of a vehicle *license* clearly had a profound impact on the auto person mode, which was increased by 1.94%. This shows that many of them are using transit and non-motorized modes because they are unable to drive a vehicle. Once they have a license they switch to the auto mode. Again the increase in this auto share comes mostly from transit showing a close relationship between the two motorized modes.

CHAPTER 5

HOME BASED SCHOOL TRIP MODEL

5.1. OVERVIEW:

The second model developed was for the Home Based School trip purpose. In both the travel demand models developed by TRANS in 1986 and 1993, modal split models were developed for only work and non-work trip purposes (Delcan, 1993), in which school trip purpose was included in the non-work trip model. In our model development work, an attempt was made to develop a separate modal split model for home based school trip purpose. This was decided considering the fact that the share of non-motorized modes in Home Based School Trips was more than 48% in the PM peak period (Exhibit 3.5) and so it was found reasonable to build a separate model for the school trips in the modeling work of motorized and non-motorized modes. Further, this model will allow us to explore the unique characteristics of this trip purpose for different modes and gain an understanding the role it plays in the overall transportation system.

5.2 LOWER LEVEL MODEL:

The walk and bike modes were again put in the lower level nest of the nested logit model and as such a lower level model with these two modes was developed first. Higher level model was then developed using the inclusive value of the lower nest. The upper level model included auto, transit and slow modes.

5.2.1 Selected Variables:

Lower level model consisted of the walk and bike modes. The number of cases for these two modes in the home based school trip model was 427. Out of this bike and walk cases were 89 and 338 respectively. The first mode considered was bike and so the coefficients of bike mode were normalized to zero. The variables selected for this model were *distance, Central Business District (CBD), population density, number of bikes per*

person and *province*. It may be noted that variable '*time*' was found to be insignificant in the initial runs and was therefore not selected. It could be because non -motorized modes are not time-efficient modes, especially for the home based school trips. Some other variables like *gender* and *age* were also excluded after the initial runs. As far as *gender* is considered both school going boys and girls use walk and bike modes equally and as such *gender* has no importance. Similarly the captive users for these trips are within 10-20 years of age so variable *'age'* could also not play an important role in the school trip model. After the exclusion of variable *time*, *distance* was found to be a significant variable and was therefore selected. All the variables taken were therefore, multinomial with bike being normalized as zero. The TSP output would therefore give coefficient values only for the walk mode with respect to the bike mode.

5.2.2 Expected Signs for the Coefficients:

Values for the variable *time* were taken in minutes, *age* in years and *number of bikes per household* in numbers. '*Gender*' was coded as 0/1 with 1 for female and 0 for male. The expected signs for the coefficients of these variables are discussed below:

1) Distance: (Dist_r)

It was found from the data queries that most of the school trips using walk mode are within 0-1 km. In order to separate the two modes properly, *distance* was therefore coded as 1, 0 with distance from 0-1 km as '1' and greater than 1 km as '0'. With this coding it was expected that *distance* would have a positive sign for the walk mode.

2) Central Business District: (CBD_ Flag)

This dummy variable indicates whether the trip was made within the Central Business District or not. The lack of proper facilities for bike mode like unavailability of separate bike lane and safety concerns due to high traffic volume, it was expected to have a negative sign for bike mode or positive sign for walk mode when the home based school trip was made to CBD.

3) Population Density: (Pop_Den)

For capturing the effect of population on the school trips, a new variable called *population density* was generated by dividing the population of the zone with its area in square km. Keeping in mind; the denser the area the more would be the walk trips; this variable was expected to have a positive sign for the walk mode.

4) Bikes Per Person: (Bik_Per)

Instead of taking *number of bikes per household* it was found reasonable to take *number of bikes per person* in the household for the home based school trips. This was done realizing that every person in the household is a potential rider and as such availability of bike was better represented by the number of bikes available per person. Expected sign for this variable was negative for the walk mode.

5) Province:

Province, as already explained earlier, has been coded as a dummy variable with 1 for Ontario and 0 for Quebec. It was expected that for walk mode this variable would have a negative sign.

5.2.3 Developed Lower Level Model For The Home Based School Trip Purpose:

Table 5.1 shows the results of the developed model for the home based school trips for walk and bike modes.

TABLE 5.1: Lower Level Model for Home Based School Trip Purpose

Mode	Distance	Central Business District	Population Density	Number of Bikes Per Person	Province	Constant
Bike						
Walk	* 2.2139 ** (5.19)	2.9031 (8.14)	0.3093E-03 (2.57)	-0.5959 (-1.13)	-1.0361 (-1.92)	1.1539 (1.78)

Distance	---	coded as 1 for trip distance between 0-1km and 0 for > 1km
Central Business District	---	coded as 1 for trip made to CBD, 0 otherwise
Population density	---	total population of the zone divided by its area in sqkm
Bikes per person	---	total number of bikes divided by total number of persons in the household
Province	---	coded as 1 for Ontario and 0 for Quebec
*	---	coefficient
**	---	t-statistic

Summary Statistics:

Number of modes	= 2
Number of bike trips	= 89 (20.84%)
Number of walk trips	= 338 (79.16%)
Total number of trips	= 427 (100.00%)
Rhosq	= 0.6279
Rhobarsq	= 0.6076
Adjusted Rhosq	= 0.4961
Adjusted Rhobarsq	= 0.4686

5.2.4 Validation:

For validating the results two different approaches were used.

- Macro Validation
- Micro Validation

The first was the macro validation of the model in which the modal split as given by the developed model was calculated and compared with the actual modal share. This would give the modal split accuracy of the model as a whole. This validation was important in presence of the borderline cases (cases whose modal probabilities are very close to each other) and as such were likely to be predicted wrong. However, they would be adjusted equally when total number of predicted cases were compared with the total number of observed cases.

The second approach was the micro validation in which the modal result of every case was compared with the selected mode. This would give the predicting ability of the model at the micro level and its percent correct (right) value.

TABLE 5.2: Macro validation

Mode	Number of Observed trips	Number of Predicted trips	Error	Percent Predictibility
Bike	89	59	-30	92.98%
Walk	338	368	+30	
Total	427	427	30	

From Table 5.2 it can be seen that the developed model is underestimating just 30 bike trips or in other words 30 walk trips are overestimated giving an overall predicting ability of 92.98% for the model. Considering the fact that only a small sample size was available for building the model, especially for bike mode, and quite a few variables were not available in the OD survey, a percent predictibility of 92.98% is fairly a good result.

TABLE 5.3: Micro Validation

Mode	Number of Observed trips	Number of trips Correctly Predicted	Percent Correct Value
Bike	89	54	60.67%
Walk	338	333	98.52%
Overall	427	387	90.63%

From Table 5.3, which is at the micro level, it can be seen that the percent correct value for bike mode is 60.67% whereas for walk mode it is 98.52%, which are extremely high for the logit model. As this was the first attempt to build a model for home based school trips for non-motorized modes; no previous values were available for any comparison. However the overall percent correct value of 90.63% of the model shows the quality and predicting ability of the model.

5.2.5 Goodness of Fit Measures:

The goodness of fit measures provide the analyst important statistical tools to measure the quality of the developed model with respect to the sample data. As discussed in Chapter 4, these measures are appropriate only for samples with equal market shares and should be corrected with respect to their market shares. The corrected measures known as, *'Corrected rhosquared'* and *'Corrected rhobarsquared'* were therefore calculated and compared with the minimum excepted values provided in Table 4.3a.

In our data set the modal split for bike and walk trips were 20.84% and 79.16% respectively, for which the minimum excepted *rhosquared* value is 0.28. The developed model has a *corrected rhobarsquared* value equal to 0.469, which is significantly higher than the minimum excepted value. This shows the quality of the model in statistical sense as well.

5.2.6 Correlation Matix:

The correlation matrix for the developed home based school trip model for walk mode is shown in Table 5.4.

TABLE 5.4: Correlation Matrix for Walk Mode

	CHOICE	CBD_FLAG	DIST_R	POP_DEN	BK_PER	PROVINCE
CHOICE	1.00000					
CBD_FLAG	0.43647	1.00000				
DIST_R	0.40261	0.27063	1.00000			
POP_DEN	-0.06657	-0.19301	-0.050695	1.00000		
BK_PER	-0.18408	-0.17539	-0.20173	0.08778	1.00000	
PROVINCE	-0.17967	-0.14802	-0.18709	0.17544	0.00484	1.00000

The correlation values between each pair of variables are shown in Tables 5.4. Whereas a lower correlation value is always desirable researchers believe that a value greater than 0.8 shows that a particular effect is being accounted for twice and only one of the two variables should be included in the model (Tardiff 1976). It can be seen from the correlation table that there is no problem of multi-colinearity among independent variables. All the independent variables are having little correlation and as such the estimated coefficients of the variables are not biased.

5.2.7 Discussion on Results:

It can be seen in Table 5.1 that all the variables have correct expected signs and except for *bikes per person* all other variables are significant at 99.5% level. *CBD* is proving to be the most significant variable with a t-statistic equal to 8.14. Its coefficient value of 2.9 is also high. Its positive sign for walk mode indicates that people would prefer the walk mode over bike when the school trip is in CBD. This may be an indication of lack of proper facilities for bike mode like unavailability of separate bike lane in the CBD or bike-storage at school. The non-availability of separate bike lane also increases the safety concerns for using bike mode especially by grade school children and people therefore find it safer to use walk mode for home based school trips.

Distance coded as 1/0 is also proving significant with a t-statistic equal to 5.19. Its estimated value of 2.2 is also high showing the role it plays in the selection of non-motorized modes. This proves that walk mode would be a preferred choice when the school trip is within 0-1 km distance whereas bike would be preferred for longer distances, normally for more than 1 km trips.

Population density has a positive sign, which is as per expectation and is significant at 99%. Its estimated coefficient seems to be low but considering the fact that the value of this variable is in thousands, this coefficient value is acceptable. Its significance confirms that as population density increases, people select the walk mode as their first choice.

Bikes per person have the expected sign although it is not proving to be a significant variable at 90% level. However considering the fact that number of bikes always plays an important role in the selection of bike mode, this variable was retained in the model.

Province is proving to be a significant variable at 95% level with the sign as per expectation. Its estimated value of -1.04 is also high confirming that people would prefer to use bike mode when they are in Ontario.

Lastly, the *Constant* is also proving significant and having a high coefficient value. This again shows that for non-motorized modes there are many factors, like safety, health, location of walkways and bikeways etc., that need to be taken in the model but for which we have no information available in the survey data.

5.2.8 Sensitivity Analysis:

A sensitivity analysis for all the modes was carried out for each variable. The results are shown in Table5.5.

TABLE 5.5: Sensitivity Analysis

Variable	% Change in walk mode
CBD from no to yes	19.56%
Distance from >1km to <=1km	18.94%
Population Density +10%	1.53%
Bike Per Person +1	-11.83%
Quebec rather than Ontario resident	12.85%

The first variable analyzed was *'CBD'*. It was found that when the trip location was changed from outside CBD to within CBD, walk trips were increased by 20%. This shows that people are extremely sensitive to the location of school trip and when the school trip is made within CBD, people shift from bike mode to the walk mode. This may be because of the fact that most of the school going children are grade school children for whom parents don't find it safe to send them using bike mode in the downtown area especially in absence of any lanes and routes for bikes. As such parents either drive them to the school using shared ride or prefer walk mode. This reasoning would further be justified by looking at the signs for *CBD* for motorized modes in the higher level model.

The second variable analyzed was *distance*. It can be seen from the table that as the trip distance becomes less than or equal to 1 km, the walk mode would increase by 19%. This shows that people prefer to walk when the home based school trip distance is within 1km. However bike is preferred over walk mode when the distance gets more than a kilometer.

The sensitivity analysis for *population density* shows that when it is increased by 10%, the walk mode would increase by 1.5%. This shows that people would choose the bike mode when there are fewer people in the area. When the population density is increased, they would shift to walk mode in the school trips. A possible reason for this decrease in the bike mode is safety, which tends to decrease as population density increases.

The analysis for *bikes per person* shows that the walk mode would decrease (or bike mode would increase) by nearly 12% with the increase in bike availability by one. This is quite a logical result, which confirms that availability of bike to a person plays an important role in the selection of non-motorized mode. It also justifies the inclusion of *bike per person* in the home based school trip model despite its low t-statistic value.

The last variable analyzed for its sensitivity was *province*. It was found that with the change of province from Ontario to Quebec walk mode is increased by 13%. That is people prefer to use bike mode when the trip starts in Ontario but shifts to walk mode in Quebec side.

5.3 HIGHER LEVEL MODEL:

The higher level model included auto, transit and non-motorized (walk and bike) modes. An inclusive value of the lower level nest was calculated and used as an independent variable in the higher level model, as has been explained in Chapter 2. This inclusive value or composite utility of the members of the nest, $I_{b,w}$, was found for each and every case using the expression:

$$I_{b,w} = \ln \sum_{n=1}^{J} e^{V_j}$$

where, J is the number of available alternatives in the nest, which in this case were walk and bike.

$$\therefore \; I_{b,w} = \ln (e^{V_b} + e^{V_w})$$

This value was then entered as a typical independent variable that had the $W_{b,w}$ variables (attributes common to all members of the nest) and the characteristics of automobile and transit to estimate a second-level (or higher level) multinomial logit model for automobile, transit and non-motorized modes.

5.3.1 Selected Variables:

The variables selected in the formation of this model were *cost*, *time*, the *inclusive value* of the lower level nest, *vehicle per household*, *license*, *Central Business District*, *gender*, *number of trips*, *purpose of trip*, and *trip starting time*. *Cost*, *time* and the *inclusive value* were again considered as conditional variables, while all other variables were multinomial. Several other variables were also tested in the initial runs like *age*, *income*, *province*, *population density* etc., but were found to be insignificant and thus dropped. In this model some new trip characteristics were included that greatly helped in improving the quality of the model. These were *number of trips*, *purpose of trip* and *starting time* of the trip.

5.3.2 Expected Signs for the Coefficients:

Values for the variable *time* were taken in minutes, *cost* in cents and *number of trips* in numbers whereas *vehicles per household, license, Central Business District, gender, purpose of trip* and *starting time* were considered as dummy variables. The expected signs for the coefficients of these variables are discussed below:

1) Cost:

Variable *cost* was taken as a conditional variable. *Cost1* was the cost for auto that included fuel and parking cost. *Cost2* was the transit cost, which included transit fare. *Cost* for non-motorized modes was assumed to be zero (however to avoid a zero value in the conditional variable for NMM, a token of 10 cents was taken in *Cost3*). As *Cost* is always a disutility in the selection of any mode, the expected sign for the coefficient for *cost* variable was negative.

2) Time:

Time was also considered as a conditional variable having different times for different modes. *Time1* was the in-vehicle travel time for auto from trip origin to trip destination. Out-of-vehicle travel time for auto was assumed to be zero. *Time2* was the transit travel time that included both in-vehicle and out-of-vehicle time. The out-of-vehicle transit time included the access time required to walk to the bus stop, waiting time at the bus stop, boarding time, transfer time and egress time. *Time3* was the travel time for non-motorized modes that was taken as the average of the walk and bike mode times (because of very little difference between the two times). Being a disutility of the mode, the expected sign for the time variable was negative.

3) Inclusive Value: (Inc_val)

This variable was taken as a conditional variable by making the values of auto and transit equal to zero. It's already been explained that to have a feasible structure of the nested

model, the coefficient of the *inclusive value* of that nest 'θ' must satisfy the condition $0 < \theta \leq 1$. As such its expected sign would be positive.

4) Vehicles Per Household: (Veh_hh_)

This has always been an important variable in the modal split modeling work for motorized modes. The variable was coded as 0, 1 and 2 for number of vehicles 0, 1 and more than 1. Being a multinomial variable, the expected sign of *vehicle ownership* for transit and non-motorized modes (auto being normalized to zero) would be negative.

5) LICENSE: (Lic_r)

License has also been one of the key variables in the selection of auto mode. A person with a driving license is more likely to use a car, if it is available. On the other hand the presence of an auto will have no effect on a person without a license. As the variable was coded as '1' for license and '0' for no-license, its expected sign was negative for both transit and NMM.

6) Central Business District: (CBD_Flag)

A dummy variable was created to capture the exclusive characteristics of the downtown area. '1' was coded for trips that were made to CBD, '0' otherwise. Considering non-availability of bike lanes, heavy traffic, fewer grade schools and presence of Ottawa University and other high schools in the region, it is expected that auto mode would increase as compared to non-motorized modes when the trip would be made to CBD.

7) Gender:

Gender was coded as 1 for male and 0 for female. The traditional behavior of women suggests that females are less likely to use the walk and bike mode as compared to males. On the other hand, they prefer to use transit. The statistics from the survey data also show that the percentage of women using transit is more than men. Considering this, it is

expected that the gender variable will have a negative sign for transit and positive sign for non-motorized mode (auto being normalized to zero).

8) Number of Trips: (Num_trip)

Total number of trips a person has made during the day was considered to be an important variable in the selection of modes for the school trips. A higher number of trips means that they are less likely to use the walk and bike modes or transit compared to the auto mode. As such, the expected signs for transit and non-motorized modes for this variable would be negative.

9) Purpose of Trip: (Purp_trip)

To capture the characteristics of secondary school trips (SSH) and higher secondary or university school trips (SU) separately, it was decided to develop a new variable called *Purp_trip*. It was coded as 0 for SU and 1 for SSH. Thus it was expected that children going for SSH trips are more likely to use transit and non-motorized modes whereas persons going for SU trips would use auto. As such the expected sign for this variable would be positive both for transit and non-motorized modes.

10) Starting Time: (St_t_r)

Starting time of the trip was also considered as an important criterion in the selection of mode choice. Whereas auto was more likely to be used in the peak hour, which starts at 1616, it was transit and non-motorized modes that would be preferred for trips starting before 16:16. With this in mind the starting time was coded as 0 for trips starting after 16:15 and 1 for trips starting before 16:15. As most of the school trips would start before 16:15, the expected signs were positive for both transit and non-motorized modes.

5.3.3 Developed Higher Level Model For The Home Based School Trip Purpose:

Table 5.6 shows the results of the developed model for the home based school trips for auto person, transit and non-motorized modes.

TABLE 5.6: Higher Level Model for Home Based School Trip Purpose

Mode	Cost	Travel Time	Inclus. Value	Num of Veh. per hhold	License	Central Bus. District	Gender	Number of trips	Starting time	Purpose of trip	Constant
Auto-Person	-0.6429 (-8.68)	-0.0299 (-10.11)									
Transit	-0.6429 (-8.68)	-0.0299 (-10.11)		-0.9195 (-6.42)	-0.7736 (-3.55)	-0.3158 (-1.24)	-0.0599 (-0.34)	-0.2326 (-3.81)	0.8331 (4.00)	1.1018 (4.51)	1.1349 (5.11)
Non-Motorized	*-0.6429 **(-8.68)	-0.0299 (-10.11)	0.4829 (10.14)	-1.4328 (-8.48)	-0.9093 (-3.64)	-1.0039 (-3.19)	0.6231 (3.16)	-0.0143 (-0.23)	0.9444 (3.85)	0.8321 (2.92)	-0.1229 (-0.23)

Auto cost	---	cost for parking and fuel consumption in cents
Transit cost	---	transit fare in cents
Non-motorized cost	---	taken as zero
Travel time	---	total time of the trip from origin to destination in min
Inclusive value	---	expected maximum utility of the lower level nest
Vehicles per household	---	coded as 0 for no veh/hh, 1 for 1 veh/hh, 2 for more than 1 veh/hh
License	---	coded as 0 for no license and 1 for license
Central Business District	---	coded as 1 for trips made within CBD, 0 otherwise
Gender	---	coded as 0 for female and 1 for male
Number of trips	---	total trips made during the day in numbers
Purpose of trip	---	coded as 0 for SU and 1 for SSH
Starting time	---	coded as 1 for trip starting between 1530-1615 and 0 for trip starting after 1615
*	---	coefficient
**	---	t-statistic

Summary Statistics:

Number of modes	= 3
Number of auto person trips	= 321 (26.75%)
Number of transit trips	= 390 (32.50%)
Number of non-motorized trips	= 489 (40.75%)
Total number of trips	= 1200 (100.00%)
Rhosq	= 0.3418
Rhobarsq	= 0.3335
Adjusted Rhosq	= 0.3329
Adjusted Rhobarsq	= 0.3183

5.3.4 STATISTICS FOR OVERALL MODEL:

The statistical measures for overall nested logit model, equivalent to ρ^2 as suggested by McFadden (1974) and the ρ_c^2 as suggested by Tardiff (1976) was calculated from:

$$\rho^2 = 1 - \{[L_1(\beta) + L_2(\beta) + \ldots\ldots + L_j(\beta)] / [L_1(0) + L_2(0) + \ldots\ldots + L_j(0)]\}$$

$$\rho_c^2 = 1 - \{[L_1(\beta) + L_2(\beta) + \ldots\ldots + L_j(\beta)] / [L_1(C) + L_2(C) + \ldots\ldots + L_j(C)]\}$$

where the subscripts 1 to j refer to the MNL models at each level. Thus,

$$\rho_{overall}^2 = 1 - \{L_{lower}(\beta) + L_{higher}(\beta)\} / \{L_{lower}(0) + L_{higher}(0)\}$$

$$= 1 - \{-110.14 - 867.69\} / \{-295.97 - 1318.33\}$$

$$= 0.3943$$

$$\rho_{c\,overall}^2 = 1 - \{L_{lower}(\beta) + L_{higher}(\beta)\} / \{L_{lower}(C) + L_{higher}(C)\}$$

$$= 1 - \{-110.14 - 867.69\} / \{-218.57 - 1300.60\}$$

$$= 0.3563$$

5.3.5 Validation:

The macro and micro validations of the model are shown in Table 5.7 and Table 5.8 respectively.

TABLE 5.7: Macro Validation

Mode	Number of Observed trips	Number of Predicted trips	Error	Percent Predictibility
Auto person	321	299	-22	97.50%
Transit	390	382	-8	
Non-motorized	489	519	+30	
Total	1200	1200	30	

From Table 5.7, which is at the macro level, it can be seen that the developed model is overestimating 30 non-motorized trips whereas auto person and transit trips are underestimated by 22 and 8 respectively giving an overall predicting ability of 97.50% for the model. Considering the complexity of the model and limitations of data, a predicting ability of 97.50% is extremely good.

TABLE 5.8: Micro Validation

Mode	Number of Observed trips	Number of trips Correctly Predicted	Percent Correct Value
Auto person	321	182	56.70%
Transit	390	250	64.10%
Non-motorized	489	410	83.84%
Overall	1200	842	70.17%

Table 5.8 presents the results at the micro level. It can be seen that the percent correct value for auto person, transit and non-motorized modes are 56.70%, 64.10% and 83.84% respectively. It may be noted here that percent correct value for auto person mode seems to be low as compared to non-motorized mode. It was again due to the shared ride problem as most of the school going children using auto person mode were in fact shared riders for which we have limited information. For example in most of the cases, a person making the school trip in auto would not pay for the trip, as he would be picked up by his/her parents, for which we have no information. Without the complete data for cost variable a percent correct value of 56.70% for auto person mode was therefore, reasonable. The overall percent correct value of 70.17% achieved with these constraints and complexities was, therefore, quite an acceptable result. This type of model was built for the first time and so no previous values were available for any comparison.

5.3.6 Goodness of Fit Measures:

The goodness of fit measures provide the analyst important statistical tools to measure the quality of the developed model with respect to the sample data. As discussed in Chapter 4, these measures are appropriate only for samples with equal market shares and should be corrected with respect to their market shares. The corrected measures known as, *'Corrected rhosquared'* and *'Corrected rhobarsquared'* were therefore calculated and compared with the minimum excepted values provided in Table 4.3a.

In our data set the modal split for auto, transit and non-motorized trips were 26.75%, 32.50% and 40.75% respectively, for which the minimum excepted *rhosquared* value is 0.03. The developed model has a *corrected rhobarsquared* value equal to 0.318, which is significantly higher than the minimum excepted value. This shows the quality of the model in statistical sense as well.

5.3.7 Correlation Matrix:

The correlation matrices for the developed higher level model for home based school trip purpose are shown in Tables 5.9, 5.10 and 5.11.

TABLE 5.9: Correlation Matrix for Auto Person Mode

	CHOICE	COST1	TIME1
CHOICE	1.00000		
COST1	-0.02406	1.00000	
TIME1	-0.49543	0.33533	1.00000

TABLE 5.10: Correlation Matrix for Transit Mode

	CHOICE	COST2	TIME2	VEH_HH_R	LIC_R	CBD_FLAG	SEX_R	NUM_TRIP	PURP_R	ST_T_R
CHOICE	1.00000									
COST2	-0.27612	1.00000								
TIME2	-0.45125	0.60647	1.00000							
VEH_HH_R	-0.16486	0.14596	0.11042	1.00000						
LIC_R	-0.27307	0.15452	0.22424	-0.03884	1.00000					
CBD_FLAG	0.02527	-0.03960	-0.04706	0.16292	-0.24795	1.00000				
SEX_R	0.04036	0.01924	-0.00289	0.05112	0.00279	-0.01766	1.00000			
NUM_TRIP	0.01389	-0.02760	-0.06992	0.03411	0.16445	-0.03329	0.00464	1.00000		
PURP_R	0.23576	-0.10829	-0.22818	0.17195	-0.59188	0.27096	0.02538	-0.05686	1.00000	
ST_T_R	0.19893	-0.08701	-0.20492	0.05320	-0.27581	0.14211	-0.01713	-0.03670	0.28023	1.00000

TABLE 5.11: Correlation Matrix for Non-Motorized Mode

	CHOICE	COST3	TIME3	INC_VL3	VEH_HH_R	LIC_R	CBD_FLAG	SEX_R	NUM_TRIP	PURP_R	ST_T_R
CHOICE	1.00000										
COST3	0.00000	0.00000									
TIME3	-0.45596	0.00000	1.00000								
INC_VL3	0.33945	0.00000	-0.36106	1.00000							
VEH_HH_R	-0.16486	0.00000	0.10124	0.41235	1.00000						
LIC_R	-0.27307	0.00000	0.25226	-0.31418	-0.03884	1.00000					
CBD_FLAG	0.02527	0.00000	-0.10181	0.46724	0.16292	-0.24795	1.00000				
SEX_R	0.04036	0.00000	0.00123	-0.01351	0.05112	0.00279	-0.01766	1.00000			
NUM_TRIP	0.01389	0.00000	-0.06912	0.06007	0.03411	0.16445	-0.03329	0.00464	1.00000		
PURP_R	0.23576	0.00000	-0.26025	0.37288	0.17195	-0.59188	0.27096	0.02538	-0.05686	1.00000	
ST_T_R	0.19893	0.00000	-0.20349	0.19692	0.05320	-0.27581	0.14211	-0.01713	-0.03670	0.28023	1.00000

The correlation values between each pair of variables are shown in Tables 5.9, 5.10 and 5.11. Whereas a lower correlation value is always desirable researchers believe that a value greater than 0.8 shows that a particular effect is being accounted for twice and only one of the two variables should be included in the model (Tardiff 1976). It can be seen from the correlation tables that there is no problem of multi-colinearity among independent variables in each of the two models. All the independent variables are having little correlation and as such the estimated coefficients of the variables are not biased.

5.3.8 Discussion on Results:

It can be seen that all the variables have correct expected signs and are significant at 99.5% level for at least one of the modes. *Cost* and *time* are again proving to be the significant variables with t-statistics equal to -8.68 and -10.11 respectively. Their coefficient values of -0.64 and -0.03 are also high considering that their units are in cents and minutes.

The coefficient of *Inclusive value* is 0.48 which is in between the required condition of 0 and 1. Thus the appropriateness of the lower level nest was established. Its t-statistics of 10.14 further proves its significance.

Vehicle per household is also proving highly significant for both transit and non-motorized modes with t-statistics equal to -6.42 and -8.48 respectively and estimated values of -0.919 and -1.432 respectively. This shows that number of vehicles has a profound negative impact on both transit and non-motorized modes in the mode choice selection.

License as expected is having a negative sign and high t-statistic value for both transit and slow modes showing its importance in the selection of auto mode. The coefficient values of -0.774 and -0.909 for transit and non-motorized modes indicate that the negative impact of having license on these two modes are just the same.

CBD on the other hand is proving to be significant only for the non-motorized modes with t-statistic equal to -3.19. This shows that people prefer auto to non-motorized modes when the school trip is in CBD. Although *CBD* is not proving to be a significant variable for transit its negative sign however, indicates the preference people give to auto over transit in the home based school trips when made within the CBD. This result also justifies the signs of this variable in the lower level model. Thus whereas people would prefer walk mode over bike in non-motorized modes it is really auto mode that would be preferred from all the available modes. And this auto mode is in fact a shared ride mode that is selected most when the school trip is in CBD. This is quite a logical result also and is further confirmed by looking at the data set where we find that shared ride is the most used modal choice for home based school trips.

Gender is proving to be insignificant in transit but highly significant in non-motorized modes with t-statistics equal to 3.16. This suggests that as far as non-motorized modes are concerned, *gender* plays an important role. Its positive sign indicates that when the gender is male, non-motorized modes are likely to be chosen over auto, keeping all other factors constant. Its insignificance in transit means that both male and female equally use transit in home based school trips and it is therefore not an important criterion.

Number of trips is having a negative sign both for transit and non-motorized modes but proving significant only in transit with a t-statistic equal to –3.81. This shows that people are not concerned with number of trips per day when using walk and bike modes but would prefer to use auto to transit for a higher number of trips.

Purpose of trip has a positive sign and is significant for both transit and non-motorized modes with t-statistics equal to 4.51 and 2.92 respectively. This shows that when the purpose is secondary school trip, both transit and non-motorized mode would be preferred over auto. However for post secondary school trips, auto person mode would be the selected choice.

Starting time of the trip is also proving to be significant for both transit and non-motorized modes with a positive sign. This shows that when the starting time of the trip is before 16:15, transit and non-motorized modes are preferred over auto. However after 16:15, auto person mode is more likely to be chosen. The probable reason for this would be the shared ride facility available at that time. Lastly, *Constant* for non-motorized mode is proving insignificant and its coefficient value is also very low. However for transit, it is proving to be significant with t-statistic equal to 5.11. The coefficient value of 1.13 is also high indicating that the developed model could not explain some of the important criteria explaining mode choice.

5.3.9 Sensitivity Analysis:

Sensitivity analysis shows the changes in modal share of the auto person, transit and NMM. The sensitivity analysis carried out for each variable is shown in Table 5.12.

TABLE 5.12: Sensitivity Analysis

Variable	% Change in auto person mode	% Change in transit mode	% Change in non-motorized mode
Auto cost +10%	-0.92%	0.75%	0.17%
Transit fare +10%	1.25%	-2.67%	1.42%
Auto time +10%	-1.00%	1.00%	0.00%
Transit time +10%	1.75%	-2.92%	1.17%
Non-motorized time +10%	0.33%	1.50%	-1.83%
Veh/hh from 0 to 1	1.16%	0.25%	-1.41%
Veh/hh from 1 to 2+	6.49%	-5.41%	-1.08%
License from no to yes	12.41%	-7.66%	-4.75%
CBD from no to yes	3.67%	-1.92%	-1.75%
Male rather than female	-0.59%	-5.66%	6.25%
Number of Trips +1	3.75%	-7.17%	3.42%
Purpose of trip from higher secondary to secondary school	-5.92%	6.67%	-0.75%
Starting Time from >1615 to <=1615	-4.75%	3.50%	1.25%

The first variable analyzed was *'Cost'*. It was found that when *auto cost* was increased by 10%, the auto person mode would decrease by 0.92%. This decrease in auto mode would cause an increment of 0.75% and 0.17% in transit and non-motorized modes respectively. This shows that more than 80% of people would shift from auto to transit and only 20% would go to non-motorized modes. This again proves that people consider the motorized modes similar but feel a real difference between motorized and non-motorized modes.

When *transit fare* was increased by 10%, there would be a significant loss of 2.67% of transit riders. This was compensated by an increase of 1.25% in auto and 1.42% in slow modes. It can be seen that the decrease in transit is nearly twice that of the auto mode when their respective costs were increased by 10%. This shows that people would accept a rise in auto cost easily but would react sharply in transit fares. It should also be noted that despite the close relationship of motorized modes, a majority of the transit users is shifting towards non-motorized modes. This was quite an opposite result with the home based work trips where most of the people shifted to auto person mode (refer Table 4.10, Sensitivity analysis of home based work trip). This indicates that people prefer to use motorized modes for home based work trips but in school trips, due to certain factors like availability of auto, license and cost etc, would force most of the transit users to shift to non-motorized modes.

The second variable analyzed was *'Travel time'*. Its sensitivity analysis was done for every mode, that is auto, transit and non-motorized modes, as shown in Table 5.10. It can be seen that the effect of 10% increase in travel time was greatest in the case of transit with a decrease of 2.92%, which was nearly three times that of auto and two times that of non-motorized modes. This shows that people are extremely sensitive with time when they travel by transit. Furthermore, when there was an increase of 10% in auto time, people shift only to the transit. This is because as far as time is concerned, non-motorized modes have no comparison with motorized modes. However, a 10% increase of time in the non-motorized modes would cause 80% of the users to shift to transit again.

Next variable analyzed was *'vehicle per household'*. As there were three different categories for this variable (0, 1, and 2), it was found reasonable to test its sensitivity under different categories. First it was analyzed when the number of vehicles per household would increase from 0 to 1 and in second case when vehicle per household would increase from 1 to 2+. It was interesting to note that the auto modal share didn't change much when the number of vehicles was changed from 0 to 1 (caused an increment of just 1.16% in auto mode), but modal share increased appreciably (+6.49%) when the category was changed from 1 to 2. This shows that the presence of just one car in the household would not inspire or provide much opportunity for a person to use the auto mode, even a shared ride. However as soon as the category would change from 1 to 2, the chances of using a car for their school trip would increase appreciably.

It is interesting to note that the increase in auto share (+1.16%) resulting from the increase in vehicles per household from 0 to 1 would also cause an increment in transit mode by 0.25% whereas non-motorized modes would decrease by 1.41%. However the increase in auto share (+6.49%) resulting from the increase in vehicle per household from 1 to 2, would cause a loss in transit and non-motorized modes by 5.41% and 1.08% respectively. This result was expected, since more autos mean greater probability of choosing auto to make a trip. The decrease in transit (5.41%) is however significant, again showing the close proximity of the two motorized modes. The decrease in non-motorized modes (1.08%), is small suggesting that walk and bike modes have some unique characteristics which are unaffected by the availability of transit or auto.

The next three variables were dummy variables. The availability of *license* clearly shows a profound impact on auto person mode, which was increased by 12.41%. This shows that many of them are using transit and non-motorized modes because of the unavailability of a driver's license. Once they have a license, they will switch to auto. The increase in this auto share would come from transit and non-motorized modes in the proportion of 7.66% and 4.75% respectively.

The analysis for the *Central Business District* variable shows that when the trip is made within the CBD, auto mode would increase by 3.67% whereas transit and non-motorized modes would decrease by 1.92% and 1.75% respectively. This again shows that for school trips the auto mode, which is in reality a shared ride mode, would be selected when the trip is made within CBD.

The sensitivity analysis for the variable *Gender* shows that when gender was changed from female to male, the non-motorized mode would increase by 6.25% with a loss of 5.66% in transit and just 0.59% loss in auto. This shows that women prefer transit while men prefer to use non-motorized modes. A small loss in auto mode suggests that gender has little significance in the auto person mode.

Next variable analyzed was *Number of trips*. It was found that when the number of trips for the person in that day was increased by 1, transit would decrease by 7.17%. This would then be compensated by an increase of 3.75% and 3.42% in auto and non-motorized modes respectively. This shows that people would not like to use transit for more number of trips as against to auto and non-motorized modes.

The analysis for *Purpose of trip* shows that when the purpose would change from higher secondary (or university) trip to secondary school trip, transit mode would increase by 6.67% whereas auto and non-motorized modes would decrease by 5.92% and 0.75% respectively. This shows that secondary school trips would mostly be undertaken by transit and non-motorized modes. But as soon as people starts going to post secondary school, the auto person mode would become more feasible and attractive.

The last variable analyzed was the *Starting time* of the trip. It was found that when the starting time was changed from >1615 to <= 1615, auto mode would decrease by 4.75% while transit and non-motorized modes would increase by 3.50% and 1.25% respectively. This shows that when the trip would start in the PM peak hour, auto mode is likely to be taken. However before and after that peak time transit and non-motorized modes would be preferred. It should again be noted that more than 70% of this change would be absorbed by transit, indicating the similar characteristics of the two motorized modes.

CHAPTER 6

NON HOME BASED WORK - NON HOME BASED SCHOOL TRIP MODEL (OTHER TRIP MODEL)

6.1 OVERVIEW:

The third model developed was for the Non Home Based Work – Non Home Based School Trip purpose. In this model all those cases were taken that were not included in the home based work trip model and home based school trip model. As such it is also called an 'Other Trip Model'. This has always been the most difficult model to develop because of the varied trip purposes. Initially the model was tried to be built in the same pattern of nested logit model, having walk and bike modes in the lower level nest. However after making several attempts with all the possible variables, the developed lower level model was far from satisfactory (for results see Section 6.2). A simple logit model was then developed for Other Trip purpose having auto person, transit and non-motorized modes at one level only.

6.2DEVELOPED LOWER LEVEL MODEL FOR OTHER TRIPS:

Tables 6.1 to 6.3 contain the results of the best model developed for the walk and bike modes at the lower level. Table 6.1 shows the developed model along with the summary statistics. Although all the selected variables were proving significant with high values of t-statistics and showing correct coefficient signs, the values for the adjusted rhosquared and adjusted rhobarsquared were far from satisfactory. It meant that there were quite a few important variables unexplained by the model. From the validation Table 6.2, which is at the macro level, it can be seen that the developed model was predicting just 3.84% of bike trips as against of 19.09% of observed trips. On the other hand the predicting ability of the model for walk mode was 96.16% as against of 80.91% of observed trips. From the validation Table 6.3, which is at the micro level, it can be seen that the percent correct value for bike mode was just 10.37% as against of 97.70% for walk mode. A prediction of just 17 out of 164 trips shows the insensitivity of model towards bike mode.

TABLE 6.1: Lower Level Model for Non Home Based Work - Non Home Based School Trip Purpose

Mode	Time	Gender	Number of Bikes/Person	Starting time	Gross Lease Area (Destination)	Gross Lease Area (Origin)	Density for Employment Zone	Density for Destination Zone	Constant
Bike	-0.0148 (-5.20)								
Walk	* -0.0148 **(-5.20)	-0.792 (-4.20)	-0.2929 (-1.54)	-0.4638 (-2.41)	0.197E-05 (3.00)	0.110E-05 (2.06)	0.281E-04 (3.05)	0.857E-04 (2.27)	2.0674 (8.03)

Travel Time --- total time of the trip from origin to destination in minutes

Starting time --- coded as 1 for trip starting between 1530-1615 and 0 for trip starting after 1615

Employment density --- total employment of the zone divided by its area in sqkm

Bikes per person --- total number of bikes divided by total number of persons in the household

Gross lease area of dest/origin--- total lease area of the shopping center of destination/origin zone in sqkm

Gender --- coded as 0 for female and 1 for male

Province --- coded as 1 for Ontario and 0 for Quebec

* --- coefficient

** --- t-statistic

Summary Statistics:

Number of modes	= 2
Number of bike trips	= 164 (19.09%)
Number of walk trips	= 695 (80.91%)
Total number of trips	= 859 (100.00%)
Rhosq	= 0.3845
Rhobarsq	= 0.3761
Adjusted Rhosq	= 0.1249
Adjusted Rhobarsq	= 0.1034

TABLE 6.2: Macro Validation

Mode	Number of Observed trips	Number of Predicted trips	Error	Percent Predictibility
Bike	164	33	-131	84.75%
Walk	695	826	+131	
Total	859	859	131	

TABLE 6.3: Micro Validation

Mode	Number of Observed trips	Number of trips Correctly Predicted	Percent Correct Value
Bike	164	17	10.37%
Walk	695	679	97.70%
Overall	859	696	81.02%

6.3 LOGIT MODEL:

It was clear from the results shown in Tables 6.1 to 6.3 that the developed lower level model was not sensitive to the bike mode as it failed to distinguish the two non-motorized modes properly and in correct proportion. This was due to the fact that we still have very little knowledge about some of the important variables and factors that play an important role in the selection of walk and bike mode for the Other Trip purpose. Based on the achieved results and availability of the limited data it was realized that it would be very difficult to build a satisfactory lower level model for the Non Home Based Work – Non Home Based School Trip Model. It was then decided to build a non-nested model i.e., a simple logit model for the Other Trip purpose having auto person, transit and non-motorized modes at one level only.

6.3.1 Selected Variables:

The Logit model for the Other Trip purpose included auto person, transit and non-motorized modes. The variables selected in the formation of this model were *cost, time, out-of- vehicle transit time, vehicles per household, license, province, age, starting time, number of trips, gross lease area for destination zone,* and *Central Business District. Cost, time* and *out-of-vehicle transit time* were considered as conditional variables, while all other variables were multinomial. Several other variables were also tested in the initial runs such as *gender, income, population density, purpose of trip*, but were found to be insignificant and thus dropped.

6.3.2 Expected Signs for the Coefficients:

Values for the variable *time* were taken in minutes, *cost* in cents, *age* in years, *number of trips* in numbers and *gross lease area* in sqkm whereas *vehicles per household, license, province, Central Business District,* and *starting time* were considered as dummy variables. The expected signs for the coefficients of these variables are discussed below:

1) Cost:

Variable *cost* was taken as a conditional variable. *Cost1* was the cost for auto that included fuel and parking cost. *Cost2* was the transit cost, which included transit fare. *Cost* for non-motorized modes was assumed to be zero (however to avoid a zero value in the conditional variable for NMM, a token of 10 cents was taken in *Cost3*). As *Cost* is always a disutility in the selection of any mode, the expected sign for the coefficient for *cost* variable was negative.

2) Travel Time:

Travel time was also considered as a conditional variable having different times for different modes. *Time1* was the in-vehicle travel time for auto from trip origin to trip destination. *Time2* was the in-vehicle travel time for transit and *Time3* was the travel time for non-motorized modes that was taken as the average of the walk and bike mode times (because of very little difference between the two times). Being a disutility of the mode, the expected sign for the time variable was negative.

3) Out-of-Vehicle Transit Time: (Ovtt)

In this model, transit travel time was divided into in-vehicle and out-of-vehicle travel times. This was done because unlike work and school trips where the trip starting times and trip origins are more or less fixed, 'Other trips' have no fixed trip time and location. As such people have to walk and wait more at the transit stations making *out-of-vehicle transit time* a distinct variable. This time was calculated by adding the access time required to walk to the bus stop, waiting time at the bus stop, boarding time, transfer time and egress time. The expected sign for out-of-vehicle transit time is definitely negative as more the out-of-vehicle travel time the less would be its utility.

4) Vehicle Per Household: (Veh_hh_)

This was again considered an important variable in the Other Trip Model. The variable was coded as 0, 1 and 2 for number of vehicles 0, 1 and more than 1. As a higher number of autos means more likelihood of auto mode being chosen, the expected sign for transit and non-motorized modes (auto, being normalized to zero) would be negative.

5) License: (Lic_r)

License has always been one of the key variables in the selection of auto mode. A person with a driving license is more likely to use a car, if it is available. On the other hand the presence of an auto will have no effect on a person without a license. As the variable was coded as '1' for license and '0' for no-license, its expected sign was negative for both transit and NMM.

6) Province:

A dummy variable called *'Province'* was created by coding 1 for Ontario and 0 for Quebec. The expected sign for this variable was not very clear but keeping in view that the facilities for transit, walk and bike are better in Ontario side, it was expected that this variable will have positive signs for both transit and non-motorized modes.

7) Age:

Age was expected to have a negative sign for transit and non-motorized modes, which meant that, as age would go up, people are more likely to use auto-person mode as compared to transit and non-motorized modes. This was due to the fact that health deteriorates as age goes up and people become less energetic forcing them to shift to more comfortable modes.

8) Starting Time: (St_t_r)

Starting time of the trip was also considered as an important criterion in the selection of mode choice. Whereas auto was more likely to be used in the peak hour, which starts at 1616, it was transit and non-motorized modes that would be preferred for trips starting before 16:16. With this in mind the starting time was coded as 0 for trips starting after 16:15 and 1 for trips starting before 16:15. As most of the school trips would start before 16:15, the expected signs were positive for both transit and non-motorized modes.

9) Gross Lease Area for Destination: (Dest_GLA)

To capture the effect of shopping centers on making trips, a variable called '*Gross Lease Area*' was created both for origin and destination zones. This variable was generated by adding the gross lease area of all the shopping centers in that zone. Considering the fact that transit service was easily available outside every shopping center in the Ottawa-Carleton Region and people find it convenient to use transit more than other modes, the expected sign for this variable would be positive for transit and negative for non-motorized modes.

10) Number of Trips: (Num_trip)

Total number of trips a person has made during the day was considered to be an important variable in the selection of modes for the school trips. More number of trips means that they are less likely to use the walk and bike modes or transit compared to the auto mode. As such the expected signs for transit and non-motorized modes for this variable would be negative.

11) Central Business District: (CBD_Flag)

A dummy variable was created to capture the exclusive characteristics of the downtown area. '1' was coded for trips that were made to CBD, '0' otherwise. Considering a good transit system in the downtown and high parking cost during the day, the coefficient of CBD was expected to have a positive sign for both transit and non-motorized modes.

6.3.3 Developed Logit Model For The Other Trip Purpose:

Table 6.4 shows the results of the developed logit model for Other Trip Purpose for auto person, transit and non-motorized modes.

TABLE 6.4: Logit Model for Other Trip Purpose

Mode	Cost	Travel Time	Out-Veh Tr. Time	No.Veh. Per Hhld	License	Prov	Age	Starting time	Gross Lease Area for Dest	Number of trips	CBD	Constant
Auto-Person	-0.7864 (-20.89)	-0.0570 (-20.67)										
Transit	-0.7864 (-20.89)	-0.0570 (-20.67)	-0.0275 (-3.18)	-1.5429 (-14.08)	-1.8794 (-11.22)	0.7033 (3.65)	-0.0264 (-4.95)	0.6685 (4.80)	0.8134E-06 (3.75)	-0.2873 (-7.55)	0.8686 (4.39)	1.8594 (7.21)
Non-Motorized	-0.7864 (-20.89)	-0.0570 (-20.67)		-1.2480 (-15.28)	-1.7536 (-13.71)	0.5777 (4.81)	-0.0261 (-6.70)	0.7113 (7.04)	-0.2051E-06 (-1.01)	-0.0952 (-4.77)	1.2289 (7.02)	1.4906 (6.73)

Auto cost --- cost for parking and fuel consumption in cents
Transit cost --- transit fare in cents
Travel time --- total time of the trip from origin to destination in minutes
Out of vehicle transit time --- time spent for walking, waiting, and boarding for transit mode
Vehicles per household --- coded as 0 for no veh/hh, 1 for 1 veh/hh, 2 for more than 1 veh/hh
License --- coded as 0 for no license and 1 for license
Province --- coded as 1 for Ontario and 0 for Quebec
Age --- age of person in years
Starting time --- coded as 1 for trip starting between 1530-1615 and 0 for trip starting after 1615
Gross lease area of destination --- total lease area of the shopping center of destination zone in sqkm
Number of trips --- total trips made during the day in numbers
Central Business District --- coded as 1 trip made within CBD, 0 otherwise

Summary Statistics:

Number of modes	= 3
Number of auto person trips	= 5838 (83.21%)
Number of transit trips	= 319 (4.55%)
Number of non-motorized trips	= 859 (12.24%)
Total number of trips	= 7016 (100.00%)
Rhosq	= 0.7058
Rhobarsq	= 0.7030
Adjusted Rhosq	= 0.4129
Adjusted Rhobarsq	= 0.4075

6.3.4 Validation:

The macro and micro validations of the model are shown in Table 6.5 and Table 6.6 respectively.

TABLE 6.5: Macro Validation

Mode	Number of Observed trips	Number of Predicted trips	Error	Percent Predictibility
Auto person	5838	6230	+392	94.41%
Transit	319	106	-213	
Non-motorized	859	680	-179	
Total	7016	7016	392	

From Table 6.5, which is at the macro level, it can be seen that the developed model is overestimating 392 auto person trips whereas transit and non-motorized trips are underestimated by 213 and 179 trips respectively giving an overall predicting ability of 94.41% for the model. Usually it is very difficult to model these trips in which the purpose of trip is not well defined. Further, the observed modal split was heavily

dominated by the auto person mode having more than 83% of total trips. On the other hand transit and non-motorized trips taken together were less than 17% with transit contributing a mere 4.55%. Considering these statistics and the nature of the model, a percent predictibility of 94.41% was indeed an outstanding result in any respect.

TABLE 6.6: Micro Validation

Mode	Number of Observed trips	Number of trips Correctly Predicted	Percent Correct Value
Auto person	5838	5678	97.26%
Transit	319	87	27.27%
Non-motorized	859	460	53.55%
Overall	7016	6225	88.73%

From Table 6.6, it can be seen that the percent correct value for auto person, transit and non-motorized modes are 97.26%, 27.27% and 53.55% respectively. It may be noted here that percent correct value for transit mode seems to be low as compared to auto-person and non-motorized modes. It was mainly due to the fact that a mode, having just 4.55% of trips in the modal split, is very difficult to be correctly predicted in a model. However, correct prediction values of 27.27% and 53.55% for transit and non-motorized modes show that the developed model is sensitive enough to these modes. Other reason for this low predicting ability of the model for transit and non-motorized modes was the unavailability of some vital factors. For example, there was no information in the OD survey for the frequency of bus service, the directness of the route from origin to destination, availability of shed at the transit station, availability of walkways and bikeways, safety consideration for non-motorized modes or health of the person. All these factors are very important in the selection of transit and/or non-motorized modes and for which we had no information. The overall percent correct value of 88.73% achieved with these constraints and complexities was therefore quite an acceptable result.

6.3.5 Goodness of Fit Measures:

The goodness of fit measures provide the analyst important statistical tools to measure the quality of the developed model with respect to the sample data. As discussed in Chapter 4, these measures are appropriate only for samples with equal market shares and should be corrected with respect to their market shares. The corrected measures known as, *'Corrected rhosquared'* and *'Corrected rhobarsquared'* were therefore calculated and compared with the minimum excepted values provided in Table 4.3a.

In our data set the modal split for auto, transit and non-motorized trips were 83.21%, 4.55% and 12.24% respectively, for which the minimum excepted *rhosquared* value is 0.28. The developed model has a *corrected rhobarsquared* value equal to 0.4075, which is significantly higher than the minimum excepted value. This shows the quality of the model in statistical sense as well.

6.3.6 Correlation Matrix:

The correlation matrices for the developed logit model for Other Trip purpose are shown in Tables 6.7, 6.8 and 6.9.

TABLE 6.7: Correlation Matrix for Auto Person Mode

	CHOICE	COST1	TIME1
CHOICE	1.0000		
COST1	0.2814	1.0000	
TIME1	-0.2747	0.1884	1.0000

TABLE 6.8: Correlation Matrix for Transit Mode

	CHOICE	COST2	TIME2	OVTT2	VEH_HH_R	LIC_R	PROVINCE	AGE	ST_T_R	DES_GLA	NUM_TRIP	CBD_FLAG
CHOICE	1.0000											
COST2	-0.1097	1.0000										
TIME2	-0.2634	0.3461	1.0000									
OVTT2	-0.1275	0.5510	0.1787	1.0000								
VEH_HH_R	-0.2817	0.1110	0.0921	0.1118	1.0000							
LIC_R	-0.3512	0.0331	0.1226	0.0265	0.1622	1.0000						
PROVINCE	0.0803	0.0755	-0.0500	0.0765	-0.0049	-0.0139	1.0000					
AGE	-0.1959	0.0378	0.0455	0.0136	0.0327	0.4376	0.0531	1.0000				
ST_T_R	0.0591	-0.0116	0.0360	0.0086	0.0319	-0.0086	0.0165	0.0582	1.0000			
DES_GLA	0.0142	-0.0363	-0.0036	-0.0741	-0.0125	-0.0124	0.0357	-0.0183	0.0024	1.0000		
NUM_TRIP	-0.1016	-0.0516	-0.0695	-0.0456	0.0221	0.1489	-0.0115	0.0375	-0.0169	-0.0149	1.0000	
CBD_FLAG	-0.1830	-0.0305	-0.0772	0.1360	0.1234	-0.0232	-0.0142	-0.0097	0.0193	-0.0162	0.0117	1.0000

TABLE 6.9: Correlation Matrix for Non-Motorized Mode

	CHOICE	COST3	TIME3	OVTT2	VEH_HH_R	LIC_R	PROVINCE	AGE	ST_T_R	DES_GLA	NUM_TRIP	CBD_FLAG
CHOICE	1.0000											
COST3	0.0000	0.0000										
TIME3	-0.2528	0.0000	1.0000									
OVTT2	-0.1275	0.0000	0.4807	1.0000								
VEH_HH_R	-0.2817	0.0000	0.1281	0.1118	1.0000							
LIC_R	-0.3512	0.0000	0.1051	0.0265	0.1622	1.0000						
PROVINCE	0.0803	0.0000	0.0425	0.0765	-0.0049	-0.0139	1.0000					
AGE	-0.1959	0.0000	0.0400	0.0136	0.0327	0.4376	0.0531	1.0000				
ST_T_R	0.0591	0.0000	0.0277	0.0086	0.0319	-0.0086	0.0165	0.0582	1.0000			
DES_GLA	0.0142	0.0000	-0.0264	-0.0741	-0.0125	-0.0124	0.0357	-0.0183	0.0024	1.0000		
NUM_TRIP	-0.1016	0.0000	-0.0776	-0.0456	0.0221	0.1489	-0.0115	0.0375	-0.0169	-0.0149	1.0000	
CBD_FLAG	-0.1830	0.0000	-0.0207	0.1360	0.1234	-0.0232	-0.0142	-0.0097	0.0193	-0.0162	0.0117	1.0000

The correlation values between each pair of variables are shown in Tables 6.7, 6.8 and 6.9. Whereas a lower correlation value is always desirable researchers believe that a value greater than 0.8 shows that a particular effect is being accounted for twice and only one of the two variables should be included in the model (Tardiff 1976). It can be seen from the correlation tables that there is no problem of multi-colinearity among independent variables in each of the two models. All the independent variables are having little correlation and as such the estimated coefficients of the variables are not biased.

6.3.7 Discussion on Results:

It can be seen that all the coefficients have correct expected signs and are significant at 99.5% level for at least one of the mode. *Cost* and *time* are again proving to be the most significant variables with t-statistics equal to -20.89 and -20.67 respectively. Their coefficient values of -0.79 and -0.06 are also quite high considering that their units are in cents and minutes. *Out - of - vehicle transit time* is also significant. However its t-statistics of -3.18 and coefficient value of -0.03 when compared with the *total in-vehicle transit time* show that the perception and importance of in-vehicle travel time is far more than out-of-vehicle transit time.

Vehicles per household is also proving highly significant for both transit and non-motorized modes with t - statistics equal to -14.08 and -15.28 and estimated values of -1.54 and -1.25 respectively. This shows that number of vehicles has a profound negative impact on both transit and non-motorized modes in the mode choice selection for other trip purpose.

License as expected is having a negative sign and high t-statistic value for both transit and slow modes showing its importance in the selection of auto mode. The coefficient values of –1.88 and –1.75 for transit and non-motorized modes indicate that the negative impact of having license on these two modes are just the same.

Coefficient of *Province* is having a positive sign for both the modes meaning that transit and non-motorized mode have a better chance of selection when the trip is in Ontario.

Central Business District has a positive sign and high t-statistic values of 4.39 and 7.02 for transit and non-motorized modes respectively. This shows that people would prefer to use transit and non-motorized modes over auto when the trip is in CBD. This was again an expected result, as not only the parking cost of auto in CBD is high during workdays but the transit service is also very good here having a high frequency of bus service to and from the GTA, making transit a preferred choice over auto. Moreover, due to the dense network of streets and traffic congestion, it may be easier to use walk and bike modes to the central business district than auto.

Age is having a negative sign and proving significant with t-statistics equal to -4.95 and -6.70 for both transit and non-motorized modes. This is again an expected result, as with increasing age people would switch to auto from transit and non-motorized modes. This confirms that auto provides the maximum convenience which is a prime factor in the selection of transportation mode in the older age.

Number of trips is having a negative sign both for transit and non-motorized modes and proving significant for both of them. This shows that people would prefer auto person mode over transit and non-motorized modes as the number of trips per day increase. This is due to the fact that transit and non-motorized modes are quite time consuming and demanding as compared to auto and as such have little attraction for people making many trips per day.

Starting time of the trip is also proving to be significant for both transit and non-motorized modes with a positive sign. This shows that when the starting time is before 16:15, transit and non-motorized modes are preferred over auto. However after 16:15 when the peak hour starts auto person mode is more likely to be chosen. The probable reason for this would be the shared ride facility available at that time.

Gross Lease Area for destination zone is coming out to be positive and significant for the transit mode. This shows that people would prefer transit over auto person mode when the destination zone has more shopping area. This is because transit service is usually very good near big shopping centers. On the other hand this variable is not proving significant at 99% level for non-motorized mode. However its negative sign indicates that people would prefer the auto mode over non-motorized modes when the destination zone has more gross lease area.

Lastly, *Constant* is proving significant for both transit and non-motorized modes with coefficient values equal to 1.86 and 1.49 respectively. This shows that despite using so many variables, there are still some important variables missing in the model. For example, frequency of bus service, directness of the transit route, availability of transit shed at the bus stop, health, physique, availability of walk and bike lane and safety consideration for non-motorized modes are some of the important variables for which there was no data available in the 1995 OD survey. In absence of these variables, the model developed and its results are quite acceptable and comparable under any standards.

6.3.8 Sensitivity Analysis:

A sensitivity analysis for all the modes was carried out for each variable. The results are shown in Table 6.10.

TABLE 6.10: Sensitivity Analysis

Variable	% Change in auto-person mode	% Change in transit mode	% Change in non-motorized mode
Auto cost +10%	-0.43%	0.16%	0.27%
Transit fare +10%	0.05%	-0.11%	0.06%
Auto time +10%	-0.16%	0.03%	0.13%
Transit time +10%	0.10%	-0.14%	0.04%
Non-motorized time +10%	0.35%	0.19%	-0.54%
Out-of-Vehicle travel time for transit +10%	0.00%	-0.01%	0.01%
Veh/hh from 0 to 1	1.01%	-0.31%	-0.70%
Veh/hh from 1 to 2+	3.09%	-0.47%	-2.62%
License from no to yes	4.61%	-0.41%	-4.20%
Province from Quebec to Ontario	-0.52%	0.07%	0.45%
Age +10years	1.44%	-0.20%	-1.24%
Starting Time from >1615 to <=1615	-2.45%	0.21%	2.24%
Gross Lease Area for Destination Zone +10%	-0.03%	0.09%	-0.06%
Number of Trips +1	0.61%	-0.28%	-0 33%
CBD from no to yes	-3.90%	0.24%	3.66%

The first variable analyzed was *'Cost'*. It was found that when *auto cost* would increase by 10%, the auto person mode would decrease by -0.43%. This decrease in auto would be absorbed in transit and non-motorized modes by 0.16% and 0.27% respectively. This shows that 60% of auto users are shifting to non-motorized mode and less than 40% are choosing transit. This is quite an interesting result as normally most of the people shift from auto to transit. This shows that transit is less attractive than non-motorized modes in the other trip purpose. This could be because of factors as the low frequency of bus service or non-availability of a direct route. This was an important finding which suggest that transit service needs to be improved to attract people making the other trip purposes.

When *transit fares* were increased by 10%, there was only a small loss of 0.11% of transit riders which would be compensated by an increase of 0.05% and 0.06% in auto and slow modes respectively. It can be seen that the decrease in transit mode would be nearly four times less than the auto mode when their respective costs were increased by 10%. This shows that people would accept this much rise in transit but not in auto. This again suggests that transit riders would not have much choice because of poor transit service so if they were getting any, they would not give it up easily despite an increase in fare. This is quite an opposite result from Home Based Work Trip and Home Based School Trip Models, where people were very sensitive to the increase in transit fares (refer Tables 4.10 and 5.10, Sensitivity analyses of Home Based Work and Home Based School Trip Models). The equal shifts in auto and non-motorized modes shows that people perceive the utilities of auto and non-motorized modes to be the same once they are out of transit mode.

The second variable analyzed was *'Travel time'*. It can be seen that the effect of 10% increase in travel time would be greatest in the case of non-motorized modes with a decrease of 0.54%, which was more than three times to that of auto and transit modes. This shows that people are extremely sensitive with time in non-motorized mode as compared to auto and transit in other trips. This could be because unlike motorized modes, the non-motorized modes are feasible only for short trips and as soon as the trip

distance (or trip time) is increased, the utility of this mode would decrease very quickly. Another thing to be noted in the analysis of time variable is that when there was an increase in auto time, more than 80% of users would shift to non-motorized modes and the remaining 20% to transit. This again proves a poor service of transit for these trips.

Thus by looking at the two highly significant variables *'cost and time'*, we find that people are less sensitive in transit with the changes in these attributes as compared to auto. This is because very few people would opt for transit in these trips. But those who select this mode are some sort of captive users and as such are less influenced by the changes in cost and time. On the other hand, people are very sensitive in non-motorized modes with the increase in its travel time (decreases by 0.54%). This was in line with the home based work trips result where the non-motorized modes were decreased by 0.75% with the 10% increase in its travel time. This shows that as far as non-motorized modes are concerned they behave in the same way in work trips and non-work trips (excluding school trips). Out-of-vehicle travel time for transit was found to be a significant variable in the model. This indicates that people perceive in-vehicle and out-of-vehicle travel time separately. However its sensitivity analysis shows that by increasing this time by 10% only 0.01% of transit riders would be reduced. That is people are practically unaffected by increasing out-of-vehicle transit time by 10%. This is quite an unexpected result, as one would expect some reduction in transit riders because of this increase. Probably it was again due to the fact that very few people would choose transit for this trip and when they would choose an increment of 10% in out-of-vehicle time would have no impact on their selection.

The next variable analyzed was *'vehicles per household'*. As there were three different categories for this variable (0, 1, and 2), its sensitivity was done under different categories. First it was analyzed when the number of vehicle per household would increase from 0 to1 and in second case when vehicle per household would increase from 1 to 2+. As we have seen in the home based work and home based school trips, the increase in auto because of this change would be much greater when vehicle per

household would increase from 1 to 2+ (an increase of 3.09%) than from increasing 0 to 1 (an increase of 1.01%). This is again due to the fact that the presence of just one car in the household would not inspire or provide much opportunity for a person to choose auto mode. However as soon as the category is changed from 1 to 2, the chances of taking a car increase appreciably. It is also interesting to note that the decrease in transit share resulting from the increase in vehicle per household from 0 to 1 and from 2 to 2+ would be just 0.31% and 0.47% respectively, whereas the corresponding values for non-motorized mode are 0.70% and 2.62%. That is more than 80% of switched users in auto would come from the non-motorized mode. This again indicates that most of the transit users are captive users unaffected by the availability of other mode. This is again an opposite result from home based work trips and home based school trips where the increase in auto mode was mostly coming from transit. These results show that the three trip purposes taken are indeed unique in their characteristics and behavior and that they should be analyzed separately.

The next three variables were all dummy variables. The availability of *license* clearly had a profound impact on auto person mode, which would increase by 4.61%. The corresponding decrease in transit and non-motorized modes would be 0.41% and 4.20% respectively. That is more than 90% of users would come from non-motorized modes. This again shows that for these trips, transit riders are unaffected by the changes in attributes of other modes.

The impact of *province* on the selected mode revealed that Quebec residents would choose auto more frequently than Ontario residents would.

The analysis of *Central Business District* show that auto mode would decrease by nearly 4% if the trip would start in CBD. The corresponding increase in transit and slow modes would be 0.24% and 3.66%, showing that the increase in non-motorized mode would be much higher than transit. This may be due to the fact that 'other trips' are generally non-

fixed trips with respect to their time and origins and as such non-motorized modes would be more convenient to use than transit.

The sensitivity analysis for variable *Age* shows that the auto mode would increase by 1.44% by an increase of 10 years in age. Again more than 85% of this shift would come from non-motorized modes which are highly sensitive with the age.

The next variable analyzed was *Number of trips*. It was found that when the number of trips for the person in that day would increase by 1, auto trips would increase by 0.61%. The increase in auto mode would come from 0.28% of transit and 0.33% of non-motorized modes. Since transit and non-motorized modes require more physical activity, persons would prefer to use auto in the subsequent trips.

From the analysis of *Starting time* of the trip it was found that when the starting time would change from >16:15 to <= 16:15, auto mode would decrease by 2.45% and transit and non-motorized modes would increase by 0.21% and 2.24% respectively. This shows that when the trip would start in the peak hour, auto person mode is likely to be taken. However before that peak time, transit and non-motorized modes would be preferred. It should again be noted that more than 90% of this change would be absorbed by non-motorized mode, indicating that non-motorized modes are affected much during the peak hour. A small decrease in transit mode indicates a better transit service during the peak hour.

The last variable analyzed was *Gross Lease Area for destination zone*. When the gross lease area would increase by 10%, transit trips would increase by 0.09% whereas auto and non-motorized trips would decrease by 0.03% and 0.06% respectively. This suggests that bigger the shopping area, the more likely transit use would be. The non-motorized modes would surely be reduced when the destination of the trip is a shopping centre since it would cause inconvenience to people to carry bags when they are walking or cycling.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATION

7.1 CONCLUSIONS:

Nested multinomial logit models were developed for motorized and non-motorized modes for the home based work, home based school and other trip purposes. It was shown that urban transportation models can be developed by including non-motorized, walk and bike modes, which have traditionally been ignored in the transportation modeling process. These walk and bike modes should however be included in a nested logit model because of the fundamental differences in their characteristics with the motorized modes. Development of these models for all the traditional trip purposes have provided us a better understanding of the environmentally friendly modes that would play a vital role in their promotion and ultimately in the achievement of a sustainable transportation.

From the results of home based work, home based school and other trip model calibrations, the following conclusions are drawn. They are grouped according to whether they are general conclusions applicable to all the three developed models or whether they pertain to a specific model. Conclusions related to the goodness of fit measures for the developed models are also made. Based on these results, statements are also made regarding the reliability of model results and the usefulness of the disaggregate behavioural approach.

7.1.1 Conclusions Relating to Specific Models:

A summary of all the three developed models and their validation results are provided in Tables 7.1, 7.2 and 7.3. It can be seen in Table 7.1 that *Cost* and *Time* are proving to be the most significant variables in all the three models. By analyzing these two variables, it becomes clear that *Cost* has more importance than *Time* in the Home Based Work Trip

Model whereas it is *Time*, which is showing more significance than *Cost* in the Home Based School Trip Model. On the other hand both *Cost* and *Time* are proving to be equally significant in the Other Trip Model.

The importance of cost in the work trips is due to the parking cost. In areas like CBD (where most of the work trip starts), parking cost is high and people prefer to use the less expensive transit mode, which is not as time efficient as auto. On the other hand in school trips, the role of cost is less as compared to time. This is because in most of the cases school going children are shared riders with their parents, who pay the cost and as such the effect of cost is reduced. This in turn makes time more significant in the school trip model.

In Other trip model, the transit level of service attributes appear to have little impact upon mode choice. It was not possible to estimate the relative importance of the individual transit level of service variables because of the limited sample size and the large numbers of trip purposes included within non-work definition.

The coefficients of *Inclusive value* for both Work Trip and School Trip Models are sufficiently and significantly unequal to 1.0 to indicate the lack of independence between the walk and bike modes, which helped to explain the improved summary statistics of the two models despite using a seemingly lower number of variables.

Number of vehicles per household and *License* show that these variables are quite significant in *Home Based Work Trip Model* and *Other Trip Model*. However, for *Home Based School Trip Model* their significance is comparatively less. This is because most of the school going children are less than 18 years of age and have no driver's license. Therefore, the number of vehicle in the household and license become less significant in the *Home Based School Trip Model.*

Table 7.1: Summary of the Three Developed Models

Model	Mode	Cost	Time	Out of Veh. Travel time	Incl_ Value	No. of Veh/hh	Province	License	CBD	Gender	No. of trips	Starting time	Purp. of trip	Age	GLA_ Dest	Constant
Model1 (HBWork)	Auto-Person	-0.6704 (-31.56)	-0.0497 (-24.11)													
	Transit	-0.6704 (-31.56)	-0.0497 (-24.11)			-1.4679 (-14.71)	0.7510 (+5.58)	-2.239 (-10.55)								0.9849 (5.19)
	Non-Motorized	-0.6704 (-31.56)	-0.0497 (-24.11)		0.7706 (+8.17)	-1.321 (-10.93)	0.8377 (+4.74)	-1.639 (-6.35)								-1.1793 (-3.58)
Model2 (HBSchl)	Auto-Person	-0.6429 (-8.68)	-0.0299 (-10.11)													
	Transit	-0.6429 (-8.68)	-0.0299 (-10.11)			-0.9195 (-6.42)		-0.7736 (-3.55)	-0.3158 (-1.24)	-0.0599 (-0.34)	-0.2326 (-3.81)	0.8331 (4.00)	1.1018 (4.51)			1.1349 (5.11)
	Non-Motorized	-0.6429 (-8.68)	-0.0299 (-10.11)		0.4829 (10.14)	-1.4328 (-8.48)		-0.9093 (-3.64)	-1.0039 (-3.19)	0.6231 (3.16)	-0.0143 (-0.23)	0.9444 (3.85)	0.8321 (2.92)			-0.1229 (-0.23)
Model3 (Other)	Auto-Person	-0.7864 (-20.89)	-0.0570 (-20.67)													
	Transit	-0.7864 (-20.89)	-0.0570 (-20.67)	-0.0275 (-3.18)		-1.5429 (-14.08)	0.7033 (3.65)	-1.8794 (-11.22)	0.8686 (4.39)		-0.2873 (-7.55)	0.6685 (4.80)		-0.0264 (-4.95)	0.813E-06 (3.75)	1.8594 (7.21)
	Non-Motorized	-0.7864 (-20.89)	-0.0570 (-20.67)			-1.2480 (-15.28)	0.5777 (4.81)	-1.7536 (-13.71)	1.2289 (7.02)		-0.0952 (-4.77)	0.7113 (7.04)		-0.0261 (-6.70)	-0.205E-06 (-1.01)	1.4906 (6.73)

TABLE 7.2: Summary of the Model Validations

Model	Mode	Modal Share	Observed Trips	Macro Validation			Micro Validation	
				Predicted Trips	Error	% Predictibility	Predicted Correctly	% Correct Val.
Home Based Work Trip Model	Auto Person	69.07%	2952	3219	+267	93.75%	2813	95.29%
	Transit	21.92%	937	807	-130		666	71.08%
	NMM	9.01%	385	248	-137		165	42.86%
	Overall	100.00%	4274	4274	267		3644	85.26%
Home Based School Trip Model	Auto Person	26.75%	321	299	-22	97.50%	182	56.70%
	Transit	32.50%	390	382	-8		250	64.10%
	NMM	40.75%	489	519	+30		410	83.84%
	Overall	100.00%	1200	1200	30		842	70.17%
Other Trip Model	Auto Person	83.21%	5838	6230	+392	94.41%	5678	97.26%
	Transit	4.55%	319	106	-213		87	27.27%
	NMM	12.24%	859	680	-179		460	53.55%
	Overall	100.00%	7016	7016	392		6225	88.73%

Table 7.3: Summary of the Goodness of Fit Measures

Model	Level	Rhosq	Rhobarsq	Adj. Rhosq	Adj. Rhobarsq	Overall Rhosq (for both lower & higher level)	Adj. Overall Rhosq (for both lower & higher level)
HB Work Trip Model	Lower Level	0.3322	0.3086	0.3073	0.2828	0.6000	0.4660
	Upper Level	0.6124	0.6109	0.4750	0.4730		
HB School Trip Model	Lower Level	0.6279	0.6076	0.4961	0.4686	0.3943	0.3563
	Upper Level	0.3418	0.3335	0.3329	0.3183		
Other Trip Model	Upper Level	0.7058	0.7030	0.4129	0.4075	0.4129	0.4075

Province is proving equally significant in both *Home Based Work Trip Model* and *Other Trip Model* indicating that the effect of *province* is great in both of these trips. The reason for this is the major contribution of auto and transit modes, which are quite different in the two areas. School trips are mostly localized trips in which the contribution of non-motorized modes is major and as such school trips are unaffected by its location and behave the same in both Ontario and Quebec. It is therefore, that *province* is absent in the *Home Based School Trip Model.*

The Central Business District variable is useful for explaining the increased opportunities for using transit and non-motorized modes as compared to auto in the CBD area in the Other Trip Model. For the School Trip Model, the variable indicates that walk and bike trips would decrease in CBD as compared to the non-CBD areas. For this trip purpose people would prefer auto to transit and non-motorized modes. This auto mode is in fact a shared ride mode that is selected most when the school trip is in CBD. This may be because of the fact that most of the school going children are grade school children for whom parents don't find it safe and convenient to send them using bike or transit mode in the downtown area especially in absence of any bike lanes. As such parents either drive them to the school using shared ride or prefer walk mode.

Effect of *number of trips* prior to that trip is significant in Other Trip purpose but is absent in Home Based Work Trip Model. This is because work trips are more or less fixed trips with both time and location known and as such additional trip would make less impact on them as compared to *other trips* which are generally non-fixed in time and location, making transit a difficult mode to use. This makes auto as their preferred choice, which could be used with the same comfort and convenience. The increased number of trips would therefore reduce the attraction to take transit or non-motorized modes in the subsequent trips as compared to auto.

Starting time is showing the same significance and impact in both Home Based School Trips and Other Trips. Their positive sign for both transit and non-motorized modes indicate that when the starting time is before16:15, transit and non-motorized modes are

preferred over auto. However after 16:15 when the peak hour starts auto person mode is more likely to be chosen.

Age is proving significant only for other trip purpose. This is because unlike to work and school trips where the age of the person is normally in a defined range (for school trip it is 10-22 years and for work trip it is 18-60 years), a person's age for 'other' trip could be anything and this makes a real difference in choosing the mode of transportation for that particular trip.

Gross Lease Area for destination zone is proving significant only for the transit mode in the Other Trip purpose. It appears that large shopping centers are quite attractive to transit users. This could be due to the fact that many of the large shopping centers in the NCR have transit stations directly at the centers.

Lastly the *Constant* is also proving significant in all the three models indicating that there are still some unknown factors that play an important role in the selection of mode for all of these purposes.

7.1.2 General Conclusions:

Factors considered important in mode choice were identified and tested. For all trips, automobile ownership is, as expected, a very important attribute affecting mode choice. The higher the level of automobile ownership in a household, the more likely is an individual to travel by automobile. The degree to which multiple car ownership is influenced by transit level of service requires further research. The results indicate that the travel cost, total travel time, vehicle ownership, availability of license and province are important variables in the choice mode for Work trip. For School trips, the important variables are travel cost, total travel time, vehicle ownership, availability of license, CBD, gender, starting time, purpose and number of trips. And for Other trips, the important variables are travel cost, total travel time, vehicle ownership, availability of license,

availability of license, province, CBD, person's age, starting time, number of trips and shopping area of the destination zone. The models were tested and were found to be predicting reasonably well the mode choice behavior.

It is concluded that, subject to some further testing, the models, which have been developed, are useful tools to evaluate transportation policies affecting the choice of travel mode.

7.1.3 Conclusions Relating to Goodness of Fit Measures:

From the validation summary shown in Table 7.2 and Rhosquared values shown in Table 7.3 it can be seen that from the three developed models, home based work trip model is showing the best results. Its percent correct value is 85.26% with an adjusted overall Rhosquared value of 0.466. This is a very good result as most of the PM peak period trips are work trips and as such a good understanding of their behavior would help in the making of an effective transportation policy.

School trip model is equally showing good results especially when we look at the modal split of its observed trips. All the three modes have nearly equal modal shares with 26.75%, 32.50% and 40.75% for auto, transit and NMM respectively. This requires the model to include the characteristics of all these modes in order to predict them correctly. The developed model fulfils this requirement despite a seemingly low number of observations. The percent correct value of 70.17% for the model and especially 83.84% for the non-motorized modes shows that the characteristics of non-motorized modes are rightly selected and as such would play a vital role in the making of transportation policies for these environmentally friendly modes.

Other trip model is also showing excellent predicting ability with a percent correct value of 88.73% and an adjusted overall Rhosquare value of 0.407. These values look ominous when realized that this is the most difficult model to build with, as this model has no

specific trip purposes. To capture its characteristics was therefore a demanding task. This model is showing the most number of variables when compared to other two models confirming diversity in its characteristics.

7.1.4 Conclusions Relating to the Usefulness of the Disaggregate Behavioural Approach:

- Reliable and consistent results can be achieved using relatively few observations.
- It is possible to identify the level of service attributes that are most likely to have the greatest effect on mode choice.
- It is a useful technique for testing transportation policies within the urban transportation planning process.
- Logit models of disaggregate travel choice can be calibrated using readily available user oriented computer programs

7.2 RELIABILITY OF THE RESULTS:

- Although the sample sizes were relatively small, the statistical indicators used to evaluate the reliability of the results confirm that in most cases, the estimated coefficients of the models are reasonable and have signs consistent with observed behavior.

- From the tests used in the model validation stage, it appears that the three developed models are able to predict an individual's mode choice well.

- The sensitivity of traveler's choice of mode to small changes in cost and travel time is comparable with the other models developed in the NCR.

- Logit estimation software 'TSP' provides several indictors of the goodness of fit of the model to the observed data. The software provides a "rho-square" and rho-bar-square" statistics which indicates the degree of certainty of the model. In theory, any

value between 0 (no fit) and 1 (perfect fit) is possible. Experience in transportation modeling studies has indicated that a model of the type developed here generally returns a value of between 0.2 and 0.8. This is consistent with the findings of this research.

- All the three developed models for work, school and other trips, have sufficiently good percent correct statistics showing the developed models are able to predict an individual's mode choice well. Although a high percent correct value is not always desirable, as such high values may sometimes result from a high degree of modal uniformity despite a poorly specified model. It is therefore recommended that the percent correct statistic should be used with other goodness of fit measures like adjusted rhosquare and adjusted rhobarsquared values.

7.3 RECOMMENDATIONS:

It can be stated that the results of the models for motorized and non-motorized modes developed in this project are useful in their present form. Notwithstanding this statement and the above conclusions, some additional model development and testing may be carried out before these models are used as policy-testing instruments and as predictive tools for long and short range planning:

- It is suggested that the main objective of any further model development for the urban areas should be to expand upon the existing models by examining auto occupancy and shared ride as discontinuous variables. This could be done by obtaining more information in the future travel surveys; however, it may be necessary to enlarge the samples particularly for the non-motorized modes for having more reliable results.
- A second possible area for further investigation is to develop separate models for two or three types of non-work trip purposes. For example, shopping trips are often separated from social/recreational trips and trips beginning or ending at the home are frequently separated from trips in which neither the origin nor the destination is the individual's home. Unlike work trips in which the place of work is fixed, an

individual often has many possible destinations from which to choose for non-work travel. The choice of destination is often dependent upon the level of availability of transportation service to each destination alternative. Therefore, another possible area of study is to build a model based on both destination and mode choice.

- It is also hypothesized that automobile ownership is related to transit level of service since a household's need for owing more than one auto is expected to decrease as transit level of service increases.
- Because of the limited data relating to the influence of parking availability and cost on mode choice, further information could be collected so that these variables could be better incorporated into the model. In this way it would be possible to estimate the impact of alternative parking strategies.

7.3.1 Need for Focused Research on Non-Motorized Transportation:

Very little research has been performed on the use of NMT in the past and the mobility needs of the urban areas. As a result, many well-meaning programs have failed because they were based on false assumptions or targeted a nonexistent clientele. For example, in the United States, bicycle planning after the mid-1970s was based on the assumption that almost all bicycle use was voluntary and very few cyclists rode because they lacked other transport options. It was not until recently that research has revealed that the poor and other transportation-disadvantaged persons make most of the NMT trips (Antanakos, 1995). Although virtually the entire subject area is ripe for investigation, the most pressing needs appear to be in the following areas:

- ***Nonmotorized Trip Generation and Distribution Patterns for NMT***

There is a need to differentiate between (a) purposeful trips to a specific location to access work, school and other trip opportunities and (b) travel taken for recreational purposes, without a destination made because the trip itself is considered the recreational opportunity.

The final product of such research would be a quantitative methodology for predicting present and future bicycle and pedestrian flows and the spatial location of these flows. Such a procedure forms the basis of the transport analysis for motorized modes and should be adopted for use by NMT planners.

- ***Methods for Objectively Evaluating the NMT Environment***

Methods for assessing how well a corridor or facility is providing service to bicycle or pedestrian users are important and should be evaluated for two reasons. First, level-of-service (LOS) is a significant determinant of route choice for NMT users. Unlike motorists, who are deflected from the shortest or fastest path between two points only by substantial congestion or severely unpleasant operational conditions, relatively small changes in the travel environment can have impacts on the selection of a travel route by NMT users (Wright, 1993). Second, the quality of the non-motorized travel environment greatly influences the go/no-go decisions of potential travelers. For those with few modal options, the lack of safe and convenient non-motorized routes results in decreased access to employment, school, shopping, medical services, and other basics of life.

- ***Better Understanding and Consistent Policies***

Walking and pedestrians need better understanding and information especially in this changing society and conditions. So whereas walking distance for home based school trips was found to be 1 km or less than 1 km in 1996, it is becoming nearly 1.5 to 2 km in recent years suggesting a dynamic approach in the modeling of these NMM. Similarly more consistent policies should be adopted if mobility and accessibility are to be maintained for the community as a whole. It is clear from this research that a considerable amount of movement takes place by these NMT modes and therefore a thorough understanding of these non-motorized movements will permit more balanced allocation of resources and improvements to overall access and mobility, a key to achieve sustainable transportation.

REFERENCES

TRANS, 1996, ***1995 NCR OD Survey: Database Validation and Users Guide,*** Region of Ottawa-Carleton, Ottawa.

TRANS, 1996, ***1995 NCR OD Survey: Design and Administration Report,*** Region of Ottawa-Carleton, Ottawa.

TRANS, 1997, ***1995 NCR OD Survey: Highlights of Demographic and Travel Patterns,*** Region of Ottawa-Carleton, Ottawa.

Transportation Research Board, 1983, ***Application of Disaggregate Travel Demand Models,*** National Co-operative Highway Research Program Report 253.

Antanakos, C., 1995, ***Nonmotor Travel in the 1990 Nationwide Personal Transportation Study,*** Presented at 74th Annual Meeting of the Transportation Research Board, Washington, D.C.

Ben-Akiva, M. E., 1973, ***Structure of Passenger Travel Demand Models,*** Ph.D. Thesis, Department of Civil Engineering, MIT, Cambridge, Massachusetts.

Ben-Akiva, M. E., and S. R. Lerman, 1985, ***Discrete Choice Analysis: Theory and Application to Travel Demand,*** MIT Press, Cambridge, Massachusetts, USA.

Brand, D., 1973, ***Travel Demand Forecasting: Some Foundations and a Review,*** Urban Travel Demand Forecasting, HRB, Special Report 143.

Daly, A., 1987, ***Estimating Tree Logit Models,*** Transportation Research Board, Vol. 21, No. 4.

Delcan, 1993, ***Technical Report: Transportation Model Development Study,*** TRANS, Region of Ottawa-Carleton, Ottawa.

Domencich, T. A., McFadden, D., 1975, ***Urban Travel Demand: A Behavioral Analysis,*** Charles River Associates Research Study, North-Holland Publishing Company, NY.

Environment Canada and Transport Canada, 1997, ***Sustainable Transportation,*** Transportation Systems Branch, Environment Canada, Ottawa, Ontario.

TRANS, 1979, ***Final Report: A Model of Individual's Choice of Travel Mode,*** Region of Ottawa-Carleton, Ottawa.

Hensher, D. A., 1991, ***Efficient Estimation of Hierarchical Logit Mode Choice Models,*** Proceedings of the Japanese Society of Civil Engineers, Vol. 425, No. 4.

Hensher, D. A., 1986, ***Sequential and Full-Information Maximum Likelihood Estimation of a Nested Logit Model,*** The Review of Economics and Statistics, Vol. 68, No. 4.

Horowitz, J. L., Koppelman F. S., and Lerman, S. R., 1986, ***A Self-Instructing Course in Disaggregate Mode Choice Modeling,*** Massachusetts Institute of Technology, Cambridge, USA.

Katz, Rod, 1995, ***Modeling Bicycle Demand as a Mainstream Transportation Planning Function,*** Transportation Research Record 1502, TRB, National Research Council, Washington, D.C.

Khan, Ata M., 1997, ***Sustainable Transportation: Selected Environmental Research Issues,*** Annual Conference of the Canadian Society of Civil Engineering, Sherbrooke, Quebec.

Koppelman F. S. and Forinash V. C., 1994, ***Application and Interpretation of Nested Logit Models of Intercity Mode Choice,*** Transportation Research Record 1413, TRB, National Research Council, Washington, D.C.

Manski, C. F., 1977, ***The Structure of Random Utility Models: Theory and Decision,*** 8:229-254.

May, L. E., Thomas, R. D., Winer, B., Woodside, A., 1984, ***Fuel Consumption of Urban Passenger Transp. Systems: An Investigation of Modeling Techniques,*** Carleton University.

McFadden D., 1974, ***Conditional Logit Analysis of Qualitative Choice Behavior,*** Frontiers in Econometrics (P. Zarembka, ed.), Academic press, New York.

Ortuzar, J. D., and Willumsen, L. G., 1994, ***Modelling Transport,*** John Wiley & Sons Ltd., West Sussex, England.

Regional Municipality of Ottawa-Carleton, 1994, ***Transportation in Ottawa-Carleton, 1994 Status Report,*** Ottawa, Canada.

Regional Municipality of Ottawa Carleton, 1996, ***Transportation Master Plan,*** Travel Demand Forecasting, Version 3, Ottawa.

Replogle, Michael, 1993, ***Improving Transportation Modeling for Quality and Long-Range Planning,*** Presented at Transportation Research Board Annual Meeting.

Replogle, Michael, 1995, ***Integrating Pedestrian and Bicycle Factors into Regional Transportation Planning Models: Summary of the State of the Art and Recommended Steps Forward,*** Environmental Defense Fund, Washington.

Sobel, K. L., 1980, ***Travel Demand Forecasting by Using the Nested Multinomial Logit Model,*** Transportation Research Record 775, TRB, National Research Council, Washington, D.C.

Spear, B. D., 1999, ***Applications of New Travel Demand Forecasting Techniques to Transportation Planning,*** Bureau of Transportation Statistics, Washington, D.C. Online Document at: http://www.bts.gov/ntl/DOCS/sicm.html

Stein R. W., 1996, ***Pedestrian and Bicycle Modeling in North America's Urban Areas: A Survey of Emerging Methodologies and MPO Practices,*** Project Report for the Master's Degree, Georgia Institute of Technology.

Stopher, P. R., Ohstrom, E. G., Kaltenbach, K. D., and Clouse, D. L., 1981, ***Logit Mode-Choice Models for Non-Work Trips,*** Transportation Research Record 987, TRB, National Research Council, Washington, D.C.

Tardiff T. J., 1976, ***A Note on Goodness-of-Fit Statistics for Probit and Logit Models,*** Transportation, Vol. 5.

Time Series Processor, 1996, ***Reference Manual,*** Ver 4.3, TSP Int., Palo Alto, CA, USA.

Time Series Processor, 1996, ***User's Guide,*** Ver 4.3, TSP Int., Palo Alto, CA, USA.

Train, Kenneth, 1986, ***Qualitative Choice Analysis: Theory, Econometrics, and an Application to Automobile Demand,*** MIT Press, Cambridge, Massachusetts, USA.

Bureau of Transportation Statistics, 1999, ***Trip Linking Procedures – Working Paper 3 – 1990 Bay Area Household Travel Survey,*** Washington, D.C.
Online Document at: http://www.bts.gov/ntl/DOCS/oak.html

Westin, R. B., and Manski, C. F., 1979, ***Theoretical and Conceptual Developments in Demand Modeling,*** Behavioural Travel Modeling (D. A. Hansher and P. R. Stopher, eds.), Croom Helm, London.

Williams, H. C. W. L., and Ortuzar, J. D., 1979, ***Behavioral Travel Theories, Model Specification, and the Response Error Problem,*** Transportation Models: Proc., Summer Annual Meeting, Planning and Transport Research and Comp Co., London, England.

Wright, C., 1993, ***Fast Wheels, Slow Traffic: Urban Transport Choices,*** Temple University Press, Philadelphia, Pa.

APPENDIX - A

GUIDELINES TO THE USE OF TIME SERIES PROCESSOR (TSP)

AN INTRODUCTION TO TIME SERIES PROCESSOR (TSP):

TSP is a general purpose computer language for econometric and statistical data processing and estimation on mainframe, mini and microcomputers. The program can be used for any of the following tasks:

Applied econometrics, including teaching
Macroeconomics research and forecasting
Sales forecasting
Financial analysis
Cost analysis and forecasting
Monte Carlo simulation
Estimation and simulation of economic models

Although TSP was developed by economists and much of its users are in economics, there is nothing in its design that limits its usefulness to economic time series. Any application involving data sets of up to about 20,000 (or more) observations is suitable for TSP. Some of the most important TSP features are:

1) Both data and commands are entered in free format
2) All standard statistical techniques are available in an accurate and efficient form: ordinary least squares (OLS), two-stage least squares (instrumental variables), limited information maximum likelihood (LIML), polynomial and Shiller distributed lags, autoregressive correction, and weighted least squares.
3) Advanced techniques are available, including non-linear least squares, estimation of GARCH models, Box-Jenkins estimation, multivariate regression, three stage least squares, GMM, full information maximum likelihood, estimation with qualitative dependent variables, programmable maximum likelihood, and solution of linear and non-linear models.
4) Data can be transformed by convenient algebraic statements.

5) Leads and lags are specified in a natural way.

6) There are few restrictions on the order of the operations in a run.

7) The output from one statistical procedure can easily be used as the input to another.

8) Panels and cross-section data sets can be handled by TSP as easily as time series. It can handle as far as 1 million observations or more.

USE OF TIME SERIES PROCESSOR:

Perhaps the major limitation to the use of TSP is its inability to calibrate using trip data in which the available mode choice set is not the same for every individual. This happens mostly when there is no transit service available, when a person does not have access to an automobile (could be because number of autos in the household is zero or he does not have a valid driver's license) or bike mode is not available due to non-availability of bike or bad weather.

The logit formulation assumes that each mode specified in the model has an equal probability of being chosen. For example, for the work trip model developed in this thesis the probability of each of the five modes being taken is: Single occupant vehicle 0.20, Shared ride - 0.20, Transit - 0.20, Bike - 0.20, Walk - 0.20. However, for a person who cannot drive, the SOV mode is unavailable to him. Therefore the actual probability of taking any of these five modes to such person would be: SOV - 0.00, Shared ride - 0.25, Transit - 0.25, Bike - 0.25, Walk - 0.25.

Unfortunately there is no method within TSP to deal with this type of situation. Therefore the only alternative to accepting any inaccuracies in mode choice estimation is to exclude individuals with a reduced choice set. However, there are other logit programs that can account for variations in mode choice availability.

It is not intended as a documentation of the program, nor as a tutorial for the TSP user. The TSP reference manual and user's guide (version 4.3) should be consulted for further details on using the program and specification restrictions.

ESTIMATION OF QUALITATIVE DEPENDENT VARIABLE MODEL:

We often encounter a research problem where the dependent variable of the structural model is not directly observed. For example, the actual value of the variable may be observed only part of the time; whether or not it is observed may depend on its value or on the values of other variables. This is the case when modeling the choice among alternatives such as different modes of transportation. For these models, ordinary least squares or other standard econometric estimators are not appropriate, because of the limited or qualitative nature of the observed dependent variable. The estimators used in such conditions are:

1) TOBIT:

The dependent variable is observed only when it lies above some threshold value. The Tobit estimator was proposed by James Tobin (1958) when he was analyzing household expenditure on automobiles. The observed expenditure for many households was zero, implying that the desired quantity of automobile service was below the minimum price of a car. Tobit assumes that any observations for which the dependent variable takes on a zero or negative value are observations not observed.

2) PROBIT:

The sign (+/- or 1/ 0) of the dependent variable is observed instead of its actual value (binary probit).

Probit is used for analyzing the determinants of a choice between two discrete alternatives, such as working/not working. Since the dependent variable is not continuous, ordinary least squares is not appropriate. Instead, the dependent variable

may be treated as an indicator of the sign of a latent continuous dependent variable. That is,

$$\text{Latent} = Xb + e$$

$$Y = 1 \text{ if Latent} > 0$$

$$Y = 0 \text{ if Latent} \leq 0$$

3) SAMPSEL:

The dependent variable is not observed when another unobserved variable in the model lies below a threshold value.

The sample selection model is a generalization of the Tobit model when observability of the dependent variable (and possibly the independent variables) in the regression equation is affected by factors other than the value of the dependent variable.

4) LOGIT:

The dependent variable is the index of a choice among several discrete alternatives (e.g., 1, 2, or 3). There is a "value equation" for each alternative, and the one chosen has the highest value, although actual values are not observed. TSP will estimate models involving characteristics of the choice (Conditional Logit), the chooser (Multinomial Logit), or both (Mixed Logit).

When the dependent variable involves two or more discrete choices, the logit model can be a good way of examining the determinants of these choices. In the case of only two choices, it provides an alternative to the probit model; estimates from the two models will be very similar. There are three basic types of logit model, depending on whether the data or coefficients are *chooser-specific* or *choice-specific.*

'Multinomial Logit Model' has chooser-specific data where coefficients vary over the choices. *'Conditional Logit Model'* has choice-specific data where coefficients are

equal for all choices. *'Mixed Logit Model'* involves both types of data and coefficients.

a) Binary or Multinomial Logit Model:

Here a separate coefficient for each regressor is estimated for all but one of the choices.

```
LOGIT dependent variable   multinomial variables ;
  LOGIT Y C X1 X2  X3 ..... XK;
```

Y can be 0/1 or 1/2 or any integral values -- if Y takes on more than 2 values, the model is multinomial logit. The names of the coefficients are determined by appending the values of Y for each choice to the names of the explanatory variables. The coefficients are normalized by setting the coefficients for the lowest choice to 0. If Y is 0/1, the coefficients C1, X11, X21, ... , XK1 would be estimated, with C0, X10, X20, ..., XK0 normalized to zero. If Y is 1/2/3, the coefficients and C2, X12, X22, ... , XK2 and C3, X13, X23, ... , XK3 would be estimated, with C1, X11, X21, ... , XK1 normalized to zero.

```
LOGIT (NCHOICE = 2) Y C X1 X2 .... XK;
```

causes TSP to check the range of Y to make sure there are only 2 choices. The model estimated has K+1 coefficients and K+1 variables.

b) Conditional Logit Model:

Conditional logit models may have a variable number of choices per chooser, since the data varies for each choice, and the coefficients are fixed across choices. When setting up data for this model, one observation for each choice is used, instead of one observation per chooser. An additional variable, either case number, or number of choices, is used to keep the observations for each chooser together. It should be

noted that the constant C is not a conditional variable since it doesn't vary across choices.

Here the regressors change across the choices, and a single coefficient is estimated for each set of regressors.

LOGIT (COND, NCHOICE = n) dependent variable conditional variables ;

For example,

LOGIT (COND, NCHOICE = 2) Y X Z;

looks for the variables X1, X2, Z1, Z2 corresponding to the 2 choices. The coefficients X and Z would be estimated. C is not allowed as a conditional variable (since it does not vary across choices, it is not identified). For a choice-specific set of dummies, C is used as a multinomial variable in mixed logit. In this case, the example shown becomes

LOGIT (COND, NCHOICE = 2) Y X Z | C;

c) Mixed Logit Model:

The LOGIT command here resembles a regression command with the dependent variable followed by a list of the choice-specific variables, and then a list of chooser-specific variables. The two lists are separated by a |. The general form of the command is now

LOGIT (COND, NCHOICE = n) dependent variable conditional variables |
multinomial variables

For example,

LOGIT (COND, NCHOICE = 3) Y ZA ZB | XA XB XC;

Y takes on the values 1,2 and 3. TSP looks for the conditional variables ZA1, ZA2,

ZA3, ZB1, ZB2, ZB3 corresponding to the 3 choices. XA, XB, XC are the multinomial variables. The coefficients ZA, ZB, XA2, XB2, XC2, XA3, XB3, XC3 would be estimated, with XA1, XB1, XC1 normalized to zero.

Consider the following model of three choices have multinomial variable X having coefficients b_1, b_2, b_3 and conditional variables Z_1, Z_2, Z_3 having coefficient g:

$$V_1 = a_1 + X^* b_1 + Z_1^* g + e_1$$
$$V_2 = a_2 + X^* b_2 + Z_2^* g + e_2$$
$$V_3 = a_3 + X^* b_3 + Z_3^* g + e_3$$

The latent values V_1, V_2, V_3 are not observed, but the chosen alternative is the one with the highest value. If alternate 2 is chosen, for example, we know that $V_2 > V_1$ and $V_2 > V_3$. If the disturbances e_1, e_2, e_3 have the Generalized Extreme Value distribution, the observed choice probabilities have the form

$$\text{Prob}(i) = \exp(a_i + Xb_i + Z_i g) / \sum(\exp(a_j + Xb_j + Z_j g))$$

TOBIT, PROBIT, and SAMPSEL models have normally distributed structural disturbances. LOGIT disturbances have the Generalized Extreme Value distribution (see Manski and McFadden (1981), Maddala (1983), or Train (1986) for further information about this distribution). Estimates obtained from the binary logit model are extremely close to those obtained by probit, up to the implied standard deviation of the disturbances (approximately 1.6 versus 1.0).

NESTED LOGIT MODEL:

The basic logit model does not imply correlations among choices. This shortcoming is the well-known "Independence of Irrelevant Alternatives" property of the multinomial logit model., sometimes called the "Blue Bus/Red Bus" problem: the ratio of probabilities between any two choices is unaffected by the availability of a third choice. The solution to this problem within the logit framework is the ***"Nested Logit Model".***

'Nested Logit Model' is used to structure the alternatives so that some are "closer" to each other than others. Although this model can't be implemented in TSP directly, it can be consistently estimated by using the conventional LOGIT procedures in stages.
The first stage will estimate the bottom branch of a set of choices, and the succeeding stages will include a predicted "inclusive value" based on the estimates of lower stages in the set of independent variables.

All these procedures are designed for structural equations where the underlying dependent variable is linear in the parameters. Non-linear structural equations can be specified for the models estimated by these procedures by writing the likelihood explicitly and using ML. All of the models are estimated by maximum likelihood, using common non-linear maximization algorithms.

OUTPUT:

The printed output of the LOGIT procedure is similar to that of the other non-linear estimation process in TSP. A title is followed by a table of the frequency distribution of the choices. Then the starting values and iteration-by-iteration printout is printed; the amount is controlled by the PRINT and SILENT options. This is followed by a message indicating final convergence status, the value of the likelihood and a table of parameter estimates and their standard errors and t-statistics. The variance-covariance matrix of the estimates is also printed if it has been unsuppressed.

STORING DATA ON EXTERNAL FILES:

The free-format data loading is easy and convenient to use, but it is not suitable for large amounts of data as the data may not be in a form that can be read this way or it may be inefficient to use free format. TSP provides alternative formats for the storage and use of data in external files.

The **FILE** = option is used to specify the external file from which the data will be read or to which the data will be written. If the data is stored in an excel file then;

```
READ (FILE = 'filename.xls'), X Y Z ;
```

where X = dependent variable (say choice)

Y = conditional variables (say cost & time)

Z = multinomial variables (say sex, num_veh, age)

For example:

```
READ (FILE = 'pkperiod.xls), choice time1 time2 cost1 cost2 sex num_veh age;

LOGIT (Cond, Nchoice = 2) choice time cost | C sex num_veh age ;
```

where C = constant

LIKELIHOOD RATIO TEST:

Likelihood ratio test is used for any maximum likelihood model like PROBIT, TOBIT, SAMPSEL, and LOGIT. For these methods, TSP prints out a value of the logarithm of the likelihood evaluated at the estimated parameters and store it under the name @LOGL. If L_1 is the value of the likelihood function for the maximum of the unconstrained model and L_0 is the value when the constraints are imposed, then the likelihood ratio test is computed as

$$LR = 2(L_1 - L_0)$$

This test is always positive (or zero) since the likelihood of the unconstrained model is necessarily higher than that of the constrained model. The LR statistic is distributed asymptotically as a chi-squared variable with degrees of freedom equal to the number of constraints.

ORDINARY LEAST SQUAURE ESTIMATION:

OLSQ is the basic regression procedure in TSP. This procedure obtains ordinary least squares estimates of the coefficients of a regression of the dependent variable on a of independent variables. Options allow you to obtain weighted least squares estimates to correct for heteroskedasticity, or to obtain standard errors which are robust in the presence of heteroskedasticity, of the disturbances. The LS or REGR (or REG) commands are equivalent to OLSQ.

APPENDIX-B

GENERATION OF VARIABLES

DEVELOPED VARIABLES:

There were many important level of service variables that were not available in the 95 OD-Survey. A list of such variables is provided below.

- a_time - total auto travel time in minutes
- a_dist - auto travel distance in km
- t_time - total transit travel time in minutes, that includes:
    - t_ivtt - transit in-vehicle travel time
    - t_aux - auxiliary transit travel time - this is a walk time to access transit bus(es)
    - t_wait - transit wait time - total wait time for all buses used for trip
    - t_bord - transit boarding time
    - t_wt1 - 1st transit wait time
    - t_txs - number of transfers
- t_dist - transit travel distance in km
- bike time
- bike distance
- walk time
- walk distance

Existing EMME/2 model of the RMOC was therefore used to develop the data for motorized modes. For non-motorized modes, a software called 'Intergraph' of Geographic Information System (GIS) was used to find the travel times and trip distances both for walk and bike modes. The detailed procedure for calculating travel times and travel distances for non-motorized modes using Intergraph is explained in the following sections.

Some Interesting Findings of Emme/2 Derived Variables:

From the SPSS queries of travel times for motorized modes derived from the Emme/2, it was found that:

1. EMME/2 model was giving a zero value for the travel time both for auto and transit for a total number of 4028 cases. The break up for this for each mode is given below:

Number of cases when auto-travel time and transit_travel time was equal to zero

SOV	=	1442
Shared ride	=	1040
Transit	=	42
Bike	=	119
Walk	=	1385
Total		**4028**

It was then found that all these cases were intra-zonal trips i.e., when orig_zone and dest_zone were same.

2. For inter-zonal trips the travel-distance and consequently the travel-time were same between any pair of zones regardless of the xy-coordinate distance of the trip. For example if there were 10 trips between zones 3 and 12 in the survey then the travel-distances for all these trips were identical and consequently the travel-times were also same for all these trips. This was true both for auto and transit.

The reason for these findings was that EMME/2 model takes the centroid of every zone in calculating the distances and times. So for all the trips in one zone, no matter where they actually started, Emme/2 assumes that they started at the centroid of that zone. Similarly

no matter where the trip was ended, Emme/2 assumed that it ended at the centroid of that zone.

Correction for Travel Distances and Travel Times:

A procedure was then designed to get rid off these short-comings of the Emme/2 model as well as to find the travel times and trip distances for walk and bike modes, as explained below:

Step1. Calculate the average speed for auto and transit for every zone.

Step2. Calculate the relations (factors) between auto_dist & xy_dist (xy co-ordinate distance) and tran_dist & xy_dist.

Step3. Apply these dist_ratios to all the trips of that zone to get the new auto and transit distances.

Step4. From the average speeds found in step1 and distances found in step3, find new travel times for every trip.

From these four steps we were not only able to get more accurate travel times and distances for every trip but we got the times and distances for intra_zonal trips as well.

Explanation of the Designed Procedure:

Step1:

It was decided to find the average speed of the auto and transit in various zones of the region by finding the arithmatic means of auto_dist, auto_time, transit_dist, and transit_time. The average speed was then calculated by dividing the average time with average distance for both auto and transit modes.

As practically it was very difficult, if not impossible, to find average speeds for every zone of the survey area, it was decided to break up the survey area in groups of small

similar zones having more or less the same traffic conditions. The average speed of any zone in a group could then be assumed to have the same speed of that group.

Based on geographic constraints like river or highway and traffic conditions, the survey area was then divided into 37 similar groups of zones (having the same land use area), assumed to have same traffic speeds.

It should be noted here that intra-zonal trips (orig_zon=dest_zon) were excluded from each group to get an unbiased mean.

The speeds of auto and transit thus calculated for these 37 zones are shown in the following table.

Group	Zones	Samp. Size 'N'	a_dist (mean)	a_time (mean)	t_dist (mean)	t_time (mean)	a_speed	t_speed
1	1-3, 11-17	344	1.1740	2.6603	1.1057	9.9957	26.48	6.64
2	4-10, 201	272	1.2700	2.3671	3.1954	10.7959	32.19	17.76
3	90-98, 100	225	2.5467	4.1780	3.2407	22.0816	36.57	8.81
4	33-50	594	3.6513	5.8477	5.6583	22.0965	37.46	15.36
5	99, 101-107, 109-110	172	2.6214	4.4702	4.6658	20.8783	35.19	13.41
6	81-83, 88-89	7	2.7229	4.6500	3.5114	23.7643	35.13	8.87
7	71-80, 84-87, 112	292	2.5706	4.0221	3.9039	20.7451	38.35	11.29
8	22-25	12	2.8592	4.9008	2.8650	23.5800	35.00	7.29
9	18-25, 28-32	175	2.2633	4.0372	2.8461	19.1032	33.64	8.94
10	26-27, 58	4	4.4500	6.7375	4.8350	31.5825	39.63	9.19
11	51,53-57,59-65,67,123	433	3.3318	5.2494	4.0906	25.5781	38.08	9.60
12	66, 120	0	-	-	-	-	-	-
13	68-70, 113, 117	45	2.1887	4.0264	3.9860	18.9151	32.62	12.64
14	114-116, 232	53	2.6842	4.3557	3.4504	20.9889	36.97	9.86
15	111, 233	0	-	-	-	-	-	-
16	143-144, 202-204, 235-241, 247	452	2.8741	4.0401	3.7575	22.2159	42.68	10.15

17	145, 243-246	12	12.5550	14.4467	11.1450	119.6225	52.14	5.59
18	140-141, 227-231	11	7.6136	7.5000	3.1000	70.9809	60.91	2.62
19	136, 221, 225-226	13	4.1785	6.3146	3.9831	31.5669	39.70	7.57
20	137, 222-224	1	5.7800	6.6500	6.2000	53.8900	52.15	6.90
21	134-135	13	12.3431	11.4623	19.3331	117.6800	64.61	9.86
22	129-130,214,216-220	188	4.0185	6.1251	7.5059	35.3578	39.36	12.74
23	132, 212-213, 215	0	-	-	-	-	-	-
24	131, 206, 210-211	22	3.4895	4.8768	3.8073	33.4814	42.93	6.82
25	207, 209	0	-	-	-	-	-	-
26	149-150	1	3.6500	4.8200	4.5800	23.0300	45.44	11.93
27	146-147, 151, 256	6	7.7917	9.0017	10.9017	63.4083	51.93	10.32
28	148, 257-258	148	1.8134	2.6724	3.0532	17.3241	40.71	10.57
29	158-161, 164	223	2.6832	4.7365	3.6000	21.3993	33.99	10.09
30	153-155, 254-255	52	1.5421	4.5565	1.3888	13.2142	20.31	6.31
31	156-157,162,164,184	55	6.5820	9.4047	7.6805	42.3482	41.99	10.88
32	165, 253	9	2.8800	4.0222	3.7100	26.1856	42.96	8.50
33	166, 169-170	42	2.0307	3.0924	2.6493	18.8669	39.40	8.43
34	167-168, 252	81	1.7041	2.6846	2.8028	15.5067	38.09	10.84
35	171-173, 249-251	99	2.6251	4.0249	3.3267	23.6199	39.13	8.45
36	174-175, 248	30	3.3717	4.6010	3.2487	28.7853	43.97	6.77
37	177-178, 181, 185	14	33.1314	28.4614	25.2279	251.1371	69.84	6.03

Step2:

To find the relation between auto_dist & xy_dist and tran_dist & xy_dist, it was decided to calculate these relations for particular range of distances like 0-0.5km trips, 0.5-1km trips, 1-1.5km trips and so on. This distribution of trips in various distances range was necessary mainly because of the limitation of EMME/2 model when it takes the centroid of every zone.

It was further argued that even for each distance range of trips, conditions are quite different in urban and rural area as urban areas are more built-up, congested, and have more roads than for rural areas. Also, the natural boundary of river between Ontario

and Quebec has only a limited places for crossing it, that would make the auto and transit distances between them much higher than their corresponding xy-coordinate distances. Because of these limitations and considerations it was decided to distribute the trips in various distances range in the 'Urban Ontario' and 'Urban Quebec' regions separately:

The trips in each region were further classified as

- Inter_zonal trips (when orig_zone ≠ dest_zone & a_dist > 0) and
- Intra-zonal trips (when orig_zon = dest_zon)

Because of the very small number of inter_zonal trips in rural areas found in initial macro runs, the interval was made to 5km for these zones. 8-macros thus developed for Step2 are attached in Appendix-C. The results of these macros are summarized in the listed tables and their corresponding graphs, as shown:

Table 1 - Inter-Zonal Cases for Urban Ontario

Table 2 - Intra-Zonal Cases for Urban Ontario

Table 3 - Inter-Zonal Cases for Urban Quebec

Table 4 - Intra-Zonal Cases for Urban Quebec

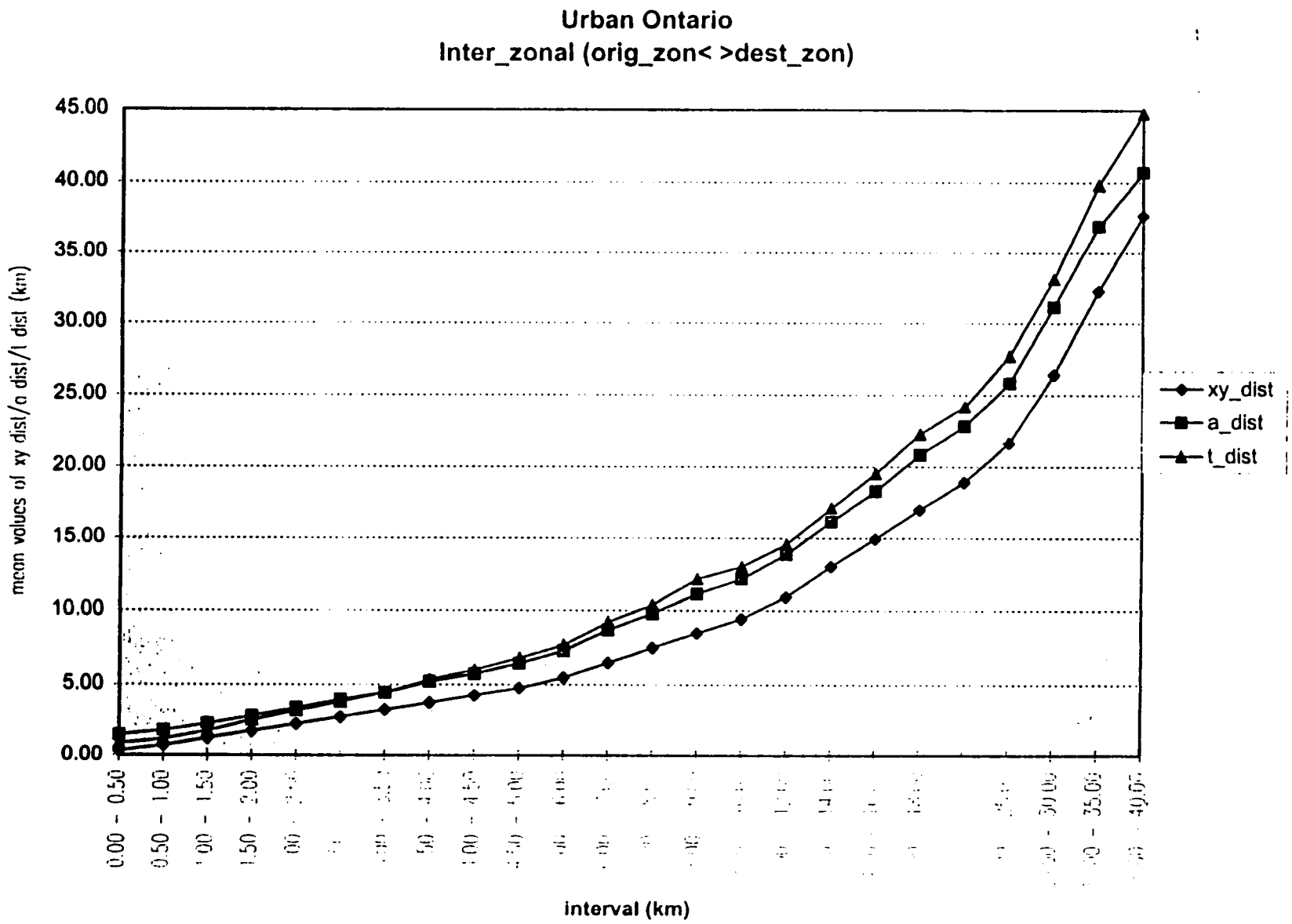
Table 1:

Mean Values

Urban-Ontario:

Inter_zonal Cases (orig_zon <> dest_zon & a_dist > 0)

Interval (km)	N	xy_dist (km)	a_dist (km)	t_dist (km)	a_dist/xy_dist	t_dist/xy_dist
0.00 - 0.50	252	0.34	1.48	0.89	4.35	2.62
0.50 - 1.00	621	0.75	1.80	1.20	2.40	1.60
1.00 - 1.50	629	1.26	2.28	1.75	1.81	1.39
1.50 - 2.00	571	1.75	2.81	2.54	1.61	1.45
2.00 - 2.50	518	2.26	3.38	3.21	1.50	1.42
2.50 - 3.00	456	2.74	3.95	3.82	1.44	1.39
3.00 - 3.50	434	3.26	4.44	4.46	1.36	1.37
3.50 - 4.00	372	3.75	5.20	5.33	1.39	1.42
4.00 - 4.50	368	4.25	5.71	5.96	1.34	1.40
4.50 - 5.00	337	4.76	6.42	6.79	1.35	1.43
5.00 - 6.00	589	5.47	7.29	7.67	1.33	1.40
6.00 - 7.00	558	6.47	8.71	9.23	1.35	1.43
7.00 - 8.00	439	7.49	9.79	10.38	1.31	1.39
8.00 - 9.00	441	8.50	11.13	12.18	1.31	1.43
9.00 - 10.00	344	9.45	12.18	13.01	1.29	1.38
10.00 - 12.00	522	10.92	13.86	14.56	1.27	1.33
12.00 - 14.00	305	13.03	16.16	17.12	1.24	1.31
14.00 - 16.00	267	14.94	18.32	19.52	1.23	1.31
16.00 - 18.00	212	17.02	20.83	22.28	1.22	1.31
18.00 - 20.00	187	18.92	22.80	24.17	1.21	1.28
20.00 - 25.00	165	21.65	25.83	27.71	1.19	1.28
25.00 - 30.00	32	26.43	31.15	33.10	1.18	1.25
30.00 - 35.00	12	32.26	36.88	39.84	1.14	1.23
35.00 - 40.00	2	37.67	40.72	44.77	1.08	1.19
40.00 - 45.00	0	-	-	-	-	-
45.00 - 50.00	0	-	-	-	-	-


Urban Ontario
Inter_zonal (orig_zon< >dest_zon)
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
mean values of xy dist/a dist/t dist (km)
0.00 - 0.50
0.50 - 1.00
1.50 - 2.00
interval (km)
xy_dist
a_dist
t_dist

164

Chart 1a

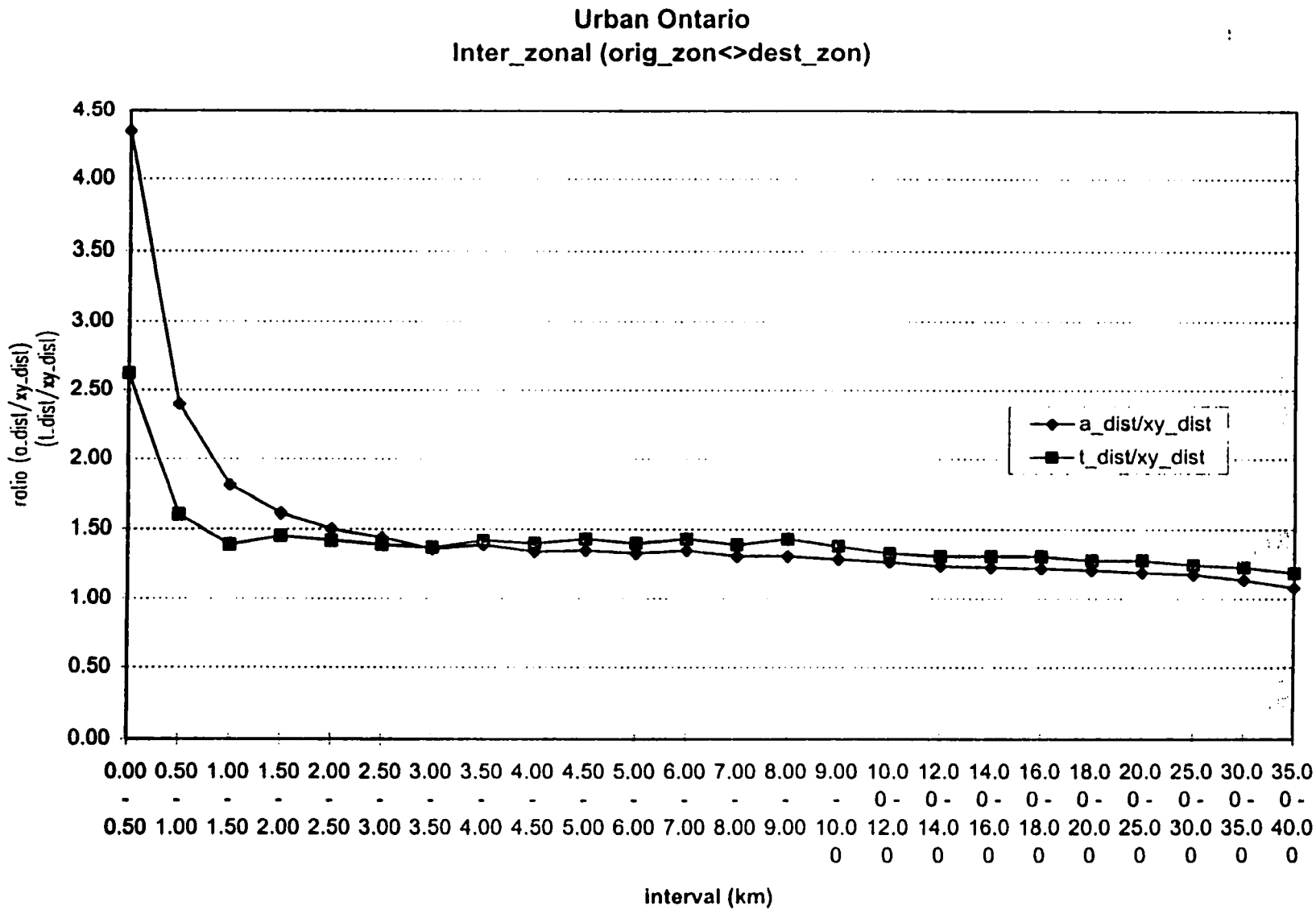

Urban Ontario
Inter_zonal (orig_zon<>dest_zon)
ratio (a_dist/xy_dist) (t_dist/xy_dist)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
a_dist/xy_dist
t_dist/xy_dist
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
3.50 - 4.00
4.00 - 4.50
4.50 - 5.00
5.00 - 6.00
6.00 - 7.00
7.00 - 8.00
8.00 - 9.00
9.00 - 10.00
10.00 - 12.00
12.00 - 14.00
14.00 - 16.00
16.00 - 18.00
18.00 - 20.00
20.00 - 25.00
25.00 - 30.00
30.00 - 35.00
35.00 - 40.00
interval (km)

Chart1b

Table 2:

Mean Values

Urban-Ontario:

Intra-zonal Cases (orig_zon = dest_zon)

Interval (km)	N	xy_dist (km)	a_dist (km)	t_dist (km)	a_dist/xy_dist	t_dist/xy_dist
0.00 - 0.50	819	0.262	0	0	0.00	0.00
0.50 - 1.00	476	0.719	0	0	0.00	0.00
1.00 - 1.50	221	1.213	0	0	0.00	0.00
1.50 - 2.00	73	1.755	0	0	0.00	0.00
2.00 - 2.50	34	2.233	0	0	0.00	0.00
2.50 - 3.00	8	2.79	0	0	0.00	0.00
3.00 - 3.50	2	3.23	0	0	0.00	0.00
3.50 - 4.00	0	-	-	-	-	-
4.00 - 4.50	1	4.156	0	0	0.00	0.00
4.50 - 5.00	0	-	-	-	-	-
5.00 - 6.00	0	-	-	-	-	-
6.00 - 7.00	0	-	-	-	-	-
7.00 - 8.00	0	-	-	-	-	-
8.00 - 9.00	0	-	-	-	-	-
9.00 - 10.00	0	-	-	-	-	-
10.00 - 12.00	0	-	-	-	-	-
12.00 - 14.00	0	-	-	-	-	-
14.00 - 16.00	0	-	-	-	-	-
16.00 - 18.00	0	-	-	-	-	-
18.00 - 20.00	0	-	-	-	-	-
20.00 - 25.00	0	-	-	-	-	-
25.00 - 30.00	0	-	-	-	-	-
30.00 - 35.00	0	-	-	-	-	-
35.00 - 40.00	0	-	-	-	-	-
40.00 - 45.00	0	-	-	-	-	-
45.00 - 50.00	0	-	-	-	-	-

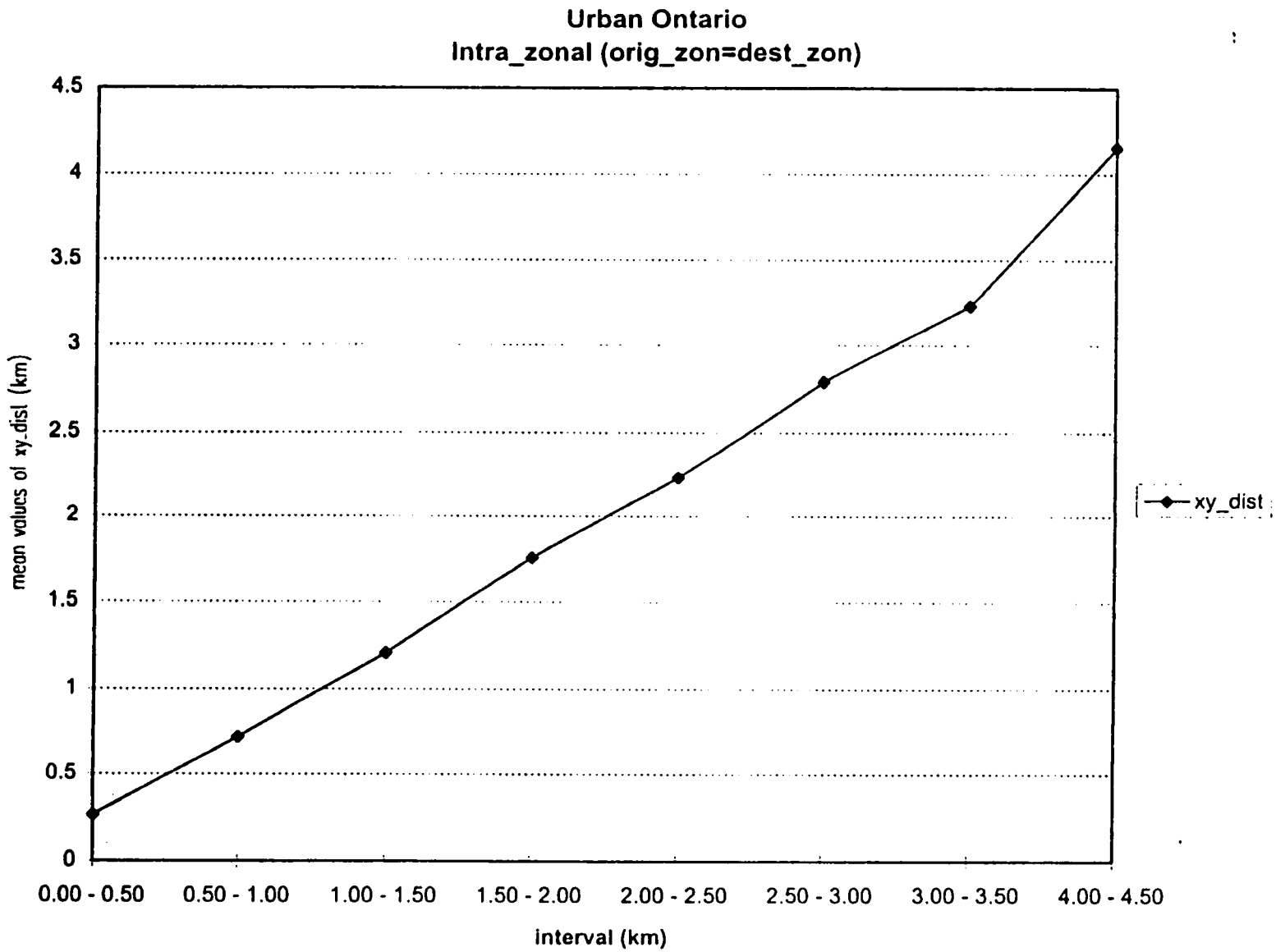

Urban Ontario
Intra_zonal (orig_zon=dest_zon)
mean values of xy_dist (km)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
4.00 - 4.50
interval (km)
xy_dist

Chart2

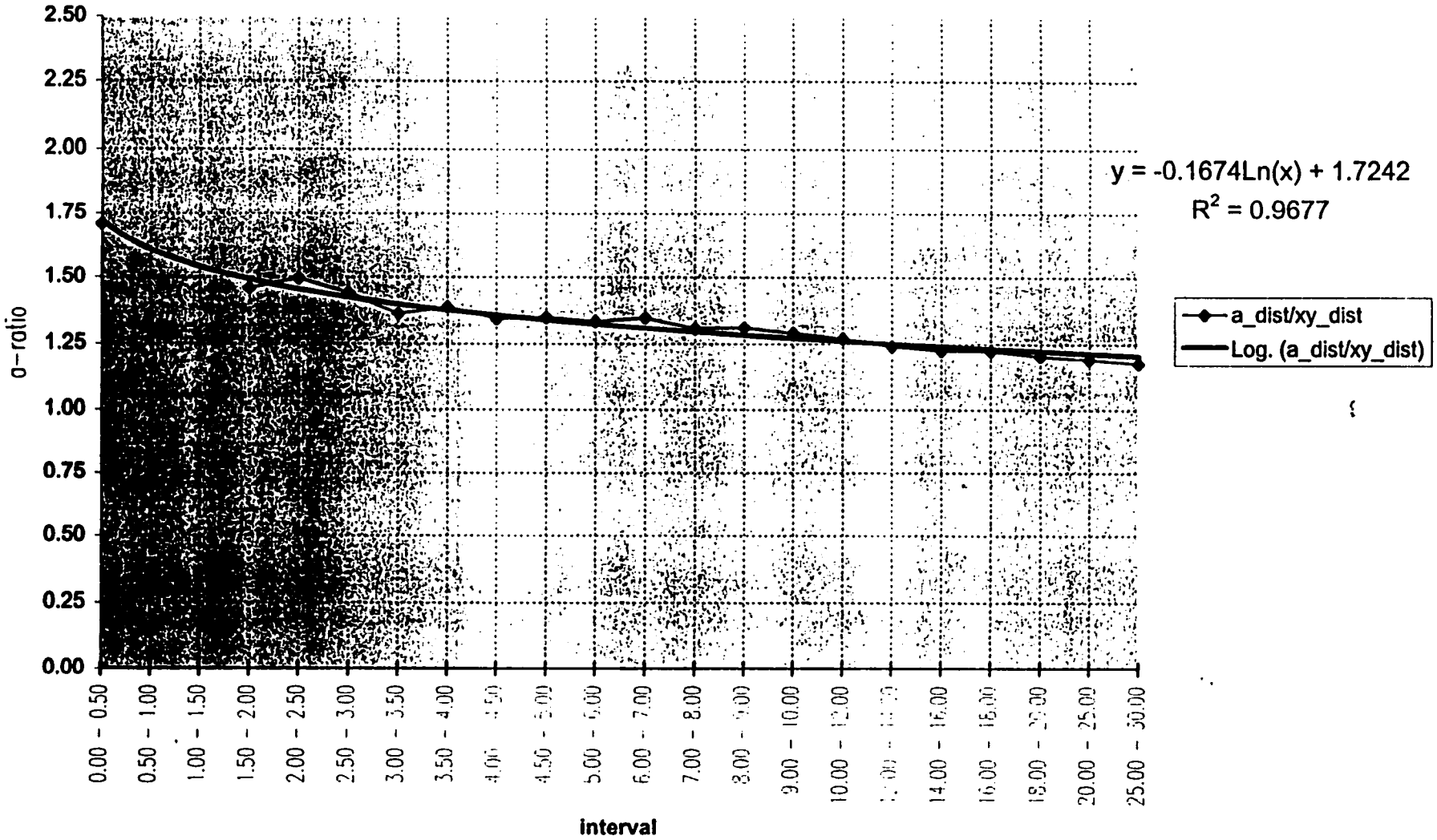
Mean Values

Urban-Ontario:

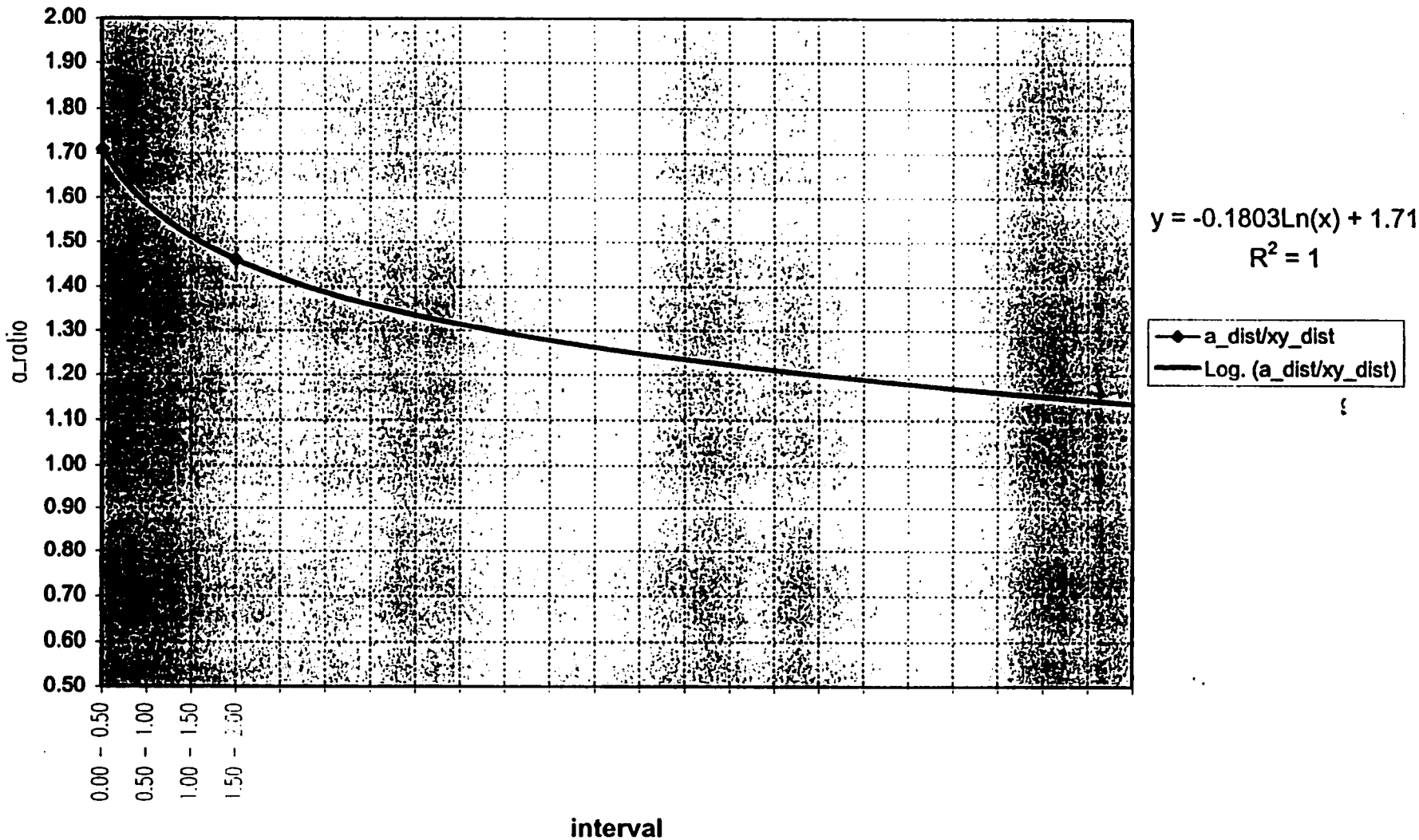
Inter_zonal Cases (orig_zon <> dest_zon & a_dist > 0)

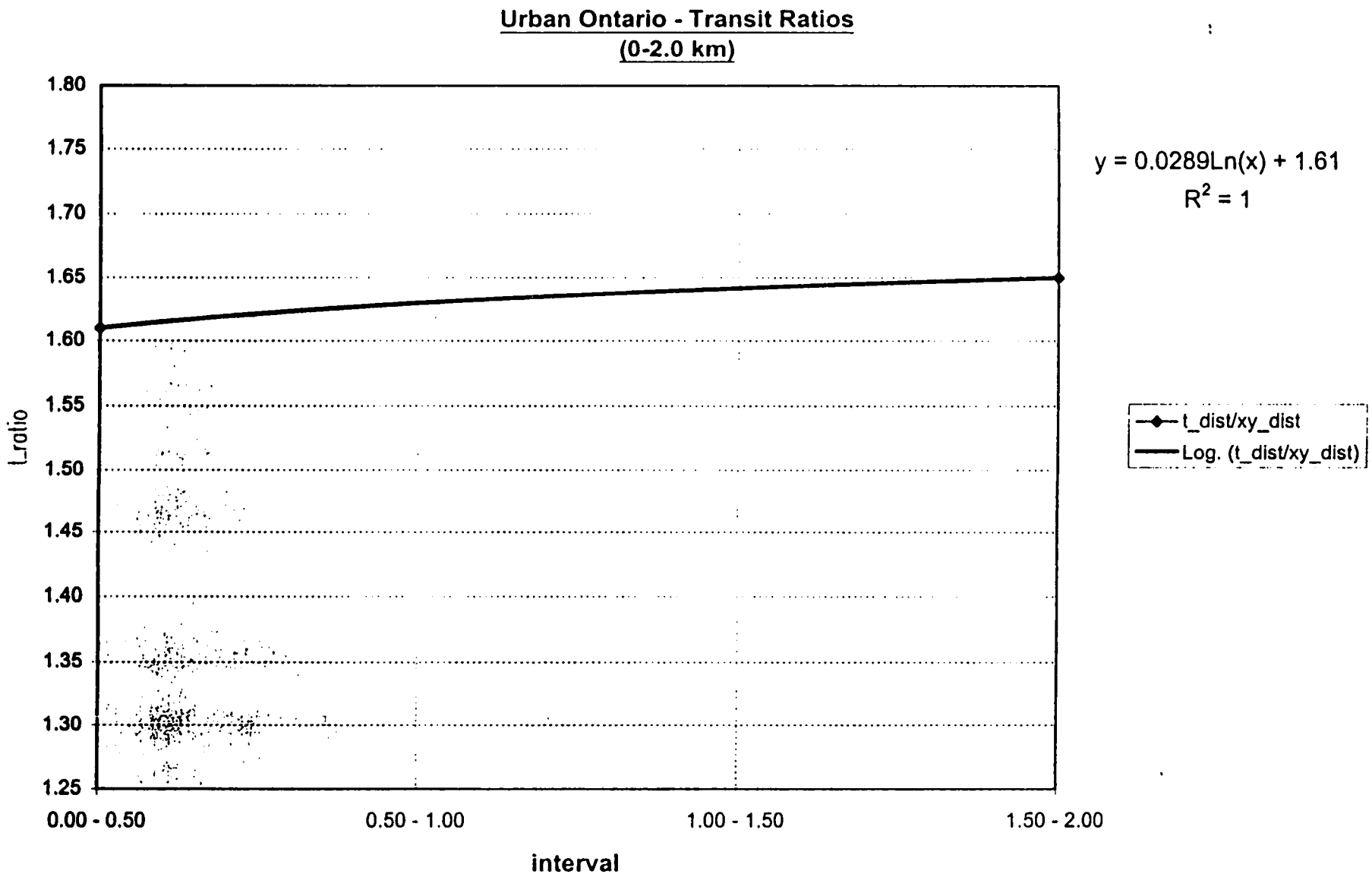
Interval	N	xy_dist	a_dist	t_dist	a_dist/xy_dist	t_dist/xy_dist	bk_dst/xy_dst	wk_dst/xy_dst
0.00 - 0.50	252	0.34			1.71	1.61	1.71	1.43
0.50 - 1.00	621	0.75						
1.00 - 1.50	629	1.26						
1.50 - 2.00	571	1.75			1.46	1.65	1.38	1.35
2.00 - 2.50	518	2.26	3.38	3.21	1.50	1.42		
2.50 - 3.00	456	2.74	3.95	3.82	1.44	1.39		
3.00 - 3.50	434	3.26	4.44	4.46	1.36	1.37		
3.50 - 4.00	372	3.75	5.20	5.33	1.39	1.42		
4.00 - 4.50	368	4.25	5.71	5.96	1.34	1.40		
4.50 - 5.00	337	4.76	6.42	6.79	1.35	1.43		
5.00 - 6.00	589	5.47	7.29	7.67	1.33	1.40	1.27	1.25
6.00 - 7.00	558	6.47	8.71	9.23	1.35	1.43		
7.00 - 8.00	439	7.49	9.79	10.38	1.31	1.39		
8.00 - 9.00	441	8.50	11.13	12.18	1.31	1.43		
9.00 - 10.00	344	9.45	12.18	13.01	1.29	1.38		
10.00 - 12.00	522	10.92	13.86	14.56	1.27	1.33		
12.00 - 14.00	305	13.03	16.16	17.12	1.24	1.31		
14.00 - 16.00	267	14.94	18.32	19.52	1.23	1.31		
16.00 - 18.00	212	17.02	20.83	22.28	1.22	1.31		
18.00 - 20.00	187	18.92	22.80	24.17	1.21	1.28		
20.00 - 25.00	165	21.65	25.83	27.71	1.19	1.28		
25.00 - 30.00	32	26.43	31.15	33.10	1.18	1.25		
30.00 - 35.00	12	32.26	36.88	39.84	1.14	1.23		
35.00 - 40.00	2	37.67	40.72	44.77	1.08	1.19		
40.00 - 45.00	0	-	-	-	-	-		
45.00 - 50.00	0	-	-	-	-	-		

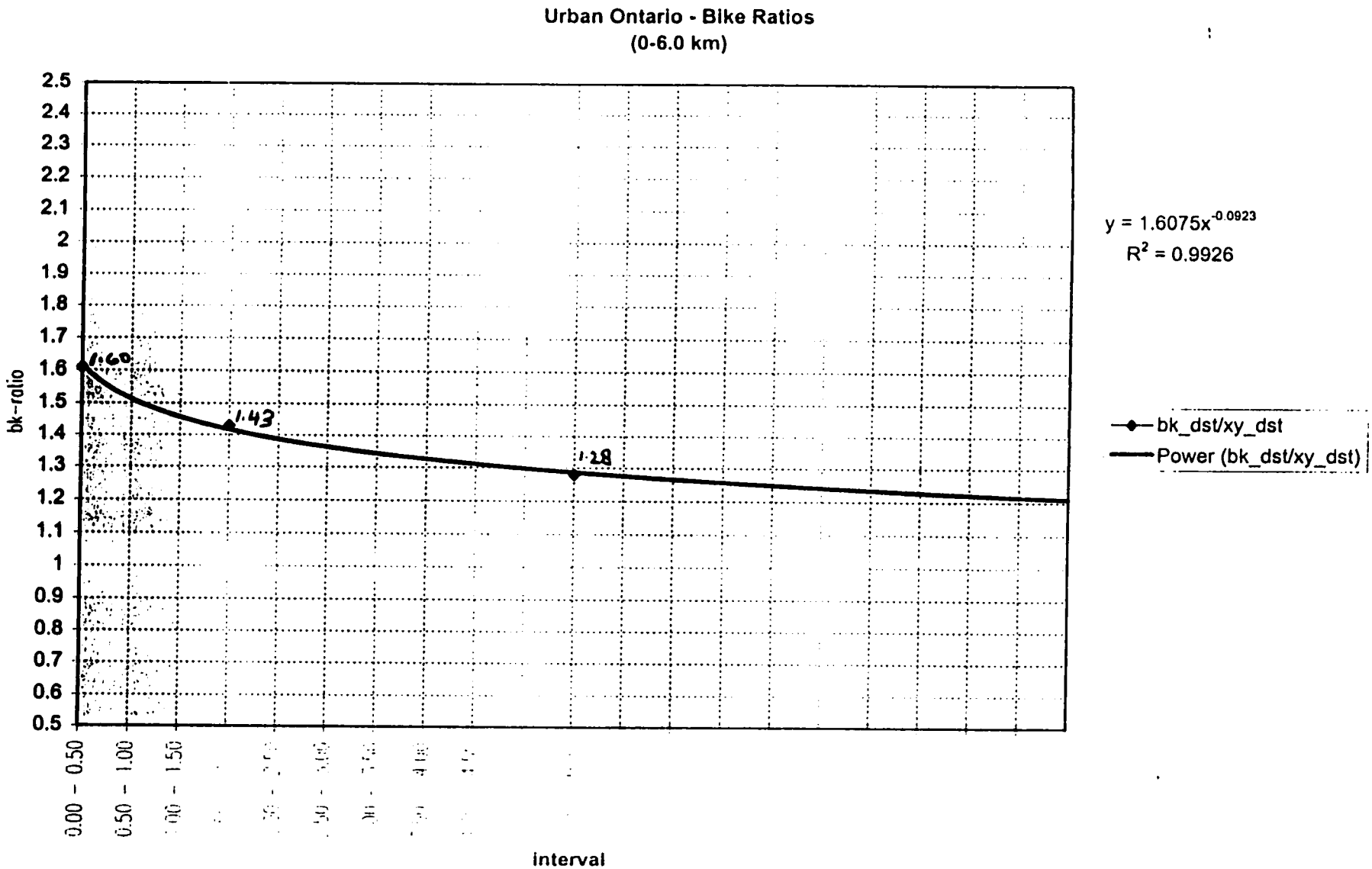
Urban Ontario - Auto Ratios
(0-30.0 km)



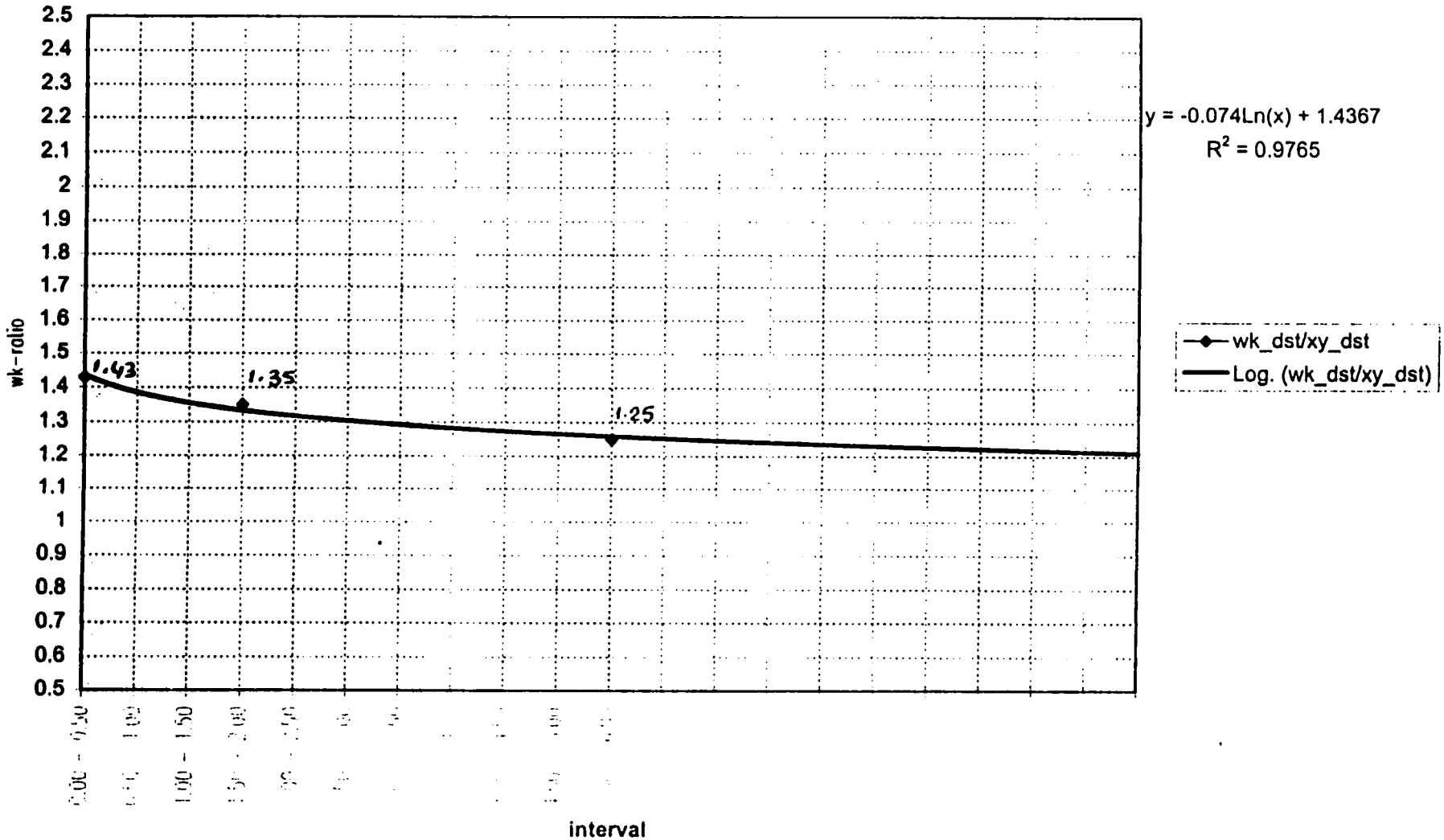
Urban Ontario - Auto Ratios
(0-2.0 km)




Urban Ontario - Transit Ratios
(0-2.0 km)
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
t_ratio
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
interval
y = 0.0289Ln(x) + 1.61
R2 = 1
t_dist/xy_dist
Log. (t_dist/xy_dist)


Urban Ontario - Bike Ratios
(0-6.0 km)
bk-ratio
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
1.60
1.43
1.28
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
interval
y = 1.6075x^-0.0923
R^2 = 0.9926
bk_dst/xy_dst
Power (bk_dst/xy_dst)

Urban Ontario - Walk Ratios
(0-6.0 km)



Mean Values

Urban - Quebec:

Inter_zonal Cases (orig_zon <> dest_zon & a_dist > 0)

Interval	N	xy_dist	a_dist	t_dist	a_dist/xy_dist	t_dist/xy_dist
0.00 - 0.50	75	0.31	2.12	1.58	6.82	5.08
0.50 - 1.00	135	0.79	2.07	1.56	2.62	1.97
1.00 - 1.50	178	1.26	2.25	1.78	1.79	1.42
1.50 - 2.00	169	1.74	2.62	2.04	1.51	1.17
2.00 - 2.50	164	2.27	3.23	2.78	1.42	1.22
2.50 - 3.00	141	2.76	3.94	3.58	1.43	1.30
3.00 - 3.50	130	3.26	4.92	4.58	1.51	1.40
3.50 - 4.00	97	3.73	6.03	5.74	1.62	1.54
4.00 - 4.50	116	4.25	6.21	6.14	1.46	1.44
4.50 - 5.00	89	4.72	6.85	6.82	1.45	1.44
5.00 - 6.00	178	5.48	7.82	7.46	1.43	1.36
6.00 - 7.00	118	6.49	9.18	8.86	1.41	1.37
7.00 - 8.00	97	7.46	10.68	10.53	1.43	1.41
8.00 - 9.00	99	8.50	11.76	11.89	1.38	1.40
9.00 - 10.00	79	9.51	13.73	13.65	1.44	1.44
10.00 - 12.00	80	10.79	15.82	15.22	1.47	1.41
12.00 - 14.00	35	12.86	19.23	18.35	1.50	1.43
14.00 - 16.00	11	15.19	20.58	19.34	1.35	1.27
16.00 - 18.00	6	16.64	20.93	18.50	1.26	1.11
18.00 - 20.00	6	19.17	24.00	21.93	1.25	1.14
20.00 - 25.00	33	22.03	28.69	24.15	1.30	1.10
25.00 - 30.00	26	27.63	35.43	33.27	1.28	1.20
30.00 - 35.00	6	31.63	37.70	39.87	1.19	1.26
35.00 - 40.00	0	-	-	-	-	-
40.00 - 45.00	0	-	-	-	-	-
45.00 - 50.00	0	-	-	-	-	-

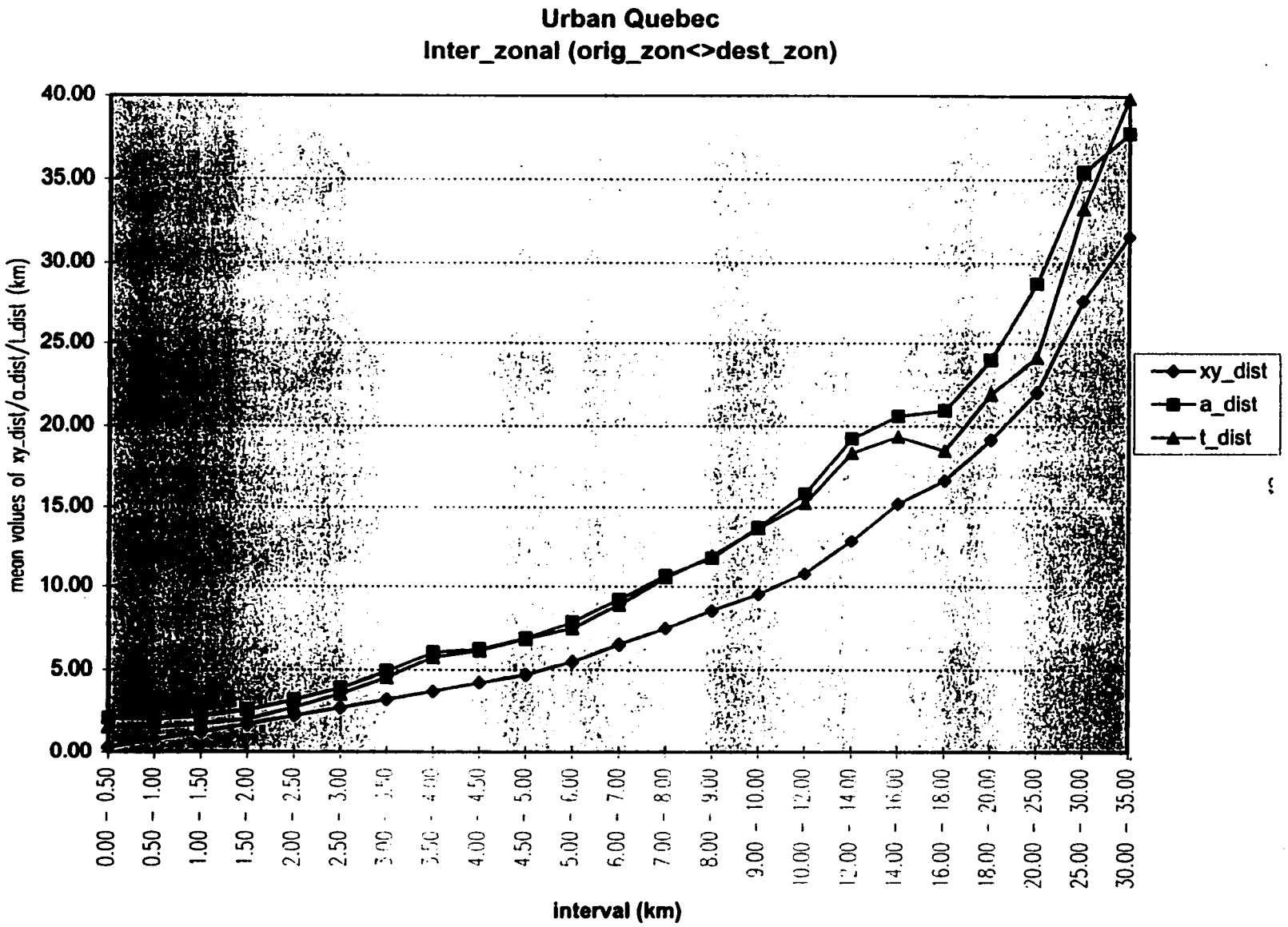

Urban Quebec
Inter_zonal (orig_zon<>dest_zon)
mean values of xy_dist/a_dist/t_dist (km)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
4.00 - 4.50
4.50 - 5.00
5.00 - 6.00
6.00 - 7.00
7.00 - 8.00
8.00 - 9.00
9.00 - 10.00
14.00 - 16.00
16.00 - 18.00
18.00 - 20.00
20.00 - 25.00
25.00 - 30.00
30.00 - 35.00
interval (km)
xy_dist
a_dist
t_dist

Chart5a

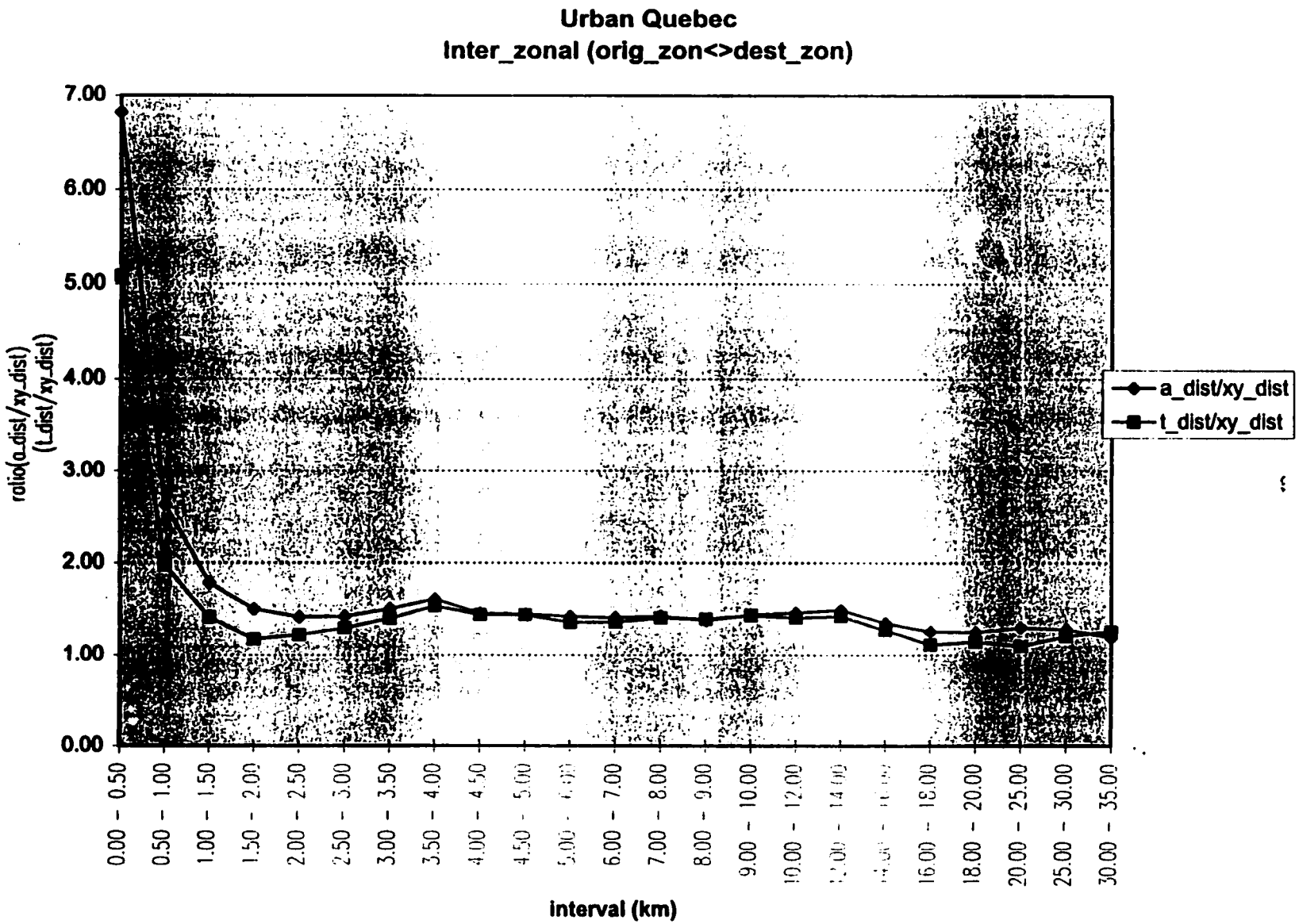

Urban Quebec
Inter_zonal (orig_zon<>dest_zon)
ratio(a_dist/xy_dist)
(t_dist/xy_dist)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
a_dist/xy_dist
t_dist/xy_dist
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
3.50 - 4.00
6.00 - 7.00
7.00 - 8.00
8.00 - 9.00
9.00 - 10.00
10.00 - 12.00
16.00 - 18.00
18.00 - 20.00
20.00 - 25.00
25.00 - 30.00
30.00 - 35.00
interval (km)

Chart5b

Table 6:

Mean Values

Urban - Quebec:

Intra-zonal Cases (orig_zon = dest_zon)

Interval (km)	N	xy_dist (km)	a_dist (km)	t_dist (km)	a_dist/xy_dist	t_dist/xy_dist
0.00 - 0.50	329	0.273	0	0	0.00	0.00
0.50 - 1.00	218	0.713	0	0	0.00	0.00
1.00 - 1.50	122	1.205	0	0	0.00	0.00
1.50 - 2.00	61	1.68	0	0	0.00	0.00
2.00 - 2.50	34	2.221	0	0	0.00	0.00
2.50 - 3.00	8	2.709	0	0	0.00	0.00
3.00 - 3.50	1	3.453	0	0	0.00	0.00
3.50 - 4.00	2	3.831	0	0	0.00	0.00
4.00 - 4.50	0	-	-	-	-	-
4.50 - 5.00	0	-	-	-	-	-
5.00 - 6.00	0	-	-	-	-	-
6.00 - 7.00	0	-	-	-	-	-
7.00 - 8.00	0	-	-	-	-	-
8.00 - 9.00	0	-	-	-	-	-
9.00 - 10.00	0	-	-	-	-	-
10.00 - 12.00	0	-	-	-	-	-
12.00 - 14.00	0	-	-	-	-	-
14.00 - 16.00	0	-	-	-	-	-
16.00 - 18.00	0	-	-	-	-	-
18.00 - 20.00	0	-	-	-	-	-
20.00 - 25.00	0	-	-	-	-	-
25.00 - 30.00	0	-	-	-	-	-
30.00 - 35.00	0	-	-	-	-	-
35.00 - 40.00	0	-	-	-	-	-
40.00 - 45.00	0	-	-	-	-	-
45.00 - 50.00	0	-	-	-	-	-

C

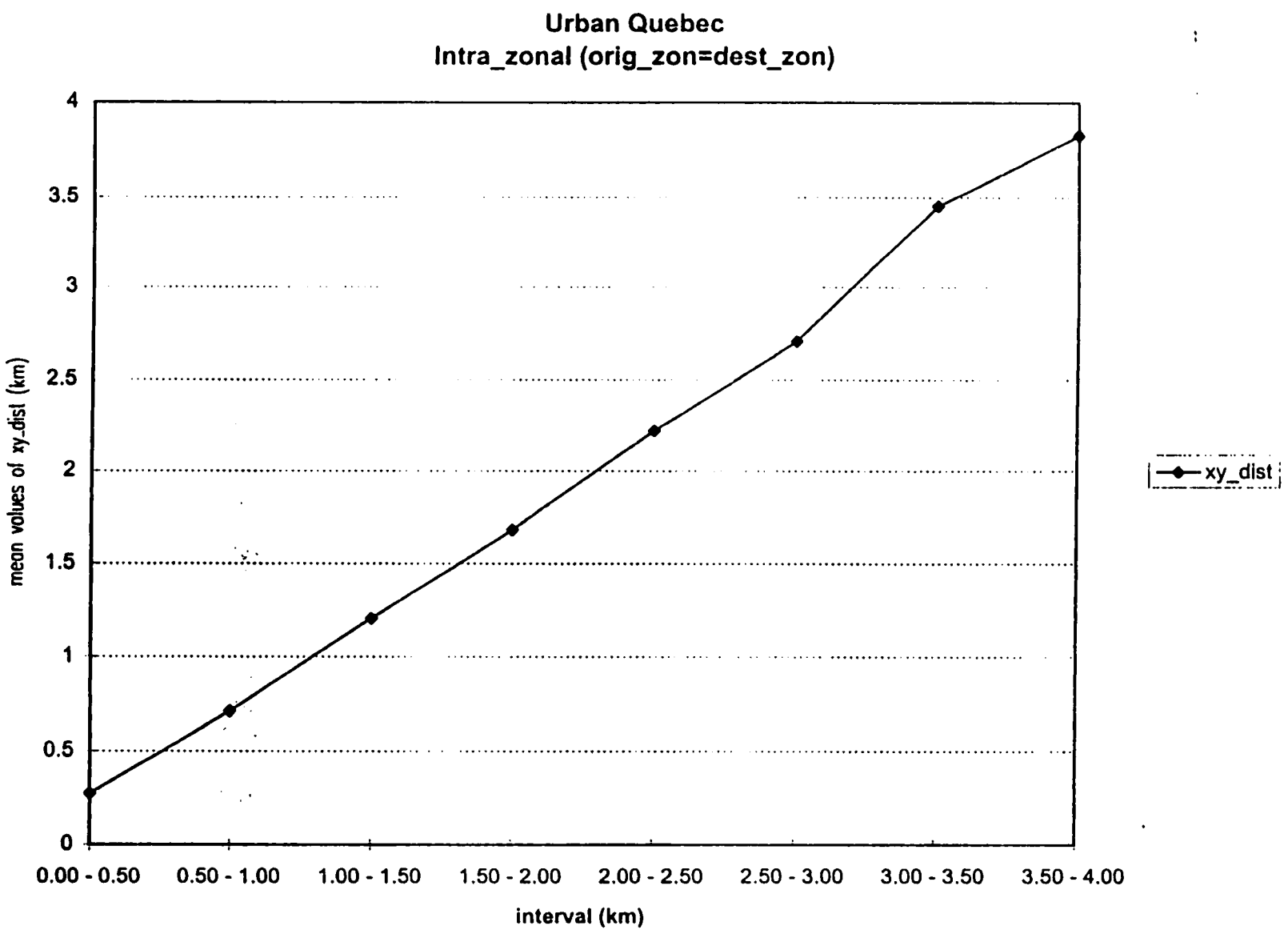

Urban Quebec
Intra_zonal (orig_zon=dest_zon)
mean values of xy_dist (km)
4
3.5
3
2.5
2
1.5
1
0.5
0
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
3.50 - 4.00
interval (km)
xy_dist

Chart6

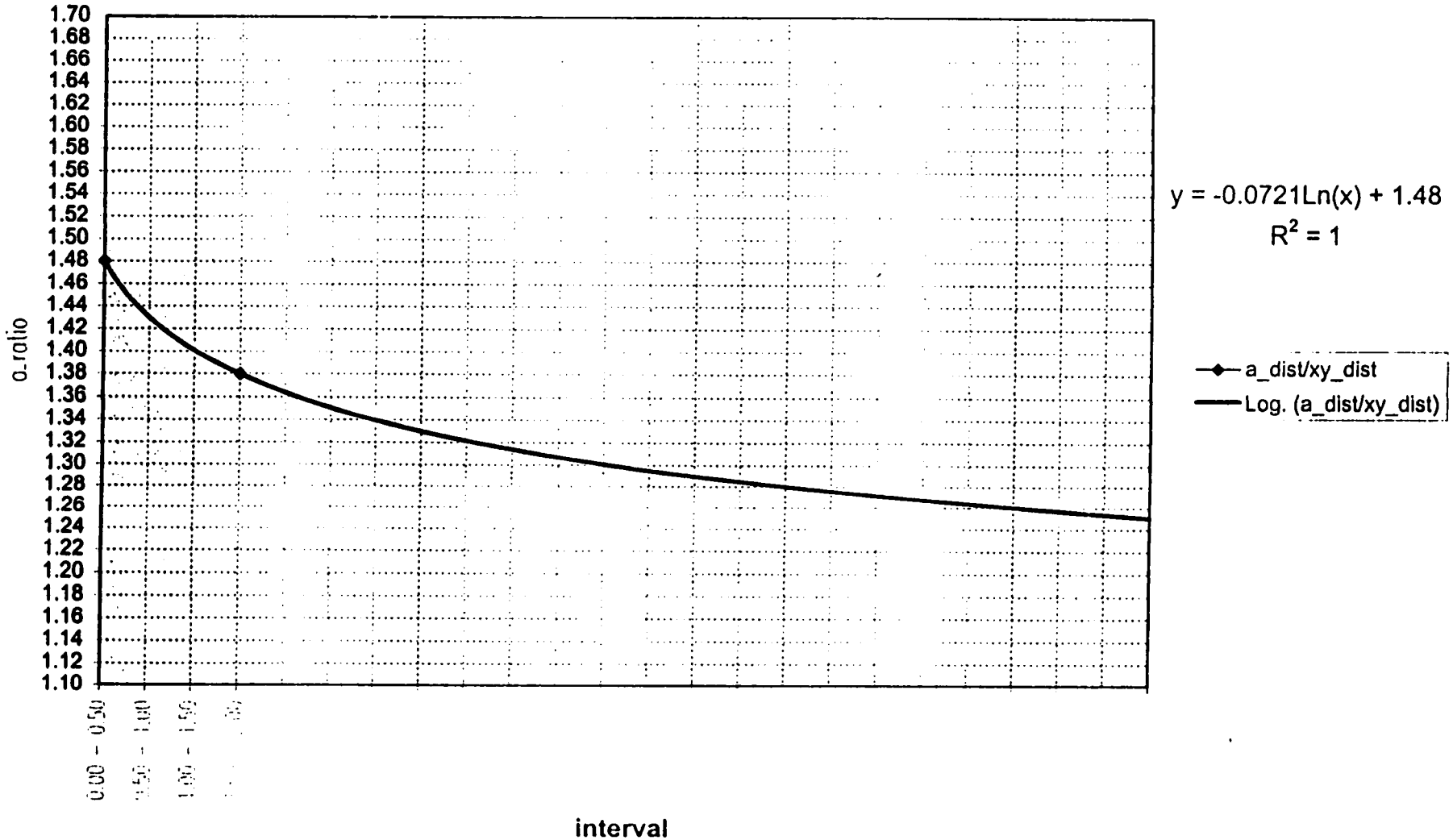
Mean Values

Urban - Quebec:

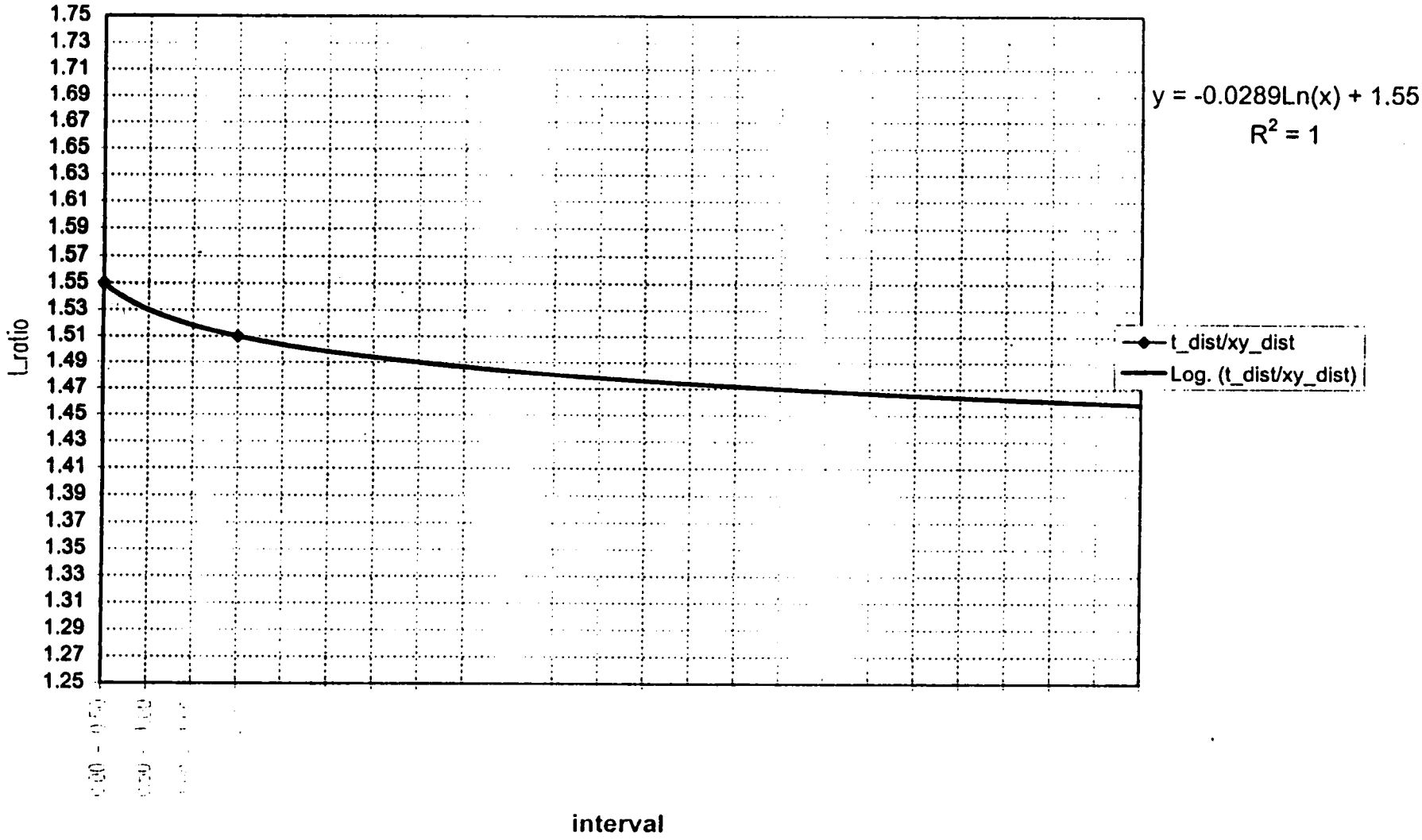
Inter_zonal Cases (orig_zon <> dest_zon & a_dist > 0)

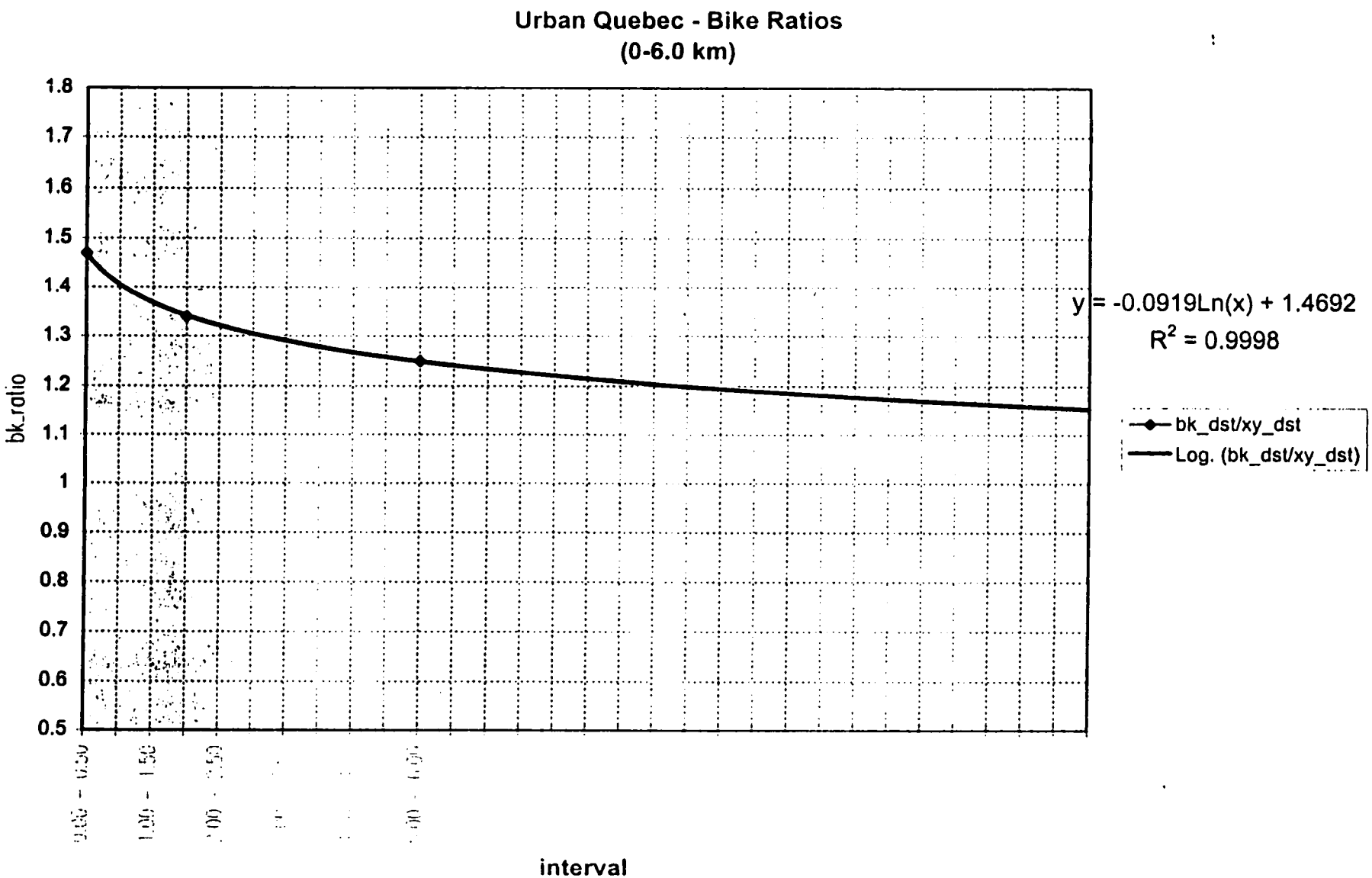
interval	N	xy_dist	a_dist	t_dist	a_dist/xy_dist	t_dist/xy_dist	bk_dst/xy_dst	wk_dst/xy_dst
0.00 - 0.50	75	0.31	2.12	1.58	1.48	1.55	1.47	1.44
0.50 - 1.00	135	0.79	2.07	1.56				
1.00 - 1.50	178	1.26	2.25	1.78				
1.50 - 2.00	169	1.74	2.62	2.04	1.38	1.51	1.34	1.34
2.00 - 2.50	164	2.27	3.23	2.78	1.42	1.22		
2.50 - 3.00	141	2.76	3.94	3.58	1.43	1.30		
3.00 - 3.50	130	3.26	4.92	4.58	1.51	1.40		
3.50 - 4.00	97	3.73	6.03	5.74	1.62	1.54		
4.00 - 4.50	116	4.25	6.21	6.14	1.46	1.44		
4.50 - 5.00	89	4.72	6.85	6.82	1.45	1.44		
5.00 - 6.00	178	5.48	7.82	7.46	1.43	1.36	1.25	1.25
6.00 - 7.00	118	6.49	9.18	8.86	1.41	1.37		
7.00 - 8.00	97	7.46	10.68	10.53	1.43	1.41		
8.00 - 9.00	99	8.50	11.76	11.89	1.38	1.40		
9.00 - 10.00	79	9.51	13.73	13.65	1.44	1.44		
10.00 - 12.00	80	10.79	15.82	15.22	1.47	1.41		
12.00 - 14.00	35	12.86	19.23	18.35	1.50	1.43		
14.00 - 16.00	11	15.19	20.58	19.34	1.35	1.27		
16.00 - 18.00	6	16.64	20.93	18.50	1.26	1.11		
18.00 - 20.00	6	19.17	24.00	21.93	1.25	1.14		
20.00 - 25.00	33	22.03	28.69	24.15	1.30	1.10		
25.00 - 30.00	26	27.63	35.43	33.27	1.28	1.20		
30.00 - 35.00	6	31.63	37.70	39.87	1.19	1.26		
35.00 - 40.00	0	-	-	-	-	-		
40.00 - 45.00	0	-	-	-	-	-		
45.00 - 50.00	0	-	-	-	-	-		

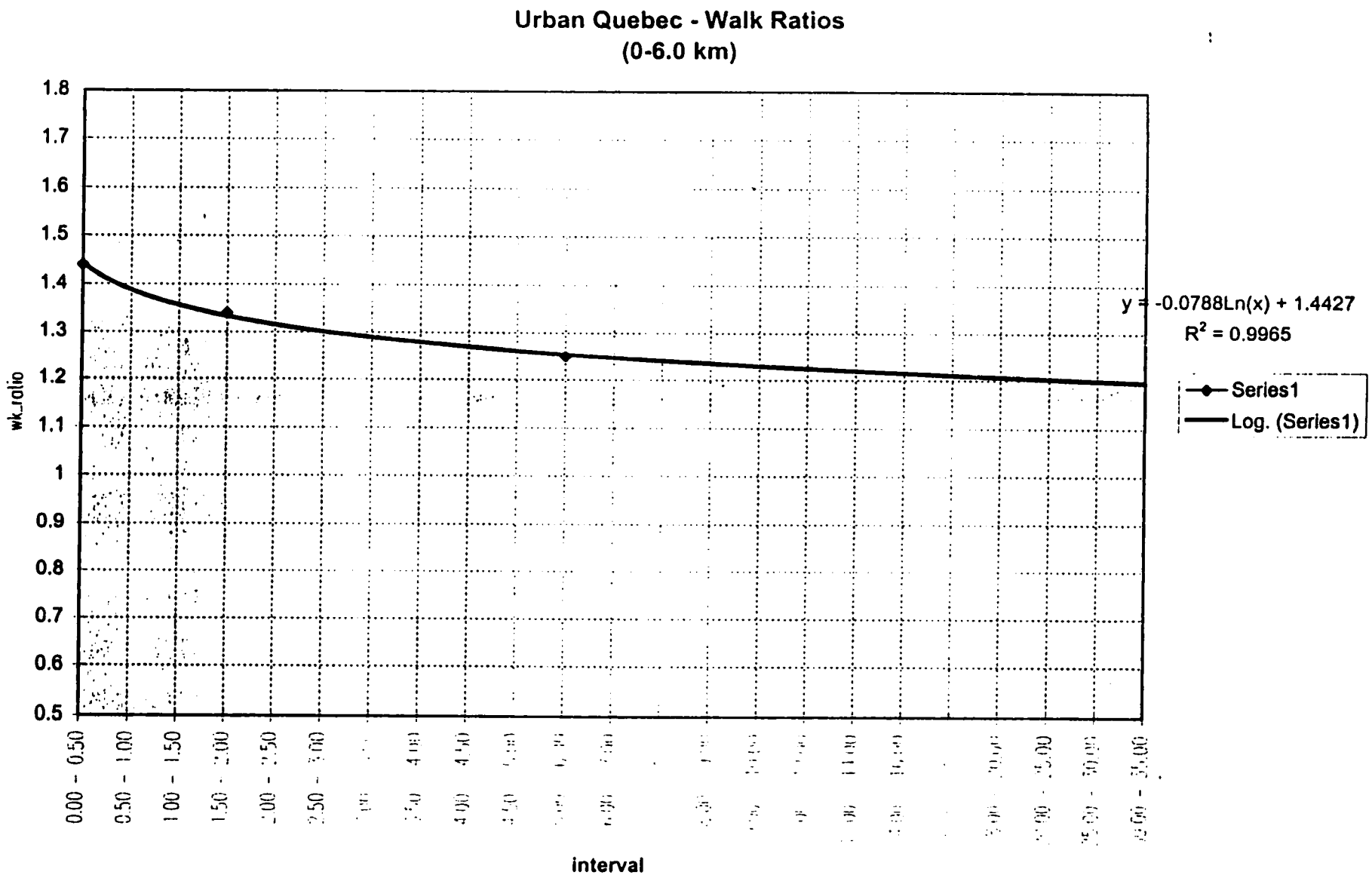
Urban Quebec - Auto Ratios
(0-2.0 km)



Urban Quebec- Transit Ratios
(0-2.0 km)




Urban Quebec - Bike Ratios
(0-6.0 km)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
bk_ratio
y = -0.0919Ln(x) + 1.4692
R² = 0.9998
bk_dst/xy_dst
Log. (bk_dst/xy_dst)
interval


Urban Quebec - Walk Ratios
(0-6.0 km)
wk_ratio
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
interval
y = -0.0788Ln(x) + 1.4427
R² = 0.9965
Series1
Log. (Series1)

It can be seen in Chart 1b of Urban Ontario that auto and transit dist_ratios are almost in a straight line i.e., having a constant slope from 1.5 or 2km onwards. But this slope changes abruptly before 1.5 or 2km. The same type of curve and values were obtained in Urban-Quebec graph (Chart 5b). In the graphs of rural regions although the pattern remains same, the sudden change in slope occurs around 5.0 km. This is because the rural zones are much bigger than the urban zones. All these graphs indicated the presence of EMME/2 modelling error in the lower distance range (between 0-5 km), as it took the centroid of the zones in calculating trip distances and times.

Validation of the Results:

To check whether it was because of the model error or some sort of real trend was there, we designed a procedure in which we selected 30 truly random samples from this region. From their x-y coordinates of origin and destination, the origin and destination points were fixed on the map using auto-cad system (Intergraph). The auto, transit, bike and walk routes were then selected as per the existing road network. The actual distances of the routes of these modes, found from the Intergraph, determined the actual dist_ratios and eventually defined the cut-off point in Chart 1b for auto and transit routes.

WALK AND BIKE TRAVEL TIMES AND DISTANCES:

It was decided to take the values of the graph equations from 0-2 km as all the error is in this range. However from 2 km onwards the walk and bike distances will be taken from the ratios of autos as shown in the table for bike and walk ratios. To calculate the distances and times for walk and bike modes following procedure was designed.

Designed Procedure:

1) Macros were developed for new distances of auto and transit for 0-2 km from these graphs (Ontario and Quebec separately).

2) In making these macros for every equation we put x = 0 if xy_dist was b/w 0-0.5 km

x = 1 if xy_dist was b/w 0.5-1.0 km

x = 2 if xy_dist was b/w 1.0-1.5 km

x = 3 if xy_dist was b/w 1.5-2.0 km

.....and so on.

The corresponding 'y' was then the auto or transit ratio.

3) Macros were developed for distances of bike and walk for all the cases from these graphs (Ontario and Quebec separately).

4) Macros were then run to get new auto and transit distances (within 0-2 km) and walk and bike distances for all interzonal (0-2km) and intrazonal cases.

5) As a check the ratio graphs were plotted again to see their consistency.

6) From the speed output, respective average speeds were then substituted in a_speed and t_speed for every intrazonal case of that zone.

7) From these speed values, a_time and t_time was calculated by dividing the distances with their respective speeds using:

   $S = Vt \Rightarrow t = S/Vi$ where i = 'a' or 't'

8) After Step –3, we had the distance values for every case in the file (for both interzonal and intrazonal).

9) After Step – 6, we had the time values for every case in the file (for both interzonal and intrazonal).

GENERATED VARIABLES:

A list of all the generated variables during the data collection stage is as follows:

1) Travel-Cost which includes

    Auto cost both for auto driver and shared ride

    Transit fare

    Parking cost

2) Auto distance

3) Transit distance

4) Bike distance

5) Walk distance

6) Auto travel time

7) Transit travel time

8) Bike travel time

9) Walk travel time

10) Urban transit area (UTA) - Dummy variable coded as 0,1

11) Purp_mc

12) Gross Lease Area

13) Population density

14) Employment density

APPENDIX-C

DEVELOPED MACROS

Macro for Developing of Main File and Variables

```
Comment  macro d:\mode_sp\mode_sp1.sps developed by mark campbell Nov/97 to Feb /98
Comment  See modal split report for details on concepts behind specific variables being developed.
comment  - - This macro creates the 24 hour spss file used for the development of
comment  note: some comments were added in after macro ran on Feb23/98 pm.
comment  - Part 1- Calls up the 4 origional dbf 95od survey files, imports them into spss, sort, then save.

GET TRANSLATE
 FILE='D:\mode_sp\Househld.dbf'
 /TYPE=DBF /MAP .
EXECUTE .

comment  - - go in and change variable name num_veh_ to num_bike

SORT CASES BY
 hh_num (A) .

comment  - save the 4 files into spss files so that they can be merged in spss

SAVE OUTFILE='D:\mode_sp\hhs_ms.sav'
  /COMPRESSED.
GET TRANSLATE
 FILE='D:\mode_sp\Person.dbf'
 /TYPE=DBF /MAP .
EXECUTE .
SORT CASES BY
 hh_num (A) per_num (A) .
SAVE OUTFILE='D:\mode_sp\pers_ms.sav'
  /COMPRESSED.
GET TRANSLATE
 FILE='D:\mode_sp\Trip.dbf'
 /TYPE=DBF /MAP .
EXECUTE .

SORT CASES BY
 hh_num (A) per_num (A) trip_num (A) .
EXECUTE .
SAVE OUTFILE='D:\mode_sp\trips_ms.sav'
  /COMPRESSED.
GET TRANSLATE
 FILE='D:\mode_sp\Transit.dbf'
 /TYPE=DBF /MAP .
EXECUTE .
SORT CASES BY
 hh_num (A) per_num (A) trip_num (A) .
SAVE OUTFILE='D:\mode_sp\trs_ms.sav'
  /COMPRESSED.
GET
 FILE='D:\mode_sp\trips_ms.sav'.
EXECUTE .

comment  - - merge trip file with person file

MATCH FILES /FILE=*
 /TABLE='D:\mode_sp\pers_ms.sav'
 /RENAME (d_r = d0)
 /BY hh_num per_num
 /DROP= d0.
EXECUTE.
```

```
comment - - merge now with household sorted file

MATCH FILES /FILE=*
 /TABLE='D:\mode_sp\hhs_ms.sav'
 /RENAME (d_r = d0)
 /BY hh_num
 /DROP= d0.
EXECUTE.

comment - - merge now with transit sorted file

MATCH FILES /FILE=*
 /TABLE='D:\mode_sp\trs_ms.sav'
 /RENAME (d_r = d0)
 /BY hh_num per_num trip_num
 /DROP= d0.
EXECUTE.

comment - part 2 - develop new trip purpose and mode variables

comment - place new definition of trip purpose (as per trip generation equations) in variable purp_mc.
comment The new variables are created by making the file var_add.sav containg household number
comment and variables with empty data into which the data will be imported.

MATCH FILES /FILE=*
 /TABLE='D:\mode_sp\var_add.sav'
 /BY hh_num.
EXECUTE.

comment - place new definition of trip purpose (as per trip generation equations) in variable purp_mc


IF (trip_pur = "N") purp_mc = "NHB"
EXECUTE .
IF (orig_pur = "W" & dest_pur="H") purp_mc = "HBW" .
EXECUTE .
IF (orig_pur = "H" & dest_pur ~= "H") purp_mc = "LH" .
EXECUTE .
IF (orig_pur ~= "W" &orig_pur ~= "S" & orig_pur ~= "9" & dest_pur = "H")
 purp_mc = "OH" .
EXECUTE .
IF (orig_pur="S") & (dest_pur="H")&(((( ( ( (sch_zone >= 1) & (sch_zone <= 145) ) | ( (sch_zone >= 201 )
 & (sch_zone <= 247) ) ) & ( (age >= 10) & (age <= 19) ) )) | (( ( ( (sch_zone >= 146) &
(sch_zone <= 185) ) | ( (sch_zone >= 248 ) & (sch_zone <= 258) ) ) & ( (age >= 10) & (age <= 18) ) ))))
  purp_mc="SSH".
EXECUTE .
 IF (orig_pur="S") & (dest_pur="H")&((( ( ( ( (sch_zone >= 1) & (sch_zone <= 145) ) | ( (sch_zone >= 201 )
 & (sch_zone <= 247) ) ) & (age > 19) )) | (( ( ( (sch_zone >= 146) & (sch_zone <= 185) ) | ( (sch_zone >= 248 )
 & (sch_zone <= 258) ) ) & (age > 18) ))))
 purp_mc="SU".
 EXECUTE .

comment - Develop flags for the 5 modes

IF (car_occ = 1 ) sov = 1 .
EXECUTE .
IF ((car_occ > 1) & (car_occ <= 5)) share_rd = 1 .
EXECUTE .
IF (prime_mo = "P") share_rd = 1 .
EXECUTE .
IF (prime_mo = "T") transit = 1 .
EXECUTE .
```

```
IF (prime_mo = "B") bike = 1 .
EXECUTE .
IF (prime_mo = "W") walk = 1 .
EXECUTE .

comment - save the 24 hour complete file

SAVE OUTFILE='D:\mode_sp\24hr_ms1.sav'
  /COMPRESSED.

comment  Part 3  Filter out records to obtain peak period valid records.
comment  -  select time interval.

SELECT IF(start_ti >= 1530 & start_ti <= 1759).
EXECUTE .

comment  - filter out external-internal, internal-external trips and invalid zone numbers.

FILTER OFF.
USE ALL.
SELECT IF(orig_zon >= 1) & (orig_zon <= 258) & (dest_zon >= 1) & (dest_zon <= 258) .
EXECUTE .

FILTER OFF.
USE ALL.
SELECT IF (((orig_zon <=185) |  (orig_zon >=201)) & ((dest_zon <=185) |  (dest_zon >=201))) .
EXECUTE .

comment  -  filter out invalid records with sex and age errors& or ommissions.

FILTER OFF.
USE ALL.
SELECT IF(sex = "M" | sex = "F").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(age >= 10 & age <= 98).
EXECUTE .

comment  -  exclude cases where school zone not coded.
COMMENT  16 school trips (orig_pur=S and dest_pur=H) having "sch_zone <1" or .
comment     "sch_zone >185 & <248" are deleted.

FILTER OFF.
USE ALL.
SELECT IF(purp_mc = "HBW") |  (purp_mc = "LH") |  (purp_mc = "OH") |
 (purp_mc = "NHB") |  (purp_mc = "SSH") |  (purp_mc = "SU").
EXECUTE .

COMMENT: exclude cases with zero co-ordinate distances

FILTER OFF.
USE ALL.
SELECT IF(orig_utm ~= dest_utm) | (v7 ~= v14).
EXECUTE .

comment  add new variables

comment  development of transitway accessibility factor
```

```
MATCH FILES /FILE='
 /TABLE='D:\mode_sp\case14_a.sav'
 /BY orig_zon dest_zon.
EXECUTE.

Comment  Part 3b Add in Nadeem's distance macros

COMMENT 1: creation of xy_dist variable depending on xy cordinates.

COMPUTE  deltaX = ABS((dest_utm) - (orig_utm)) .
COMPUTE deltaY = ABS((v14) - (v7)) .
COMPUTE xy_dist = SQRT((deltax) ** 2 + (deltay) ** 2) / 1000 .
EXECUTE .

COMPUTE xy_dist = xy_dist * 100 .
EXECUTE .
COMPUTE xy_dist = RND(xy_dist) .
EXECUTE .
COMPUTE xy_dist = xy_dist / 100 .
EXECUTE .

comment creating auto and transit speeds .

COMPUTE a_speed = (a_dist / a_time) * 60 .
EXECUTE .

COMPUTE t_speed = (t_dist / t_time) * 60 .
EXECUTE.

comment  Nadeem's macro starts here .


COMMENT      complete macro for filling up all the missing values
COMMENT      developed by Nadeem on 4th Mar. 1998

COMMENT  filling values for auto and transit speeds for intrazonal cases (when a_dist = 0)
COMMENT  and interzonal cases (when xy_dist<=2)

COMMENT  group 1

IF (((((orig_zon >= 1) & (orig_zon <= 5)) | (orig_zon = 10) | (orig_zon =
 201))&(((dest_zon >= 1) & (dest_zon <= 5)) |(dest_zon = 10) | (dest_zon =
 201))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 23.38 .
EXECUTE .
IF (((((orig_zon >= 1) & (orig_zon <= 5)) | (orig_zon = 10) | (orig_zon =
 201))&(((dest_zon >= 1) & (dest_zon <= 5)) | (dest_zon = 10) | (dest_zon =
 201))) & ((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 7.47 .
EXECUTE .

COMMENT  group 2

IF (((((orig_zon >= 11) & (orig_zon <= 15)) | (orig_zon = 16) | (orig_zon =
 17))&(((dest_zon >= 11) & (dest_zon <= 15)) | (dest_zon = 16) | (dest_zon =
 17))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 20.64 .
EXECUTE .
IF (((((orig_zon >= 11) & (orig_zon <= 15)) | (orig_zon = 16) | (orig_zon =
 17))&(((dest_zon >= 11) & (dest_zon <= 15)) | (dest_zon = 16) | (dest_zon =
 17))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 4.95 .
EXECUTE .
```

```
COMMENT group 3

IF (((((orig_zon >= 6) & (orig_zon <= 7)) | (orig_zon = 8) | (orig_zon =
 9))&(((dest_zon >= 6) & (dest_zon <= 7)) | (dest_zon = 8) | (dest_zon =
 9))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 31.36 .
EXECUTE .
IF (((((orig_zon >= 6) & (orig_zon <= 7)) | (orig_zon = 8) | (orig_zon =
 9))&(((dest_zon >= 6) & (dest_zon <= 7)) | (dest_zon = 8) | (dest_zon =
 9))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 7.33 .
EXECUTE .

COMMENT group 4

IF (((((orig_zon >= 95) & (orig_zon <= 97)) | (orig_zon = 92) | (orig_zon =
 98))&(((dest_zon >= 95) & (dest_zon <= 97)) | (dest_zon = 92) | (dest_zon =
 98))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 28.61 .
EXECUTE .
IF (((((orig_zon >= 95) & (orig_zon <= 97)) | (orig_zon = 92) | (orig_zon =
 98))&(((dest_zon >= 95) & (dest_zon <= 97)) | (dest_zon = 92) | (dest_zon =
 98))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 6.54 .
EXECUTE .

COMMENT group 5

IF (((((orig_zon >= 90) & (orig_zon <= 90)) | (orig_zon = 91) | (orig_zon =
 93))&(((dest_zon >= 90) & (dest_zon <= 90)) | (dest_zon = 91) | (dest_zon =
 93))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 35.16 .
EXECUTE .
IF (((((orig_zon >= 90) & (orig_zon <= 90)) | (orig_zon = 91) | (orig_zon =
 93))&(((dest_zon >= 90) & (dest_zon <= 90)) | (dest_zon = 91) | (dest_zon =
 93))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 4.14 .
EXECUTE .

COMMENT group 6

IF (((((orig_zon >= 99) & (orig_zon <= 101)) | (orig_zon = 94) | (orig_zon =
 106))&(((dest_zon >= 99) & (dest_zon <= 101)) | (dest_zon = 94) | (dest_zon =
 106))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 30.20 .
EXECUTE .
IF (((((orig_zon >= 99) & (orig_zon <= 101)) | (orig_zon = 94) | (orig_zon =
 106))&(((dest_zon >= 99) & (dest_zon <= 101)) | (dest_zon = 94) | (dest_zon =
 106))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 6.67 .
EXECUTE .

COMMENT group 7

IF (((((orig_zon >= 102) & (orig_zon <= 103)) | (orig_zon = 104) | (orig_zon =
 105))&(((dest_zon >= 102) & (dest_zon <= 103)) | (dest_zon = 104) | (dest_zon =
 105))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 27.68 .
EXECUTE .
IF (((((orig_zon >= 102) & (orig_zon <= 103)) | (orig_zon = 104) | (orig_zon =
 105))&(((dest_zon >= 102) & (dest_zon <= 103)) | (dest_zon = 104) | (dest_zon =
 105))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 8.8 .
EXECUTE .

COMMENT group 8

IF (((((orig_zon >= 107) & (orig_zon <= 108)) | (orig_zon = 109) | (orig_zon =
 110))&(((dest_zon >= 107) & (dest_zon <= 108)) | (dest_zon = 109) | (dest_zon =
 110))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 26.23 .
EXECUTE .
IF (((((orig_zon >= 107) & (orig_zon <= 108)) | (orig_zon = 109) | (orig_zon =
```

```
 110))&(((dest_zon >= 107) & (dest_zon <= 108)) | (dest_zon = 109) | (dest_zon =
 110))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 9.94 .
EXECUTE .

COMMENT group 9

IF (((((orig_zon >= 202) & (orig_zon <= 202)) | (orig_zon = 203) | (orig_zon =
 235))&(((dest_zon >= 202) & (dest_zon <= 202)) | (dest_zon = 203) | (dest_zon =
 235))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 34.23 .
EXECUTE .
IF (((((orig_zon >= 202) & (orig_zon <= 202)) | (orig_zon = 203) | (orig_zon =
 235))&(((dest_zon >= 202) & (dest_zon <= 202)) | (dest_zon = 203) | (dest_zon =
 235))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 4.44 .
EXECUTE .

COMMENT group 10

IF (((((orig_zon >= 142) & (orig_zon <= 143)) | (orig_zon = 236) | (orig_zon =
 237) | (orig_zon =
 247))&(((dest_zon >= 142) & (dest_zon <= 143)) | (dest_zon = 236) | (dest_zon =
 237) | (dest_zon =
 247))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 32.48 .
EXECUTE .
IF (((((orig_zon >= 142) & (orig_zon <= 143)) | (orig_zon = 236) | (orig_zon =
 237) | (orig_zon =
 247))&(((dest_zon >= 142) & (dest_zon <= 143)) | (dest_zon = 236) | (dest_zon =
 237) | (dest_zon =
 247))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 4.16 .
EXECUTE .

COMMENT group 11

IF (((((orig_zon >= 238) & (orig_zon <= 241)) | (orig_zon = 144) | (orig_zon =
 204))&(((dest_zon >= 238) & (dest_zon <= 241)) | (dest_zon = 144) | (dest_zon =
 204))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 34.13 .
EXECUTE .
IF (((((orig_zon >= 238) & (orig_zon <= 241)) | (orig_zon = 144) | (orig_zon =
 204))&(((dest_zon >= 238) & (dest_zon <= 241)) | (dest_zon = 144) | (dest_zon =
 204))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 9.53 .
EXECUTE .

COMMENT group 12

IF (((((orig_zon >= 242) & (orig_zon <= 245)) | (orig_zon = 246) | (orig_zon =
 145))&(((dest_zon >= 242) & (dest_zon <= 245)) | (dest_zon = 246) | (dest_zon =
 145))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 38.10 .
EXECUTE .
IF (((((orig_zon >= 242) & (orig_zon <= 245)) | (orig_zon = 246) | (orig_zon =
 145))&(((dest_zon >= 242) & (dest_zon <= 245)) | (dest_zon = 246) | (dest_zon =
 145))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 5.34 .
EXECUTE .

COMMENT group 13

IF (((((orig_zon >= 81) & (orig_zon <= 83)) | (orig_zon = 88) | (orig_zon =
 89))&(((dest_zon >= 81) & (dest_zon <= 83)) | (dest_zon = 88) | (dest_zon =
 89))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 29.45 .
EXECUTE .
IF (((((orig_zon >= 81) & (orig_zon <= 83)) | (orig_zon = 88) | (orig_zon =
 89))&(((dest_zon >= 81) & (dest_zon <= 83)) | (dest_zon = 88) | (dest_zon =
 89))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 7.57 .
EXECUTE .
```

```
COMMENT group 14

IF (((((orig_zon >= 84) & (orig_zon <= 87)) | (orig_zon = 76) | (orig_zon =
 77) |  (orig_zon = 78) | (orig_zon = 79) |(orig_zon =
 80))&(((dest_zon >= 84) & (dest_zon <= 87)) | (dest_zon = 76) | (dest_zon =
 77) |  (dest_zon = 78) | (dest_zon = 79) |(dest_zon =
 80))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 32.56 .
EXECUTE .
IF (((((orig_zon >= 84) & (orig_zon <= 87)) | (orig_zon = 76) | (orig_zon =
 77) | (orig_zon = 78) | (orig_zon = 79) | (orig_zon =
 80))&(((dest_zon >= 84) & (dest_zon <= 87)) | (dest_zon = 76) | (dest_zon =
 77) |  (dest_zon = 78) | (dest_zon = 79) |(dest_zon =
 80))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 6.95 .
EXECUTE .

COMMENT group 15

IF (((((orig_zon >= 71) & (orig_zon <= 73)) | (orig_zon = 74) | (orig_zon =
 75))&(((dest_zon >= 71) & (dest_zon <= 73)) | (dest_zon = 74) | (dest_zon =
 75)))& ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 32.78 .
EXECUTE .
IF (((((orig_zon >= 71) & (orig_zon <= 73)) | (orig_zon = 74) | (orig_zon =
 75))&(((dest_zon >= 71) & (dest_zon <= 73)) | (dest_zon = 74) | (dest_zon =
 75))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 7.81 .
EXECUTE .

COMMENT group 16

IF (((((orig_zon >= 68) & (orig_zon <= 69)) | (orig_zon = 70) | (orig_zon =
 113))&(((dest_zon >= 68) & (dest_zon <= 69)) | (dest_zon = 70) | (dest_zon =
 113))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 34.88 .
EXECUTE .
IF (((((orig_zon >= 68) & (orig_zon <= 69)) | (orig_zon = 70) | (orig_zon =
 113))&(((dest_zon >= 68) & (dest_zon <= 69)) | (dest_zon = 70) | (dest_zon =
 113))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.83 .
EXECUTE .

COMMENT group 17

IF (((((orig_zon >= 23) & (orig_zon <= 23)) | (orig_zon = 24) | (orig_zon =
 25))&(((dest_zon >= 23) & (dest_zon <= 23)) | (dest_zon = 24) | (dest_zon =
 25))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 28.91 .
EXECUTE .
IF (((((orig_zon >= 23) & (orig_zon <= 23)) | (orig_zon = 24) | (orig_zon =
 25))&(((dest_zon >= 23) & (dest_zon <= 23)) | (dest_zon = 24) | (dest_zon =
 25))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 7.20 .
EXECUTE .

COMMENT group 18

IF (((((orig_zon >= 19) & (orig_zon <= 20)) | (orig_zon = 21) | (orig_zon =
 22))&(((dest_zon >= 19) & (dest_zon <= 20)) | (dest_zon = 21) | (dest_zon =
 22))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 24.89 .
EXECUTE .
IF (((((orig_zon >= 19) & (orig_zon <= 20)) | (orig_zon = 21) | (orig_zon =
 22))&(((dest_zon >= 19) & (dest_zon <= 20)) | (dest_zon = 21) | (dest_zon =
 22))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.49 .
EXECUTE .

COMMENT group 19

IF (((((orig_zon >= 31) & (orig_zon <= 32)) | (orig_zon = 18) | (orig_zon =
 26))&(((dest_zon >= 31) & (dest_zon <= 32)) | (dest_zon = 18) | (dest_zon =
```

```
 26))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 31.68 .
EXECUTE .
IF (((((orig_zon >= 31) & (orig_zon <= 32)) | (orig_zon = 18) | (orig_zon =
 26))&(((dest_zon >= 31) & (dest_zon <= 32)) | (dest_zon = 18) | (dest_zon =
 26))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.03 .
EXECUTE .

COMMENT group 20

IF (((((orig_zon >= 33) & (orig_zon <= 35)) | (orig_zon = 36) | (orig_zon =
 37))&(((dest_zon >= 33) & (dest_zon <= 35)) | (dest_zon = 36) | (dest_zon =
 37))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 34.28 .
EXECUTE .
IF (((((orig_zon >= 33) & (orig_zon <= 35)) | (orig_zon = 36) | (orig_zon =
 37))&(((dest_zon >= 33) & (dest_zon <= 35)) | (dest_zon = 36) | (dest_zon =
 37))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 4.71 .
EXECUTE .

COMMENT group 21

IF (((((orig_zon >= 38) & (orig_zon <= 40)) | (orig_zon = 28) | (orig_zon =
 29) | (orig_zon =
 30))&(((dest_zon >= 38) & (dest_zon <= 40)) | (dest_zon = 28) | (dest_zon =
 29) | (dest_zon =
 30))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 30.23 .
EXECUTE .
IF (((((orig_zon >= 38) & (orig_zon <= 40)) | (orig_zon = 28) | (orig_zon =
 29) | (orig_zon =
 30))&(((dest_zon >= 38) & (dest_zon <= 40)) | (dest_zon = 28) | (dest_zon =
 29) | (orig_zon =
 30))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 9.39 .
EXECUTE .

COMMENT group 22

IF (((((orig_zon >= 41) & (orig_zon <= 47)) | (orig_zon = 48) | (orig_zon =
 56))&(((dest_zon >= 41) & (dest_zon <= 47)) | (dest_zon = 48) | (dest_zon =
 56))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 25.12 .
EXECUTE .
IF (((((orig_zon >= 41) & (orig_zon <= 47)) | (orig_zon = 48) | (orig_zon =
 56))&(((dest_zon >= 41) & (dest_zon <= 47)) | (dest_zon = 48) | (dest_zon =
 56))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 7.91 .
EXECUTE .

COMMENT group 23

IF (((((orig_zon >= 49) & (orig_zon <= 49)) | (orig_zon = 50) | (orig_zon =
 126))&(((dest_zon >= 49) & (dest_zon <= 49)) | (dest_zon = 50) | (dest_zon =
 126))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 32.90 .
EXECUTE .
IF (((((orig_zon >= 49) & (orig_zon <= 49)) | (orig_zon = 50) | (orig_zon =
 126))&(((dest_zon >= 49) & (dest_zon <= 49)) | (dest_zon = 50) | (dest_zon =
 126))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 8.39 .
EXECUTE .

COMMENT group 24

IF (((((orig_zon >= 57) & (orig_zon <= 57)) | (orig_zon = 58) | (orig_zon =
 27))&(((dest_zon >= 57) & (dest_zon <= 57)) | (dest_zon = 58) | (dest_zon =
 27))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 29.34 .
EXECUTE .
IF (((((orig_zon >= 57) & (orig_zon <= 57)) | (orig_zon = 58) | (orig_zon =
 27))&(((dest_zon >= 57) & (dest_zon <= 57)) | (dest_zon = 58) | (dest_zon =
```

```
 27))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.68 .
EXECUTE .

COMMENT group 25

IF (((((orig_zon >= 63) & (orig_zon <= 65)) | (orig_zon = 66) | (orig_zon =
 67))&(((dest_zon >= 63) & (dest_zon <= 65)) | (dest_zon = 66) | (dest_zon =
 67))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 28.18 .
EXECUTE .
IF (((((orig_zon >= 63) & (orig_zon <= 65)) | (orig_zon = 66) | (orig_zon =
 67))&(((dest_zon >= 63) & (dest_zon <= 65)) | (dest_zon = 66) | (dest_zon =
 67))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 6.04 .
EXECUTE .

COMMENT group 26

IF (((((orig_zon >= 59) & (orig_zon <= 60)) | (orig_zon = 61) | (orig_zon =
 62))&(((dest_zon >= 59) & (dest_zon <= 60)) | (dest_zon = 61) | (dest_zon =
 62))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 33.40 .
EXECUTE .
IF (((((orig_zon >= 59) & (orig_zon <= 60)) | (orig_zon = 61) | (orig_zon =
 62))&(((dest_zon >= 59) & (dest_zon <= 60)) | (dest_zon = 61) | (dest_zon =
 62))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 8.21 .
EXECUTE .

COMMENT group 27

IF (((((orig_zon >= 51) & (orig_zon <= 55)) | (orig_zon = 123) | (orig_zon =
 125))&(((dest_zon >= 51) & (dest_zon <= 55)) | (dest_zon = 123) | (dest_zon =
 125))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 32.96 .
EXECUTE .
IF (((((orig_zon >= 51) & (orig_zon <= 55)) | (orig_zon = 123) | (orig_zon =
 125))&(((dest_zon >= 51) & (dest_zon <= 55)) | (dest_zon = 123) | (dest_zon =
 125))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 6.91 .
EXECUTE .

COMMENT group 28

IF (((((orig_zon >= 120) & (orig_zon <= 120)) | (orig_zon = 121) | (orig_zon =
 122))&(((dest_zon >= 120) & (dest_zon <= 120)) | (dest_zon = 121) | (dest_zon =
 122))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 30.19 .
EXECUTE .
IF (((((orig_zon >= 120) & (orig_zon <= 120)) | (orig_zon = 121) | (orig_zon =
 122))&(((dest_zon >= 120) & (dest_zon <= 120)) | (dest_zon = 121) | (dest_zon =
 122))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 7.86 .
EXECUTE .

COMMENT group 29

IF (((((orig_zon >= 225) & (orig_zon <= 226)) | (orig_zon = 224) | (orig_zon =
 136))&(((dest_zon >= 225) & (dest_zon <= 226)) | (dest_zon = 224) | (dest_zon =
 136))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 35.98 .
EXECUTE .
IF (((((orig_zon >= 225) & (orig_zon <= 226)) | (orig_zon = 224) | (orig_zon =
 136))&(((dest_zon >= 225) & (dest_zon <= 226)) | (dest_zon = 224) | (dest_zon =
 136))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 9.31 .
EXECUTE .

COMMENT group 30

IF (((((orig_zon >= 111) & (orig_zon <= 111)) | (orig_zon = 112) | (orig_zon =
 233))&(((dest_zon >= 111) & (dest_zon <= 111)) | (dest_zon = 112) | (dest_zon =
 233))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 30.43 .
```

```
EXECUTE .
IF (((((orig_zon >= 111) & (orig_zon <= 111)) | (orig_zon = 112) | (orig_zon =
 233))&(((dest_zon >= 111) & (dest_zon <= 111)) | (dest_zon = 112) | (dest_zon =
 233))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 11.28 .
EXECUTE .

COMMENT group 31

IF (((((orig_zon >= 114) & (orig_zon <= 115)) | (orig_zon = 116) | (orig_zon =
 232))&(((dest_zon >= 114) & (dest_zon <= 115)) | (dest_zon = 116) | (dest_zon =
 232))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 30.13 .
EXECUTE .
IF (((((orig_zon >= 114) & (orig_zon <= 115)) | (orig_zon = 116) | (orig_zon =
 232))&(((dest_zon >= 114) & (dest_zon <= 115)) | (dest_zon = 116) | (dest_zon =
 232))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 10.20 .
EXECUTE .

COMMENT group 32

IF (((((orig_zon >= 117) & (orig_zon <= 117)) | (orig_zon = 118) | (orig_zon =
 119))&(((dest_zon >= 117) & (dest_zon <= 117)) | (dest_zon = 118) | (dest_zon =
 119))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 39.29 .
EXECUTE .
IF (((((orig_zon >= 117) & (orig_zon <= 117)) | (orig_zon = 118) | (orig_zon =
 119))&(((dest_zon >= 117) & (dest_zon <= 117)) | (dest_zon = 118) | (dest_zon =
 119))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 12.02 .
EXECUTE .

COMMENT group 33

IF (((((orig_zon >= 207) & (orig_zon <= 210)) | (orig_zon = 211) | (orig_zon =
 131))&(((dest_zon >= 207) & (dest_zon <= 210)) | (dest_zon = 211) | (dest_zon =
 131))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 35.07 .
EXECUTE .
IF (((((orig_zon >= 207) & (orig_zon <= 210)) | (orig_zon = 211) | (orig_zon =
 131))&(((dest_zon >= 207) & (dest_zon <= 210)) | (dest_zon = 211) | (dest_zon =
 131))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 11.26 .
EXECUTE .

COMMENT group 34

IF (((((orig_zon >= 129) & (orig_zon <= 129)) | (orig_zon = 130) | (orig_zon =
 220))&(((dest_zon >= 129) & (dest_zon <= 129)) | (dest_zon = 130) | (dest_zon =
 220))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 27.18 .
EXECUTE .
IF (((((orig_zon >= 129) & (orig_zon <= 129)) | (orig_zon = 130) | (orig_zon =
 220))&(((dest_zon >= 129) & (dest_zon <= 129)) | (dest_zon = 130) | (orig_zon =
 220))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 5.75 .
EXECUTE .

COMMENT group 35

IF (((((orig_zon >= 216) & (orig_zon <= 217)) | (orig_zon = 218) | (orig_zon =
 219))&(((dest_zon >= 216) & (dest_zon <= 217)) | (dest_zon = 218) | (dest_zon =
 219))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 35.05 .
EXECUTE .
IF (((((orig_zon >= 216) & (orig_zon <= 217)) | (orig_zon = 218) | (orig_zon =
 219))&(((dest_zon >= 216) & (dest_zon <= 217)) | (dest_zon = 218) | (dest_zon =
 219))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.02 .
EXECUTE .

COMMENT group 36
```

```
IF (((((orig_zon >= 228) & (orig_zon <= 230)) | (orig_zon = 231) | (orig_zon =
 141))&(((dest_zon >= 228) & (dest_zon <= 230)) | (dest_zon = 231) | (dest_zon =
 141))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 55.0 .
EXECUTE .
IF (((((orig_zon >= 228) & (orig_zon <= 230)) | (orig_zon = 231) | (orig_zon =
 141))&(((dest_zon >= 228) & (dest_zon <= 230)) | (dest_zon = 231) | (dest_zon =
 141))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.0 .
EXECUTE .

COMMENT group 37

IF (((((orig_zon >= 124) & (orig_zon <= 124)) | (orig_zon = 127) | (orig_zon =
 128))&(((dest_zon >= 124) & (dest_zon <= 124)) | (dest_zon = 127) | (dest_zon =
 128))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 55.0 .
EXECUTE .
IF (((((orig_zon >= 124) & (orig_zon <= 124)) | (orig_zon = 127) | (orig_zon =
 128))&(((dest_zon >= 124) & (dest_zon <= 124)) | (dest_zon = 127) | (dest_zon =
 128))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.0 .

COMMENT group 38

IF (((((orig_zon >= 132) & (orig_zon <= 135)) | (orig_zon = 138) | (orig_zon =
 139))&(((dest_zon >= 132) & (dest_zon <= 135)) | (dest_zon = 138) | (dest_zon =
 139))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 54.05 .
EXECUTE .
IF (((((orig_zon >= 132) & (orig_zon <= 135)) | (orig_zon = 138) | (orig_zon =
 139))&(((dest_zon >= 132) & (dest_zon <= 135)) | (dest_zon = 138) | (dest_zon =
 139))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.0 .

COMMENT group 39

IF (((((orig_zon >= 179) & (orig_zon <= 180)) | (orig_zon = 182) | (orig_zon =
 183))&(((dest_zon >= 179) & (dest_zon <= 180)) | (dest_zon = 182) | (dest_zon =
 183))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 44.06 .
EXECUTE .
IF (((((orig_zon >= 179) & (orig_zon <= 180)) | (orig_zon = 182) | (orig_zon =
 183))&(((dest_zon >= 179) & (dest_zon <= 180)) | (dest_zon = 182) | (dest_zon =
 183))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 8.13 .


COMMENT Quebec zones
COMMENT group 40

IF (((((orig_zon >= 149) & (orig_zon <= 149)) | (orig_zon = 149) | (orig_zon =
 150))&(((dest_zon >= 149) & (dest_zon <= 149)) | (dest_zon = 149) | (dest_zon =
 150))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 50.0 .
EXECUTE .
IF (((((orig_zon >= 149) & (orig_zon <= 149)) | (orig_zon = 149) | (orig_zon =
 150))&(((dest_zon >= 149) & (dest_zon <= 149)) | (dest_zon = 149) | (dest_zon =
 150))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.0 .
EXECUTE .

COMMENT group 41

IF (((((orig_zon >= 146) & (orig_zon <= 147)) | (orig_zon = 151) | (orig_zon = 163) | (orig_zon =
 256))&(((dest_zon >= 146) & (dest_zon <= 147)) | (dest_zon = 151) | (orig_zon = 163) | (dest_zon =
 256))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 30.86 .
EXECUTE .
IF (((((orig_zon >= 146) & (orig_zon <= 147)) | (orig_zon = 151) | (orig_zon = 163) | (orig_zon =
 256))&(((dest_zon >= 146) & (dest_zon <= 147)) | (dest_zon = 151) | (orig_zon = 163) | (dest_zon =
 256))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 13.36 .
EXECUTE .
```

```
COMMENT group 42

IF (((((orig_zon >= 257) & (orig_zon <= 258)) | (orig_zon = 148) | (orig_zon =
  148))&(((dest_zon >= 257) & (dest_zon <= 258)) | (dest_zon = 148) | (dest_zon =
  148))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 33.77 .
EXECUTE .
IF (((((orig_zon >= 257) & (orig_zon <= 258)) | (orig_zon = 148) | (orig_zon =
  148))&(((dest_zon >= 257) & (dest_zon <= 258)) | (dest_zon = 148) | (dest_zon =
  148))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 8.58 .
EXECUTE .

COMMENT group 43

IF (((((orig_zon >= 158) & (orig_zon <= 161)) | (orig_zon = 152) | (orig_zon =
  164))&(((dest_zon >= 158) & (dest_zon <= 161)) | (dest_zon = 152) | (dest_zon =
  164))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 28.83 .
EXECUTE .
IF (((((orig_zon >= 158) & (orig_zon <= 161)) | (orig_zon = 152) | (orig_zon =
  164))&(((dest_zon >= 158) & (dest_zon <= 161)) | (dest_zon = 152) | (dest_zon =
  164))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 7.71 .
EXECUTE .

COMMENT group 44

IF (((((orig_zon >= 153) & (orig_zon <= 155)) | (orig_zon = 254) | (orig_zon =
  255))&(((dest_zon >= 153) & (dest_zon <= 155)) | (dest_zon = 254) | (dest_zon =
  255))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 17.15 .
EXECUTE .
IF (((((orig_zon >= 153) & (orig_zon <= 155)) | (orig_zon = 254) | (orig_zon =
  255))&(((dest_zon >= 153) & (dest_zon <= 155)) | (dest_zon = 254) | (dest_zon =
  255))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 6.72 .
EXECUTE .

COMMENT group 45

IF (((((orig_zon >= 156) & (orig_zon <= 157)) | (orig_zon = 162) | (orig_zon =
  164) | (orig_zon =
  184))&(((dest_zon >= 156) & (dest_zon <= 157)) | (dest_zon = 162) | (dest_zon =
  164) | (dest_zon =
  184))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 50.0 .
EXECUTE .
IF (((((orig_zon >= 156) & (orig_zon <= 157)) | (orig_zon = 162) | (orig_zon =
  164) | (orig_zon =
  184))&(((dest_zon >= 156) & (dest_zon <= 157)) | (dest_zon = 162) | (dest_zon =
  164) | (dest_zon =
  184))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.0 .
EXECUTE .

COMMENT group 46

IF (((((orig_zon >= 165) & (orig_zon <= 165)) | (orig_zon = 165) | (orig_zon =
  253))&(((dest_zon >= 165) & (dest_zon <= 165)) | (dest_zon = 165) | (dest_zon =
  253))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 35.73 .
EXECUTE .
IF (((((orig_zon >= 165) & (orig_zon <= 165)) | (orig_zon = 165) | (orig_zon =
  253))&(((dest_zon >= 165) & (dest_zon <= 165)) | (dest_zon = 165) | (dest_zon =
  253))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 12.24 .
EXECUTE .

COMMENT group 47

IF (((((orig_zon >= 169) & (orig_zon <= 169)) | (orig_zon = 170) | (orig_zon =
  166))&(((dest_zon >= 169) & (dest_zon <= 169)) | (dest_zon = 170) | (dest_zon =
```

```
 166))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 33.01 .
EXECUTE .
IF (((((orig_zon >= 169) & (orig_zon <= 169)) | (orig_zon = 170) | (orig_zon =
 166))&(((dest_zon >= 169) & (dest_zon <= 169)) | (dest_zon = 170) | (dest_zon =
 166))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 2.99 .
EXECUTE .

COMMENT group 48

IF (((((orig_zon >= 167) & (orig_zon <= 167)) | (orig_zon = 168) | (orig_zon =
 252))&(((dest_zon >= 167) & (dest_zon <= 167)) | (dest_zon = 168) | (dest_zon =
 252))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 31.87 .
EXECUTE .
IF (((((orig_zon >= 167) & (orig_zon <= 167)) | (orig_zon = 168) | (orig_zon =
 252))&(((dest_zon >= 167) & (dest_zon <= 167)) | (dest_zon = 168) | (dest_zon =
 252))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 6.03 .
EXECUTE .

COMMENT group 49

IF (((((orig_zon >= 171) & (orig_zon <= 173)) | (orig_zon = 249) | (orig_zon =
 250) | (orig_zon =
 251))&(((dest_zon >= 171) & (dest_zon <= 173)) | (dest_zon = 249) | (dest_zon =
 250) | (dest_zon =
 251))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 33.57 .
EXECUTE .
IF (((((orig_zon >= 171) & (orig_zon <= 173)) | (orig_zon = 249) | (orig_zon =
 250) | (orig_zon =
 251))&(((dest_zon >= 171) & (dest_zon <= 173)) | (dest_zon = 249) | (dest_zon =
 250) | (dest_zon =
 251))) &((a_dist=0) | ((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 8.86 .
EXECUTE .

COMMENT group 50

IF (((((orig_zon >= 174) & (orig_zon <= 174)) | (orig_zon = 175) | (orig_zon =
 248))&(((dest_zon >= 174) & (dest_zon <= 174)) | (dest_zon = 175) | (dest_zon =
 248))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 36.0 .
EXECUTE .
IF (((((orig_zon >= 174) & (orig_zon <= 174)) | (orig_zon = 175) | (orig_zon =
 248))&(((dest_zon >= 174) & (dest_zon <= 174)) | (dest_zon = 175) | (dest_zon =
 248))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 5.45 .
EXECUTE .

COMMENT group 51

IF (((((orig_zon >= 177) & (orig_zon <= 178)) | (orig_zon = 181) | (orig_zon =
 185))&(((dest_zon >= 177) & (dest_zon <= 178)) | (dest_zon = 181) | (dest_zon =
 185))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) a_speed = 50.0 .
EXECUTE .
IF (((((orig_zon >= 177) & (orig_zon <= 178)) | (orig_zon = 181) | (orig_zon =
 185))&(((dest_zon >= 177) & (dest_zon <= 178)) | (dest_zon = 181) | (dest_zon =
 185))) & ((a_dist=0) |((xy_dist >= 0) & (xy_dist <= 2)))) t_speed = 3.0 .
EXECUTE .

COMMENT group 52

IF (((orig_zon = 132)  |  (orig_zon = 133) | (orig_zon = 135) |
((orig_zon >= 137) & (orig_zon <= 141)) | (orig_zon = 146) | (orig_zon = 147)
 | (orig_zon = 177) | ((orig_zon >= 181) & (orig_zon <= 185)) | ((orig_zon
 >= 212) & (orig_zon <= 215)) | ((orig_zon >= 227) & (orig_zon <=  230))) |
((dest_zon = 132)  |  (dest_zon = 133) | (dest_zon = 135) |
((dest_zon >= 137) & (dest_zon <= 141)) | (dest_zon = 146) | (dest_zon = 147)
```

```
 | (dest_zon = 177) | ((dest_zon >= 181) & (dest_zon <= 185)) | ((dest_zon >=
 212) & (dest_zon <= 215)) | ((dest_zon >= 227) & (dest_zon <=  230)))) t_time = 2000 .
EXECUTE .

COMMENT  group 53

IF (((orig_zon = 132)  |  (orig_zon = 133) | (orig_zon = 135) |
((orig_zon >= 137) & (orig_zon <= 141)) | (orig_zon = 146) | (orig_zon = 147)
 | (orig_zon = 177) | ((orig_zon >= 181) & (orig_zon <= 185)) | ((orig_zon
 >= 212) & (orig_zon <= 215)) | ((orig_zon >= 227) & (orig_zon <=  230))) |
((dest_zon = 132)  |  (dest_zon = 133) | (dest_zon = 135) |
((dest_zon >= 137) & (dest_zon <= 141)) | (dest_zon = 146) | (dest_zon = 147)
 | (dest_zon = 177) | ((dest_zon >= 181) & (dest_zon <= 185)) | ((dest_zon >=
 212) & (dest_zon <= 215)) | ((dest_zon >= 227) & (dest_zon <=  230)))) t_dist = 50 .
EXECUTE .

COMMENT  group 54

IF (((orig_zon = 132)  |  (orig_zon = 133) | (orig_zon = 135) |
((orig_zon >= 137) & (orig_zon <= 141)) | (orig_zon = 146) | (orig_zon = 147)
 | (orig_zon = 177) | ((orig_zon >= 181) & (orig_zon <= 185)) | ((orig_zon
 >= 212) & (orig_zon <= 215)) | ((orig_zon >= 227) & (orig_zon <=  230))) |
((dest_zon = 132)  |  (dest_zon = 133) | (dest_zon = 135) |
((dest_zon >= 137) & (dest_zon <= 141)) | (dest_zon = 146) | (dest_zon = 147)
 | (dest_zon = 177) | ((dest_zon >= 181) & (dest_zon <= 185)) | ((dest_zon >=
 212) & (dest_zon <= 215)) | ((dest_zon >= 227) & (dest_zon <=  230)))) t_speed = 1.5 .
EXECUTE .

COMMENT misc groups

IF ((orig_zon = 137) & (dest_zon = 137)) a_speed = 54.05 .
EXECUTE .
IF ((orig_zon = 137) & (dest_zon = 137)) t_speed = 3.0 .
EXECUTE .

IF ((orig_zon = 140) & (dest_zon = 140)) a_speed = 35.98 .
EXECUTE .
IF ((orig_zon = 140) & (dest_zon = 140)) t_speed = 9.31 .
EXECUTE .

IF ((orig_zon = 176) & (dest_zon = 176)) a_speed = 36.0 .
EXECUTE .
IF ((orig_zon = 176) & (dest_zon = 176)) t_speed = 5.45 .
EXECUTE .

IF ((orig_zon = 205) & (dest_zon = 205)) a_speed = 30.13 .
EXECUTE .
IF ((orig_zon = 205) & (dest_zon = 205)) t_speed = 10.20 .
EXECUTE .

IF ((orig_zon = 227) & (dest_zon = 227)) a_speed = 55.0 .
EXECUTE .
IF ((orig_zon = 227) & (dest_zon = 227)) t_speed = 3.0 .
EXECUTE .

IF ((orig_zon = 234) & (dest_zon = 234)) a_speed = 27.68 .
EXECUTE .
IF ((orig_zon = 234) & (dest_zon = 234)) t_speed = 8.80 .
EXECUTE .

IF (((orig_zon  >= 221) & (orig_zon <= 223)) & ((dest_zon >= 221) & (dest_zon
 <= 223))) a_speed = 35.98 .
EXECUTE .
```

```
IF (((orig_zon  >= 221) & (orig_zon <= 223)) & ((dest_zon >= 221) & (dest_zon
  <= 223))) t_speed = 9.31 .
EXECUTE .

IF ((((orig_zon  >= 212) & (orig_zon <= 215)) | (orig_zon = 206)) &
  (((dest_zon >= 212) & (dest_zon <= 215)) | (dest_zon = 206))) a_speed = 35.07 .
EXECUTE .
IF ((((orig_zon  >= 212) & (orig_zon <= 215)) | (orig_zon = 206)) &
  (((dest_zon >= 212) & (dest_zon <= 215)) | (dest_zon = 206))) t_speed = 11.26 .
EXECUTE .


COMMENT  creation of x values

IF ((xy_dist > 0 0) & (xy_dist <= 0.5)) x = 1 .
EXECUTE .

IF ((xy_dist > 0.5) & (xy_dist <= 1.0)) x = 2 .
EXECUTE .

iF ((xy_dist > 1.0) & (xy_dist <= 1.5)) x = 3 .
EXECUTE .

IF ((xy_dist > 1.5) & (xy_dist <= 2.0)) x = 4 .
EXECUTE .

IF ((xy_dist > 2.0) & (xy_dist <= 2.5)) x = 5 .
EXECUTE .

IF ((xy_dist > 2.5) & (xy_dist <= 3.0)) x = 6 .
EXECUTE .

IF ((xy_dist > 3.0) & (xy_dist <= 3.5)) x = 7 .
EXECUTE .

IF ((xy_dist > 3.5) & (xy_dist <= 4.0)) x = 8 .
EXECUTE .

IF ((xy_dist > 4.0) & (xy_dist <= 4.5)) x = 9 .
EXECUTE .

IF ((xy_dist > 4.5) & (xy_dist <= 5.0)) x = 10 .
EXECUTE .

IF ((xy_dist > 5.0) & (xy_dist <= 6.0)) x = 11 .
EXECUTE .

IF ((xy_dist > 6.0) & (xy_dist <= 7.0)) x = 12 .
EXECUTE .

IF ((xy_dist > 7.0) & (xy_dist <= 8.0)) x = 13 .
EXECUTE .

IF ((xy_dist > 8.0) & (xy_dist <= 9.0)) x = 14 .
EXECUTE .

IF ((xy_dist > 9.0) & (xy_dist <= 10.0)) x = 15 .
EXECUTE .

IF ((xy_dist > 10.0) & (xy_dist <= 12.0)) x = 16 .
EXECUTE .
```

```
IF ((xy_dist > 12.0) & (xy_dist <= 14.0)) x = 17 .
EXECUTE .

IF ((xy_dist > 14.0) & (xy_dist <= 16.0)) x = 18 .
EXECUTE .

IF ((xy_dist > 16.0) & (xy_dist <= 18.0)) x = 19 .
EXECUTE .

IF ((xy_dist > 18.0) & (xy_dist <= 20.0)) x = 20 .
EXECUTE .

IF ((xy_dist > 20.0) & (xy_dist <= 25.0)) x = 21 .
EXECUTE .

IF ((xy_dist > 25.0) & (xy_dist <= 30.0)) x = 22 .
EXECUTE .

IF ((xy_dist > 30.0) & (xy_dist <= 35.0)) x = 23 .
EXECUTE .

IF ((xy_dist > 35.0) & (xy_dist <= 40.0)) x = 24 .
EXECUTE .

IF ((xy_dist > 40.0) & (xy_dist <= 45.0)) x = 25 .
EXECUTE .

IF ((xy_dist > 45.0) & (xy_dist <= 50.0)) x = 26 .
EXECUTE .


COMMENT computing bk_dist for  Ontario

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & (xy_dist <= 2)) bk_dist = (1.6075*((x) ** (-0.0923))) * xy_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247))))  & ((xy_dist > 2) & (xy_dist <= 2.5))) bk_dist = (1/ 1.05) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247))))  & ((xy_dist > 2.5) & (xy_dist <= 4.0))) bk_dist = (1/ 1.04) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247))))  & ((xy_dist > 4) & (xy_dist <= 5.0))) bk_dist = (1/ 1.03) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247))))  & ((xy_dist > 5) & (xy_dist <= 10.0))) bk_dist = (1/ 1.02) * a_dist .
EXECUTE .
```

```
IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 10.0) & (xy_dist <= 16.0))) bk_dist = (1/ 1.01) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 16) & (xy_dist <= 50.0))) bk_dist = (1/ 1.00) * a_dist .
EXECUTE .

COMMENT  computing wk_dist for Ontario

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & (xy_dist <= 2)) wk_dist = (-0.074*LN(x) + 1.4367) * xy_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 2) & (xy_dist <= 2.5))) wk_dist = (1/ 1.10) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 2.5) & (xy_dist <= 3.5))) wk_dist = (1/ 1.09) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 3.5) & (xy_dist <= 4.0))) wk_dist = (1/ 1.07) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 4.0) & (xy_dist <= 5.0))) wk_dist = (1/ 1.06) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 5.0) & (xy_dist <= 7.0))) wk_dist = (1/ 1.05) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 7.0) & (xy_dist <= 8.0))) wk_dist = (1/ 1.04) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((xy_dist > 8.0) & (xy_dist <= 10.0))) wk_dist = (1/ 1.03) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
```

```
 <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
 247)))) & ((xy_dist > 10.0) & (xy_dist <= 14.0))) wk_dist = (1/ 1.02) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
 <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
 247)))) & ((xy_dist > 14.0) & (xy_dist <= 18.0))) wk_dist = (1/ 1.01) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
 <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
 247)))) & ((xy_dist > 18.0) & (xy_dist <= 50.0))) wk_dist = (1/ 1.00) * a_dist .
EXECUTE .

COMMENT  computing bk_dist for Quebec

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & (xy_dist <= 2)) bk_dist = (-0.0919*LN(x) + 1.4692) * xy_dist .
EXECUTE .

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((xy_dist > 2) & (xy_dist <= 2.5))) bk_dist = (1/ 1.03) * a_dist .
EXECUTE .

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((xy_dist > 4.0) & (xy_dist <= 5.0))) bk_dist = (1/ 1.01) * a_dist .
EXECUTE .

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((xy_dist > 5.0) & (xy_dist <= 50.0))) bk_dist = (1/ 1.00) * a_dist .
EXECUTE .


COMMENT  computing wk_dist for Quebec

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & (xy_dist <= 2)) wk_dist = (-0.0788*LN(x) + 1.4427) * xy_dist .
EXECUTE .

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((xy_dist > 2) & (xy_dist <= 2.5))) wk_dist = (1/ 1.04) * a_dist .
EXECUTE .

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((xy_dist > 2.5) & (xy_dist <= 3.5))) wk_dist = (1/ 1.03) * a_dist .
EXECUTE .
```

```
IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
  <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
  258)))) & ((xy_dist > 3.5) & (xy_dist <= 4.5))) wk_dist = (1/ 1.01) * a_dist .
EXECUTE .

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
  <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
  258)))) & ((xy_dist > 4.5) & (xy_dist <= 50.0))) wk_dist = (1/ 1.00) * a_dist .
EXECUTE .

COMMENT bike and walk distances for cases between ont and quebec

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
  258))))) |
((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
  <= 258))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247))))) bk_dist = (1/ 1.03) * a_dist .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
  258))))) |
((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
  <= 258))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247))))) wk_dist = (1/ 1.05) * a_dist .
EXECUTE .


COMMENT: computing bike and walk times

COMPUTE bk_time = ((bk_dist) / 14.50) * 60 .
EXECUTE .
COMPUTE wk_time = ((wk_dist) / 3.5) * 60 .
EXECUTE .


COMMENT adjustment of a_dist and t_dist when a_dist=0 or xy_dist <= 2 for Ontario

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((a_dist = 0) | (xy_dist <= 2))) a_dist = (-0.1803 * LN(x) + 1.71) * (xy_dist) .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
  <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
  247)))) & ((a_dist = 0) | (xy_dist <= 2))) t_dist = (0.0289 * LN(x) + 1.61) * (xy_dist) .
EXECUTE .


COMMENT adjustment of a_dist and t_dist when a_dist=0 or xy_dist <= 2 for Quebec

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
  <= 258))) &
```

```
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((a_dist = 0) | (xy_dist <= 2))) a_dist = (-0.0721 * LN(x) + 1.48) * (xy_dist) .
EXECUTE .

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((a_dist = 0) | (xy_dist <= 2))) t_dist = (-0.0289 * LN(x) + 1.55) * (xy_dist) .
EXECUTE .


COMMENT adjustment of a_time and t_time when a_time=0 or xy_dist <=2 for Ontario

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
 <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
 247)))) & ((a_time = 0) | (xy_dist <= 2))) a_time = (a_dist / a_speed) * 60 .
EXECUTE .

IF (((((orig_zon >= 1) & (orig_zon <= 145)) | ((orig_zon >= 201) & (orig_zon
 <= 247))) &
(((dest_zon >= 1) & (dest_zon <= 145)) | ((dest_zon >= 201) & (dest_zon <=
 247)))) & ((a_time = 0) | (xy_dist <= 2))) t_time = (t_dist / t_speed) * 60 .
EXECUTE


COMMENT adjustment of a_time and t_time when a_time=0 or xy_dist <=2 for Quebec

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((a_time = 0) | (xy_dist <= 2))) a_time = (a_dist / a_speed) * 60 .
EXECUTE .

IF (((((orig_zon >= 146) & (orig_zon <= 185)) | ((orig_zon >= 248) & (orig_zon
 <= 258))) &
(((dest_zon >= 146) & (dest_zon <= 185)) | ((dest_zon >= 248) & (dest_zon <=
 258)))) & ((a_time = 0) | (xy_dist <= 2))) t_time = (t_dist / t_speed) * 60 .
EXECUTE .

comment end of Nadeem's macro .

comment calculating trip length for all intrazonal trips.

Comment - Step 5 Develop uta flag; if in UTA, flag=1, if outside UTA, flag=0

IF (orig_zon <= 131 | orig_zon=134 | orig_zon = 136 |( orig_zon >= 142 &
 orig_zon <= 145) |( orig_zon >= 148 & orig_zon <= 176) | (orig_zon >= 178 &
 orig_zon <= 180) | (orig_zon >= 201 & orig_zon <= 211) | (orig_zon >= 216 &
 orig_zon <= 226) | (orig_zon >= 231 & orig_zon <= 258)) |
((dest_zon <= 131 | dest_zon=134 | dest_zon = 136 |( dest_zon >= 142 &
 dest_zon <= 145) |( dest_zon >= 148 & dest_zon <= 176) | (dest_zon >= 178 &
 dest_zon <= 180) | (dest_zon >= 201 & dest_zon <= 211) | (dest_zon >= 216 &
 dest_zon <= 226) | (dest_zon >= 231 & dest_zon <= 258))) uta_flag = 1 .
EXECUTE .

comment - Part 6 Developing transit fare variable.

IF (orig_zon <= 45 | (orig_zon >= 57 & orig_zon <= 104) | orig_zon = 106 |
 (orig_zon >= 110 &orig_zon <= 122) | (orig_zon = 201) | (orig_zon >= 232 &
 orig_zon <= 234)) t_fare_o = 1 .
EXECUTE .
IF (((orig_zon >= 46 & orig_zon <= 56) | (orig_zon >= 123 & orig_zon <= 133)
```

```
 | (orig_zon >= 135 & orig_zon <= 138) | (orig_zon = 140) |  (orig_zon >= 206 &
 orig_zon <= 215) | (orig_zon >= 220 & orig_zon <= 231))) t_fare_o = 2 .
EXECUTE .
IF (((orig_zon = 105) | (orig_zon >= 107 & orig_zon <= 109)  | (orig_zon = 139) |
  (orig_zon>=141 & orig_zon <= 144) | (orig_zon >= 202 & orig_zon <= 205) | (orig_zon >=
 235 & orig_zon <= 247))) t_fare_o = 3 .
EXECUTE .
IF ((orig_zon >= 216 & orig_zon <= 219)) t_fare_o = 4 .
EXECUTE .
IF ((orig_zon = 134)) t_fare_o = 5 .
EXECUTE .
IF ((orig_zon = 145)) t_fare_o = 6 .
EXECUTE .
IF ((orig_zon >= 146 & orig_zon <= 164) | (orig_zon >= 182 & orig_zon <= 184)
 | (orig_zon >= 254 & orig_zon <= 258)) t_fare_o = 7 .
EXECUTE .
IF ((orig_zon >= 165 & orig_zon <= 181) | orig_zon = 185 | (orig_zon >= 248 &
 orig_zon <= 253)) t_fare_o = 8 .
EXECUTE .
IF ((orig_zon >= 186 & orig_zon <= 200)) t_fare_o = 9 .
EXECUTE .

IF (dest_zon <= 45 | (dest_zon >= 57 & dest_zon <= 104) | dest_zon = 106 |
 (dest_zon >= 110 &dest_zon <=  122) | (dest_zon = 201) | (dest_zon >= 232 &
 dest_zon <= 234)) t_fare_d = 1 .
EXECUTE .
IF (((dest_zon>= 46 & dest_zon<= 56) | (dest_zon>= 123 & dest_zon<= 133)
 | (dest_zon>= 135 & dest_zon<= 138) | (dest_zon= 140) |  (dest_zon>= 206 &
 dest_zon<= 215) | (dest_zon>= 220 & dest_zon<= 231))) t_fare_d = 2 .
EXECUTE .
IF (((dest_zon= 105) | (dest_zon>= 107 & dest_zon<= 109)  | (dest_zon= 139) |
  (dest_zon>=141 & dest_zon<= 144) | (dest_zon>= 202 & dest_zon<= 205) | (dest_zon>=
 235 & dest_zon<= 247))) t_fare_d = 3 .
EXECUTE .
IF ((dest_zon >= 216 & dest_zon <= 219)) t_fare_d = 4 .
EXECUTE .
IF ((dest_zon = 134)) t_fare_d = 5 .
EXECUTE .
IF ((dest_zon = 145)) t_fare_d = 6 .
EXECUTE .
IF ((dest_zon >= 146 & dest_zon <= 164) | (dest_zon >= 182 & dest_zon <= 184)
 | (dest_zon >= 254 & dest_zon <= 258)) t_fare_d = 7 .
EXECUTE .
IF ((dest_zon >= 165 & dest_zon <= 181) | dest_zon = 185 | (dest_zon >= 248 &
 dest_zon <= 253)) t_fare_d = 8 .
EXECUTE .
IF ((dest_zon >= 186 & dest_zon <= 200)) t_fare_d = 9 .
EXECUTE .

comment  -  placing fare in record based on t_fare_o $ t_fare_d

COMPUTE t_fare = 1.35 .
EXECUTE .
IF ((t_fare_o = 1 & t_fare_d = 2) |(t_fare_o = 1 & t_fare_d = 3) |  (t_fare_o
 = 1 & t_fare_d = 8) | (t_fare_o = 2 & t_fare_d = 3) | (t_fare_o = 2 &
 t_fare_d = 8) | (t_fare_o = 3 & t_fare_d = 2) | (t_fare_o = 3 & t_fare_d =
 8) | (t_fare_o = 4 & t_fare_d = 3) | (t_fare_o = 4 &t_fare_d  = 8) |
 (t_fare_o = 5 & t_fare_d = 3) |( t_fare_o = 5 & t_fare_d = 8) | (t_fare_o =
 6 & t_fare_d = 2  ) | (t_fare_o = 6 & t_fare_d = 3) | (t_fare_o = 6 &
 t_fare_d = 8) | (t_fare_o = 7 & t_fare_d = 2) | (t_fare_o = 7 & t_fare_d =
 3) | (t_fare_o = 7 & t_fare_d = 8) | (t_fare_o = 8 & t_fare_d = 2) |(
 t_fare_o = 8 & t_fare_d = 3)) t_fare = 1.73 .
EXECUTE .
```

```
IF (((t_fare_o = 1 &( t_fare_d >= 4 & t_fare_d <= 6)) | (t_fare_o = 2 &
 (t_fare_d >= 5 & t_fare_d <= 6)) |  ( t_fare_o = 3 & (t_fare_d >= 4 &
 t_fare_d <= 6)) |  ( t_fare_o = 4 & (t_fare_d >= 5 & t_fare_d <= 6)) |
 (t_fare_o = 5 & t_fare_d = 4) | (t_fare_o = 5 & t_fare_d = 6) | (t_fare_o =
 6 & (t_fare_d >= 4 & t_fare_d <= 5)) | (t_fare_o = 7 & (t_fare_d >= 4 &
 t_fare_d <= 6)) | (t_fare_o = 8 & (t_fare_d >= 4 & t_fare_d <= 6)))) t_fare =
 3.1 .
EXECUTE .

comment  reduce transit fare for students


IF (purp_mc = "SSH" | purp_mc = "SU") t_fare = t_fare * .8 .
EXECUTE .


comment  Part 7  Developing SOV and shared ride costs.
comment  -  - first compile parking cost

IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon = 2 | orig_zon = 3)) a_$park = 4.8 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =1 |  orig_zon =201)) a_$park = 4.2 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & ( orig_zon =154 )) a_$park = 3.75 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =32 | orig_zon = 5 | orig_zon = 6))
a_$park = 3.6 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =255)) a_$park  = 3.30 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =10 | orig_zon = 18)) a_$park = 3.15 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =12)) a_$park = 3.0 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =25)) a_$park = 2.85 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =4 | orig_zon = 15 | orig_zon = 30))
a_$park = 2.80 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =7 | orig_zon = 34)) a_$park = 2.50 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =160 | orig_zon = 31 | orig_zon = 254))
a_$park = 2.40 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =70 | orig_zon =78)) a_$park = 2.25 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =26)) a_$park = 2.1 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =36 | orig_zon =52 | orig_zon =71))
a_$park = 2.0 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =60)) a_$park = 1.90 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =14 | orig_zon = 16 | orig_zon = 101))
a_$park = 1.80 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =79 | orig_zon = 95 | orig_zon = 155))
a_$park = 1.50 .
EXECUTE .
```

```
comment  develop fixed cost.

COMPUTE a_$km = a_dist * .05 .
EXECUTE .
COMPUTE sov_$ = a_$km + a_$park .
EXECUTE .
COMPUTE sov_t = a_time .
EXECUTE .
IF (car_occ <2) s_ride_t = a_time +3 * 1.34 .
EXECUTE .
IF (car_occ  >= 2 ) s_ride_t = a_time +3 * car_occ -1.
EXECUTE .


comment  Add parking cost to fixed cost and save into appropriate variables.


IF (car_occ <2 ) s_ride_$ = ( a_dist * .05 + a_$park) / 2.34 .
EXECUTE .
IF (car_occ  >= 2 ) s_ride_$ = ( a_dist * .05 + a_$park) /car_occ .
EXECUTE .

comment   input the rounded value of expansion factor in the file.

COMPUTE fac_rnd = RND(fac) .
EXECUTE .

comment  Part 8 save the file.

SAVE OUTFILE='D:\mode_sp\pmpkpd.sav'
  /COMPRESSED.
```

Macro for Developing of Files for Various Trip Purposes

```
COMMENT: File for Home based work trip (higher level)

GET
 FILE='G:\policy\datamf\nadeem\tsp43\pmpkpdfiltered.sav'.
EXECUTE .

comment: selection of HBW trips
FILTER OFF.
USE ALL.
SELECT IF((purp_mc = "HBW")).
EXECUTE .


COMMENT: File for Home based work trip (lower level)

GET
 FILE='G:\policy\datamf\nadeem\tsp43\pmpkpdfiltered.sav'.
EXECUTE .

comment: Selection of HBW trips
FILTER OFF.
USE ALL.
SELECT IF((purp_mc = "HBW")).
EXECUTE .

comment: selection of walk and bike modes
FILTER OFF.
USE ALL.
SELECT IF(bike = 1 | walk = 1).
EXECUTE .

comment: filtering for num_bik = 0
FILTER OFF.
USE ALL.
SELECT IF((num_veh_ >= 1)).
EXECUTE.


COMMENT: File for Home based school trips (higher level)

GET
 FILE='G:\policy\datamf\nadeem\tsp43\pmpkpdfiltered.sav'.
EXECUTE .

comment: Selection of HBSchool trips
FILTER OFF.
USE ALL.
SELECT IF(purp_mc = "SSH") | (purp_mc = "SU").
EXECUTE .


COMMENT: File for Home based school trips (lower level)

GET
 FILE='G:\policy\datamf\nadeem\tsp43\pmpkpdfiltered.sav'.
EXECUTE .

comment: Selection of HBSchool trips
FILTER OFF.
```

```
USE ALL.
SELECT IF(purp_mc = "SSH") | (purp_mc = "SU").
EXECUTE .

comment: selection of walk and bike modes
FILTER OFF.
USE ALL.
SELECT IF(bike = 1 | walk = 1).
EXECUTE .

comment: filtering for num_bik = 0
FILTER OFF.
USE ALL.
SELECT IF((num_veh_ >= 1)).
EXECUTE.


COMMENT: File for Other trips (higher level)

GET
 FILE='G:\policy\datamf\nadeem\tsp43\pmpkpdfiltered.sav'.
EXECUTE .

comment: Selection of Other trips
FILTER OFF.
USE ALL.
SELECT IF(purp_mc = "LH") | (purp_mc = "OH") |
 (purp_mc = "NHB").
EXECUTE .

comment: filtering for num_bik = 0
FILTER OFF.
USE ALL.
SELECT IF((num_veh_ >= 1)).
EXECUTE.


comment: File for Other trips (lower level)

GET
 FILE='G:\policy\datamf\nadeem\tsp43\pmpkpdfiltered.sav'.
EXECUTE .

comment: Selection of Other trips
FILTER OFF.
USE ALL.
SELECT IF(purp_mc = "LH") | (purp_mc = "OH") |
 (purp_mc = "NHB").
EXECUTE .

comment: selection of walk and bike modes
FILTER OFF.
USE ALL.
SELECT IF(bike = 1 | walk = 1).
EXECUTE .

comment: filtering for num_bik = 0
FILTER OFF.
USE ALL.
SELECT IF((num_veh_ >= 1)).
EXECUTE.
```

Macro for Filtration

```
comment - select modes

FILTER OFF.
USE ALL.
SELECT IF(sov=1 | share_rd = 1 | transit = 1 | bike = 1 | walk = 1).
EXECUTE .
FILTER OFF.
USE ALL.


comment - exclude cases where school zone not coded (not used in filtering chart).
COMMENT 16 school trips (orig_pur=S and dest_pur=H) having "sch_zone <1" or .
comment    "sch_zone >185 & <248" are deleted.

FILTER OFF.
USE ALL.
SELECT IF(purp_mc = "HBW") | (purp_mc = "LH") | (purp_mc = "OH") |
 (purp_mc = "NHB") | (purp_mc = "SSH") | (purp_mc = "SU").
EXECUTE .



comment Part 3 Filter out records to obtain peak period valid records.
comment - select time interval.

SELECT IF(start_ti >= 1530 & start_ti <= 1759).
EXECUTE .



COMMENT:filtering for weeks for week 9 and onwards

FILTER OFF.
USE ALL.
SELECT IF((trip_wee >= 0) & (trip_wee <= 8)).
EXECUTE .



comment - filter out external-internal, internal-external trips and invalid zone numbers.

FILTER OFF.
USE ALL.
SELECT IF(orig_zon >= 1) & (orig_zon <= 258) & (dest_zon >= 1) & (dest_zon <= 258) .
EXECUTE .

FILTER OFF.
USE ALL.
SELECT IF (((orig_zon <=185) | (orig_zon >=201)) & ((dest_zon <=185) | (dest_zon >=201))) .
EXECUTE .



COMMENT: filtering for non-uta zones

FILTER OFF.
USE ALL.
SELECT IF((uta_flag = 1)).
EXECUTE .
```

```
COMMENT: exclude cases with zero co-ordinate distances

FILTER OFF.
USE ALL.
SELECT IF(orig_utm ~= dest_utm) | (v7 ~= v14).
EXECUTE .


comment - filter out invalid records with sex and age errors& or ommissions.

FILTER OFF.
USE ALL.
SELECT IF(sex = "M" | sex = "F").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(age >= 10 & age <= 98).
EXECUTE .


COMMENT: filtering for num_bik more than 10

FILTER OFF.
USE ALL.
SELECT IF((num_veh_ <= 10)).
EXECUTE .


Comment: filtering for num_bik = 0

FILTER OFF.
USE ALL.
SELECT IF((num_veh_ >= 1)).
EXECUTE.


COMMENT: filtering for no driving licenses

FILTER OFF.
USE ALL.
SELECT IF((LICENSE = "Y")).
EXECUTE.
```

Macro for Work Trip Model

```
comment  work4.sps APril 9/98  .
comment  auto cost 6.5cents per km .
comment parking cost zone 8=2.00 11=3.15 37=2.00 .
comment  tway) add zone 37.

GET
 FILE='K:\POLICY\DataM&F\mark\mode_sp\pmpkpd.sav'.
EXECUTE .


COMMENT: filtering for Hbw trips

FILTER OFF.
USE ALL.
SELECT IF((purp_mc = "HBW")).
EXECUTE .


IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon = 8)) a_$park = 2.0 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =11)) a_$park = 3.15 .
EXECUTE .
IF (pay_park = "Y" &(orig_zon = emp_zone) &purp_mc="HBW" & ( orig_zon =37 )) a_$park = 2.0 .
EXECUTE .


IF (pay_park = "N" & prime_mo="D") a_park = 0 .
EXECUTE .


COMMENT  estimate parking cost for other modes .

IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon = 2 | orig_zon = 3))
a_$park = 4.8 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =1 |  orig_zon =201))
a_$park = 4.2 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & ( orig_zon =154 )) a_$park =
3.75 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =32 | orig_zon = 5 |
orig_zon = 6)) a_$park = 3.6 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =255)) a_$park  =
3.30 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =10 | orig_zon = 18))
a_$park = 3.15 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =12)) a_$park = 3.0 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =25)) a_$park = 2.85
.
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =4 | orig_zon = 15 |
orig_zon = 30)) a_$park = 2.80 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =7 | orig_zon = 34))
a_$park = 2.50 .
EXECUTE .
```

```
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =160 | orig_zon = 31
| orig_zon = 254)) a_$park = 2.40 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =70 | orig_zon =78))
a_$park = 2.25 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =26)) a_$park = 2.1 .
EXECUTE .

IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =36 | orig_zon =52 |
orig_zon =71)) a_$park = 2.0 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =60)) a_$park = 1.90
.
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =14 | orig_zon = 16 |
orig_zon = 101)) a_$park = 1.80 .
EXECUTE .
IF ((prime_mo="P" | prime_mo= "T") &(orig_zon = emp_zone) &purp_mc="HBW" & (orig_zon =79 | orig_zon = 95 |
orig_zon = 155)) a_$park = 1.50 .
EXECUTE .


IF (orig_zon = 37) tway_o = 1 .


IF (sov = 1) choice = 1 .
EXECUTE .
IF (share_rd=1) choice = 1 .
EXECUTE .
IF (transit = 1) choice = 2 .
EXECUTE .
IF (bike = 1) choice = 3 .
EXECUTE .
IF (walk = 1) choice = 3 .
EXECUTE .


comment car ownership .

IF (num_veh = 0) veh_hh_r = 0 .
EXECUTE .
IF (num_veh = 1) veh_hh_r = 1 .
EXECUTE .
IF (num_veh > 1) veh_hh_r =2 .
EXECUTE .

comment sex recoding .

IF (sex="M") sex_r = 1 .
EXECUTE .
IF (sex="F") sex_r = 0 .
EXECUTE .

comment ln ivtt .

COMPUTE ivtt_la = LN(a_time) .
EXECUTE .
IF (t_ivtt > 0) ivtt_tl = LN(t_ivtt) .
EXECUTE .
IF (t_ivtt= 0) ivtt_tl = 0 .
EXECUTE .
```

```
comment ln ovtt .

COMPUTE  ovtt_la = 0 .
EXECUTE.
IF ((t_aux + t_bord + t_wait) > 0) ovtt_ltr = LN(t_wait + t_aux + t_bord) .
EXECUTE .
IF ((t_aux + t_bord + t_wait) = 0) ovtt_ltr = 0 .
EXECUTE .

comment ln total time.

COMPUTE time_aln = LN(a_time) .
EXECUTE .
COMPUTE TIME_TLN = LN( t_ivtt + t_wait + t_aux + t_bord) .
EXECUTE .


comment cost travel.

IF (car_occ > 0 ) a_cost  = ( a_dist *  05 + a_$park) / car_occ .
EXECUTE .
IF ( share_rd=1 & car_occ = 0 ) a_cost = ( a_dist * .05 + a_$park) / 2 .
EXECUTE .
IF ( transit = 1| bike=1 | walk=1) a_cost = ( a_dist * .05 + a_$park*2.0)/ (1.2528-.0032*a_dist) .
EXECUTE .


COMPUTE cbd_flag = 0 .
EXECUTE .
IF ((orig_zon >= 1 & orig_zon <=16) | (orig_zon = 201)  | (orig_zon >= 153 &
 orig_zon <= 155) | (orig_zon >= 254 & orig_zon <= 255)) cbd_flag = 1 .
EXECUTE .


SORT CASES BY
 hh_zone (A) .

MATCH FILES /FILE='
 /TABLE='K:\POLICY\DataM&F\mark\mode_sp\income.sav'
 /BY hh_zone.
EXECUTE.


COMPUTE cost_ina = a_cost * 10000/income .
EXECUTE .
COMPUTE cost_int = t_fare * 10000/income .
EXECUTE .


SAVE TRANSLATE OUTFILE='K:\policy\datam&f\nadeem\tsp43\revpkpd.xls'
 /TYPE=XLS /MAP /REPLA /FIELDNAMES.
```

Macro for School Trip Model

```
Comment: Developed by Nadeem on may 19, 1998


COMMENT: computing bike and walk times

COMPUTE bk_time = ((bk_dist) / 14.50) * 60 .
EXECUTE .
COMPUTE wk_time = ((wk_dist) / 3.5) * 60 .
EXECUTE .


COMMENT: filtering for school trips

FILTER OFF.
USE ALL.
SELECT IF((purp_mc = "SSH") | (purp_mc = "SU")).
EXECUTE .


COMMENT: filtering for num_bik more than 10

FILTER OFF.
USE ALL.
SELECT IF((num_veh_ <= 10)).
EXECUTE .


IF (sov = 1) choice = 1 .
EXECUTE .
IF (share_rd=1) choice = 1 .
EXECUTE .
IF (transit = 1) choice = 2
EXECUTE .
IF (bike = 1) choice = 3 .
EXECUTE .
IF (walk = 1) choice = 3 .
EXECUTE .


comment car ownership .

IF (num_veh = 0) veh_hh_r = 0 .
EXECUTE .
IF (num_veh = 1) veh_hh_r = 1 .
EXECUTE .
IF (num_veh > 1) veh_hh_r =2 .
EXECUTE .

comment  sex recoding .

IF (sex="M") sex_r = 1 .
EXECUTE .
IF (sex="F") sex_r = 0 .
EXECUTE .


comment cost travel.

COMPUTE a_$park = 0 .
EXECUTE .
```

```
IF ((orig_zon=25 ) & (orig_zon=sch_zone) & (student="S")) a_$park = 3 .
EXECUTE .
IF ((orig_zon=25 ) & (orig_zon=sch_zone) & (student="P")) a_$park = 3/2 .
EXECUTE .
IF ((orig_zon=25 ) & (orig_zon ~= sch_zone) & (student= "S"  | student= "P")) a_$park = 3/2 .
EXECUTE .


IF ((orig_zon=10 | orig_zon= 4 ) & (orig_zon=sch_zone) & (student="S")) a_$park = 3.5 .
EXECUTE .
IF ((orig_zon= 10 | orig_zon= 4 ) & (orig_zon=sch_zone) & (student="P")) a_$park = 3.5/2 .
EXECUTE .
IF ((orig_zon= 10 | orig_zon= 4 ) & (orig_zon ~= sch_zone) & (student="S" |  student= "P")) a_$park = 3.5/2 .
EXECUTE .


IF ((orig_zon= 60  ) & (orig_zon=sch_zone) & (student="S")) a_$park = 2 .
EXECUTE .
IF ((orig_zon= 60) & (orig_zon=sch_zone) & (student="P")) a_$park = 2/2 .
EXECUTE .
IF ((orig_zon= 60) & (orig_zon ~= sch_zone) & (student="S" | student= "P" )) a_$park = 2/2 .
EXECUTE .


IF ((orig_zon= 152 ) & (orig_zon=sch_zone) & (student="S")) a_$park = 3 5
EXECUTE .
IF ((orig_zon=152 ) & (orig_zon=sch_zone) & (student="P")) a_$park = 3.5/2 .
EXECUTE .
IF ((orig_zon= 152 ) & (orig_zon ~= sch_zone) & (student="S" |  student= "P")) a_$park = 3.5/2 .
EXECUTE .


COMPUTE a_$km = a_dist * .05 .
EXECUTE .

IF (car_occ > 0 ) a_cost  = ( a_$km + a_$park) / car_occ .
EXECUTE .
IF ( share_rd=1 & car_occ = 0 ) a_cost = ( a_$km + a_$park) / 2 .
EXECUTE .
IF ( transit = 1| bike=1 | walk=1) a_cost = ( a_$km + a_$park*2.0)/ (1.2528-.0032*a_dist) .
EXECUTE .


COMPUTE cbd_flag = 0 .
EXECUTE .
IF ((orig_zon >= 1 & orig_zon <=16) | (orig_zon = 201)  | (orig_zon >= 153 &
 orig_zon <= 155) | (orig_zon >= 254 & orig_zon <= 255)) cbd_flag = 1 .
EXECUTE .
```

Macro for Other Trip Model

```
comment  work4.sps APril 9/98  .
comment  auto cost 6.5cents per km .
comment parking cost zone 8=2.00 11=3.15 37=2.00 .
comment  tway) add zone 37.


COMMENT: filtering for non_hbw trips

FILTER OFF.
USE ALL.
SELECT IF((purp_mc = "NHB") | (purp_mc="LH") | (purp_mc= "OH")).
EXECUTE .

COMMENT: computing bike and walk times

COMPUTE bk_time = ((bk_dist) / 14.50) * 60 .
EXECUTE .
COMPUTE wk_time = ((wk_dist) / 3.5) * 60 .
EXECUTE .


COMMENT: filtering for num_bik more than 10

FILTER OFF.
USE ALL.
SELECT IF((num_veh_ <= 10)).
EXECUTE .


IF (pay_park = "Y"  & (orig_zon = 8)) a_$park = 2.0 .
EXECUTE .
IF (pay_park = "Y"  & (orig_zon =11)) a_$park = 3.15 .
EXECUTE .
IF (pay_park = "Y"  & ( orig_zon =37 )) a_$park = 2.0 .
EXECUTE .
IF (pay_park = "N" & prime_mo="D") a_park = 0 .
EXECUTE .


COMMENT  estimate parking cost for other modes .

IF ( (orig_zon = 2 | orig_zon = 3)) a_$park = 4.8 .
EXECUTE .
IF ( (orig_zon =1 |  orig_zon =201)) a_$park = 4.2 .
EXECUTE .
IF ( ( orig_zon =154 )) a_$park = 3.75 .
EXECUTE .
IF ( (orig_zon =32 | orig_zon = 5 | orig_zon = 6)) a_$park = 3.6 .
EXECUTE .
IF ( (orig_zon =255)) a_$park  = 3.30 .
EXECUTE .
IF ( (orig_zon =10 | orig_zon = 18)) a_$park = 3.15 .
EXECUTE .
IF ( (orig_zon =12)) a_$park = 3.0 .
EXECUTE .
IF ( (orig_zon =25)) a_$park = 2.85 .
EXECUTE .
IF ( (orig_zon =4 | orig_zon = 15 | orig_zon = 30)) a_$park = 2.80 .
EXECUTE .
```

```
IF ( (orig_zon =7 | orig_zon = 34)) a_$park = 2.50 .
EXECUTE .
IF ( (orig_zon =160 | orig_zon = 31 | orig_zon = 254)) a_$park = 2.40 .
EXECUTE .
IF (  (orig_zon =70 | orig_zon =78)) a_$park = 2.25 .
EXECUTE .
IF ( (orig_zon =26)) a_$park = 2.1 .
EXECUTE .
IF ( (orig_zon =36 | orig_zon =52 | orig_zon =71)) a_$park = 2.0 .
EXECUTE .
IF ( (orig_zon =60)) a_$park = 1.90 .
EXECUTE .
IF ( (orig_zon =14 | orig_zon = 16 | orig_zon = 101)) a_$park = 1.80 .
EXECUTE .
IF ( (orig_zon =79 | orig_zon = 95 | orig_zon = 155)) a_$park = 1.50 .
EXECUTE .

IF (orig_zon = 37) tway_o = 1 .
EXECUTE .

IF (sov = 1) choice = 1 .
EXECUTE .
IF (share_rd=1) choice = 1 .
EXECUTE .

IF (transit = 1) choice = 2 .
EXECUTE .
IF (bike = 1) choice = 3 .
EXECUTE .
IF (walk = 1) choice = 3 .
EXECUTE .

comment car ownership .

IF (num_veh = 0) veh_hh_r = 0 .
EXECUTE .
IF (num_veh = 1) veh_hh_r = 1 .
EXECUTE .
IF (num_veh > 1) veh_hh_r =2  .
EXECUTE .

comment  sex recoding .

IF (sex="M") sex_r = 1 .
EXECUTE .
IF (sex="F") sex_r = 0 .
EXECUTE .

comment cost travel.

IF (car_occ > 0 ) a_cost  = ( a_dist * .05 + a_$park) / car_occ .
EXECUTE .
IF ( share_rd=1 & car_occ = 0 ) a_cost = ( a_dist * .05 + a_$park) / 2 .
EXECUTE .
IF ( transit = 1| bike=1 | walk=1) a_cost = ( a_dist * .05 + a_$park*2.0)/ (1.2528-.0032*a_dist) .
EXECUTE .

COMPUTE cbd_flag = 0 .
EXECUTE .
IF ((orig_zon >= 1 & orig_zon <=16) | (orig_zon = 201)  | (orig_zon >= 153 &
 orig_zon <= 155) | (orig_zon >= 254 & orig_zon <= 255)) cbd_flag = 1 .
EXECUTE .
```

Parking cost for Other Trip

Comment: Computing parking cost for non-home based work / non-home based school trips (Other trips).
Comment: Developed by nadeem on 11/5/98.

```
COMPUTE a_cost = 0 .
EXECUTE .

IF (cbd_flag = 1 & car_occ > 0) a_cost = (a_$km + 5.0) / car_occ .
EXECUTE .

IF (cbd_flag = 1 & car_occ =  0) a_cost = (a_$km + 5.0) / 2 .
EXECUTE

IF (cbd_flag = 0 & car_occ  >   0) a_cost = a_$km  / car_occ .
EXECUTE .

IF (cbd_flag = 0 & car_occ   =    0) a_cost = a_$km / 2 .
EXECUTE .
```

Macro for xy_distance

```
COMMENT 1: creation of xy_dist variable depending on xy cordinates


COMPUTE  deltaX = ABS((dest_utm) - (orig_utm)) .

COMPUTE deltaY = ABS((v14) - (v7)) .

COMPUTE xy_dist = SQRT((deltax) ** 2 + (deltay) ** 2) / 1000 .
EXECUTE .
```

Macro for Speed Zones

```
USE ALL.
COMPUTE filter_$=(((((orig_zon >= 1) & (orig_zon <= 3)) | ((orig_zon >= 11) &
 (orig_zon <= 17))) &(((dest_zon >= 1) & (dest_zon <= 3)) | ((dest_zon  >=
 11) & (dest_zon <= 17))) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 1) & (orig_zon <= 3)) | ((orig_zon'+
' >= 11) & (orig_zon <= 17))) &(((dest_zon >= 1) & (dest_zo... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 4) & (orig_zon <= 10)) | (orig_zon = 201))
 & (((dest_zon >= 4) & (dest_zon <= 10)) | (dest_zon = 201)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 4) & (orig_zon <= 10)) | (orig_zon ='+
' 201)) & (((dest_zon >= 4) & (dest_zon <= 10)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 90) & (orig_zon <= 98)) | (orig_zon = 100))
 & (((dest_zon >= 90) & (dest_zon <= 98)) | (dest_zon = 100)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 90) & (orig_zon <= 98)) | (orig_zon ='+
' 100)) & (((dest_zon >= 90) & (dest_zon <= 98)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=(((((orig_zon >= 33) & (orig_zon <= 49)) | (orig_zon = 50))
 & (((dest_zon >= 33) & (dest_zon <= 49)) | (dest_zon = 50)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 33) & (orig_zon <= 49)) | (orig_zon ='+
' 50)) & (((dest_zon >= 33) & (dest_zon <= 49)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
```

```
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 101) & (orig_zon <= 107)) | (orig_zon = 99)
 | (orig_zon = 109) | (orig_zon = 110)) & (((dest_zon >= 101) & (dest_zon <=
 107)) | (dest_zon = 99) | (dest_zon = 109) | (dest_zon = 110)) & (a_dist ~=
 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 101) & (orig_zon <= 107)) |'+
' (orig_zon = 99) | (orig_zon = 109) | (orig_zon = 110)) & (((dest...'+
' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 81) & (orig_zon <= 83)) | (orig_zon = 88)
 | (orig_zon = 89)) & (((dest_zon >= 81) & (dest_zon <= 83)) | (dest_zon = 88) | (dest_zon = 89)) &
 (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 81) & (orig_zon <= 83)) |'+
' (orig_zon = 88) | (orig_zon = 89)) & (((dest...'+ ' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 71) & (orig_zon <= 80)) | ((orig_zon >= 84) &
 (orig_zon <= 87)) | (orig_zon = 112)) & (((dest_zon >= 71) & (dest_zon <= 80)) | ((dest_zon  >=
 84) & (dest_zon <= 87)) | (dest_zon = 112)) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 71) & (orig_zon <= 80)) | ((orig_zon'+
' >= 84) & (orig_zon <= 87)) | (orig_zon = 112)) &(((dest_zon >= 71) & (dest_zo... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=(((((orig_zon >=20 ) & (orig_zon <= 25)) & ((dest_zon  >=
 20) & (dest_zon <= 25))) & (a_dist ~= 0) & (t_bord ~= 0))).
```

```
VARIABLE LABEL filter_$ '((((orig_zon >=20 ) & (orig_zon <= 25)) & ((dest_zon'+
' >= 20) & (dest_zon <= 25))) & (a_dist ~= 0) & (t_bord ... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 18) & (orig_zon <= 25)) | ((orig_zon >= 28) &
  (orig_zon <= 32))) &(((dest_zon >= 18) & (dest_zon <= 25)) | ((dest_zon  >=
  28) & (dest_zon <= 32))) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 18) & (orig_zon <= 25)) | ((orig_zon'+
' >= 28) & (orig_zon <= 32))) &(((dest_zon >= 18) & (dest_zo... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 26) & (orig_zon <= 27)) | (orig_zon = 58))
  & (((dest_zon >= 26) & (dest_zon <= 27)) | (dest_zon = 58)) & (a_dist ~= 0)
  & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 26) & (orig_zon <= 27)) | (orig_zon ='+
' 58)) & (((dest_zon >= 26) & (dest_zon <= 27)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=((((((orig_zon >= 53) & (orig_zon <= 57)) | ((orig_zon >=
  59) &
  (orig_zon <= 65)) | (orig_zon = 51) |  (orig_zon = 123) |   (orig_zon =
  67))) &
 (((dest_zon >= 53) & (dest_zon <= 57)) | ((dest_zon  >= 59) &     (dest_zon
  <= 65)) | (dest_zon = 51) | (dest_zon = 123) |     (dest_zon = 67)))  &
  (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '(((((orig_zon >= 53) & (orig_zon <= 57)) |'+
' ((orig_zon >= 59) &'+
'  (orig_zon <= 65)) | (orig_zon = 51) |  (or... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
```

```
FREQUENCIES
  VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=((((orig_zon = 66) | (orig_zon = 120)) & ((dest_zon=66) |
  (dest_zon=120)) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((orig_zon = 66) | (orig_zon = 120)) &'+
 ' ((dest_zon=66) | (dest_zon=120)) & (a_dist ~= 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_S=(((((orig_zon >= 68) & (orig_zon <= 69)) | (orig_zon = 70)
  | (orig_zon = 113) | (orig_zon = 117)) & (((dest_zon >= 68) & (dest_zon <=
  69)) | (dest_zon = 70) | (dest_zon = 113) | (dest_zon = 117)) & (a_dist ~=
  0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 68) & (orig_zon <= 69)) |'+
 ' (orig_zon = 70) | (orig_zon = 113) | (orig_zon = 117)) & (((dest...'+
 ' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_S (f1.0).
FILTER BY filter_S.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 114) & (orig_zon <= 116)) | (orig_zon = 232))
  & (((dest_zon >=114) & (dest_zon <= 116)) | (dest_zon =232)) & (a_dist ~= 0)
  & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 114) & (orig_zon <= 116)) | (orig_zon ='+
 ' 232)) & (((dest_zon >= 114) & (dest_zon <= 116)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=((((orig_zon = 111) | (orig_zon=233)) & ((dest_zon = 111) |
```

```
 (dest_zon=233)) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((orig_zon = 111) | (orig_zon=233)) & ((dest_zon ='+
' 111) | (dest_zon=233)) & (a_dist ~= 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=((((((orig_zon >= 235) & (orig_zon <= 241)) | ((orig_zon  >=
  143) & (orig_zon  <= 144)) | ((orig_zon >= 202) & (orig_zon <= 204)) |
 (orig_zon=247)) & (((dest_zon >= 235) & (dest_zon <= 241)) | ((dest_zon  >=
 143)  &  (dest_zon  <= 144)) | ((dest_zon >= 202) & (dest_zon <= 204)) |
 (dest_zon=247))) &
(a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((((orig_zon >= 235) & (orig_zon <= 241)) |'+
' ((orig_zon  >=  143) & (orig_zon  <= 144)) | ((orig_zon >= 202)...'+
' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 243) & (orig_zon <= 246)) | (orig_zon = 145))
 & (((dest_zon >= 243) & (dest_zon <= 246)) | (dest_zon = 145)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 243) & (orig_zon <= 246)) | (orig_zon ='+
' 145)) & (((dest_zon >= 243) & (dest_zon <= 246)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 140) & (orig_zon <= 141)) | ((orig_zon >= 227) &
 (orig_zon <= 231))) &(((dest_zon >= 140) & (dest_zon <= 141)) | ((dest_zon  >=
 227) & (dest_zon <= 231))) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 140) & (orig_zon <= 141)) | ((orig_zon'+
' >= 227) & (orig_zon <= 231))) &(((dest_zon >= 140) & (dest_zo... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
```

```
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .

 --

USE ALL.
COMPUTE filter_$=(((((orig_zon >= 221) & (orig_zon <= 221)) | (orig_zon = 136)
 | (orig_zon = 225) | (orig_zon = 226)) & (((dest_zon >= 221) & (dest_zon <=
 221)) | (dest_zon = 136) | (dest_zon = 225) | (dest_zon = 226)) & (a_dist ~=
 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 221) & (orig_zon <= 221)) |'+
' (orig_zon = 136) | (orig_zon = 225) | (orig_zon = 226)) & (((dest...'+
' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 222) & (orig_zon <= 224)) | (orig_zon = 137))
 & (((dest_zon >= 222) & (dest_zon <= 224)) | (dest_zon = 137)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 222) & (orig_zon <= 224)) | (orig_zon ='+
' 137)) & (((dest_zon >= 222) & (dest_zon <= 224)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1 0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=((((orig_zon = 134) | (orig_zon=135)) & ((dest_zon = 134) |
 (dest_zon=135)) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((orig_zon = 134) | (orig_zon=135)) & ((dest_zon ='+
' 134) | (dest_zon=135)) & (a_dist ~= 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
```

```
COMPUTE filter_$=(((((orig_zon >= 216) & (orig_zon <= 220)) | (orig_zon = 214)
 | (orig_zon = 129) | (orig_zon = 130)) & (((dest_zon >= 216) & (dest_zon <=
 220)) | (dest_zon = 214) | (dest_zon = 129) | (dest_zon = 130)) & (a_dist ~=
 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 216) & (orig_zon <= 220)) |'+
' (orig_zon = 214) | (orig_zon = 129) | (orig_zon = 130)) & (((dest...'+
' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 212) & (orig_zon <= 213)) | (orig_zon = 215)
 | (orig_zon = 132)) & (((dest_zon >= 212) & (dest_zon <= 213)) | (dest_zon = 215) | (dest_zon = 132)) &
 (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 212) & (orig_zon <= 213)) |'+
' (orig_zon = 215) | (orig_zon = 132)) & (((dest...'+ ' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 210) & (orig_zon <= 211)) | (orig_zon = 206)
 | (orig_zon = 131)) & (((dest_zon >= 210) & (dest_zon <= 211)) | (dest_zon = 206) | (dest_zon = 131)) &
 (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 210) & (orig_zon <= 211)) |'+
' (orig_zon = 206) | (orig_zon = 131)) & (((dest...'+ ' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=((((orig_zon = 207) | (orig_zon=209)) & ((dest_zon = 207) |
 (dest_zon=209)) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((orig_zon = 207) | (orig_zon=209)) & ((dest_zon ='+
' 207) | (dest_zon=209)) & (a_dist ~= 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
```

```
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=((((orig_zon = 149) | (orig_zon=150)) & ((dest_zon = 149) |
 (dest_zon=150)) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((orig_zon = 149) | (orig_zon=150)) & ((dest_zon ='+
' 149) | (dest_zon=150)) & (a_dist ~= 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=(((((orig_zon >= 146) & (orig_zon <= 147)) | (orig_zon = 151)
 | (orig_zon = 256)) & (((dest_zon >= 146) & (dest_zon <= 147)) | (dest_zon = 151) | (dest_zon = 256)) &
 (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 146) & (orig_zon <= 147)) |'+
' (orig_zon = 151) | (orig_zon = 256)) & (((dest...'+ ' (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=(((((orig_zon >= 257) & (orig_zon <= 258)) | (orig_zon = 148))
 & (((dest_zon >= 257) & (dest_zon <= 258)) | (dest_zon = 148)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 257) & (orig_zon <= 258)) | (orig_zon ='+
' 148)) & (((dest_zon >= 257) & (dest_zon <= 258)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=(((((orig_zon >= 158) & (orig_zon <= 161)) | (orig_zon = 164))
 & (((dest_zon >= 158) & (dest_zon <= 161)) | (dest_zon = 164)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 158) & (orig_zon <= 161)) | (orig_zon ='+
```

```
' 164)) & (((dest_zon >= 158) & (dest_zon <= 161)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 153) & (orig_zon <= 155)) | ((orig_zon >= 254) &
 (orig_zon <= 255))) &(((dest_zon >= 153) & (dest_zon <= 155)) | ((dest_zon  >=
 254) & (dest_zon <= 255))) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 153) & (orig_zon <= 155)) | ((orig_zon'+
' >= 254) & (orig_zon <= 255))) &(((dest_zon >= 153) & (dest_zo... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 156) & (orig_zon <= 157)) | (orig_zon = 162)
 | (orig_zon = 164) | (orig_zon = 184)) & (((dest_zon >= 156) & (dest_zon <=
 157)) | (dest_zon = 162) | (dest_zon = 164) | (dest_zon = 184)) & (a_dist ~=
 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 156) & (orig_zon <= 157)) |'+
' (orig_zon = 162) | (orig_zon = 164) | (orig_zon = 184)) & (((dest...'+
' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=((((orig_zon = 165) | (orig_zon=253)) & ((dest_zon = 165) |
 (dest_zon=253)) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((orig_zon = 165) | (orig_zon=253)) & ((dest_zon ='+
' 165) | (dest_zon=253)) & (a_dist ~= 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .
```

```
USE ALL.
COMPUTE filter_$=(((((orig_zon >= 169) & (orig_zon <= 170)) | (orig_zon = 166))
 & (((dest_zon >= 169) & (dest_zon <= 170)) | (dest_zon = 166)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 169) & (orig_zon <= 170)) | (orig_zon ='+
' 166)) & (((dest_zon >= 169) & (dest_zon <= 170)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 167) & (orig_zon <= 168)) | (orig_zon = 252))
 & (((dest_zon >= 167) & (dest_zon <= 168)) | (dest_zon = 252)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 167) & (orig_zon <= 168)) | (orig_zon ='+
' 252)) & (((dest_zon >= 167) & (dest_zon <= 168)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 171) & (orig_zon <= 173)) | ((orig_zon >= 249) &
 (orig_zon <= 251))) &(((dest_zon >= 171) & (dest_zon <=173)) | ((dest_zon  >=
 249) & (dest_zon <= 251))) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 171) & (orig_zon <= 173)) | ((orig_zon'+
' >= 249) & (orig_zon <= 251))) &(((dest_zon >= 171) & (dest_zo... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 174) & (orig_zon <= 175)) | (orig_zon = 248))
 & (((dest_zon >= 174) & (dest_zon <= 175)) | (dest_zon = 248)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 174) & (orig_zon <= 175)) | (orig_zon ='+
' 248)) & (((dest_zon >= 174) & (dest_zon <= 175)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
```

```
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd orig_zon dest_zon
 /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=(((((orig_zon >= 177) & (orig_zon <= 178)) | (orig_zon = 181)
 | (orig_zon = 185)) & (((dest_zon >= 177) & (dest_zon <= 178)) | (dest_zon = 181) | (dest_zon = 185)) &
 (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 177) & (orig_zon <= 178)) |'+
' (orig_zon = 181) | (orig_zon = 185)) & (((dest...'+ ' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .
```

Macro for New Speed Zones

```
COMMENT development of new speed zones
COMMENT run this macro on pkpd2

USE ALL.
COMPUTE filter_$=(((orig_zon = 12) | (orig_zon=13)) & ((dest_zon = 12) |
 (dest_zon=13)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 12) | (orig_zon=13)) & ((dest_zon = 12)'+
' | (dest_zon=13)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 3) | (orig_zon=11)) & ((dest_zon = 3) |
 (dest_zon=11)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 3) | (orig_zon=11)) & ((dest_zon = 3)'+
' | (dest_zon=11)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 6) | (orig_zon=7)) & ((dest_zon = 6) |
 (dest_zon=7)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 6) | (orig_zon=7)) & ((dest_zon = 6)'+
' | (dest_zon=7)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 7) | (orig_zon=8)) & ((dest_zon = 7) |
 (dest_zon=8)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 7) | (orig_zon=8)) & ((dest_zon = 7)'+
' | (dest_zon=8)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
```

```
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 95) | (orig_zon=96)) & ((dest_zon = 95) |
 (dest_zon=96)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 95) | (orig_zon=96)) & ((dest_zon = 95)'+
' | (dest_zon=96)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 97) | (orig_zon=100)) & ((dest_zon = 97) |
 (dest_zon=100)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 97) | (orig_zon=100)) & ((dest_zon = 97)'+
' | (dest_zon=100)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 38) | (orig_zon=40)) & ((dest_zon = 38) |
 (dest_zon=40)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 38) | (orig_zon=40)) & ((dest_zon = 38)'+
' | (dest_zon=40)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 47) | (orig_zon=48)) & ((dest_zon = 47) |
```

```
 (dest_zon=48)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 47) | (orig_zon=48)) & ((dest_zon = 47)'+
' | (dest_zon=48)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 102) | (orig_zon=103)) & ((dest_zon = 102) |
 (dest_zon=103)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 102) | (orig_zon=103)) & ((dest_zon = 102)'+
' | (dest_zon=103)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 107) | (orig_zon=109)) & ((dest_zon = 107) |
 (dest_zon=109)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 107) | (orig_zon=109)) & ((dest_zon = 107)'+
' | (dest_zon=109)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 82) | (orig_zon=83)) & ((dest_zon = 82) |
 (dest_zon=83)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 82) | (orig_zon=83)) & ((dest_zon = 82)'+
' | (dest_zon=83)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .
```

```
USE ALL.
COMPUTE filter_$=(((orig_zon = 83) | (orig_zon=89)) & ((dest_zon = 83) |
 (dest_zon=89)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 83) | (orig_zon=89)) & ((dest_zon = 83)'+
' | (dest_zon=89)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 75) | (orig_zon=77)) & ((dest_zon = 75) |
 (dest_zon=77)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 75) | (orig_zon=77)) & ((dest_zon = 75)'+
' | (dest_zon=77)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 84) | (orig_zon=85)) & ((dest_zon = 84) |
 (dest_zon=85)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 84) | (orig_zon=85)) & ((dest_zon = 84)'+
' | (dest_zon=85)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 20) | (orig_zon=24)) & ((dest_zon = 20) |
 (dest_zon=24)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 20) | (orig_zon=24)) & ((dest_zon = 20)'+
' | (dest_zon=24)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
```

```
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 19) | (orig_zon=20)) & ((dest_zon = 19) |
 (dest_zon=20)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 19) | (orig_zon=20)) & ((dest_zon = 19)'+
' | (dest_zon=20)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 27) | (orig_zon=58)) & ((dest_zon = 27) |
 (dest_zon=58)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 27) | (orig_zon=58)) & ((dest_zon = 27)'+
' | (dest_zon=58)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 26) | (orig_zon=27)) & ((dest_zon = 26) |
 (dest_zon=27)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 26) | (orig_zon=27)) & ((dest_zon = 26)'+
' | (dest_zon=27)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 64) | (orig_zon=65)) & ((dest_zon = 64) |
 (dest_zon=65)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 64) | (orig_zon=65)) & ((dest_zon = 64)'+
' | (dest_zon=65)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
```

```
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 53) | (orig_zon=54)) & ((dest_zon = 53) |
  (dest_zon=54)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 53) | (orig_zon=54)) & ((dest_zon = 53)'+
' | (dest_zon=54)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 66) | (orig_zon=120)) & ((dest_zon = 66) |
  (dest_zon=120)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 66) | (orig_zon=120)) & ((dest_zon = 66)'+
' | (dest_zon=120)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 69) | (orig_zon=113)) & ((dest_zon = 69) |
  (dest_zon=113)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 69) | (orig_zon=113)) & ((dest_zon = 69)'+
' | (dest_zon=113)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
```

```
COMPUTE filter_$=(((orig_zon = 113) | (orig_zon=117)) & ((dest_zon = 113) |
 (dest_zon=117)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 113) | (orig_zon=117)) & ((dest_zon = 113)'+
' | (dest_zon=117)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 115) | (orig_zon=116)) & ((dest_zon = 115) |
 (dest_zon=116)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 115) | (orig_zon=116)) & ((dest_zon = 115)'+
' | (dest_zon=116)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 115) | (orig_zon=232)) & ((dest_zon = 115) |
 (dest_zon=232)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 115) | (orig_zon=232)) & ((dest_zon = 115)'+
' | (dest_zon=232)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 111) | (orig_zon=233)) & ((dest_zon = 111) |
 (dest_zon=233)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 111) | (orig_zon=233)) & ((dest_zon = 111)'+
' | (dest_zon=233)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .
```

```
USE ALL.
COMPUTE filter_$=(((orig_zon = 238) | (orig_zon=239)) & ((dest_zon = 238) |
 (dest_zon=239)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 238) | (orig_zon=239)) & ((dest_zon = 238)'+
' | (dest_zon=239)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 143) | (orig_zon=237)) & ((dest_zon = 143) |
 (dest_zon=237)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 143) | (orig_zon=237)) & ((dest_zon = 143)'+
' | (dest_zon=237)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 230) | (orig_zon=231)) & ((dest_zon = 230) |
 (dest_zon=231)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 230) | (orig_zon=231)) & ((dest_zon = 230)'+
' | (dest_zon=231)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 136) | (orig_zon=225)) & ((dest_zon = 136) |
 (dest_zon=225)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 136) | (orig_zon=225)) & ((dest_zon = 136)'+
' | (dest_zon=225)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
```

```
  VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 129) | (orig_zon=220)) & ((dest_zon = 129) |
  (dest_zon=220)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 129) | (orig_zon=220)) & ((dest_zon = 129)'+
 ' | (dest_zon=220)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 130) | (orig_zon=220)) & ((dest_zon = 130) |
  (dest_zon=220)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 130) | (orig_zon=220)) & ((dest_zon = 130)'+
 ' | (dest_zon=220)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 131) | (orig_zon=211)) & ((dest_zon = 131) |
  (dest_zon=211)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 131) | (orig_zon=211)) & ((dest_zon = 131)'+
 ' | (dest_zon=211)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 210) | (orig_zon=211)) & ((dest_zon = 210) |
  (dest_zon=211)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 210) | (orig_zon=211)) & ((dest_zon = 210)'+
 ' | (dest_zon=211)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
```

```
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 207) | (orig_zon=209)) & ((dest_zon = 207) |
  (dest_zon=209)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 207) | (orig_zon=209)) & ((dest_zon = 207)'+
' | (dest_zon=209)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 149) | (orig_zon=150)) & ((dest_zon = 149) |
  (dest_zon=150)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 149) | (orig_zon=150)) & ((dest_zon = 149)'+
' | (dest_zon=150)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 150) | (orig_zon=256)) & ((dest_zon = 150) |
  (dest_zon=256)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 150) | (orig_zon=256)) & ((dest_zon = 150)'+
' | (dest_zon=256)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .
```

```
USE ALL.
COMPUTE filter_$=(((orig_zon = 257) | (orig_zon=258)) & ((dest_zon = 257) |
 (dest_zon=258)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 257) | (orig_zon=258)) & ((dest_zon = 257)'+
' | (dest_zon=258)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 148) | (orig_zon=258)) & ((dest_zon = 148) |
 (dest_zon=258)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 148) | (orig_zon=258)) & ((dest_zon = 148)'+
' | (dest_zon=258)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 159) | (orig_zon=161)) & ((dest_zon = 159) |
 (dest_zon=161)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 159) | (orig_zon=161)) & ((dest_zon = 159)'+
' | (dest_zon=161)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 158) | (orig_zon=159)) & ((dest_zon = 158) |
 (dest_zon=159)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 158) | (orig_zon=159)) & ((dest_zon = 158)'+
' | (dest_zon=159)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
```

```
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 153) | (orig_zon=155)) & ((dest_zon = 153) |
 (dest_zon=155)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 153) | (orig_zon=155)) & ((dest_zon = 153)'+
' | (dest_zon=155)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 153) | (orig_zon=254)) & ((dest_zon = 153) |
 (dest_zon=254)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 153) | (orig_zon=254)) & ((dest_zon = 153)'+
' | (dest_zon=254)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 156) | (orig_zon=157)) & ((dest_zon = 156) |
 (dest_zon=157)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 156) | (orig_zon=157)) & ((dest_zon = 156)'+
' | (dest_zon=157)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 162) | (orig_zon=164)) & ((dest_zon = 162) |
 (dest_zon=164)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 162) | (orig_zon=164)) & ((dest_zon = 162)'+
' | (dest_zon=164)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
```

```
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 165) | (orig_zon=253)) & ((dest_zon = 165) |
 (dest_zon=253)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 165) | (orig_zon=253)) & ((dest_zon = 165)'+
' | (dest_zon=253)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 166) | (orig_zon=169)) & ((dest_zon = 166) |
 (dest_zon=169)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 166) | (orig_zon=169)) & ((dest_zon = 166)'+
' | (dest_zon=169)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 169) | (orig_zon=170)) & ((dest_zon = 169) |
 (dest_zon=170)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 169) | (orig_zon=170)) & ((dest_zon = 169)'+
' | (dest_zon=170)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 167) | (orig_zon=168)) & ((dest_zon = 167) |
```

```
 (dest_zon=168)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 167) | (orig_zon=168)) & ((dest_zon = 167)'+
' | (dest_zon=168)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 167) | (orig_zon=252)) & ((dest_zon = 167) |
 (dest_zon=252)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 167) | (orig_zon=252)) & ((dest_zon = 167)'+
' | (dest_zon=252)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 173) | (orig_zon=250)) & ((dest_zon = 173) |
 (dest_zon=250)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 173) | (orig_zon=250)) & ((dest_zon = 173)'+
' | (dest_zon=250)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((orig_zon = 172) | (orig_zon=249)) & ((dest_zon = 172) |
 (dest_zon=249)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 172) | (orig_zon=249)) & ((dest_zon = 172)'+
' | (dest_zon=249)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .
```

```
USE ALL.
COMPUTE filter_$=(((orig_zon = 175) | (orig_zon=248)) & ((dest_zon = 175) |
 (dest_zon=248)) & (a_dist ~= 0) & (t_dist ~= 0)).
VARIABLE LABEL filter_$ '((orig_zon = 175) | (orig_zon=248)) & ((dest_zon = 175)'+
' | (dest_zon=248)) & (a_dist ~= 0) & (t_dist ~= 0) (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .
```

Macro for Auto and Transit Distance Ratios

```
IF ((a_dist ~= 0) & (distance ~= 0)) a_ratio = a_dist / distance .
EXECUTE .
IF ((t_dist ~= 0) & (distance ~= 0)) t_ratio = t_dist / distance .
EXECUTE .
```

Macro for Bike Walk - Time Distance Coding

```
F ((bk_dist > 0) & (bk_dist <= 1)) bk_dist = 1 .
EXECUTE .
iF ((bk_dist > 1) & (bk_dist <= 2)) bk_dist = 2 .
EXECUTE .

iF ((bk_dist > 2) & (bk_dist <= 3)) bk_dist = 3 .
EXECUTE .

IF ((bk_dist > 3) & (bk_dist <= 4)) bk_dist = 4 .
EXECUTE .
iF ((bk_dist > 4) & (bk_dist <= 5)) bk_dist = 5.
EXECUTE .

iF ((bk_dist > 5) & (bk_dist <= 6)) bk_dist = 6 .
EXECUTE .
IF ((bk_dist > 6) & (bk_dist <= 7)) bk_dist = 7 .
EXECUTE .
iF ((bk_dist > 7) & (bk_dist <= 8)) bk_dist = 8.
EXECUTE .

iF ((bk_dist > 8) & (bk_dist <= 9)) bk_dist = 9 .
EXECUTE .
IF ((bk_dist > 9) & (bk_dist <= 10)) bk_dist = 10 .
EXECUTE .
iF ((bk_dist > 10) & (bk_dist <= 11)) bk_dist = 11 .
EXECUTE .

iF ((bk_dist > 11) & (bk_dist <= 12)) bk_dist = 12 .
EXECUTE .

IF ((bk_dist > 12) & (bk_dist <= 13)) bk_dist = 13 .
EXECUTE .
iF ((bk_dist > 13) & (bk_dist <= 14)) bk_dist = 14 .
EXECUTE .

iF ((bk_dist > 14) & (bk_dist <= 15)) bk_dist = 15 .
EXECUTE .
IF ((bk_dist > 15) & (bk_dist <= 16)) bk_dist = 16 .
EXECUTE .
iF ((bk_dist > 16) & (bk_dist <= 17)) bk_dist = 17 .
EXECUTE .

iF ((bk_dist > 17) & (bk_dist <= 18)) bk_dist = 18 .
EXECUTE .
IF ((bk_dist > 18) & (bk_dist <= 19)) bk_dist = 19 .
EXECUTE .
iF ((bk_dist > 19) & (bk_dist <= 20)) bk_dist = 20 .
EXECUTE .
IF ((bk_dist > 20) & (bk_dist <= 21)) bk_dist = 21 .
EXECUTE .
iF ((bk_dist > 21) & (bk_dist <= 22)) bk_dist = 22 .
EXECUTE .

iF ((bk_dist > 22) & (bk_dist <= 23)) bk_dist = 23 .
EXECUTE .

IF ((bk_dist > 23) & (bk_dist <= 24)) bk_dist = 24 .
EXECUTE .
iF ((bk_dist > 24) & (bk_dist <= 25)) bk_dist = 25.
EXECUTE .
```

```
iF ((bk_dist  > 25) & (bk_dist  <= 26)) bk_dist = 26 .
EXECUTE .
IF ((bk_dist  > 26) & (bk_dist  <= 27)) bk_dist = 27 .
EXECUTE .
iF ((bk_dist  > 27) & (bk_dist  <= 28)) bk_dist = 28.
EXECUTE .

iF ((bk_dist  > 28) & (bk_dist  <= 29)) bk_dist = 29 .
EXECUTE .
IF ((bk_dist  > 29) & (bk_dist  <= 30)) bk_dist = 30 .
EXECUTE .
iF ((bk_dist  > 30) & (bk_dist  <= 31)) bk_dist = 31 .
EXECUTE .

iF ((bk_dist  > 31) & (bk_dist  <= 32)) bk_dist = 32 .
EXECUTE .

IF ((bk_dist  > 32) & (bk_dist  <= 33)) bk_dist = 33 .
EXECUTE .
iF ((bk_dist  > 33) & (bk_dist  <= 34)) bk_dist = 34 .
EXECUTE .

iF ((bk_dist  > 34) & (bk_dist  <= 35)) bk_dist = 35 .
EXECUTE .
IF ((bk_dist  > 35) & (bk_dist  <= 36)) bk_dist = 36 .
EXECUTE .
iF ((bk_dist  > 36) & (bk_dist  <= 37)) bk_dist = 37 .
EXECUTE .

iF ((bk_dist  > 37) & (bk_dist  <= 38)) bk_dist = 38 .
EXECUTE .
IF ((bk_dist  > 38) & (bk_dist  <= 39)) bk_dist = 39 .
EXECUTE .
iF ((bk_dist  > 39) & (bk_dist  <= 40)) bk_dist = 40 .
EXECUTE .
IF ((bk_dist  > 40) & (bk_dist  <= 41)) bk_dist = 41 .
EXECUTE .
iF ((bk_dist  > 41) & (bk_dist  <= 42)) bk_dist = 42 .
EXECUTE .

iF ((bk_dist  > 42) & (bk_dist  <= 43)) bk_dist = 43 .
EXECUTE .

IF ((bk_dist  > 43) & (bk_dist  <= 44)) bk_dist = 44 .
EXECUTE .
iF ((bk_dist  > 44) & (bk_dist  <= 45)) bk_dist = 45.
EXECUTE .

iF ((bk_dist  > 45) & (bk_dist  <= 46)) bk_dist = 46 .
EXECUTE .
IF ((bk_dist  > 46) & (bk_dist  <= 47)) bk_dist = 47 .
EXECUTE .
iF ((bk_dist  > 47) & (bk_dist  <= 48)) bk_dist = 48.
EXECUTE .

iF ((bk_dist  > 48) & (bk_dist  <= 49)) bk_dist = 49 .
EXECUTE .
IF ((bk_dist  > 49) & (bk_dist  <= 50)) bk_dist = 50 .
EXECUTE .
iF ((bk_dist  > 50) & (bk_dist  <= 51)) bk_dist = 51 .
EXECUTE .
```

```
iF ((bk_dist  > 51) & (bk_dist  <= 52)) bk_dist = 52 .
EXECUTE .

IF ((bk_dist  > 52) & (bk_dist  <= 53)) bk_dist = 53 .
EXECUTE .
iF ((bk_dist  > 53) & (bk_dist  <= 54)) bk_dist = 54 .
EXECUTE .

iF ((bk_dist  > 54) & (bk_dist  <= 55)) bk_dist = 55 .
EXECUTE .
IF ((bk_dist  > 55) & (bk_dist  <= 56)) bk_dist = 56 .
EXECUTE .
iF ((bk_dist  > 56) & (bk_dist  <= 57)) bk_dist = 57 .
EXECUTE .

iF ((bk_dist  > 57) & (bk_dist  <= 58)) bk_dist = 58 .
EXECUTE .
IF ((bk_dist  > 58) & (bk_dist  <= 59)) bk_dist = 59 .
EXECUTE .
iF ((bk_dist  > 59) & (bk_dist  <= 60)) bk_dist = 60 .
EXECUTE .


IF ((bk_time  > 0) & (bk_time  <= 1)) bk_time = 1 .
EXECUTE .
iF ((bk_time  > 1) & (bk_time  <= 2)) bk_time = 2 .
EXECUTE .

iF ((bk_time  > 2) & (bk_time  <= 3)) bk_time = 3 .
EXECUTE .

IF ((bk_time  > 3) & (bk_time  <= 4)) bk_time = 4 .
EXECUTE .
iF ((bk_time  > 4) & (bk_time  <= 5)) bk_time = 5.
EXECUTE .

iF ((bk_time  > 5) & (bk_time  <= 6)) bk_time = 6 .
EXECUTE .
IF ((bk_time  > 6) & (bk_time  <= 7)) bk_time = 7 .
EXECUTE .
iF ((bk_time  > 7) & (bk_time  <= 8)) bk_time = 8.
EXECUTE .

iF ((bk_time  > 8) & (bk_time  <= 9)) bk_time = 9 .
EXECUTE .
IF ((bk_time  > 9) & (bk_time  <= 10)) bk_time = 10 .
EXECUTE .
iF ((bk_time  > 10) & (bk_time  <= 11)) bk_time = 11 .
EXECUTE .

iF ((bk_time  > 11) & (bk_time  <= 12)) bk_time = 12 .
EXECUTE .

IF ((bk_time  > 12) & (bk_time  <= 13)) bk_time = 13 .
EXECUTE .
iF ((bk_time  > 13) & (bk_time  <= 14)) bk_time = 14 .
EXECUTE .

iF ((bk_time  > 14) & (bk_time  <= 15)) bk_time = 15 .
EXECUTE .
```

```
IF ((bk_time > 15) & (bk_time <= 16)) bk_time = 16 .
EXECUTE .
iF ((bk_time > 16) & (bk_time <= 17)) bk_time = 17 .
EXECUTE .

iF ((bk_time > 17) & (bk_time <= 18)) bk_time = 18 .
EXECUTE .
IF ((bk_time > 18) & (bk_time <= 19)) bk_time = 19 .
EXECUTE .
iF ((bk_time > 19) & (bk_time <= 20)) bk_time = 20 .
EXECUTE .
IF ((bk_time > 20) & (bk_time <= 21)) bk_time = 21 .
EXECUTE .
iF ((bk_time > 21) & (bk_time <= 22)) bk_time = 22 .
EXECUTE .

iF ((bk_time > 22) & (bk_time <= 23)) bk_time = 23 .
EXECUTE .

IF ((bk_time > 23) & (bk_time <= 24)) bk_time = 24 .
EXECUTE .
iF ((bk_time > 24) & (bk_time <= 25)) bk_time = 25.
EXECUTE .

iF ((bk_time > 25) & (bk_time <= 26)) bk_time = 26 .
EXECUTE .
IF ((bk_time > 26) & (bk_time <= 27)) bk_time = 27 .
EXECUTE .
iF ((bk_time > 27) & (bk_time <= 28)) bk_time = 28.
EXECUTE .

iF ((bk_time > 28) & (bk_time <= 29)) bk_time = 29 .
EXECUTE .
IF ((bk_time > 29) & (bk_time <= 30)) bk_time = 30 .
EXECUTE .
iF ((bk_time > 30) & (bk_time <= 31)) bk_time = 31 .
EXECUTE .

iF ((bk_time > 31) & (bk_time <= 32)) bk_time = 32 .
EXECUTE .

IF ((bk_time > 32) & (bk_time <= 33)) bk_time = 33 .
EXECUTE .
iF ((bk_time > 33) & (bk_time <= 34)) bk_time = 34 .
EXECUTE .

iF ((bk_time > 34) & (bk_time <= 35)) bk_time = 35 .
EXECUTE .
IF ((bk_time > 35) & (bk_time <= 36)) bk_time = 36 .
EXECUTE .
iF ((bk_time > 36) & (bk_time <= 37)) bk_time = 37 .
EXECUTE .

iF ((bk_time > 37) & (bk_time <= 38)) bk_time = 38 .
EXECUTE .
IF ((bk_time > 38) & (bk_time <= 39)) bk_time = 39 .
EXECUTE .
iF ((bk_time > 39) & (bk_time <= 40)) bk_time = 40 .
EXECUTE .
IF ((bk_time > 40) & (bk_time <= 41)) bk_time = 41 .
EXECUTE .
```

```
iF ((bk_time  > 41) & (bk_time  <= 42)) bk_time = 42 .
EXECUTE .

iF ((bk_time  > 42) & (bk_time  <= 43)) bk_time = 43 .
EXECUTE .

IF ((bk_time  > 43) & (bk_time  <= 44)) bk_time = 44 .
EXECUTE .
iF ((bk_time  > 44) & (bk_time  <= 45)) bk_time = 45.
EXECUTE .

iF ((bk_time  > 45) & (bk_time  <= 46)) bk_time = 46 .
EXECUTE .
IF ((bk_time  > 46) & (bk_time  <= 47)) bk_time = 47 .
EXECUTE .
iF ((bk_time  > 47) & (bk_time  <= 48)) bk_time = 48.
EXECUTE .

iF ((bk_time  > 48) & (bk_time  <= 49)) bk_time = 49 .
EXECUTE .
IF ((bk_time  > 49) & (bk_time  <= 50)) bk_time = 50 .
EXECUTE .
iF ((bk_time  > 50) & (bk_time  <= 51)) bk_time = 51 .
EXECUTE .

iF ((bk_time  > 51) & (bk_time  <= 52)) bk_time = 52 .
EXECUTE .

IF ((bk_time  > 52) & (bk_time  <= 53)) bk_time = 53 .
EXECUTE .
iF ((bk_time  > 53) & (bk_time  <= 54)) bk_time = 54 .
EXECUTE .

iF ((bk_time  > 54) & (bk_time  <= 55)) bk_time = 55 .
EXECUTE .
IF ((bk_time  > 55) & (bk_time  <= 56)) bk_time = 56 .
EXECUTE .
iF ((bk_time  > 56) & (bk_time  <= 57)) bk_time = 57 .
EXECUTE .

iF ((bk_time  > 57) & (bk_time  <= 58)) bk_time = 58 .
EXECUTE .
IF ((bk_time  > 58) & (bk_time  <= 59)) bk_time = 59 .
EXECUTE .
iF ((bk_time  > 59) & (bk_time  <= 60)) bk_time = 60 .
EXECUTE .


IF ((wk_time  > 0) & (wk_time  <= 1)) wk_time = 1 .
EXECUTE .
iF ((wk_time  > 1) & (wk_time  <= 2)) wk_time = 2 .
EXECUTE .

iF ((wk_time  > 2) & (wk_time  <= 3)) wk_time = 3 .
EXECUTE .

IF ((wk_time  > 3) & (wk_time  <= 4)) wk_time = 4 .
EXECUTE .
iF ((wk_time  > 4) & (wk_time  <= 5)) wk_time = 5.
EXECUTE .
```

```
iF ((wk_time > 5) & (wk_time <= 6)) wk_time = 6 .
EXECUTE .
IF ((wk_time > 6) & (wk_time <= 7)) wk_time = 7 .
EXECUTE .
iF ((wk_time > 7) & (wk_time <= 8)) wk_time = 8.
EXECUTE .

iF ((wk_time > 8) & (wk_time <= 9)) wk_time = 9 .
EXECUTE .
IF ((wk_time > 9) & (wk_time <= 10)) wk_time = 10 .
EXECUTE .
iF ((wk_time > 10) & (wk_time <= 11)) wk_time = 11 .
EXECUTE .

iF ((wk_time > 11) & (wk_time <= 12)) wk_time = 12 .
EXECUTE .

IF ((wk_time > 12) & (wk_time <= 13)) wk_time = 13 .
EXECUTE .
iF ((wk_time > 13) & (wk_time <= 14)) wk_time = 14 .
EXECUTE .

iF ((wk_time > 14) & (wk_time <= 15)) wk_time = 15 .
EXECUTE .
IF ((wk_time > 15) & (wk_time <= 16)) wk_time = 16 .
EXECUTE .
iF ((wk_time > 16) & (wk_time <= 17)) wk_time = 17 .
EXECUTE .

iF ((wk_time > 17) & (wk_time <= 18)) wk_time = 18 .
EXECUTE .
IF ((wk_time > 18) & (wk_time <= 19)) wk_time = 19 .
EXECUTE .
iF ((wk_time > 19) & (wk_time <= 20)) wk_time = 20 .
EXECUTE .
IF ((wk_time > 20) & (wk_time <= 21)) wk_time = 21 .
EXECUTE .
iF ((wk_time > 21) & (wk_time <= 22)) wk_time = 22 .
EXECUTE .

iF ((wk_time > 22) & (wk_time <= 23)) wk_time = 23 .
EXECUTE .

IF ((wk_time > 23) & (wk_time <= 24)) wk_time = 24 .
EXECUTE .
iF ((wk_time > 24) & (wk_time <= 25)) wk_time = 25.
EXECUTE .

iF ((wk_time > 25) & (wk_time <= 26)) wk_time = 26 .
EXECUTE .
IF ((wk_time > 26) & (wk_time <= 27)) wk_time = 27 .
EXECUTE .
iF ((wk_time > 27) & (wk_time <= 28)) wk_time = 28.
EXECUTE .

iF ((wk_time > 28) & (wk_time <= 29)) wk_time = 29 .
EXECUTE .
IF ((wk_time > 29) & (wk_time <= 30)) wk_time = 30 .
EXECUTE .
iF ((wk_time > 30) & (wk_time <= 31)) wk_time = 31 .
EXECUTE .
```

```
iF ((wk_time  > 31) & (wk_time  <= 32)) wk_time = 32 .
EXECUTE .

IF ((wk_time  > 32) & (wk_time  <= 33)) wk_time = 33 .
EXECUTE .
iF ((wk_time  > 33) & (wk_time  <= 34)) wk_time = 34 .
EXECUTE .

iF ((wk_time  > 34) & (wk_time  <= 35)) wk_time = 35 .
EXECUTE .
IF ((wk_time  > 35) & (wk_time  <= 36)) wk_time = 36 .
EXECUTE .
iF ((wk_time  > 36) & (wk_time  <= 37)) wk_time = 37 .
EXECUTE .

iF ((wk_time  > 37) & (wk_time  <= 38)) wk_time = 38 .
EXECUTE .
IF ((wk_time  > 38) & (wk_time  <= 39)) wk_time = 39 .
EXECUTE .
iF ((wk_time  > 39) & (wk_time  <= 40)) wk_time = 40 .
EXECUTE .
IF ((wk_time  > 40) & (wk_time  <= 41)) wk_time = 41 .
EXECUTE .
iF ((wk_time  > 41) & (wk_time  <= 42)) wk_time = 42 .
EXECUTE .

iF ((wk_time  > 42) & (wk_time  <= 43)) wk_time = 43 .
EXECUTE .

IF ((wk_time  > 43) & (wk_time  <= 44)) wk_time = 44 .
EXECUTE .
iF ((wk_time  > 44) & (wk_time  <= 45)) wk_time = 45.
EXECUTE .

iF ((wk_time  > 45) & (wk_time  <= 46)) wk_time = 46 .
EXECUTE .
IF ((wk_time  > 46) & (wk_time  <= 47)) wk_time = 47 .
EXECUTE .
iF ((wk_time  > 47) & (wk_time  <= 48)) wk_time = 48.
EXECUTE .

iF ((wk_time  > 48) & (wk_time  <= 49)) wk_time = 49 .
EXECUTE .
IF ((wk_time  > 49) & (wk_time  <= 50)) wk_time = 50 .
EXECUTE .
iF ((wk_time  > 50) & (wk_time  <= 51)) wk_time = 51 .
EXECUTE .

iF ((wk_time  > 51) & (wk_time  <= 52)) wk_time = 52 .
EXECUTE .

IF ((wk_time  > 52) & (wk_time  <= 53)) wk_time = 53 .
EXECUTE .
iF ((wk_time  > 53) & (wk_time  <= 54)) wk_time = 54 .
EXECUTE .

iF ((wk_time  > 54) & (wk_time  <= 55)) wk_time = 55 .
EXECUTE .
IF ((wk_time  > 55) & (wk_time  <= 56)) wk_time = 56 .
EXECUTE .
iF ((wk_time  > 56) & (wk_time  <= 57)) wk_time = 57 .
EXECUTE .
```

```
iF ((wk_time > 57) & (wk_time <= 58)) wk_time = 58 .
EXECUTE .
IF ((wk_time > 58) & (wk_time <= 59)) wk_time = 59 .
EXECUTE .
iF ((wk_time > 59) & (wk_time <= 60)) wk_time = 60 .
EXECUTE .


IF ((wk_dist > 0) & (wk_dist <= 1)) wk_dist = 1 .
EXECUTE .
iF ((wk_dist > 1) & (wk_dist <= 2)) wk_dist = 2 .
EXECUTE .

iF ((wk_dist > 2) & (wk_dist <= 3)) wk_dist = 3 .
EXECUTE .

IF ((wk_dist > 3) & (wk_dist <= 4)) wk_dist = 4 .
EXECUTE .
iF ((wk_dist > 4) & (wk_dist <= 5)) wk_dist = 5.
EXECUTE .

iF ((wk_dist > 5) & (wk_dist <= 6)) wk_dist = 6 .
EXECUTE .
IF ((wk_dist > 6) & (wk_dist <= 7)) wk_dist = 7 .
EXECUTE .
iF ((wk_dist > 7) & (wk_dist <= 8)) wk_dist = 8.
EXECUTE .

iF ((wk_dist > 8) & (wk_dist <= 9)) wk_dist = 9 .
EXECUTE .
IF ((wk_dist > 9) & (wk_dist <= 10)) wk_dist = 10 .
EXECUTE .
iF ((wk_dist > 10) & (wk_dist <= 11)) wk_dist = 11 .
EXECUTE .

iF ((wk_dist > 11) & (wk_dist <= 12)) wk_dist = 12 .
EXECUTE .

IF ((wk_dist > 12) & (wk_dist <= 13)) wk_dist = 13 .
EXECUTE .
iF ((wk_dist > 13) & (wk_dist <= 14)) wk_dist = 14 .
EXECUTE .

iF ((wk_dist > 14) & (wk_dist <= 15)) wk_dist = 15 .
EXECUTE .
IF ((wk_dist > 15) & (wk_dist <= 16)) wk_dist = 16 .
EXECUTE .
iF ((wk_dist > 16) & (wk_dist <= 17)) wk_dist = 17 .
EXECUTE .

iF ((wk_dist > 17) & (wk_dist <= 18)) wk_dist = 18 .
EXECUTE .
IF ((wk_dist > 18) & (wk_dist <= 19)) wk_dist = 19 .
EXECUTE .
iF ((wk_dist > 19) & (wk_dist <= 20)) wk_dist = 20 .
EXECUTE .
IF ((wk_dist > 20) & (wk_dist <= 21)) wk_dist = 21 .
EXECUTE .
iF ((wk_dist > 21) & (wk_dist <= 22)) wk_dist = 22 .
EXECUTE .
```

```
iF ((wk_dist > 22) & (wk_dist <= 23)) wk_dist = 23 .
EXECUTE .

IF ((wk_dist > 23) & (wk_dist <= 24)) wk_dist = 24 .
EXECUTE .
iF ((wk_dist > 24) & (wk_dist <= 25)) wk_dist = 25.
EXECUTE .

iF ((wk_dist > 25) & (wk_dist <= 26)) wk_dist = 26 .
EXECUTE .
IF ((wk_dist > 26) & (wk_dist <= 27)) wk_dist = 27 .
EXECUTE .
iF ((wk_dist > 27) & (wk_dist <= 28)) wk_dist = 28.
EXECUTE .

iF ((wk_dist > 28) & (wk_dist <= 29)) wk_dist = 29 .
EXECUTE .
IF ((wk_dist > 29) & (wk_dist <= 30)) wk_dist = 30 .
EXECUTE .
iF ((wk_dist > 30) & (wk_dist <= 31)) wk_dist = 31 .
EXECUTE .

iF ((wk_dist > 31) & (wk_dist <= 32)) wk_dist = 32 .
EXECUTE .

IF ((wk_dist > 32) & (wk_dist <= 33)) wk_dist = 33 .
EXECUTE .
iF ((wk_dist > 33) & (wk_dist <= 34)) wk_dist = 34 .
EXECUTE .

iF ((wk_dist > 34) & (wk_dist <= 35)) wk_dist = 35 .
EXECUTE .
IF ((wk_dist > 35) & (wk_dist <= 36)) wk_dist = 36 .
EXECUTE .
iF ((wk_dist > 36) & (wk_dist <= 37)) wk_dist = 37 .
EXECUTE .

iF ((wk_dist > 37) & (wk_dist <= 38)) wk_dist = 38 .
EXECUTE .
IF ((wk_dist > 38) & (wk_dist <= 39)) wk_dist = 39 .
EXECUTE .
iF ((wk_dist > 39) & (wk_dist <= 40)) wk_dist = 40 .
EXECUTE .
IF ((wk_dist > 40) & (wk_dist <= 41)) wk_dist = 41 .
EXECUTE .
iF ((wk_dist > 41) & (wk_dist <= 42)) wk_dist = 42 .
EXECUTE .

iF ((wk_dist > 42) & (wk_dist <= 43)) wk_dist = 43 .
EXECUTE .

IF ((wk_dist > 43) & (wk_dist <= 44)) wk_dist = 44 .
EXECUTE .
iF ((wk_dist > 44) & (wk_dist <= 45)) wk_dist = 45.
EXECUTE .

iF ((wk_dist > 45) & (wk_dist <= 46)) wk_dist = 46 .
EXECUTE .
IF ((wk_dist > 46) & (wk_dist <= 47)) wk_dist = 47 .
EXECUTE .
iF ((wk_dist > 47) & (wk_dist <= 48)) wk_dist = 48.
EXECUTE .
```

```
iF ((wk_dist  > 48) & (wk_dist  <= 49)) wk_dist = 49 .
EXECUTE .
IF ((wk_dist  > 49) & (wk_dist  <= 50)) wk_dist = 50 .
EXECUTE .
iF ((wk_dist  > 50) & (wk_dist  <= 51)) wk_dist = 51 .
EXECUTE .

iF ((wk_dist  > 51) & (wk_dist  <= 52)) wk_dist = 52 .
EXECUTE .

IF ((wk_dist  > 52) & (wk_dist  <= 53)) wk_dist = 53 .
EXECUTE .
iF ((wk_dist  > 53) & (wk_dist  <= 54)) wk_dist = 54 .
EXECUTE .

iF ((wk_dist  > 54) & (wk_dist  <= 55)) wk_dist = 55 .
EXECUTE .
IF ((wk_dist  > 55) & (wk_dist  <= 56)) wk_dist = 56 .
EXECUTE .
iF ((wk_dist  > 56) & (wk_dist  <= 57)) wk_dist = 57 .
EXECUTE .

iF ((wk_dist  > 57) & (wk_dist  <= 58)) wk_dist = 58 .
EXECUTE .
IF ((wk_dist  > 58) & (wk_dist  <= 59)) wk_dist = 59 .
EXECUTE .
iF ((wk_dist  > 59) & (wk_dist  <= 60)) wk_dist = 60 .
EXECUTE .
```

Macro for Random Selection of Urban-Ontario Cases

```
COMMENT random selection of Urban-Ontario cases when (orig_zon <> dest_zon) and (a_dist > 0)
        (for xy_dist = 0 - 0.5 km)

FILTER OFF.
USE ALL.
SELECT IF(((((orig_zon >= 1) & (orig_zon <= 131)) | (orig_zon = 136) |
 ((orig_zon >= 142) & (orig_zon <= 144)) | ((orig_zon >= 201) & (orig_zon <=  211)) |
 (orig_zon = 220) | (orig_zon = 225) | ((orig_zon >= 231) & (orig_zon  <= 241))) &
(((dest_zon >= 1) & (dest_zon <= 131)) | (dest_zon = 136) | ((dest_zon >=  142) &
 (dest_zon <= 144)) | ((dest_zon >= 201) & (dest_zon <= 211)) |
 (dest_zon = 220) | (dest_zon = 225) | ((dest_zon >= 231) & (dest_zon <=  241))) &
(orig_zon ~= dest_zon) & (a_dist > 0))).
EXECUTE .


FILTER OFF.
USE ALL.
SELECT IF(((dist_2 > 0) & (dist_2 <= .50))).
EXECUTE .


FILTER OFF.
USE ALL.
SAMPLE 20 from  421.
EXECUTE .
```

Macro for Selecting Urban Ontario, Urban Quebec and Urban Ont-Urban Queb Cases:

COMMENT: selection of Urban Ontario cases, Urban Quebec cases, and Urban Ont-Urban Queb cases.

```
FILTER OFF.
USE ALL.
SELECT IF(((((((orig_zon >= 1) & (orig_zon <= 131)) | (orig_zon = 136) |
  ((orig_zon >= 142) & (orig_zon <= 144)) | ((orig_zon >= 201) & (orig_zon <=
   211)) |
  (orig_zon = 220) | (orig_zon = 225) | ((orig_zon >= 231) & (orig_zon  <=
  241))) &
(((dest_zon >= 1) & (dest_zon <= 131)) | (dest_zon = 136) | ((dest_zon >=
  142) &
  (dest_zon <= 144)) | ((dest_zon >= 201) & (dest_zon <= 211)) |
  (dest_zon = 220) | (dest_zon = 225) | ((dest_zon >= 231) & (dest_zon <=
  241))))) ) |
 (((((orig_zon >= 148) & (orig_zon <= 176)) | ((orig_zon >= 178) &
  (orig_zon <= 180)) | ((orig_zon >= 248) & (orig_zon <= 258))) &
(((dest_zon >= 148) & (dest_zon <= 176)) | ((dest_zon >= 178) & (dest_zon <=
  180)) | ((dest_zon >= 248) & (dest_zon <= 258))))) |
((((((orig_zon >= 1) & (orig_zon <= 131)) | (orig_zon = 136) |
  ((orig_zon >= 142) & (orig_zon <= 144)) | ((orig_zon >= 201) & (orig_zon <=
   211)) |
  (orig_zon = 220) | (orig_zon = 225) | ((orig_zon >= 231) & (orig_zon  <=
  241))) &
(((dest_zon >= 148) & (dest_zon <= 176)) | ((dest_zon >= 178) & (dest_zon <=
  180)) | ((dest_zon >= 248) & (dest_zon <= 258)))) |
((((dest_zon >= 1) & (dest_zon <= 131)) | (dest_zon = 136) | ((dest_zon >=
  142) &
  (dest_zon <= 144)) | ((dest_zon >= 201) & (dest_zon <= 211)) |
  (dest_zon = 220) | (dest_zon = 225) | ((dest_zon >= 231) & (dest_zon <=
  241))) &
(((orig_zon >= 148) & (orig_zon <= 176)) | ((orig_zon >= 178) &
  (orig_zon <= 180)) | ((orig_zon >= 248) & (orig_zon <= 258))))))).
EXECUTE .
```

Macro for Selecting Inter-Urban Cases Between Ont and Quebec

```
COMMENT: selects inter-urban cases between Ontario and Quebec

FILTER OFF.
USE ALL.
SELECT IF((((((orig_zon >= 1) & (orig_zon <= 131)) | (orig_zon = 136) |
  ((orig_zon >= 142) & (orig_zon <= 144)) | ((orig_zon >= 201) & (orig_zon <=
   211)) |
  (orig_zon = 220) | (orig_zon = 225) | ((orig_zon >= 231) & (orig_zon  <=
  241))) &
(((dest_zon >= 148) & (dest_zon <= 176)) | ((dest_zon >= 178) & (dest_zon <=
  180)) | ((dest_zon >= 248) & (dest_zon <= 258)))) |
((((dest_zon >= 1) & (dest_zon <= 131)) | (dest_zon = 136) | ((dest_zon >=
  142) &
  (dest_zon <= 144)) | ((dest_zon >= 201) & (dest_zon <= 211)) |
  (dest_zon = 220) | (dest_zon = 225) | ((dest_zon >= 231) & (dest_zon <=
  241))) &
(((orig_zon >= 148) & (orig_zon <= 176)) | ((orig_zon >= 178) &
  (orig_zon <= 180)) | ((orig_zon >= 248) & (orig_zon <= 258))))).
FREQUENCIES
  VARIABLES=prime_mo.
EXECUTE .
```

Macro for Selecting Urban Zones in Ottawa-Carlton Region

COMMENT 1: selects urban zones in Ottawa-Carlton region.

```
FILTER OFF.
USE ALL.
SELECT IF(((((orig_zon >= 1) & (orig_zon <= 131)) | (orig_zon = 136) |
  ((orig_zon >= 142) & (orig_zon <= 144)) | ((orig_zon >= 201) & (orig_zon <=  211)) |
  (orig_zon = 220) | (orig_zon = 225) | ((orig_zon >= 231) & (orig_zon  <= 241))) &
(((dest_zon >= 1) & (dest_zon <= 131)) | (dest_zon = 136) | ((dest_zon >=  142) &
  (dest_zon <= 144)) | ((dest_zon >= 201) & (dest_zon <= 211)) |
  (dest_zon = 220) | (dest_zon = 225) | ((dest_zon >= 231) & (dest_zon <=  241))) &
(orig_zon ~= dest_zon) & (a_dist > 0))).
FREQUENCIES
  VARIABLES=prime_mo.
EXECUTE .
```

Macro for Selecting Urban Zones in Ontario and Quebec Region

COMMENT 1: selects urban zones in Ontario and Quebec region.

```
FILTER OFF.
USE ALL.
SELECT IF((((((orig_zon >= 148) & (orig_zon <= 176)) | ((orig_zon >= 178) &
  (orig_zon <= 180)) | ((orig_zon >= 248) & (orig_zon <= 258))) &
(((dest_zon >= 148) & (dest_zon <= 176)) | ((dest_zon >= 178) & (dest_zon <=
  180)) | ((dest_zon >= 248) & (dest_zon <= 258))) &
  (orig_zon ~= dest_zon)  &  (a_dist > 0))) |
(((((orig_zon >= 1) & (orig_zon <= 131)) | (orig_zon = 136) |
  ((orig_zon >= 142) & (orig_zon <= 144)) | ((orig_zon >= 201) & (orig_zon <=  211)) |
  (orig_zon = 220) | (orig_zon = 225) | ((orig_zon >= 231) & (orig_zon  <= 241))) &
(((dest_zon >= 1) & (dest_zon <= 131)) | (dest_zon = 136) | ((dest_zon >=  142) &
  (dest_zon <= 144)) | ((dest_zon >= 201) & (dest_zon <= 211)) |
  (dest_zon = 220) | (dest_zon = 225) | ((dest_zon >= 231) & (dest_zon <=  241))) &
(orig_zon ~= dest_zon) & (a_dist > 0)))).
FREQUENCIES
  VARIABLES=prime_mo.
EXECUTE .
```

Macro for Selecting Urban Zones in Quebec Region

```
COMMENT 1: selects urban zones in Quebec region.

FILTER OFF.
USE ALL.
SELECT IF(((((orig_zon >= 148) & (orig_zon <= 176)) | ((orig_zon >= 178) &
  (orig_zon <= 180)) | ((orig_zon >= 248) & (orig_zon <= 258))) &
(((dest_zon >= 148) & (dest_zon <= 176)) | ((dest_zon >= 178) & (dest_zon <=
  180)) | ((dest_zon >= 248) & (dest_zon <= 258))) &
  (orig_zon ~= dest_zon)  &  (a_dist > 0))).
FREQUENCIES
  VARIABLES=prime_mo.
EXECUTE .
```

Macro for Calculating Distance Ratios

```
IF ((a_dist ~= 0) & (distance ~= 0)) a_ratio = a_dist / distance .
EXECUTE .
IF ((t_dist ~= 0) & (distance ~= 0)) t_ratio = t_dist / distance .
EXECUTE .

USE ALL.
COMPUTE filter_$=((((distance > 0) & (distance <= 0.50)) & (a_dist ~= 0) &
 (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 0) & (distance <= 0.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
 VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
 /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
 VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > .50) & (distance <= 1.00)) & (a_dist ~= 0) &
 (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance >.50) & (distance <= 1.00)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
 VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
 /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
 VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 1.00) & (distance <= 1.50)) & (a_dist ~= 0) &
 (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 1.0) & (distance <= 1.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
 VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
 /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
 VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 1.50) & (distance <= 2.00)) & (a_dist ~= 0) &
 (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 1.50) & (distance <= 2.00)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
```

```
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.
```

```
USE ALL.
COMPUTE filter_$=((((distance > 2.0) & (distance <= 2.50)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 2.0) & (distance <= 2.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.
```

```
USE ALL.
COMPUTE filter_$=((((distance > 2.50) & (distance <= 3.00)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 2.50) & (distance <= 3.00)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.
```

```
USE ALL.
COMPUTE filter_$=((((distance > 3.0) & (distance <= 3.50)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 3.0) & (distance <= 3.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
```

```
FREQUENCIES
 VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 3.50) & (distance <= 4.00)) & (a_dist ~= 0) &
 (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 3.50) & (distance <= 4.00)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
 VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
 /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
 VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 4.00) & (distance <= 4.50)) & (a_dist ~= 0) &
 (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 4.00) & (distance <= 4.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
 VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
 /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
 VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 4.50) & (distance <= 5.00)) & (a_dist ~= 0) &
 (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 4.50) & (distance <= 5.00)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
 VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
 /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
 VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 5.00) & (distance <= 5.50)) & (a_dist ~= 0) &
 (t_dist ~= 0))).
```

```
VARIABLE LABEL filter_$ '(((distance > 5.00) & (distance <= 5.50)) & (a_dist ~='+
 ' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 5.50) & (distance <= 6.00)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 5.50) & (distance <= 6.00)) & (a_dist ~='+
 ' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 6.00) & (distance <= 6.50)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 6.00) & (distance <= 6.50)) & (a_dist ~='+
 ' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 6.50) & (distance <= 7.00)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 6.50) & (distance <= 7.00)) & (a_dist ~='+
 ' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
```

```
FREQUENCIES
  VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 7.00) & (distance <= 7.50)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 7.00) & (distance <= 7.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 7.50) & (distance <= 8.00)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 7.50) & (distance <= 8.00)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 8.00) & (distance <= 8.50)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 8.00) & (distance <= 8.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.


USE ALL.
COMPUTE filter_$=((((distance > 8.50) & (distance <= 9.00)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
```

```
VARIABLE LABEL filter_$ '(((distance > 8.50) & (distance <= 9.00)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.
```

```
USE ALL.
COMPUTE filter_$=((((distance > 9.00) & (distance <= 9.50)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 9.00) & (distance <= 9.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.
```

```
USE ALL.
COMPUTE filter_$=((((distance > 9.50) & (distance <= 10.00)) & (a_dist ~= 0) &
  (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((distance > 0) & (distance <= 0.50)) & (a_dist ~='+
' 0) & (t_dist ~= 0)) (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
DESCRIPTIVES
  VARIABLES=distance a_dist a_time auto_spd t_dist t_time tran_spd a_ratio t_ratio
  /STATISTICS=MEAN STDDEV MIN MAX .
FREQUENCIES
  VARIABLES=prime_mo.
```

Macro for Adjustment of Zones

```
COMMENT adjustment of zone done on 2/3/98
COMMENT  this macro will be added to the main one

USE ALL.
COMPUTE filter_$=(((((orig_zon >= 49) & (orig_zon <= 50)) | (orig_zon = 126))
 & (((dest_zon >= 49) & (dest_zon <= 50)) | (dest_zon = 126)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 49) & (orig_zon <= 50)) | (orig_zon ='+
' 126)) & (((dest_zon >= 49) & (dest_zon <= 50)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .

USE ALL.
COMPUTE filter_$=(((((orig_zon >= 41) & (orig_zon <= 48)) | (orig_zon = 56))
 & (((dest_zon >= 41) & (dest_zon <= 48)) | (dest_zon = 56)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 41) & (orig_zon <= 48)) | (orig_zon ='+
' 56)) & (((dest_zon >= 41) & (dest_zon <= 48)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 107) & (orig_zon <= 109)) | (orig_zon = 110))
 & (((dest_zon >= 107) & (dest_zon <= 109)) | (dest_zon = 110)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 107) & (orig_zon <= 109)) | (orig_zon ='+
' 110)) & (((dest_zon >= 107) & (dest_zon <= 109)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 242) & (orig_zon <= 246)) | (orig_zon = 145))
 & (((dest_zon >= 242) & (dest_zon <= 246)) | (dest_zon = 145)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 242) & (orig_zon <= 246)) | (orig_zon ='+
' 145)) & (((dest_zon >= 242) & (dest_zon <= 246)) | (dest_z... (FILTER)'.
```

```
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 224) & (orig_zon <= 226)) | (orig_zon = 136))
  & (((dest_zon >= 224) & (dest_zon <= 226)) | (dest_zon = 136)) & (a_dist ~= 0)
  & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((((orig_zon >= 224) & (orig_zon <= 226)) | (orig_zon ='+
' 136)) & (((dest_zon >= 224) & (dest_zon <= 226)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 117) & (orig_zon <= 118)) | (orig_zon = 119))
  & (((dest_zon >= 117) & (dest_zon <= 118)) | (dest_zon = 119)) & (a_dist ~= 0)
  & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((((orig_zon >= 117) & (orig_zon <= 118)) | (orig_zon ='+
' 119)) & (((dest_zon >= 117) & (dest_zon <= 118)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 207) & (orig_zon <= 211)) | (orig_zon = 131))
  & (((dest_zon >= 207) & (dest_zon <= 211)) | (dest_zon = 131)) & (a_dist ~= 0)
  & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '(((((orig_zon >= 207) & (orig_zon <= 211)) | (orig_zon ='+
' 131)) & (((dest_zon >= 207) & (dest_zon <= 211)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .
```

```
USE ALL.
COMPUTE filter_$=(((((orig_zon >= 127) & (orig_zon <= 128)) | (orig_zon = 124))
 & (((dest_zon >= 127) & (dest_zon <= 128)) | (dest_zon = 124)) & (a_dist ~= 0)
 & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 127) & (orig_zon <= 128)) | (orig_zon ='+
' 124)) & (((dest_zon >= 127) & (dest_zon <= 128)) | (dest_z... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 132) & (orig_zon <= 135)) | ((orig_zon >= 138) &
 (orig_zon <= 139))) &(((dest_zon >= 132) & (dest_zon <= 135)) | ((dest_zon  >=
 138) & (dest_zon <= 139))) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 132) & (orig_zon <= 135)) | ((orig_zon'+
' >= 138) & (orig_zon <= 139))) &(((dest_zon >= 132) & (dest_zo... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 179) & (orig_zon <= 180)) | ((orig_zon >= 182) &
 (orig_zon <= 183))) &(((dest_zon >= 179) & (dest_zon <= 180)) | ((dest_zon  >=
 182) & (dest_zon <= 183))) & (a_dist ~= 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 179) & (orig_zon <= 180)) | ((orig_zon'+
' >= 182) & (orig_zon <= 183))) &(((dest_zon >= 179) & (dest_zo... (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
 VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
 VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
 /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 146) & (orig_zon <= 147)) | (orig_zon = 151)
 | (orig_zon = 256) | (orig_zon = 163)) & (((dest_zon >= 146) & (dest_zon <=
 147)) | (dest_zon = 151) | (dest_zon = 256) | (dest_zon = 163)) & (a_dist ~=
 0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 146) & (orig_zon <= 147)) |'+
' (orig_zon = 151) | (orig_zon = 256) | (orig_zon = 163)) & (((dest...'+
' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
```

```
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES

  --
VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 158) & (orig_zon <= 161)) | (orig_zon = 164)
  | (orig_zon = 152) | (orig_zon = 152)) & (((dest_zon >= 158) & (dest_zon <=
  161)) | (dest_zon = 164) | (dest_zon = 152) | (dest_zon = 152)) & (a_dist ~=
  0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 158) & (orig_zon <= 161)) |'+
 ' (orig_zon = 164) | (orig_zon = 152) | (orig_zon = 152)) & (((dest...'+
 ' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .


USE ALL.
COMPUTE filter_$=(((((orig_zon >= 51) & (orig_zon <= 54)) | (orig_zon = 55)
  | (orig_zon = 123) | (orig_zon = 125)) & (((dest_zon >= 51) & (dest_zon <=
  54)) | (dest_zon = 55) | (dest_zon = 123) | (dest_zon = 125)) & (a_dist ~=
  0) & (t_dist ~= 0))).
VARIABLE LABEL filter_$ '((((orig_zon >= 51) & (orig_zon <= 54)) |'+
 ' (orig_zon = 55) | (orig_zon = 123) | (orig_zon = 125)) & (((dest...'+
 ' (FILTER)'.
VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_zon dest_zon  .
DESCRIPTIVES
  VARIABLES=a_dist a_time auto_spd t_dist t_time tran_spd
  /STATISTICS=MEAN STDDEV MIN MAX .
```

```
IF (orig_zon >= 1 & orig_zon <= 4 | (orig_zon >= 9 & orig_zon <= 10) |
 orig_zon = 15 | orig_zon = 22 | orig_zon = 36 | (orig_zon >= 45 & orig_zon <=
 46) | orig_zon = 48 | (orig_zon >= 53 & orig_zon <= 54) | orig_zon = 59 |
 orig_zon = 60 | orig_zon = 69 | (orig_zon >= 70 & orig_zon <= 73) |
 (orig_zon >= 78 & orig_zon <= 82) | orig_zon = 93 | orig_zon = 104 |
 orig_zon = 105 | orig_zon = 114 | orig_zon = 116 | orig_zon = 201 | orig_zon
 = 204 | orig_zon = 234) tway_o = 1 .
EXECUTE .

IF (dest_zon >= 1 & dest_zon <= 4 | (dest_zon >= 9 & dest_zon <= 10) |
 dest_zon = 15 | dest_zon = 22 | dest_zon = 36 | (dest_zon >= 45 & dest_zon <=
 46) | dest_zon = 48 | (dest_zon >= 53 & dest_zon <= 54) | dest_zon = 59 |
 dest_zon = 60 | dest_zon = 69 | (dest_zon >= 70 & dest_zon <= 73) |
 (dest_zon >= 78 & dest_zon <= 82) | dest_zon = 93 | dest_zon = 104 |
 dest_zon = 105 | dest_zon = 114 | dest_zon = 116 | dest_zon = 201 | dest_zon
 = 204 | dest_zon = 234) tway_d = 1 .
EXECUTE .


comment  development of the province variable Ont=0, PQ=1

IF ((dest_zon >= 146 & dest_zon <= 185) | (dest_zon >= 248 & dest_zon <=
 258)) province = 1 .
EXECUTE .


comment  -  select modes

FILTER OFF.
USE ALL.
SELECT IF(sov=1 | share_rd = 1 | transit = 1 | bike = 1 | walk = 1).
EXECUTE .
FILTER OFF.
USE ALL.



Comment  Part 4 Merging emme2 auto (case14_a.sav) and transit (case14_t.sav)
comment   attribute files to the main file.

SORT CASES BY
 orig_zon (A) dest_zon (A) .
MATCH FILES /FILE=*
 /TABLE='D:\mode_sp\case14_t.sav'
 /BY orig_zon dest_zon.
EXECUTE.

comment  - modify emme2 transit data- aux time needs to be .25 of what model gives

COMPUTE t_aux = t_aux / 4 .
EXECUTE .
COMPUTE t_time = t_ivtt + t_bord + t_wait + t_aux  .
EXECUTE .

comment  - - the .05 converts pedestrian time to distance based on speed of 3kph.

COMPUTE t_dist = t_dist -(4* t_aux * .05) +( t_aux * .05).
EXECUTE .

comment  -  batch in auto variables from emme2 in file case14_a.sav
```

APPENDIX-D

MODEL OUTPUTS

Home Based Work Trip Model For Lower Level

```
                    TSP Version 4.3A
              (10/26/95) DOS/Win      15MB
        Copyright (C) 1995 TSP International
                    ALL RIGHTS RESERVED
                     12/16/98 5:25 PM
In case of questions or problems, see your local TSP
consultant or send a description of the problem and the
associated TSP output to:
                    TSP International
              P.O. Box 61015, Station A
                 Palo Alto, CA 94306
                         USA
        PROGRAM
LINE  ***************************************************************
|      1  options memory = 15;
|      2  supres dpdx dpdz;
|      3  read (file='newbkw~1.xls'), choice sex1 sex2
|      3    bktime1 bktime2 wktime1 wktime2 numbk1 numbk2 time1 time2 sex_r
   income
|      3    age num_veh province cbd_flag num_veh_ bike_hh start_ti st_tim_r
|      3    lic_r emp_f bik_r num_trip dist1 dist2;
|      4  logit(cond,nchoice=2) choice time | sex_r  num_veh_ age C;
|      5  set y = @nob*log(1/2);
|      6  set x = -2*(y - @logl);
|      7  set rhosq = 1-(@logl/y);
|      8  show list;
|      9  set rhobarsq = 1-((@logl-5)/y);
|     10  print y,x,@logl,rhosq,rhobarsq;
|     11  msd (all,corr,print) choice time1 time2 sex_r num_veh_ age
|     11
        EXECUTION
*************************************************************************
COLUMN NAME > 8 CHARACTERS:  [bk_actual]
COLUMN NAME > 8 CHARACTERS:  [bk_pred corr]
COLUMN NAME > 8 CHARACTERS:  [wk_actual]
COLUMN NAME > 8 CHARACTERS:  [wk_pred corr]
COLUMN NAME > 8 CHARACTERS:  [Incl val/exp max util]
COLUMN NAME > 8 CHARACTERS:  [totbk_pred]
COLUMN NAME > 8 CHARACTERS:  [totwk_pred]
Note: Number of column names (     147) not equal to
Number of data columns in file (     159).

Current sample:  1 to 306


                          Equation   1
                          ============

                   MIXED LOGIT ESTIMATION

CHOICE     FREQUENCY  PERCENT
1                119  38.8889  (COEFFICIENTS NORMALIZED TO ZERO)
2                187  61.1111
Working space used: 5639
                   STARTING VALUES

                   TIME        SEX_R2      NUM_VEH2        AGE2          C2
VALUE           0.00000       0.00000       0.00000     0.00000     0.00000

F=   212.10     FNEW=   150.58     ISQZ=  0 STEP=  1.0000     CRIT=  109.27
F=   150.58     FNEW=   142.55     ISQZ=  0 STEP=  1.0000     CRIT=  13.615
F=   142.55     FNEW=   141.67     ISQZ=  0 STEP=  1.0000     CRIT=  1.6409
F=   141.67     FNEW=   141.65     ISQZ=  0 STEP=  1.0000     CRIT= 0.28780E-01
F=   141.65     FNEW=   141.65     ISQZ=  0 STEP=  1.0000     CRIT= 0.95339E-05
```

```
CONVERGENCE ACHIEVED AFTER   5 ITERATIONS

   10 FUNCTION EVALUATIONS.

     DEPENDENT VARIABLE: CHOICE

                LOG OF LIKELIHOOD FUNCTION =    -141.652
                           NUMBER OF CASES =    306
                         NUMBER OF CHOICES =    612

                         Standard
Parameter  Estimate        Error       t-statistic
TIME       -.026801      .433910E-02   -6.17654
SEX_R2     1.09630       .315585       3.47386
NUM_VEH2   -.478897      .135052       -3.54601
AGE2       .560053E-02   .014249       .393044
C2         2.14999       .634532       3.38832

Standard Errors computed from   analytic second derivatives
(Newton)

Class     Name      Description
-----     ----      -----------

LIST      @LHV      1 members
          @RNMS     5 members

                Y             X          @LOGL      RHOSQ      RHOBARSQ
Value  -212.10304     140.90115    -141.65246    0.33215       0.30858


                              Correlation Matrix

                      CHOICE         TIME1         TIME2         SEX_R
CHOICE               1.00000
TIME1               -0.49236        1.0000
TIME2               -0.48923       0.99992       1.00000
SEX_R                0.29852      -0.19362      -0.19260       1.00000
NUM_VEH_            -0.34579       0.27009       0.26921      -0.14008
AGE                -0.081161      0.094008      0.092974      -0.14836


                    NUM_VEH_           AGE
NUM_VEH_             1.00000
AGE                  0.14012        1.0000

*****************************************************************************

END OF OUTPUT.

  MEMORY USAGE:    ITEM:    DATA ARRAY  TOTAL MEMORY
                 UNITS:  (4-BYTE WORDS) (MEGABYTES)
  MEMORY ALLOCATED         :   3250000      15.0
  MEMORY ACTUALLY REQUIRED :     28621       2.2
  CURRENT VARIABLE STORAGE :      9686
```

Home Based Work Trip Model For Higher Level

```
                    TSP Version 4.3A
              (10/26/95) DOS/Win      15MB
         Copyright (C) 1995 TSP International
                   ALL RIGHTS RESERVED
                    12/02/99 5:08 PM
      In case of questions or problems, see your local TSP
      consultant or send a description of the problem and the
      associated TSP output to:
                    TSP International
                 P.O. Box 61015, Station A
                    Palo Alto, CA 94306
                           USA
        PROGRAM
LINE  ****************************************************************
|       1  options memory = 15;
|       2  supres dpdx dpdz;
|       3  read (file='atbw.xls'), choice cost1 cost2 cost3 time1 time2 time3
|       3    province veh_hh_r inc_val1 inc_val2 inc_val3  sl_dst1 sl_dst2
   sl_dst3
|       3    sl_time1 sl_time2 sl_time3 payprk1 payprk2 payprk3 ivtt1 ivtt2
   ivtt3
|       3    t_wait1 t_wait2 t_wait3 veh_hh1 veh_hh2 veh_hh3 tway1 tway2 tway3
   sex_r
|       3    cex1 cex2 cex3 car_hh1 car_hh2 car_hh3 cbd1 cbd2 cbd3 e_tot_d
   pop_t_d
|       3    popdn1 popdn2 popdn3 empdn1 empdn2 empdn3 tway_o tway_d tr_wait
   twy_prx
|       3    age xy_dist income ln_inc dw_ty_r parking t_time_r lic_r no_trsf
   d1 d2 d3
|       3    cbd_flag prov;
|       4  logit(cond,nchoice=3) choice cost inc_val time | veh_hh_r province
   lic_r
|       4    C;
|       5  set y = @nob*log(1/3);
|       6  set x = -2*(y - @logl);
|       7  set rhosq = 1-(@logl/y);
|       8  show list;
|       9  set rhobarsq = 1-((@logl-7)/y);
|      10  print y,x,@logl,rhosq,rhobarsq;
|      11  msd (corr,print) choice cost1 cost2 cost3 inc_val3
|      11    veh_hh_r province lic_r  time1 time2 time3;
|      12
|      12
|      12
        EXECUTION
*****************************************************************************
COLUMN NAME > 8 CHARACTERS:  [car per hh]
COLUMN NAME > 8 CHARACTERS:  [av-sl-time]
COLUMN NAME > 8 CHARACTERS:  [tr-actual]
COLUMN NAME > 8 CHARACTERS:  [sl-actual]
COLUMN NAME > 8 CHARACTERS:  [a-pred corr]
COLUMN NAME > 8 CHARACTERS:  [tr-pred corr]
COLUMN NAME > 8 CHARACTERS:  [sl-pred corr]
COLUMN NAME > 8 CHARACTERS:  [tot-a-pred]
COLUMN NAME > 8 CHARACTERS:  [tot-tr-pred]
COLUMN NAME > 8 CHARACTERS:  [tot-sl-pred]
COLUMN NAME > 8 CHARACTERS:  [nad_order]
COLUMN NAME > 8 CHARACTERS:  [fixed cost]
COLUMN NAME IGNORED DUE TO BLANKS:  [tot cost]
COLUMN NAME > 8 CHARACTERS:  [A_COSTwith park=2]
Note: Number of column names (     157) not equal to
Number of data columns in file (     175).

Current sample:  1 to 4274
```

```
                                        Equation   1
                                        ============

                                   MIXED LOGIT ESTIMATION

CHOICE      FREQUENCY  PERCENT
1                2952  69.0688  (COEFFICIENTS NORMALIZED TO ZERO)
2                 937  21.9233
3                 385   9.0080
Working space used: 145721
                                   STARTING VALUES

                   COST       INC_VAL          TIME      VEH_HH_2      PROVINC2
VALUE           0.00000       0.00000       0.00000       0.00000       0.00000


                 LIC_R2            C2      VEH_HH_3      PROVINC3        LIC_R3
VALUE           0.00000       0.00000       0.00000       0.00000       0.00000


                     C3
VALUE           0.00000

F=   4695.5     FNEW=   2242.4     ISQZ=  0 STEP=  1.0000     CRIT=  4771.5
F=   2242.4     FNEW=   1959.6     ISQZ=  0 STEP=  1.0000     CRIT=  446.14
F=   1959.6     FNEW=   1848.8     ISQZ=  0 STEP=  1.0000     CRIT=  178.68
F=   1848.8     FNEW=   1822.1     ISQZ=  0 STEP=  1.0000     CRIT=  46.411
F=   1822.1     FNEW=   1820.2     ISQZ=  0 STEP=  1.0000     CRIT=  3.5448
F=   1820.2     FNEW=   1820.2     ISQZ=  0 STEP=  1.0000     CRIT= 0.22088E-01
F=   1820.2     FNEW=   1820.2     ISQZ=  0 STEP=  1.0000     CRIT= 0.89967E-06

CONVERGENCE ACHIEVED AFTER   7 ITERATIONS


   14 FUNCTION EVALUATIONS.

     DEPENDENT VARIABLE: CHOICE

                 LOG OF LIKELIHOOD FUNCTION =    -1820.19
                            NUMBER OF CASES =   4274
                          NUMBER OF CHOICES =  12822

                          Standard
Parameter  Estimate         Error        t-statistic
COST       -.670435       .021243        -31.5601
INC_VAL    .770568        .094338        8.16815
TIME       -.049696       .206162E-02    -24.1053
VEH_HH_2   -1.46790       .099795        -14.7092
PROVINC2   .751026        .134556        5.58153
LIC_R2     -2.23881       .212111        -10.5549
C2         0.98490        .242260        5.19324
VEH_HH_3   -1.32035       .120817        -10.9285
PROVINC3   .837651        .176875        4.73585
LIC_R3     -1.63950       .258004        -6.35457
C3         -1.17934       .496684        -3.58244

Standard Errors computed from   analytic second derivatives
(Newton)

Class     Name      Description
-----     ----      -----------

LIST      @LHV      1 members
          @RNMS     11 members
```

	Y	X	@LOGL	RHOSQ	RHOBARSQ
Value	-4695.46892	5750.55495	-1820.19145	0.61235	0.61086

Correlation Matrix

	CHOICE	COST1	COST2	COST3
CHOICE	1.00000			
COST1	0.37115	1.00000		
COST2	-0.16433	0.25522	1.0000	
COST3	0.00000	0.00000	0.00000	0.00000
INC_VAL3	-0.0079718	0.081610	0.077223	0.00000
VEH_HH_R	-0.36133	-0.093202	0.19746	0.00000
PROVINCE	0.11876	0.077304	0.12061	0.00000
LIC_R	-0.20240	0.0013477	0.085414	0.00000
TIME1	-0.21476	0.46866	0.58349	0.00000
TIME2	-0.27299	0.29030	0.75314	0.00000
TIME3	-0.22302	0.41830	0.66185	0.00000

	INC_VAL3	VEH_HH_R	PROVINCE	LIC_R
INC_VAL3	1.00000			
VEH_HH_R	0.11560	1.00000		
PROVINCE	0.022284	-0.016824	1.00000	
LIC_R	0.11146	0.25598	-0.017003	1.0000
TIME1	0.19612	0.16935	-0.10965	0.10109
TIME2	0.15595	0.21791	-0.045709	0.11309
TIME3	0.18534	0.19134	0.017259	0.10244

	TIME1	TIME2	TIME3
TIME1	1.00000		
TIME2	0.86318	1.0000	
TIME3	0.94811	0.91142	1.00000

****

END OF OUTPUT.

MEMORY USAGE:	ITEM:	DATA ARRAY	TOTAL MEMORY
	UNITS:	(4-BYTE WORDS)	(MEGABYTES)
MEMORY ALLOCATED	:	3250000	15.0
MEMORY ACTUALLY REQUIRED	:	888555	5.7
CURRENT VARIABLE STORAGE	:	322380	

Home Based School Trip Model For Lower Level

```
                    TSP Version 4.3A
              (10/26/95) DOS/Win      15MB
        Copyright (C) 1995 TSP International
                 ALL RIGHTS RESERVED
                  11/14/99 7:15 PM
In case of questions or problems, see your local TSP
consultant or send a description of the problem and the
associated TSP output to:
                  TSP International
             P.O. Box 61015, Station A
                 Palo Alto, CA 94306
                        USA
        PROGRAM
LINE  ****************************************************************
|      1  options memory = 15;
|      2  supres dpdx dpdz;
|      3  read (file='lwr2_vl.xls'), choice  bktime1 bktime2 wktime1 wktime2
|      3    province  sex_r age age_r xy_dist income num_bik sex1 sex2 hh_sch
   dwell_ty
|      3    stud_r lic_r bk_time wk_time veh_hh_r ln_inc cbd_flag bk_dist
   wk_dist
|      3    cbd_flag numbk bk_per tway_d inc_pm trip_num trp_n_r age_rr
   inc_hh dist_r
|      3    wktim_r tim_dst pop_den ln_wktm ln_bktm time1 time2 dist1 dist2
   pop_r
|      3    incom_r ;
|      4  logit(nchoice=2) choice  cbd_flag dist_r pop_den bk_per  province C;
|      5  set y = @nob*log(1/2);
|      6  set x = -2*(y - @log1);
|      7  set rhosq = 1-(@log1/y);
|      8  show list;
|      9  set rhobarsq = 1-((@log1-6)/y);
|     10  print y,x,@log1,rhosq,rhobarsq;
|     11  msd (corr, print) choice  cbd_flag
|     11   dist_r pop_den bk_per province;
|     12
        EXECUTION
*****************************************************************************
COLUMN NAME > 8 CHARACTERS:  [nad_order]
COLUMN NAME > 8 CHARACTERS:  [bk-actual]
COLUMN NAME > 8 CHARACTERS:  [wk-actual]
COLUMN NAME > 8 CHARACTERS:  [bk-pred corr]
COLUMN NAME > 8 CHARACTERS:  [wk-pred corr]
COLUMN NAME > 8 CHARACTERS:  [tot-bk-pred]
COLUMN NAME > 8 CHARACTERS:  [tot-wk-pred]
Note: Number of column names (     160) not equal to
Number of data columns in file (     167).

Current sample:  1 to 427


                                   Equation   1
                                   ============

                        MULTINOMIAL LOGIT ESTIMATION

CHOICE      FREQUENCY  PERCENT
1                  89  20.8431  (COEFFICIENTS NORMALIZED TO ZERO)
2                 338  79.1569
Working space used: 7425
                                STARTING VALUES

            CBD_FLA2       DIST_R2       POP_DEN2       BK_PER2       PROVINC2
VALUE        0.00000       0.00000        0.00000       0.00000        0.00000
```

```
                    C2
VALUE           0.00000

F=   295.97     FNEW=   131.71     ISQZ=  0 STEP=  1.0000     CRIT=  295.49
F=   131.71     FNEW=   114.02     ISQZ=  0 STEP=  1.0000     CRIT=  29.173
F=   114.02     FNEW=   110.46     ISQZ=  0 STEP=  1.0000     CRIT=  6.1181
F=   110.46     FNEW=   110.14     ISQZ=  0 STEP=  1.0000     CRIT= 0.58900
F=   110.14     FNEW=   110.14     ISQZ=  0 STEP=  1.0000     CRIT= 0:75133E-02
F=   110.14     FNEW=   110.14     ISQZ=  0 STEP=  1.0000     CRIT= 0.14019E-05

CONVERGENCE ACHIEVED AFTER   6 ITERATIONS


   12 FUNCTION EVALUATIONS.

     DEPENDENT VARIABLE: CHOICE

                 LOG OF LIKELIHOOD FUNCTION =    -110.139
                            NUMBER OF CASES =    427
                           NUMBER OF CHOICES =    854
                   SUM OF SQUARED RESIDUALS =     31.6792
                                  R-SQUARED =    0.550356
               PERCENT CORRECT PREDICTIONS =    0.906323

                           Standard
Parameter  Estimate          Error        t-statistic
CBD_FLA2   2.90312         .602452        8.13861
DIST_R2    2.21390         .426219        5.19429
POP_DEN2   .309336E-03     .120583E-03    2.56533
BK_PER2    -.595873        .529628        -1.12508
PROVINC2   -1.03609        .539491        -1.92049
C2         1.15396         .38976         1.78429

Standard Errors computed from   analytic second derivatives
(Newton)

Class     Name      Description
-----     ----      -----------

LIST      @LHV      1 members
          @RNMS     6 members

                 Y            X          @LOGL        RHOSQ       RHOBARSQ
Value   -295.97385    371.66913    -110.13928      0.62787       0.60760


                                Correlation Matrix

                       CHOICE      CBD_FLAG        DIST_R        POP_DEN
CHOICE                1.00000
CBD_FLAG              0.43647        1.0000
DIST_R                0.40261       0.27063       1.00000
POP_DEN              -0.066568      -0.19301     -0.050695       1.00000
BK_PER                -0.18408      -0.17539      -0.20173      0.087779
PROVINCE              -0.17967      -0.14802      -0.18709       0.17544


                       BK_PER      PROVINCE
BK_PER                1.00000
PROVINCE            0.0048408       1.00000

*******************************************************************************

END OF OUTPUT.
```

```
MEMORY USAGE:     ITEM:     DATA ARRAY  TOTAL MEMORY
                 UNITS:  (4-BYTE WORDS) (MEGABYTES)
MEMORY ALLOCATED          :   3250000       15.0
MEMORY ACTUALLY REQUIRED  :     60998        2.3
CURRENT VARIABLE STORAGE  :     20810
```

Home Based School Trip Model For Higher Level

```
                    TSP Version 4.3A
                (10/26/95) DOS/Win      15MB
            Copyright (C) 1995 TSP International
                     ALL RIGHTS RESERVED
                      11/15/99 7:45 PM
        In case of questions or problems, see your local TSP
        consultant or send a description of the problem and the
        associated TSP output to:
                      TSP International
                 P.O. Box 61015, Station A
                    Palo Alto, CA 94306
                           USA
      PROGRAM
LINE  ******************************************************************
|      1  options memory = 15;
|      2  supres dpdx dpdz;
|      3  read (file='hyr2new.xls'), choice province  sex_r age xy_dist income
|      3    dwell_ty bk_time wk_time veh_hh_r cbd_flag bk_dist wk_dist tway_d
|      3    trip_num num_trip tway_o  t_txs t_wait num_pers t_aux start_ti
   a_cost
|      3    time1 time2 time3 inc_vl1 inc_vl2 inc_vl3 dest_pop xy_dist lic_r
   st_t_r
|      3    purp_r cost1 cost2 cost3 pop_den1 pop_den2 age_r orig_pop;
|      4  logit(nchoice=3) choice cost time inc_vl | veh_hh_r
|      4     lic_r cbd_flag sex_r num_trip purp_r st_t_r C;
|      5  set y = @nob*log(1/3);
|      6  set x = -2*(y - @logl);
|      7  set rhosq = 1-(@logl/y);
|      8  show list;
|      9  set rhobarsq = 1-((@logl-11)/y);
|     10  print y,x,@logl,rhosq,rhobarsq;
|     11  msd (all,corr,print) choice cost1 cost2 cost3 time1 time2 time3
    inc_vl3
|     11   veh_hh_r lic_r cbd_flag sex_r num_trip purp_r st_t_r;
      EXECUTION
*****************************************************************************
COLUMN NAME > 8 CHARACTERS:  [av_sl_time]
COLUMN NAME > 8 CHARACTERS:  [tr-actual]
COLUMN NAME > 8 CHARACTERS:  [sl-actual]
COLUMN NAME > 8 CHARACTERS:  [a-pred corr]
COLUMN NAME > 8 CHARACTERS:  [tr-pred corr]
COLUMN NAME > 8 CHARACTERS:  [sl-pred corr]
COLUMN NAME > 8 CHARACTERS:  [tot-a-pred]
COLUMN NAME > 8 CHARACTERS:  [tot-tr-pred]
COLUMN NAME > 8 CHARACTERS:  [tot-sl-pred]
Note: Number of column names (     167) not equal to
Number of data columns in file (     177).

Current sample:  1 to 1200


                                  Equation   1
                                  ============

                             MIXED LOGIT ESTIMATION

CHOICE     FREQUENCY  PERCENT
1                321  26.7500  (COEFFICIENTS NORMALIZED TO ZERO)
2                390  32.5000
3                489  40.7500
Working space used: 51381
                             STARTING VALUES

                   COST          TIME        INC_VL       VEH_HH_2        LIC_R2
VALUE           0.00000       0.00000       0.00000        0.00000        0.00000
```

	CBD_FLA2	SEX_R2	NUM_TRI2	PURP_R2	ST_T_R2
VALUE	0.00000	0.00000	0.00000	0.00000	0.00000

	C2	VEH_HH_3	LIC_R3	CBD_FLA3	SEX_R3
VALUE	0.00000	0.00000	0.00000	0.00000	0.00000

	NUM_TRI3	PURP_R3	ST_T_R3	C3
VALUE	0.00000	0.00000	0.00000	0.00000

```
F=   1318.3     FNEW=   914.70     ISQZ=  0 STEP=  1.0000     CRIT=  757.59
F=   914.70     FNEW=   873.69     ISQZ=  0 STEP=  1.0000     CRIT=  68.948
F=   873.69     FNEW=   867.91     ISQZ=  0 STEP=  1.0000     CRIT=  10.411
F=   867.91     FNEW=   867.69     ISQZ=  0 STEP=  1.0000     CRIT= 0.41546
F=   867.69     FNEW=   867.69     ISQZ=  0 STEP=  1.0000     CRIT= 0.89596E-03
F=   867.69     FNEW=   867.69     ISQZ=  0 STEP=  1.0000     CRIT= 0.45030E-08

CONVERGENCE ACHIEVED AFTER   6 ITERATIONS


   12 FUNCTION EVALUATIONS.

     DEPENDENT VARIABLE: CHOICE

                LOG OF LIKELIHOOD FUNCTION =    -867.693
                           NUMBER OF CASES =   1200
                         NUMBER OF CHOICES =   3600
```

Parameter	Estimate	Standard Error	t-statistic
COST	-.642926	.074105	-8.67591
TIME	-.029922	.295935E-02	-10.1109
INC_VL	.482931	.047608	10.1438
VEH_HH_2	-.919493	.143325	-6.41546
LIC_R2	-.773625	.217753	-3.55277
CBD_FLA2	-.315793	.254468	-1.24100
SEX_R2	-.059909	.174130	-.344045
NUM_TRI2	-.232645	.061060	-3.81009
PURP_R2	1.10181	.244596	4.50461
ST_T_R2	.833131	.208303	3.99960
C2	1.13490	.417381	5.11498
VEH_HH_3	-1.43276	.168953	-8.48022
LIC_R3	-.909313	.250169	-3.63479
CBD_FLA3	-1.00389	.314531	-3.19170
SEX_R3	.623081	.197209	3.15950
NUM_TRI3	-.014296	.060735	-.235378
PURP_R3	.832096	.285489	2.91464
ST_T_R3	.944365	.245573	3.84556
C3	-.122904	.528337	-.232625

```
Standard Errors computed from   analytic second derivatives
(Newton)

Class     Name      Description
-----     ----      -----------

LIST      @LHV      1 members
          @RNMS     19 members
```

	Y	X	@LOGL	RHOSQ	RHOBARSQ
Value	-1318.33475	901.28439	-867.69255	0.34183	0.33348

Correlation Matrix

	CHOICE	COST1	COST2	COST3
CHOICE	1.0000			
COST1	-0.024061	1.00000		
COST2	-0.27612	0.15205	1.00000	
COST3	0.00000	0.00000	0.00000	0.00000
TIME1	-0.49543	0.33533	0.54344	0.00000
TIME2	-0.45125	0.25534	0.60647	0.00000
TIME3	-0.45596	0.29879	0.57682	0.00000
INC_VL3	0.33945	-0.37875	-0.12652	0.00000
VEH_HH_R	-0.16486	-0.18996	0.14596	0.00000
LIC_R	-0.27307	0.46610	0.15452	0.00000
CBD_FLAG	0.025273	-0.45455	-0.039598	0.00000
SEX_R	0.040356	-0.050057	0.019243	0.00000
NUM_TRIP	0.013894	0.031273	-0.027598	0.00000
PURP_R	0.23576	-0.52968	-0.10829	0.00000
ST_T_R	0.19893	-0.29298	-0.087008	0.00000

	TIME1	TIME2	TIME3	INC_VL3
TIME1	1.00000			
TIME2	0.90399	1.0000		
TIME3	0.96568	0.91198	1.0000	
INC_VL3	-0.42661	-0.39367	-0.36106	1.00000
VEH_HH_R	0.10033	0.11042	0.10124	0.41235
LIC_R	0.29376	0.22424	0.25226	-0.31418
CBD_FLAG	-0.15315	-0.047057	-0.10181	0.46724
SEX_R	0.0018252	-0.0028882	0.0012303	-0.013514
NUM_TRIP	-0.067158	-0.069923	-0.069118	0.060073
PURP_R	-0.30442	-0.22818	-0.26025	0.37288
ST_T_R	-0.23323	-0.20492	-0.20349	0.19692

	VEH_HH_R	LIC_R	CBD_FLAG	SEX_R
VEH_HH_R	1.0000			
LIC_R	-0.038836	1.00000		
CBD_FLAG	0.16292	-0.24795	1.00000	
SEX_R	0.051123	0.0027921	-0.017658	1.00000
NUM_TRIP	0.034105	0.16445	-0.033290	0.0046427
PURP_R	0.17195	-0.59188	0.27096	0.025384
ST_T_R	0.053201	-0.27581	0.14211	-0.017133

	NUM_TRIP	PURP_R	ST_T_R
NUM_TRIP	1.00000		
PURP_R	-0.056862	1.00000	
ST_T_R	-0.036702	0.28023	1.00000

****

END OF OUTPUT.

MEMORY USAGE:	ITEM:	DATA ARRAY	TOTAL MEMORY
	UNITS:	(4-BYTE WORDS)	(MEGABYTES)
MEMORY ALLOCATED	:	3250000	15.0
MEMORY ACTUALLY REQUIRED	:	148619	2.7
CURRENT VARIABLE STORAGE	:	57726	

Non Home Based Work - Non Home Based School Trip Model For Lower Level
(Other Trip Model For Lower Level)

```
                    TSP Version 4.3A
                (10/26/95) DOS/Win      15MB
            Copyright (C) 1995 TSP International
                     ALL RIGHTS RESERVED
                      01/23/99 8.06 PM
        In case of questions or problems, see your local TSP
        consultant or send a description of the problem and the
        associated TSP output to:
                      TSP International
                 P.O. Box 61015, Station A
                    Palo Alto, CA 94306
                           USA
        PROGRAM
LINE  ****************************************************************
|      1  options memory = 15;
|      2  supres dpdx dpdz;
|      3  read (file='lower3.xls'), choice sex_r bk_time wk_time num_bik
   veh_hh_r
|      3   xy_dist wktim_r bktim_r orig_den dest_den emp_den org_gla des_gla
   dist_r
|      3    cbd_flag income age province start_ti dw_ty_r age_r time1 time2
   dist1
|      3    dist2 num_trip lic_r tway_d purp_r bk_dst_r wk_dst_r bk_tim_r
   stud_r
|      3    veh_r wk_tim_r park_r st_tim_r bik_per emp_r or_pur_r de_pur_r
   tr_pur_r
|      3    com_pur prov1 prov2;
|      4  logit(cond,nchoice=2) choice time | sex_r  bik_per  st_tim_r
|      4     des_gla org_gla emp_den dest_den C ;
|      5  set y = @nob*log(1/2);
|      6  set x = -2*(y - @logl);
|      7  set rhosq = 1-(@logl/y);
|      8  show list;
|      9  set rhobarsq = 1-((@logl-5)/y);
|     10  print y,x,@logl,rhosq,rhobarsq;
|     11  msd(all, corr,print) choice time1 time2 sex_r bik_per st_tim_r
    des_gla
|     11   org_gla emp_den dest_den
|     11
        EXECUTION
*****************************************************************************
COLUMN NAME > 8 CHARACTERS:  [bk-actual]
COLUMN NAME > 8 CHARACTERS:  [wk-actual]
COLUMN NAME > 8 CHARACTERS:  [bk-pred corr]
COLUMN NAME > 8 CHARACTERS:  [wk-pred corr]
COLUMN NAME > 8 CHARACTERS:  [tot-bk-pred]
COLUMN NAME > 8 CHARACTERS:  [tot-wk-pred]
Note: Number of column names (     163) not equal to
Number of data columns in file (     173).

Current sample:  1 to 859


                                   Equation   1
                                   ============

                              MIXED LOGIT ESTIMATION

CHOICE     FREQUENCY  PERCENT
1                164  19.0920  (COEFFICIENTS NORMALIZED TO ZERO)
2                695  80.9080
Working space used: 22625
                              STARTING VALUES
```

	TIME	SEX_R2	BIK_PER2	ST_TIM_2	DES_GLA2
VALUE	0.00000	0.00000	0.00000	0.00000	0.00000

	ORG_GLA2	EMP_DEN2	DEST_DE2	C2
VALUE	0.00000	0.00000	0.00000	0.00000

```
F=   595.41     FNEW=   382.19     ISQZ=  0 STEP=  1.0000     CRIT=  390.96
F=   382.19     FNEW=   367.89     ISQZ=  0 STEP=  1.0000     CRIT=  24.754
F=   367.89     FNEW=   366.54     ISQZ=  0 STEP=  1.0000     CRIT=  2.4810
F=   366.54     FNEW=   366.50     ISQZ=  0 STEP=  1.0000     CRIT= 0.65395E-01
F=   366.50     FNEW=   366.50     ISQZ=  0 STEP=  1.0000     CRIT= 0.79553E-04

CONVERGENCE ACHIEVED AFTER   5 ITERATIONS


   10 FUNCTION EVALUATIONS.

     DEPENDENT VARIABLE: CHOICE

                 LOG OF LIKELIHOOD FUNCTION =    -366.502
                            NUMBER OF CASES =    859
                          NUMBER OF CHOICES =   1718
```

Parameter	Estimate	Standard Error	t-statistic
TIME	-.014758	.283748E-02	-5.20108
SEX_R2	-.792081	.188618	-4.19940
BIK_PER2	-.292935	.190831	-1.53505
ST_TIM_2	-.463822	.192884	-2.40468
DES_GLA2	.197035E-05	.656391E-06	3.00180
ORG_GLA2	.109697E-05	.533803E-06	2.05500
EMP_DEN2	.280796E-04	.921157E-05	3.04830
DEST_DE2	.857268E-04	.376920E-04	2.27440
C2	2.06738	.257351	8.03328

Standard Errors computed from analytic second derivatives (Newton)

Class	Name	Description
LIST	@LHV	1 members
	@RNMS	9 members

	Y	X	@LOGL	RHOSQ	RHOBARSQ
Value	-595.41343	457.82265	-366.50210	0.38446	0.37606

Correlation Matrix

	CHOICE	TIME1	TIME2	SEX_R
CHOICE	1.00000			
TIME1	-0.24587	1.0000		
TIME2	-0.24658	0.99216	1.0000	
SEX_R	-0.14729	0.069458	0.060923	1.00000
BIK_PER	-0.069841	0.18677	0.18863	0.063465
ST_TIM_R	-0.084155	0.010740	0.017604	0.087761
DES_GLA	0.10527	-0.042080	-0.040521	0.0020670
ORG_GLA	0.087871	-0.024032	-0.024468	0.091963
EMP_DEN	0.12424	-0.043339	-0.047712	0.050250
DEST_DEN	0.064880	-0.040920	-0.044878	0.036648

	BIK_PER	ST_TIM_R	DES_GLA	ORG_GLA
BIK_PER	1.0000			

ST_TIM_R	0.025767	1.0000		
DES_GLA	-0.029991	0.043382	1.00000	
ORG_GLA	0.059798	0.0057582	0.20066	1.00000
EMP_DEN	0.13323	0.0028348	-0.012203	0.088795
DEST_DEN	0.10586	0.045954	-0.28564	-0.039314

	EMP_DEN	DEST_DEN
EMP_DEN	1.00000	
DEST_DEN	0.22551	1.00000

****

END OF OUTPUT.

MEMORY USAGE:	ITEM:	DATA ARRAY	TOTAL MEMORY
	UNITS:	(4-BYTE WORDS)	(MEGABYTES)
MEMORY ALLOCATED	:	3250000	15.0
MEMORY ACTUALLY REQUIRED	:	120749	2.6
CURRENT VARIABLE STORAGE	:	42050	

Non Home Based Work - Non Home Based School Trip Model For Higher Level
(Other Trip Model For Higher Level)

```
                    TSP Version 4.3A
              (10/26/95) DOS/Win      15MB
          Copyright (C) 1995 TSP International
                    ALL RIGHTS RESERVED
                     11/16/99 7:56 PM
     In case of questions or problems, see your local TSP
     consultant or send a description of the problem and the
     associated TSP output to:
                    TSP International
               P.O. Box 61015, Station A
                  Palo Alto, CA 94306
                          USA
        PROGRAM
LINE  ****************************************************************
|      1  options memory = 15;
|      2  supres dpdx dpdz;
|      3  read (file='hig3bnew.xls'), choice province sex_r age veh_hh_r
   tway_d num_trip
|      3    lic_r cost1 cost2 cost3 des_gla purp_r ivtt1 ivtt2 ivtt3 ovtt1
   ovtt2
|      3    ovtt3 st_ti_r adj t1 t2 t3 cbd_flag income org_gla orig_den
   dest_den
|      3    emp_den;
|      4  logit(cond,nchoice=3) choice cost t  ovtt| veh_hh_r
|      4     lic_r province age st_ti_r num_trip cbd_flag des_gla
|      4     C;
|      5  set y = @nob*log(1/3);
|      6  set x = -2*(y - @logl);
|      7  set rhosq = 1-(@logl/y);
|      8  show list;
|      9  set rhobarsq = 1-((@logl-16)/y);
|     10  print y,x,@logl,rhosq,rhobarsq;
|     11  msd (all,corr,print) choice cost1 cost2 cost3 t1 t2 t3 ovtt1 ovtt2
    ovtt3
|     11    veh_hh_r lic_r province  age st_ti_r num_trip cbd_flag des_gla
|     11
        EXECUTION
*****************************************************************************
COLUMN NAME > 8 CHARACTERS:  [tr-actual]
COLUMN NAME > 8 CHARACTERS:  [sl-actual]
COLUMN NAME > 8 CHARACTERS:  [a-pred corr]
COLUMN NAME > 8 CHARACTERS:  [tr-pred corr]
COLUMN NAME > 8 CHARACTERS:  [sl-pred corr]
COLUMN NAME > 8 CHARACTERS:  [tot-a-pred]
COLUMN NAME > 8 CHARACTERS:  [tot-tr-pred]
COLUMN NAME > 8 CHARACTERS:  [tot-sl-pred]
Note: Number of column names (      56) not equal to
Number of data columns in file (     156).

Current sample:  1 to 7016


                                   Equation   1
                                   ============

                              MIXED LOGIT ESTIMATION

CHOICE      FREQUENCY  PERCENT
1                5838  83.2098  (COEFFICIENTS NORMALIZED TO ZERO)
2                 319   4.5468
3                 859  12.2434
Working space used: 309869
                              STARTING VALUES
```

	COST	T	OVTT	VEH_HH_2	LIC_R2
VALUE	0.00000	0.00000	0.00000	0.00000	0.00000

	PROVINC2	AGE2	ST_TI_R2	NUM_TRI2	CBD_FLA2
VALUE	0.00000	0.00000	0.00000	0.00000	0.00000

	DES_GLA2	C2	VEH_HH_3	LIC_R3	PROVINC3
VALUE	0.00000	0.00000	0.00000	0.00000	0.00000

	AGE3	ST_TI_R3	NUM_TRI3	CBD_FLA3	DES_GLA3
VALUE	0.00000	0.00000	0.00000	0.00000	0.00000

	C3
VALUE	0.00000

```
F=   7707.9     FNEW=   2872.7     ISQZ=  0 STEP=  1.0000     CRIT=  9620.9
F=   2872.7     FNEW=   2461.1     ISQZ=  0 STEP=  1.0000     CRIT=  654.22
F=   2461.1     FNEW=   2309.2     ISQZ=  0 STEP=  1.0000     CRIT=  245.09
F=   2309.2     FNEW=   2271.5     ISQZ=  0 STEP=  1.0000     CRIT=  64.638
F=   2271.5     FNEW=   2268.1     ISQZ=  0 STEP=  1.0000     CRIT=  6.4397
F=   2268.1     FNEW=   2268.0     ISQZ=  0 STEP=  1.0000     CRIT= 0.81585E-01
F=   2268.0     FNEW=   2268.0     ISQZ=  0 STEP=  1.0000     CRIT= 0.14352E-04

CONVERGENCE ACHIEVED AFTER   7 ITERATIONS

   14 FUNCTION EVALUATIONS.

     DEPENDENT VARIABLE: CHOICE

                 LOG OF LIKELIHOOD FUNCTION =    -2268.05
                            NUMBER OF CASES =   7016
                          NUMBER OF CHOICES =  21048
```

Parameter	Estimate	Standard Error	t-statistic
COST	-.786410	.037654	-20.8850
T	-.057034	.275949E-02	-20.6681
OVTT	-.027524	.866302E-02	-3.17718
VEH_HH_2	-1.54288	.109565	-14.0818
LIC_R2	-1.87940	.167553	-11.2167
PROVINC2	.703298	.192540	3.65273
AGE2	-.026357	.531989E-02	-4.95443
ST_TI_R2	.668545	.139224	4.80193
NUM_TRI2	-.287251	.038031	-7.55306
CBD_FLA2	.868575	.197858	4.38989
DES_GLA2	.813447E-06	.217076E-06	3.74729
C2	1.85941	.269675	7.20874
VEH_HH_3	-1.24802	.081694	-15.2767
LIC_R3	-1.75364	.127884	-13.7128
PROVINC3	.577746	.120223	4.80560
AGE3	-.026113	.389497E-02	-6.70425
ST_TI_R3	.711266	.101042	7.03929
NUM_TRI3	-.095220	.019966	-4.76919
CBD_FLA3	1.22889	.175058	7.01988
DES_GLA3	-.205103E-06	.203989E-06	-1.00546
C3	1.49056	.251345	6.73495

Standard Errors computed from analytic second derivatives (Newton)

Class	Name	Description
---	---	---

```
LIST      @LHV      1 members
          @RNMS     21 members
```

	Y	X	@LOGL	RHOSQ	RHOBARSQ
Value	-7707.86382	10879.63037	-2268.04863	0.70575	0.70367

Correlation Matrix

	CHOICE	COST1	COST2	COST3
CHOICE	1.0000			
COST1	0.28143	1.00000		
COST2	-0.10966	0.066293	1.0000	
COST3	0.00000	0.00000	0.00000	0.00000
T1	-0.27471	0.18838	0.47890	0.00000
T2	-0.26340	0.15876	0.34610	0.00000
T3	-0.25284	0.12938	0.51044	0.00000
OVTT1	0.00000	0.00000	0.00000	0.00000
OVTT2	-0.12751	-0.069966	0.55104	0.00000
OVTT3	0.00000	0.00000	0.00000	0.00000
VEH_HH_R	-0.28167	-0.089441	0.11100	0.00000
LIC_R	-0.35121	0.039988	0.033097	0.00000
PROVINCE	0.080348	0.076852	0.075540	0.00000
AGE	-0.19592	0.021157	0.037781	0.00000
ST_TI_R	0.059078	0.020904	-0.011559	0.00000
NUM_TRIP	-0.10164	-0.060234	-0.051553	0.00000
CBD_FLAG	-0.18298	-0.71101	-0.030476	0.00000
DES_GLA	0.014215	0.028704	-0.036265	0.00000

	T1	T2	T3	OVTT1
T1	1.00000			
T2	0.92708	1.00000		
T3	0.94943	0.88547	1.0000	
OVTT1	0.00000	0.00000	0.00000	0.00000
OVTT2	0.35848	0.17873	0.48066	0.00000
OVTT3	0.00000	0.00000	0.00000	0.00000
VEH_HH_R	0.11678	0.092062	0.12806	0.00000
LIC_R	0.12428	0.12257	0.10505	0.00000
PROVINCE	-0.010207	-0.049960	0.042515	0.00000
AGE	0.049561	0.045538	0.040015	0.00000
ST_TI_R	0.027487	0.036034	0.027729	0.00000
NUM_TRIP	-0.073851	-0.069501	-0.077624	0.00000
CBD_FLAG	-0.10914	-0.077158	-0.020728	0.00000
DES_GLA	-0.025589	-0.0035760	-0.026438	0.00000

	OVTT2	OVTT3	VEH_HH_R	LIC_R
OVTT2	1.00000			
OVTT3	0.00000	0.00000		
VEH_HH_R	0.11175	0.00000	1.00000	
LIC_R	0.026496	0.00000	0.16223	1.0000
PROVINCE	0.076483	0.00000	-0.0048836	-0.013873
AGE	0.013574	0.00000	0.032749	0.43757
ST_TI_R	0.0085783	0.00000	0.031857	-0.0086480
NUM_TRIP	-0.045624	0.00000	0.022139	0.14887
CBD_FLAG	0.13596	0.00000	0.12335	-0.023154
DES_GLA	-0.074111	0.00000	-0.012481	-0.012367

	PROVINCE	AGE	ST_TI_R	NUM_TRIP
PROVINCE	1.00000			
AGE	0.053101	1.0000		
ST_TI_R	0.016495	0.058171	1.00000	
NUM_TRIP	-0.011517	0.037461	-0.016873	1.0000

```
CBD_FLAG            -0.014170     -0.0097363     0.019338      0.011693
DES_GLA              0.035697     -0.018307     0.0024166    -0.014885


                     CBD_FLAG       DES_GLA
CBD_FLAG              1.00000
DES_GLA              -0.016157       1.00000

*******************************************************************************

END OF OUTPUT.

  MEMORY USAGE:     ITEM:     DATA ARRAY  TOTAL MEMORY
                   UNITS:  (4-BYTE WORDS) (MEGABYTES)
  MEMORY ALLOCATED          :   3250000       15.0
  MEMORY ACTUALLY REQUIRED :    633687        4.6
  CURRENT VARIABLE STORAGE :    255412
```