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***Development of Nested Logit Models for Simulating and
Evaluating Vehicle Occupancy***

By

Sabbirali Saiyed M. Eng.

M. S. University of Baroda

Baroda, India, 1990

*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
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the acceptance of the thesis*

***“Development of Nested Logit Models for Simulating and
Evaluating Vehicle Occupancy”***

By

Sabbirali Saiyed *M. Eng.*

Carleton University, 1999

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

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ABSTRACT

Over the years, emphasis has been shifting from building and providing additional auto and transit facilities to using existing facilities more efficiently to accommodate travel demand growth. As a result, more stress is being laid on planning and analysis of operational road improvements and increasing car occupancy in urban area. This study reports on the development of models which can be used to estimate the sensitivity of the modal choice process to a variety of urban transportation policies designed to encourage the use of higher car occupancy with the goal of using the road system more efficiently.

This research focuses on the development of logit modal split models that are sensitive to car occupancy policy issues. Logit models were selected because they are explanatory in nature and can be used to evaluate the sensitivity of individuals to policies influencing auto occupancy, the key requirement of this research.

Modal split models were developed for the National Capital Region for simulating afternoon peak period auto and transit mode choice. In the models, the auto mode was further divided into single occupant vehicle, two persons per vehicle and three or more persons per vehicle. Two models were developed: one for work to home trip purpose and the other for all other trip purposes excluding school to home trips.

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 mode choice for work trips and the non-work trip purposes.

It is concluded that the models which have been developed are sensitive to vehicle occupancy and are useful tools to evaluate transportation policies affecting the choice of travel mode including high occupancy vehicles.

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CHAPTER 1

RESEARCH PROBLEM DEFINITION

1.1 NEED FOR NEW MODAL SPLIT MODELS

Transportation systems provide a vital service to our community by moving people and goods within the urban area. In today's modern society, transportation systems have become more crucial and more important than ever before. Their normal day to day operation has become an important concern for the elected officials, transportation planners and people in general. Many towns and cities have experienced tremendous growth in transportation resulting in a significant increase in the number of vehicles using the transportation system. This has put pressures on elected officials, transportation engineers and planners to provide better and more efficient transportation facilities with a satisfactory level of service in a cost-effective manner.

Many municipalities and local governments do not have sufficient funds to build new roads to cope with growing transportation needs. Hence the emphasis is to improve the efficiency of existing transportation infrastructures. This could be done by maximizing the people moving capability of the transportation systems by increasing the number of persons per vehicle. This in turn will help in reducing the number of vehicles using the transportation systems and delay the need to build new costly facilities. Strategies are being examined to find methods to increase the number of persons per vehicle such as the implementation of high-occupancy vehicle (HOV) facilities.

HOV facilities have been accepted throughout North America and other parts of the world in recent years as a way to move more people efficiently on existing roadways. In order to gain insight into when these facilities can be implemented successfully, there is a need to develop in the urban planning framework, a methodology that can be used to aid

engineers, planners and decision makers to plan and review options to increase auto occupancy in an objective manner. Analytical models for simulating the impacts of policy options to increase auto occupancy show potential in reducing the uncertainty inherent in evaluating options to increase car occupancy as HOV facilities. In this research, an effort is made to develop modal split models sensitive to car occupancy and to analyze individual mode choice behaviors in the National Capital Region (NCR).

The Region of Ottawa-Carleton, Communauté urbaine de l'Outaouais together with National Capital Commission have encouraged the increased use of policies to increase car occupancy. Several HOV facilities are now in place increasing mobility at minimum cost to residents. However, the planning of other options to increase auto occupancy in the region could be made more effective if a methodology were available to simulate car occupancy in greater detail than is currently available.

In order to evaluate options aimed at increasing auto occupancy in the NCR, it would be desirable to develop modal split models that are sensitive to vehicle occupancy. To achieve this, a more refined modal split model is required. Such a model will have numerous benefits as:

- Indication of realistic levels of potential HOV usage in order to assess the validity of the transportation objectives regarding HOV usage.
- Identification of the HOV operating strategies which encourage high levels of high occupant vehicle ridership commensurate with low operating cost.
- Ability to test the sensitivity of modal choice with respect to vehicle occupancy, travel cost, travel time, socio-economic variables such as number of vehicles per household, number of persons per household and employment.

TRANS, a joint transportation technical committee comprising of representatives from Region of Ottawa-Carleton, Communauté urbaine de l'Outaouais (CUO), OC Transpo, the Société de transport de l'Outaouais (STO), the Ministère des Transports de Québec

(MTQ) and the Ministry of Transportation Ontario (MTO) is the agency responsible for the development of travel demand models in the National capital Area (NCR). The NCR consists of area under the jurisdiction of Region of Ottawa-Carleton, Communauté urbaine de l'Outaouais (CUO) and the Municipalité régionale de Comté des Collines-de-l'Outaouais (MRC). This area is comprised of 22 local municipalities of Ontario and Quebec province. TRANS has shown interest in carrying out research in conjunction with Carleton University into the development of modal split models.

This research project focuses on the development of disaggregate mode choice models to simulate auto and transit modes. The nested logit models have been developed to simulate and predict P.M. peak period modal split for auto and transit. The auto mode has been further divided into single occupant vehicle (SOV), two persons in vehicle (2P) and three or more persons in vehicle (3P+). This modeling research will constitute an important portion of the TRANS Transportation Model Development Program.

1.2 RESEARCH OBJECTIVES

The objectives of this research are:

- To investigate urban modal split modeling methodologies used in urban areas for simulating auto and transit mode split and to review how these models attempt to account for auto occupancy.
- To develop modal split models sensitive to vehicle occupancy for the NCR.
- To develop models of such a design that can be incorporated into the travel demand modelling framework used in the NCR.
- To carry out the mode split sensitivity analysis for the developed models.

1.3 RESEARCH SCOPE

Based upon a through review of urban modal split modeling theory and models developed in a number of American and Canadian cities, a style of model appropriate to the objectives of this research was obtained. It was found that the logit model based on “Disaggregate Behavior Analysis” was the most suitable for the study. With this decision made that the model would be developed for the NCR, work was carried out to find a data source to develop the model. The 1995 OD survey carried out by TRANS was selected as the principal data source for developing the model. Additional data were added to the survey databank from various sources as the existing TRANS model and demographic data from the Planning Department of the RMOC and CUO.

With the database prepared, various options were investigated to develop a model sensitive to vehicle occupancy. Models were developed for the P. M. peak period for work to home trips and another model for the remaining trip purposes excluding school to home trips. Various strategies were tested to simulate the auto mode in a manner that provided the most satisfactory results simulating car occupancy. With the models developed, they were tested to determine their accuracy in predicting mode choice behavior. Sensitivity analysis was then carried out to gain insight into the behavior characteristics of the auto users influencing auto occupancy.

1.4 RESEARCH METHODOLOGY

The research methodology adopted to achieve the study objectives is shown in the Figure 1.1. A brief description of the study methodology is presented in order to describe the study procedure as well as the inter-relationships among the various steps.

The main data source used in the study is the 1995 Origin and Destination Travel Survey which is the most recent comprehensive travel survey undertaken in the National Capital Region. The trip origins and destinations for all trips taken by specific household are collected with the attributes associated with each household, person, trip and transit data.

The data provides the baseline information used for both short and long range transportation planning.

From the 1995 OD Survey, the travel mode and trip purposes are selected. The linking of trips is carried out so that trips were grouped as per their true and legitimate trip purposes. With the linking of trips, a new file was prepared for the P. M. peak period trips. Then the filtration was done to select the trips to be included in the model. The new variables were generated from the existing variables as well as from multi-modal network EMME/2 auto and transit networks. The models were calibrated for work as well as non-work trip purposes. The results of the model were tested and the best models were selected. These models are presented in detail later in this report.

Figure 1.1 Research Methodology

1.5 Thesis Organization

The thesis has been organized into eight chapters and appendices.

Chapter 1 is the introduction. It describes the background, research objectives, research scope, research approach, research methodology and thesis organization.

Chapter 2 provides an overview of modal split models used in selected American and Canadian cities. An evaluation is presented of the limitations of the models to simulating auto occupancy for policies sensitive to car occupancy.

Chapter 3 describes the theory of disaggregate mode choice models. It discusses the advantages and disadvantages of mode choice modeling. It also deals with the theoretical aspect of logit and nested logit models.

Chapter 4 describes data preparation process. It starts with overview, selection of the study area, data source, selection of modes, selection of trip purposes. It also discusses the development of variables.

Chapter 5 presents the nested logit model for the home based work trip. This consists of three models in hierarchy, thus forming a nest. The lowest level model is a model for two and three or more persons per vehicle. The next model is for SOV and non-SOV (more than one persons in vehicle) modes. The higher level model is for auto and transit. This chapter describes the developed model, validation, sensitivity analysis and discussion of results of all models.

Chapter 6 describes the non-work trip model which includes non-home based, other home based and leave home trips. The logit model developed is presented in detail with model calibration, validation and discussion of results along with correlation and sensitivity analysis.

Chapter 7 provides the comparison summary of the work as well as non-work trip models. Chapter 8 presents the conclusions and the recommendations of this research.

CHAPTER 2

URBAN MODAL SPLIT MODELS

2.1 OVERVIEW

One of the primary responsibilities of today's urban transportation modelers is to simulate travel demand and predict how this demand changes by mode in response to present and future transportation policies. The accuracy of this simulation depends to a large extent on the models and methodologies used to analyze individual travel behavior.

A substantial amount of research has gone into modeling individual travel choice behavior and as a result new methodologies have developed. Many of these developments have found their way into the modal split models used in the traditional four stage urban transportation modeling process. Of particular interest in this research is the simulation of the auto mode such that it takes into account auto occupancy and can be used in policy analysis of ridesharing strategies such as HOV facilities. The purpose of this chapter is to provide an overview of the development of urban mode choice models to simulate in particular the auto mode.

2.2 DEFINING TRAVEL MODES

The modes most frequently used in urban areas are auto, transit, bike and walk. In most instances, the auto and transit modes are included in the travel demand modeling process. This is in part due to past needs to supply a transportation system that the public desired, an auto based system supplemented with public transit. Furthermore, the walk and bike modes utilize sidewalks and bike lanes located along the road system. Therefore, if the urban area supplies the road system for the auto and transit system, they indirectly supply the facilities for the most part for the walk and bike users. In this research, only the transit mode and the auto mode are included in the modal split modeling methodology.

There is a wide variety of ways to define the auto mode when building modal split models. In the simplest state, all auto users are grouped into one auto mode. In this modal split model, it is not possible to distinguish between the auto users who travel alone or travel as a passenger. An advantage of this mode definition is that it may provide the most reliable mode split model to simulate auto and transit mode choice. This is because only two modes are simulated. As the number of auto modes increases in the model, there is a tendency that the accuracy with which transit mode share can be simulated decreases as the complexity of the modal split model increases. This mode definition is not sensitive to vehicle occupancy and therefore cannot distinguish and predict the impacts of transportation policies aimed at altering auto occupancy rates. If only one auto mode is used to define auto in the modal split model, a vehicle occupancy factor can be applied after the mode split model is run to convert the auto mode into auto vehicles and auto passengers.

Another option in defining the auto mode is to divide the auto mode into auto drivers and auto passengers. The travel characteristics of auto drivers is different than the auto passengers. The problem with this style of model is that it is not sensitive to vehicle occupancy. The model would not be able to distinguish the impacts of varying number of auto passengers in a vehicle. Another difficulty with this mode definition is that it treats the SOV driver the same as the driver in a vehicle with passengers. In the development of logit models, this definition is problematic. It does not let the modeler clearly define the cost of travel for the auto driver. If the driver is the only person in the vehicle, then the auto cost would all be proportioned to the driver. On the other hand, if the driver is sharing a ride with others, then the cost should be split among all the persons in the vehicle. With this definition of the auto mode, this is not possible and as a result, the reliability of simulating the auto mode in this fashion could be problematic.

Another option of defining the auto mode is SOV and non-SOV. With this definition, the problem is resolved of distinguishing between the auto driver who is sharing a ride with the SOV driver. However, we are still not able to distinguish between various levels of

auto occupancy. Furthermore, there are problems also in defining the cost and time of travel for the non-SOV user. If we assume that cost is a function of the number of persons in the vehicle, then it is not possible to obtain an accurate estimate of cost for this mode. Assumptions must be made regarding auto occupancy and then a cost is prepared. In a similar manner, travel time must be based on the average time to accommodate the extra persons in the vehicle. Furthermore, since we cannot distinguish vehicles with 3 or more person vehicles, this model cannot be used to analyze HOV policies.

The auto mode could also be defined as SOV, 2P, 3P+. This model will be sensitive to vehicle occupancy. This way of classifying auto mode will help us in differentiating the travel characteristics of a single occupant vehicle, two persons per vehicle and three or more persons per vehicle. This definition of the auto mode could be used to analyze HOV policies and other ride sharing strategies. In order to develop this type of model, it is necessary to have as much observed information as possible describing cost and travel time for every auto user. The potential disadvantage of this type of approach to simulating the auto mode is the complexity and the potential difficulties of simulating transit satisfactorily.

2.3 SELECTED MODAL SPLIT MODELS

The development of modal split models sensitive to the characteristics of auto as well as the transit mode is dependant on many factors as data availability and the desired application of the model. Several models developed in the United States as well as Canada are reviewed and discussed as to their suitability to the needs of this research. The type of variables used in the models is also described to provide insight into the model formulation.

2.3.1 San Diego Model

San Diego County had the firm Peat Marwick, Mitchell and Co. develop a logit modal split model for their urban area in 1977 [Spear, 1977]. The model they developed had a

typical style of logit models developed in the late 1970's when these models were first introduced into the urban transportation modeling process. The model was used only for the home to work trip purpose. Three travel modes were considered, auto driver, auto passenger and transit. To capture the differences in observed transit usage, separate modal split models were developed for the CBD and the non-CBD areas. The variables used in the models include in-vehicle travel time, out-of-vehicle travel time and travel cost. An income variable was also developed to assist in explaining between modes based on the individual's sensitivity to cost with respect to their wealth.. The San Diego model is as shown in Table 2.1.

Table 2.1 San Diego Model

Models	Modes	Income	Cost	Time	Constant
CBD	Auto Passenger	0.0000			
	Auto Driver	1.935			-1.4809
	Transit	0.0916	0.0106	0.0563	1.1636
Non-CBD	Auto Passenger	0.0000			
	Auto Driver	2.6800			-0.5441
	Transit	0.1314	0.0184	0.0192	1.6600

The values of the coefficient for cost are based in US currency and reflect the cost of travel by older vehicles back in 1977. For these reasons, the values of the coefficient are not directly comparable to travel costs of today. As outlined earlier, this modal definition of the auto mode has limitations in a study focusing on auto occupancy. However, it does provide insight into the type of variables that are required for inclusion in a logit model and introduces the concept that geographic area can play a role in defining the modal split model.

This model was also applied to Boston and San Francisco. The simulation results provided acceptable simulation results of the observed mode split in the two cities which had significantly different transit service characteristics.

2.3.2 Denver Regional Model

Logit models were developed for the Denver Regional Transportation District, USA [Spear, 1977]. The models examined choice between drive alone, shared ride and transit. Only two variables were used in the model, travel cost and composite travel time consisting of in-vehicle time plus 2.5 times out-of vehicle time. Separate models were developed for four trip types: home based work, home based shop, home based other and non-home based. For each home based trip purpose, separate models were developed for four levels of income. These models were calibrated using data from an OD Survey.

2.3.3 Twin Cities Model

Logit models were developed for the Twin Cities Metropolitan Council by R.H. Pratt and Associates, USA [Spear, 1977]. Separate models were developed for four income levels in each of three trip purposes: home based work, home based other and non-home based. Three modes were included, drive alone, shared ride and transit. The model is shown in Table 2.2.

This model was not able to estimate the average auto occupancy for the share ride mode. Therefore a separate auto occupancy model was developed. This model stratified the share ride into two person, three person, four person and five or more person carpools. In order to identify sufficient level of service differences in auto occupancy levels, pick up time penalties were added to the running times and used in the models and travel cost was divided by the occupancy levels. The other variables used in the models included auto parking time, income, transit access, wait, transfer times, transit fare and accessibility.

Time penalties were introduced for picking car pool passengers. These were based on the average discrepancy between reported and skim travel times for different levels of auto occupancy for each trip purpose. Time penalties for the work trip ranged from 1.1 minutes for a two person car-pool to 4.3 minutes for a five person carpools. Time penalties for the other trip purposes were all under one minute.

Table 2.2 Twin City Work Trip Model

Models	Modes	Cost	IVTT	Parking Time	Income	Distance	Walk Time	Wait Time
Three Mode Model	SOV	-0.0200	-0.0320	-0.2570	0.5670			
	Sh. Ride	-0.0200	-0.0320	-0.3420	0.3360	-0.0090		
	Transit	-0.0200	-0.0320				-0.0440	0.0320
Five Mode Model	SOV	-0.0140	-0.0310	-0.2060	0.6060			
	2P	-0.0140	-0.0310	-0.3490	0.2390			
	3P	-0.0140	-0.0310	-0.6050	-0.0780			
	4P+	-0.0140	-0.0310	-0.6050	-0.2820			
	Transit	-0.0140	-0.0310				-0.0440	-0.0300
Auto Occ. Model	2P	-0.0230	-0.9620					
	3P	-0.0230	-0.9620		-0.3020			
	4P+	-0.0230	-0.9620		-0.3020			

One of the important variables used was trip density. It was believed that as trip density increases, it would be easier for trip makers to pair up for automobile trips, thereby increasing average auto occupancy.

As with the San Diego model, care must be taken in drawing conclusions of the model coefficients for cost.

2.3.4 Greater Toronto Area Model

1991 Modal Split Model

The mode choice model for the Greater Toronto Area (GTA) was developed by IBI Group, Toronto [MTO, 1991]. The modal split model for the work trips included auto and transit. The transit mode included trips where the auto mode was used to access or egress the transit mode. The developed model is the logit model. The level of service variables were obtained from EMME/2 model. These variables included zone to zone auto time, auto distance, in-vehicle time, out-of-vehicle time for the transit. The model was developed for the A.M. peak hour. The model is as shown in Table 2.3.

Table 2.3 GTA Modal Split Model

Models	Modes	Cost	IVTT	OVTT	Pop. Density	Emp. Density	Park & Ride	OD sub. Var.	Const.
Model 1	Auto	-0.103	-0.021						
	Transit	-0.103	-0.021	-0.081	1.0E-05	8.1E-07	0.238	0.419	-0.686
Model 2	Auto	-0.106	-0.023						
	Transit	-0.106	-0.023	-0.079	1.0E-05	8.5E-07			-0.712
Model 3	Auto	-0.150							
	Transit	-0.311	-0.018	-0.058	9.8E-06	7.2E-07	0.851	0.377	-0.820
Model 4	Auto	-0.175							
	Transit	-0.245	-0.024	-0.058	1.0E-05	7.4E-07			0.897

Models 1 and 2 are generic models where each variable is given a weight that is constant across all alternatives and the models 3 and 4 are alternative specific models where each variable is given a different weighting for different alternatives. For each pair of models, specifications with and without dummy variables were included. All four models shown in Table 2.3 are similar in terms of the component variables, with the exception of the dummy variables.

The variables included in the model were auto cost, auto time, transit fare, in-vehicle-travel time, out-of-vehicle travel time, population density by zone, employment density by zone, park and ride dummy variable between the regions and planning district, a dummy variable for trips with origins and destinations adjacent to the subway/RT system and a constant. The dummy variables are meant to capture unique spatial relationships which are not apparent solely from level of service data. These two dummy variables improve the quality of model.

Model 1 was considered the best model for Toronto region. The model had explicit travel cost and time with strong dummy variables. The model had better prediction and reasonable sensitivity to policy variables.

These models could not be used in our analysis as the model was developed for Toronto region which has appreciably different travel characteristics and needs than NCR.

1997 Modal Split Model

This mode choice model for the Greater Toronto Area (GTA) was developed in conjunction with University of Toronto [Joint Program in Transportation, 1997]. The models were developed for three trip purposes: home to work, home to school and non-work trips. Seven modes of travel such as auto passengers, transit, subway with auto access, go-rail with transit access, go-rail with auto access, walk and auto driver.

The home to work mode choice model was developed for the morning peak period. The model was developed for the entire GTA area consisting of metro as well as non-metro traffic. The workers with access to the auto drive mode possess significantly different modal utility parameters than the workers who can not drive. Hence two separate mode choice models were estimated, one for workers without access to the auto drive mode and one for workers who have auto drive in their choice set. The variables included in the work to home model were cost, in-vehicle-time, number of vehicles, transit access, transit wait, walk distance and constant.

The non-work trip model considered two modes of travel. They are auto and transit. The auto mode included auto passengers and auto drivers. For more details, the travel demand modeling system model documentation [Joint Program in Transportation, 1997] should be referred.

2.3.5 Vancouver/Surrey Model

The modal split model developed in the late 1980's for the District of Surrey, a suburb of Vancouver consisted of an auto user and the transit mode [District of Surrey, 1988]. Separate logit style models were developed for three trip purpose definitions for the PM peak hour. The model style is similar the model used for the Greater Vancouver Regional District (GVRD) except that the GVRD model simulates the am peak hour. The modal

split model included a composite auto impedance function consisting of time, auto occupancy, distance, and parking cost while the transit impedance function included access and egress walk time, total perceived transit time, and fare.

The generalized forms of auto occupancy, auto impedance and transit impedance were first calculated. These variables were then used in separate modal split equations specific to the particular characteristics of the different journey purposes.

Auto Occupancy

$$\text{autocc} = 1 + (0.12 * \exp(-0.015 * \text{audist}) * (1 + 0.6(\text{pkorg} + \text{pkdes})))$$

where autocc = Generalized auto occupancy between zones in persons per car

autodist = auto distance between zones in kilometers

pkorg = ½ the average daily parking charge for monthly parkers at the zone of the origin

pkdes = ½ the average daily parking charge for monthly parkers at the zone of destination

This equation is based on the premise, that the greater the volume of the trips between zones, the more opportunity for car sharing and therefore higher auto occupancy.

Auto Impedance

This measure used in the modal split equations is a composite variable that expresses both the monetary and time cost disincentives of travel by auto in common units of time, by converting money costs to time.

$$\text{Auimp} = \text{auveti} + (23/\text{autocc}) * ((0.068 * \text{audist}) + (\text{pkorg} + \text{pkdes}))$$

where auimp = auto impedance

auveti = auto vehicle time

autocc = auto occupancy

audist = auto distance in kilometers

pkorg = park cost at origin in \$ as above

pkdes = park cost at destination in \$ as above

The number 23 is the time value of money or 23 minutes per dollar. The distance coefficient of 0.068 is the cost per kilometers for both 1985 and 1987 for operating a car in B. C.

Transit Impedance

This measure expresses the composite disincentive to travel by transit in time units.

$$\text{Trimp} = \text{trkor} + \text{trwkde} + \text{trtoti} + 23 * \text{trfare}$$

where trimp = transit impedance

trwkde = transit walk time at origin zone based on the network density

trtoti = total perceived transit time as output from the transit assignment module. It includes in-vehicle time in real minutes, but weights waiting time for the first bus and transfers at 1.5 times the average actual wait as determined by the bus route headway. This is based on findings from other studies that conclude that people in making mode choices, perceive waiting time as more inconvenient than actual time riding.

trfare = transit fares. Adult zone fares from B. C. Transit schedules. These fares increased significantly from 1985 to 1987 and appropriate fare used for the model runs of each of these years.

The proportion of trips by transit between zones is calculated by a logit model which expresses this proportion as a function of the relative impedance of the auto and transit modes. The number of transit trips are calculated by multiplying these transit shares by

the total person trips. The number of auto trips are calculated by subtracting transit trips from total person trips and then dividing these auto person trips by auto occupancy.

Home from work trip modal split

The home from work trip modal split is given by the following equation:

$$hmktr = hmkpe * (\exp(-0.04 * trimp) / (\exp(-0.04 * trimp) + \exp(-0.04 * auimp)))$$

where $hmktr$ = home from work trips by transit

$hmkpe$ = home from work total person trips

$$hmkdr = (hmkpe - hmktr) / \text{autocc} / 1.02$$

$hmkdr$ = home from work drivers trips

Walk trips are deducted by subtracting all trips less than 1.5 km. long, including all interzonal trips from total person trips for this purpose.

2.3.6 National Capital Region Models

In the NCR, OD surveys were carried out in 1986 and 1995. As a result, travel demand models were developed based on each of the OD surveys by TRANS, the agency responsible for developing the travel demand models..

1986 TRANS Model

The 1986 model was developed by Delcan on behalf of TRANS and was based upon 1986 OD Survey [TRANS, 1993]. The model simulated auto drivers, auto passengers and transit for the National Capital Region. The logit model was developed for the work trips. The variables included in the model are cost, IVTT, OVTT, number of vehicles, province, transitway proximity and constant. The model for the P.M. peak period is as shown in the Table 2.4

Table 2.4 1986 TRANS Model

Modes	Cost	IVTT	OVTT	No. of Vehicles	Province	T_way	Const.
Auto	-0.6138	-0.0051		0.5963			-0.4103
A_Passenger	-0.6138	-0.0051	-0.0164	0.2229			-2.049
Transit	-0.6138	-0.0051	-0.0164		-1.1431	1.2511	

Cost	...	Travel cost from trip origin to trip destination
IVTT	...	In-vehicle-travel time
OVTT	...	For auto passengers wait time penalty was 5 minutes and for transit access and wait time included.
T_way	...	A dummy variable indicating if the employment zone is located on Transitway station (1 if so, 0 otherwise)
Province	...	A dummy variable indicting if the place of residence is located in Outaouais (1 if so, 0 if in RMOC)

This model was not able to differentiate between various vehicle occupancies and hence can not be directly applied to analyze car occupancy policies.

1995 TRANS Model

The 1995 modal split model was developed in-house by TRANS staff and is based on the 1995 OD Survey [RMOC, 1998]. The style of 1995 model was different than 1986 model in several key areas. The new logit model for work trips included the modes auto person and transit rather than auto driver, auto passenger and transit. It was found that greater accuracy of predicting transit mode split, a key requirement of the model, was obtained with this model style. A car occupancy model was developed outside of the logit model to convert auto persons to auto vehicles in the new model. The home based work trip model is shown in Table 2.5

Table 2.5 1995 TRANS model

Modes	Cost	Time	Number of Veh/hh	Province	Constant
Auto Person	-0.8641 (-27.9)	-0.0096 (-2.14)			
Transit	*-0.8641 **(-27.9)	-0.0096 (-2.14)	-1.738 (-15.6)	-0.8367 (-5.64)	0.9091 (-5.41)

* ... Variable coefficient

** ... t-statistic

Cost ... Travel cost from trip origin to trip destination

Time ... Travel time from trip origin to trip destination

No. of vehicles ... 0 for no vehicles/household, 1 for 1 vehicle/household and
2 for more than 1 vehicle per household

Province ... 0 for Ontario and 1 for Quebec

The auto occupancy for work trips in urban transit area is given by the following equation.

$$\text{Auto occupancy} = 1.249 - 0.00259 * \text{distance}$$

where the distance is expressed in kilometers.

The auto person mode is unable to differentiate between single occupant vehicle and share ride trips. Hence this model is not sensitive to vehicle occupancy and it cannot be applied to evaluate car occupancy policies.

2.4 PROPOSED MODEL

As discussed above, the 1995 calibration of the TRANS model is a logit model for P.M. peak hour to simulate auto person and transit demand. Using this type of definition of the auto mode, it is not possible to analyze policies sensitive to auto occupancy issues.

Based on discussions with RMOC staff, it was found that there is a need to carry out research to determine if a modal split model could be developed that could meet the following objectives:

- The model should simulate logical relationships between single occupant vehicles, two persons per vehicle and three or more persons per vehicle.
- It should be sensitive to transportation policy relating to car occupancy issues.
- The mode choice models should be capable of being integrated into the existing 1995 modelling framework calibrated with the 1995 OD survey.

CHAPTER 3

DISAGGREGATE MODE CHOICE MODELS

3.1 OVERVIEW

Many urban transportation policy issues are concerned with mode choice. The importance of mode choice in policy analysis has led to a variety of methods for predicting the effects of policy measures on traveler's mode choice. Two well known and frequently used prediction methods are aggregate mode split modeling and disaggregate mode choice modeling. Aggregate mode choice models can be exceedingly costly and cumbersome to develop. They are subject to serious biases and prediction errors owing to more reliance on aggregate travel data. The range of policy questions that can be treated with aggregate models is quite limited. According to Horowitz [1986], it is also not possible to carry out multi-modal analyses with the aggregate models. For example analyses in which it is necessary to predict the use of several different modes such as bus transit, rail transit, carpool and single occupant automobile.

Disaggregate mode choice models have long been available for use in transportation planning and policy analysis. Many transportation planners and agencies now use these models for practical policy analysis. Mode choice models constitute best practice for metropolitan areas with significant SOV, two persons per vehicle, three or more persons per vehicle and transit mode. Mode choice models represent traveler decisions about which vehicular mode to use as a function of level of service characteristics and the traveler's characteristics. The level of detail and precision required in the mode choice model is sufficient to answer policy issues such as the impacts of pricing strategies, HOV and non-motorized travel [TMIP, 1998].

3.2 AGGREGATE MODELS

The conventional aggregate demand models typically involves four stages which are as follows:

- Trip Generation
- Trip Distribution
- Modal Split
- Trip Assignment

These four sequences are often called as “Aggregate Models”, because they explain the travel of a group of households or individuals, e.g. all households in a traffic analysis zone [NCHRP, 1983]. Further, aggregate data are used in estimating the models. In the aggregate models the average household trip frequency for a zone is a function of the average household size and average auto ownership level in the zone. The data available at the household (disaggregate) level is averaged before estimating aggregate models.

In contrast, disaggregate models explain the travel of individuals directly. The data used in the disaggregate model is collected at the individual level or disaggregate level and they are used directly without averaging into large aggregates.

3.3 ADVANTAGES OF DISAGGREGATE MODELS

Disaggregate models have many practical advantages over the aggregate mode split models. Some of the advantages are:

- Disaggregate models achieve a higher degree of policy sensitivity than the aggregate models [Horowitz, 1986].
- Disaggregate models avoid the aggregate biases inherent in aggregate models.
- Disaggregate models are much more efficient than the aggregate models in terms of data and computational requirements. These models can use each trip record from a

home interview survey as a separate observation. The conventional models must combine anywhere from ten to one hundred individual trip records to get a stable value for a zonal or group mean [TMIP, 1998].

- These models can be developed using data from only 1000 - 3000 households less than one tenth the number required by aggregate models and they can be implemented with computers.
- Disaggregate models can treat multi-modal issues easily. Thus they can analyze and predict the use of several different modes such as bus, rail, carpool and single occupant vehicles [TMIP, 1998].
- Disaggregate choice models can be applied at any level of aggregation. This means that a model which has been calibrated using individual trips records can be used to forecast trip making behavior for any aggregation of trips either at geographical units such as traffic zones or at any other socio-economic units.
- Disaggregate models are probabilistic. They estimate the probabilities of all the modes under consideration rather than stating explicitly which mode will be chosen. Thus they use the probability concept.
- Disaggregate models allow us to include more explanatory variables of our choice. This means that transportation policies can be represented with various attributes of our choice and the one that explains the behavior explicitly and more significantly. This concept is extremely useful in investigating the sensitivity of demand to small changes in policy such as changes in parking and fuel cost and travel time.
- Disaggregate models are based on theories of individual behavior [TMIP, 1998]. This means that an individual's choice is influenced by the available options at the time of choice as well as conditions pertaining to that time. This shows that an individual will behave in the same fashion every time under similar conditions provided that every thing remains the same as per the previous situation.

Thus it can be seen that disaggregate mode choice models have important practical advantages over the other available methods for predicting mode choice. But the

successful application of the model depends upon how well the conditions are utilized to the advantage by the analyst. It is explicitly true that the analyst does not have full information of the mode choice models. But it is clear that disaggregate models require relatively small data and are more efficient in computation and in requirements.

3.4 LIMITATIONS OF DISAGGREGATE MODELS

Disaggregate mode choice models have a number of limitations which could be used as arguments against their use. But many of these limitations also apply to other types of model as well. The following is a list of some of the possible limitations or in other words issues arising out of disaggregate mode choice modeling.

- In disaggregate mode choice models, it is presumed that similar individuals would be expected to make the same travel choices when faced with the same set of alternatives. However in reality, this is not the practice. The same individual will make different choices when faced with same alternatives on different occasions. Some individuals vary their choices from day to day and time to time for no apparent reasons. Hence it is very difficult to explain such variations through disaggregate mode choice models [Horowitz, 1986].
- It is possible that analyst does not have sufficient and reliable data in disaggregate mode choice models. It is also matter of fact that the analyst is unlikely to know all the characteristics of all individuals and their mode choice. Thus it is true that the analyst does not have all complete data and there is no realistic possibility of obtaining the complete and satisfactory data.
- It is also true that not all individuals have exact knowledge of all the attributes of available mode alternatives in the disaggregate models. Also every individual has different opinions and perceptions of these attributes, which are likely to differ significantly. It is also not possible to obtain exact information about all individual's opinions and perceptions. This will affect the prediction of mode choices.

- In disaggregate mode choice models, it is possible that one or more important variables which are important to the traveler are not included or omitted due to lack of data. It is also practically difficult to include variables representing comfort, reliability, privacy, etc. As well, all individuals weigh some attributes differently than others, hence it is difficult to include these different perceptions precisely.
- Disaggregate models have also to accommodate errors due to software inefficiency and measurement errors. Some important and useful network models such as EMME/2 provide data on travel time which gives estimate of travel time between zone centroids. Because of this, simulated travel time and actual travel time may be significantly different.
- Disaggregate models do not include information on day to day variations in mode choice. Hence these exceptional circumstances and situations which have important influence on mode choice are not reflected in prediction estimation.
- Disaggregate mode choice models have to face an important limitation due to independence from irrelevant alternatives. This property says that the ratio of the market shares of two alternatives is unaffected by the presence or absence of any other alternatives [TMIP, 1998]. This property is also known as Red Bus/Blue Bus paradox. This IIA property limits the responses to transportation changes that can be predicted.
- It is difficult to forecast aggregate behavior from the disaggregate mode choice models. The disaggregate mode choice models predict the probabilities of individual's choice and not that of group. In order to calculate the group probabilities, all individual choice probabilities are computed and added. This is a difficult procedure when the data set is very large. Hence the aggregation bias is introduced which is adjusted by the special adjustment aggregation procedure.

Thus these are the limitations of disaggregate mode choice models. It is clear that some of these limitations are common to other types of model also. The successful application of any model depends upon how well the favorable properties are utilized by the analyst, depending upon individual project's circumstances. It is clear that disaggregate mode

choice models offer good solution with their efficient data and computational requirements. The disaggregate mode choice models remain powerful tools to evaluate the impacts of alternative changes in transportation policies.

3.5 THE LOGIT MODEL

The logit model of individual choice behavior is the most prominent methodology used in the disaggregate travel demand models [NCHRP, 1983]. The logit model assumes that each individual makes selections from among a set of alternatives. In making the selection, he/she assigns a utility value to each alternative. The individual selects the alternative which gives the highest or maximum utility.

For modeling purposes, the utility is composed of two components [NCHRP, 1983]. The first component is a component based on observed attributes. This is the deterministic portion of the utility function and is composed of the observable characteristics of the alternatives and the decision maker and it measures the average (systematic) tastes of decision makers within each category of socio-economic descriptors. The second component is the random utility component. This component contains the unobservable attributes of the alternatives and the decision makers, which includes idiosyncratic variations in taste that may be present in the population of decision makers [Sobel, 1981]. This is also referred as random taste variations.

The utilities can be expressed mathematically. Assume that each trip maker assigns some utility to each of his travel alternatives. Let U_{it} be the utility of the i^{th} alternative for the t^{th} trip maker. Let us assume that each alternative can be divided into deterministic portion V_{it} and its random portion, ϵ_{it} . Thus we have,

$$U_{it} = V_{it} + \epsilon_{it} \quad \dots\dots\dots(3.1)$$

The trip makers are assumed to choose the travel alternative that yields the highest utility. Thus an individual t will choose alternative i over alternative j if

$$U_{it} > U_{jt} \quad \dots\dots\dots (3.2)$$

From equations (3.1) and (3.2), it is clear that the alternative i is chosen if

$$V_{it} + \epsilon_{it} > V_{jt} + \epsilon_{jt} \quad \dots\dots\dots(3.3)$$

or equivalently, if

$$V_{it} - V_{jt} > \epsilon_{jt} - \epsilon_{it} \quad \dots\dots\dots (3.4)$$

From the above it is clear that one can not predict with certainty which alternative an individual will choose, i or j. This is because although V_{it} and V_{jt} can be estimated and compared, it is not possible to determine if $(V_{it} - V_{jt})$ exceeds $(\epsilon_{jt} - \epsilon_{it})$. Hence it is necessary to determine the probability with which $(\epsilon_{jt} - \epsilon_{it})$ will be less than $(V_{it} - V_{jt})$. This is done by assuming that the random component of the utility ϵ 's are independently and identically distributed with the Weibull distribution. [NCHRP, 1983]. Based on these assumptions, it can be shown that the probability that the t^{th} individual will choose the i^{th} alternative is given by the equation:

$$P_t(i) = \frac{e^{V_{it}}}{\sum_{j=1}^j e^{V_{jt}}} \quad \dots\dots\dots(3.5)$$

where in j = the number of alternatives including the i^{th} alternative
 e = the base of the natural logarithm.

The above equation (3.5) is the logit model.

3.5.1 Desirable Properties of the Logit Model

Logit models should have some desirable properties. [TMIP, 1998]. These properties are listed below:

- The probability of choosing a particular alternative should depend on the deterministic component of the utilities of all available alternatives. The chosen alternative is the one with the highest total utility.
- The probability that an alternative is chosen should increase when the deterministic component of the utility increases. It should decrease when the deterministic component of the utility of any other alternative increases.
- The model should accommodate choice sets containing any number of alternatives and should be able to predict the effects of changes in alternatives.
- The model should be easy to understand and to use in practice.

3.5.2 Types of Logit Models

The important types of logit models are:

- Binomial Logit Models
- Multinomial Logit Models
- Nested Logit Models

3.5.3 The Binomial Logit Model

The name binomial suggest that the choice is between two alternatives. Thus there are two alternatives. In this model, the probability that alternative 1 is chosen when there are two alternatives is given by the formula:

$$\text{Pr (1)} = \frac{\exp (V_1)}{\exp (V_1) + \exp (V_2)} \dots\dots\dots (3.6)$$

where Pr (1) is the probability that alternative 1 is chosen, exp () is the exponential function and V_1 and V_2 are the deterministic component of the utilities of alternative 1 and 2.

The binomial logit model has all the desirable properties of the logit models except that it can treat only two alternatives.

3.5.4 Multinomial Logit Models

When the binomial logit model is extended to accommodate choices among more than two alternatives, it is known as a multinomial logit model. For example, when there are three alternatives, the probability that alternative 1 is chosen is given by:

$$\text{Pr (1)} = \frac{\exp (V_1)}{\exp (V_1) + \exp (V_2) + \exp (V_3)} \dots\dots\dots (3.7)$$

where Pr (1) is the probability that alternative 1 is chosen, exp () is the exponential function and V_1 , V_2 and V_3 are the deterministic component of the utilities of alternative 1, 2 and 3.

In more general terms, the multinomial logit model is given by the formula:

$$\Pr(i) = \frac{\exp(V_i)}{\sum_{j=1}^J \exp(V_j)} \dots\dots\dots(3.8)$$

The variables included in the above expression V can be either conditional (also referred to as generic) or multinomial (also referred to as specific) variables [Horowitz, 1986; Ortuzar and Willumsen, 1994]. Conditional variables appear in the utility function of every alternative and their coefficients can be assumed identical.. An example of this variable is travel cost and travel time.

The multinomial variables are either chooser-specific or mode specific variables. In multinomial models, these variables are normalized by setting the coefficients of the first choice to zero. Multinomial variables include *gender, province, and number of vehicles per household*. In-vehicle travel time could also be considered as a mode specific variable. The behavioral rationale is that the time spent in a vehicle as a driver could be perceived differently from the time spent as a passenger who is able to read and relax during the auto trip.

In the multinomial logit model, it should be noted that choice probabilities depend only on the differences between the deterministic components of the alternatives' utilities.

The multinomial logit model satisfies the axioms of independence of irrelevant alternatives (IIA) which can be stated as:

“ Where any two alternatives have a non-zero probability of being chosen, the ratio of one probability over the other is unaffected by the presence or absence of any additional alternative in the choice set ” [Luce and Suppes, 1965].

This means that the ratio of the market shares of two alternatives is unaffected by the presence or absence of any other alternatives. This property is also known as Red Bus/ Blue Bus paradox. This IIA property limits the responses to transportation changes that can be predicted. But the research has also shown that the independence of irrelevant alternatives is not always an undesirable property. Many times it may become a valid assumption. Charles Rivers Associates Inc.[1965], found that in some instances the problems attributed to this property can be solved through better specifications of explanatory variables or a more careful selection of choice alternatives for the models.

The other approach to solve the independence of irrelevant alternatives issue is to use a nested logit model [Spears, 1977]. This is discussed in the following article in more detail.

3.6 THE NESTED LOGIT MODEL

3.6.1 Overview

Several suggestions have been made for resolving the problem arising out of the independence of irrelevant alternatives issue in multinomial logit model. The nested logit model is the simplest, practical and effective approach to mitigate independence of irrelevant problem. The nested logit model was developed in a path-breaking paper by Williams (1977) and was independently derived by Daly and Zachary (1978)[May et al., 1984]. In this section, the nested logit model is discussed.

3.6.2 Nested Logit Model Description

The nested logit model can be depicted by a simple tree structure that represents all the alternatives as follows:

Figure 3.1 Nested Model Structure

The multinomial logit model treats all alternatives equally whereas the nested logit model includes intermediate branches that group more closely related alternatives as shown in Figure 3.1. The grouping of these alternatives indicate the degree of sensitivity (cross elasticity) among alternatives. The alternatives in the common nest show the same degree of sensitivity as alternatives not in the nest. In the above figure, auto and transit are at the same level. Auto is further divided into SOV and Share ride. This difference in structure can result in dramatically different mode ridership projections since the nested logit model involves different nesting levels which are significantly different from the multinomial logit model.

The principle of utility maximization is used in the analysis. Each alternative is evaluated by the individuals according to utility functions. Now as per the principle of utility maximization, individuals are conceptualized as selecting the alternatives that have the greatest value of the utility. In the above situation, each individual is assumed to evaluate each of the alternatives that has the same multinomial model. However there is a composite utility of the nest made by SOV and Share ride in auto mode. The composite utility includes the expected value of the maximum utility of the members of the nest, given by the following equation:

$$I_{\text{sov, shrd}} = E [\max (U_i)] = \ln \sum_{i=1}^N \exp(V_i) \dots\dots\dots(3.9)$$

Where $I_{\text{sov, shrd}}$ is the expected maximum utility of the members of the auto nest., N is the number of available alternatives in the nest, U is the utility function and V is the deterministic portion of the utility function.

The nest's composite utility is then written as

$$V_{\text{sov, shrd}} = \theta I_{\text{sov, shrd}} + g W_{\text{sov, shrd}} \dots\dots\dots(3.10)$$

where θ is an estimated coefficient, g is a vector of estimated coefficients and $W_{\text{sov, shrd}}$ is a vector of attributes common to all members of the nest

The above nested logit can be estimated by using standard logit estimation software in two stages: first a simple binary logit model between SOV and Share ride is estimated. The results allow the calculation of the expected maximum utility of the nest $I_{\text{sov, shrd}}$ as per the equation (3.9) above. This value is then entered as an independent variable that has the $W_{\text{sov, shrd}}$ variables and the characteristics of transit into a second level simple binary logit model between auto and transit.

The first level logit model yields $P(\text{sov} | \text{sov, shrd})$ and $P(\text{shrd} | \text{sov, shrd})$, the conditional probabilities of the SOV and Share ride given that the choice is restricted to auto mode. The second level logit model yields $P(\text{sov, shrd})$ and $P(t)$, the marginal probabilities of auto and transit respectively. The probabilities of SOV and Share ride choice probabilities can be calculated by:

$$P_{\text{sov}} = P(\text{sov} | \text{sov, shrd}) \cdot P(\text{sov, shrd}) \dots\dots\dots(3.11)$$

$$P_{\text{shrd}} = P(\text{shrd} | \text{sov, shrd}) \cdot P(\text{sov, shrd}) \dots\dots\dots(3.12)$$

The transit choice probability is given directly by the second logit model.

3.6.3 Acceptability of the Nested Logit Model

The coefficient of maximum utility or the inclusive value of the nest θ must satisfy the condition

$$0 < \theta \leq 1 \quad \dots\dots\dots(3.13)$$

This is proved by Williams and Ortuzar [1994] in their research report. This means that the inclusive value should not be negative. It should be positive and must lie between 0 and 1. If $\theta < 0$, then improving the utility of one member of the nest, for example SOV can decrease the choice probability of selection of P_{sov} of that alternative. If $\theta = 0$, then an improvement in the utility of one or both members of nest will not change the choice probability of the nest. If $\theta > 1$, then improving the utility of one member of a nest such as SOV will not only improve its choice probability P_{sov} but may also improve the choice probability of other members of the nest such as share ride. If $\theta = 1$, then the model nested logit model structure collapses and the choice probability calculations yield algebraically equivalent results to those of simple multinomial logit model. This means that the nested logit model becomes mathematically equivalent to multinomial logit model.

Ortuzar and Willumsen [1994] write that in cases with more nesting levels of the nested logit model, each branch of the structure should satisfy the condition

$$0 \leq \theta_1 \leq \theta_2 \leq \theta_3 \leq \dots \leq \theta_s \leq 1 \quad \dots\dots\dots(3.14)$$

where θ_1 corresponds to the most inclusive parameter and θ_s to that of the highest level.

But McFadden [NCHRP, 1983] has shown that in a nested structure containing more than two layers, the only condition is that the inclusive value θ should lie in the 0 to 1 range.

Hence the above condition that the inclusive coefficient should not decrease as one moves up to higher level is not necessary.

3.6.4 Limitations of the Nested Logit Model

Some limitations of the nested logit model as mentioned by Ortuzar and Willumsen [1994], are as follows:

- The nested logit model compared to the multinomial logit model is not a random coefficient model, so it can not cope with taste variations among individuals.
- The Nested logit model can handle as many interdependencies among options as nests have been specified in the structure. The alternatives in one nest can not be correlated with the alternatives in another nest.
- The search for the best nested logit structure may imply the tentative examination of many nesting patterns. The modeling exercise therefore becomes more tedious and takes much longer than the multinomial logit model.
- The nested logit model requires a sequential estimation method. Hence it relies more on the estimation capability of the software. If there is no sufficient data to estimate lower nest models, the estimate becomes inefficient and some information is omitted and this error is then passed to the next superior levels.
- Some appealing and complicated structures can not be tested due to the need of sequential estimation method.

In spite of these limitations, it is clear that nested logit models have great appeal in addressing structural choice situations.

3.7 MODEL DEVELOPMENT

Logit Models are generally developed by two alternative procedures [NCHRP, 1983]. They are:

- Maximum likelihood approach
- Least square approach

In the first approach, the data on the calibration sample is loaded into a maximum likelihood estimation computer package for the logit models. The maximum likelihood approach iteratively solves for the sets of coefficients and generates the best fit to the observed pattern of choices in the calibration sample. The estimation package iterates through the problem until the estimated coefficients reach a specified convergence criterion or the estimation completes the specified number of convergences.

In the least square approach, the data is preprocessed into a log odds format and the model is estimated by using a least squares multiple regression computer routine. This approach finds the set of coefficients that minimizes the sum of the squared errors between the predicted and observed log odds ratios.

In this modeling research, we have used the first approach which is the maximum likelihood approach. We have used Times Series Processor (TSP) software [TSP International, 1996], to estimate the coefficients. The data required is the individual trip record based on household. The variable coefficients have been specified as generic or alternative-specific. The generic coefficients such as cost and time take the same value across all alternatives. The alternative specific coefficients take on a different estimated value for each alternative. These variables are number of vehicles per household, province of residence etc. in this research.

3.8 STATISTICAL SIGNIFICANCE TESTS

This section summarizes the appropriate techniques for performing tests of statistical significance of disaggregate logit mode parameters estimates, overall measures of model goodness of fit. Here the model parameters are derived from maximum likelihood estimation technique.

3.8.1 Maximum Likelihood Method

A likelihood function describes the probability of observing a given choice sample when the distribution of the underlying random component of utility is known. This sample is our data for which we have to estimate the coefficients in the logit model. For the logit model the underlying distribution is the Weibull distribution. In general the value of the likelihood function $L(\theta)$ is given by Sobel [1981],

$$L(\theta) = \prod_{ij} P_{ij}^{N_{ij}} \dots\dots\dots(3.15)$$

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. P_{ij} is found above from equation 3.5. It is desired to find estimates of the parameters θ which maximize the likelihood of observing the sample used in the estimation.

3.8.2 Measures of Overall Goodness of Fit

Three different measures could be applied to test how well the logit model fits into the observed data. They are:

- (1) Goodness of fit measures
- (2) Percent correct estimation
- (3) Examination of coefficients and t-statistics

Goodness of Fit Measures

The goodness of fit measures for logit models depend on the values of the logarithm of the model's likelihood function, when the coefficient assumes various values. This likelihood function is given by equation 3.15.

The logarithm of L^* when all the coefficients are set to zero is denoted by $L^*(0)$ and this represents the maximum amount of uncertainty that can be removed by developing a perfect model. $L^*(0)$ corresponds to an initial state of information that all alternatives are equally likely. The $L^*(0)$ is a large negative number.

When the coefficients are set to their maximum likelihood estimated values, the result is $L^*(\theta)$. This is a smaller negative number. A value of zero for $L^*(\theta)$ would indicate a perfect model. $L^*(\theta)$ corresponds to a final state of information about the likelihood of alternatives when the information is fully known. Most logit estimation software reports $L^*(0)$ and $L^*(\theta)$ value as part of their output.

When all the coefficients are set to zero except the coefficients of the alternative specific coefficient term, the resulting value is $L^*(C)$. This is a negative number. It lies within the range

$$L^*(0) \leq L^*(C) \leq L^*(\theta) \quad \text{.....(3.16)}$$

$L^*(C)$ corresponds to a second initial state of information that alternatives are as likely to be chosen as their aggregate market shares. $L^*(C)$ is given by as reported by Sobel [1981],

$$L^*(C) = \sum_{i=1}^N x_i [\ln(X_i / Y_i)] \quad \text{.....(3.17)}$$

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 are available.

Rho-Squared

This measure is analogous to the squared multiple correlation coefficient (R^2) in the linear statistical model. If the model perfectly predicts the choices of all individuals in sample,

the likelihood function in equation 3.15 will have the value 1. At the other end , if all the parameters in a logit model are 0, the model predicts that all the choices for any individual are equally likely. Here the model does not explain the choice variations and the likelihood function is much smaller. A natural measure of goodness of fit that can be used to compare alternative models estimated on the same data set is given by:

$$\rho^2 = 1 - [L^*(\theta) / L^*(0)] \dots\dots\dots (3.18)$$

in which $L^*(\theta)$ = Log of the likelihood for the vector of estimated coefficients.
 $L^*(0)$ = the value of L^* for $\theta = 0$

The value of ρ^2 varies between 0 (for no fit) and 1 (for perfect fit). But according to Ortuzar and Willumsen [1994], this limit of 0 and 1 does not have an intuitive interpretation for intermediate values. In fact the value around 0.4 may be considered a perfect fit. Ortuzar and Willumsen [1994] have also reported minimum ρ^2 values for a sample which is as shown in Table 3.1.

Table 3.1 Minimum ρ^2 for Various Relative Frequencies

Sample proportion selecting the first alternative	Minimum Value of Rho-square
0.50	0.00
0.60	0.03
0.70	0.12
0.80	0.28
0.90	0.53
0.95	0.71

Rho-square can be corrected to make it more sensitive to the market share by the following simple formula:

$$\rho_c^2 = 1 - [L^*(\theta) / L^*(C)] \dots\dots\dots (3.19)$$

This ρ_c^2 lies between 0 and 1. This ρ_c^2 allows comparisons between models estimated with observation sets that have different market shares.

In nested logit model, the ρ^2 takes the form as given by Ortuzar and Willumsen [1994]

$$\rho^2 = 1 - \{[l_1^*(\theta) + l_2^*(\theta) + \dots + l_s^*(\theta)] / [l_1^*(C) + l_2^*(C) + \dots + l_s^*(C)]\} \dots\dots\dots (3.20)$$

where the subscript 1 to S refers to the multinomial logit models at each nest.

Percent Correct Estimated

This is the measure that simply computes the proportion of individuals effectively choosing the option with the highest modeled utility. Here the highest predicted probability is for the alternative that is actually chosen. This is an unambiguous indicator of model reliability. Too high a value of percent correct estimated leads to model rejection as well as too low value. The disadvantage of this measure can be exemplified by the fact that although the percentage correct estimated of 55 % may be good in general, it is not so in actual case. Also percentage correct of 90 % is good in actual case, it may not be good if one option has market share of 95 %. In spite of its limitations, this is a good measure of model reliability.

Variable Coefficients

The significance of the individual variables may be investigated through an examination of the coefficients of these variables. The sign of the coefficient should reflect the expected human behavior based on common sense, judgement and experience. Variables with the correct sign should be included in the model while those with the wrong sign should be avoided as much as possible. Ortuzar and Willumsen [1994] reports that the current practice is to include a relevant variable with the correct sign even if it fails any significance test. The reason is that the estimated coefficient is the best approximation

available for its real value. The lack of significance may simply be caused by lack of sufficient data.

Policy variables such as cost and time are highly relevant variables. They have a solid theoretical backing and are crucial to model forecasting. If the policy variables have the wrong sign, it means that there is a big problem and even if this variable is highly significant, it should not be included in the model and re-estimation should be carried out. The other explanatory variables which are not crucial for policy evaluation but are good indicators of socio-economic importance should also have the correct sign and if significant should be included in the model, otherwise they should be rejected.

T-statistics

The t-statistics of a coefficient is the estimated value of the coefficient divided by the standard error of the estimate. The t-statistic of a coefficient is useful for deciding whether the variable associated with the coefficient explains or fully describes the data or not. If the t-statistic is not significant then the variable should be dropped. In general the variables whose coefficients have higher positive or negative t-statistics have greater explanatory power than the variables whose t-statistics approaches zero.

The t-statistic increases with confidence in the statistical significance of the sign and magnitude of the function. A t-statistic of more than 1.65 or less than -1.65 indicates significance of more than 95 percent confidence interval. A t-statistic of greater than 2.3 or less than -2.3 shows significance of more than 99 percent confidence interval.

Experience has shown that it is a good policy to retain variables whose coefficients have t-statistics that are greater than 1.0 or less than -1.0. Variables whose coefficients have t-statistics between -1.0 and 1.0 should be dropped from the model.

CHAPTER 4

DATA PREPARATION

4.1 OVERVIEW

This chapter presents the details of the data preparation process that was followed for building the modal split model for the National Capital Region. The primary data source used in this research is the 1995 Origin Destination Travel Survey carried out by TRANS agencies in the fall of 1995. The chapter also discusses the details of selection of modes and selection of trip purposes as well as linking of trips. Linking of trips is a special and important feature of this research, which is discussed in detail. After linking of trips, a filtering process is carried out to group the trips as per trip purposes and time period. New variables are generated from the EMME/2 model and also from existing variables. Once the database for developing the model is complete, it is then possible to build and calibrate the model as described in subsequent chapters.

4.2 SELECTION OF STUDY AREA

The selected study area is National Capital Region. This area is under the jurisdiction of Region of Ottawa-Carleton, 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. Figure 4.1 shows the study area.

The study area selected for building the transportation model is unique in several ways. Ottawa is the capital city of Canada and the Federal Government has a major influence in the affairs of the region. Furthermore, the National Capital Commission plays an important role in addressing Federal transportation needs. The selected study area falls under two provinces: Ontario and Quebec. Hull, a city of Quebec province lies to the

north of the Ottawa river while the city of Ottawa lies to the south. Ottawa and Hull are connected by five bridges across the Ottawa River. The combined metropolitan area of Ottawa-Hull constitutes the fourth largest urban area in Canada after Toronto, Montreal and Vancouver. Another salient feature of the area is the presence of extensive public transit facilities. Public transit in the Ontario province is provided by the Ottawa-Carleton Regional Transit Commission, more commonly known as OC Transpo and in Quebec, it is provided by Société de transport de l'Outaouais, popularly known as STO. The bus transit in Ottawa-Hull region is considered to be one of the best public transit systems in North America, due to the presence of an extensive transitways and excellent para-transit service.

Finally the selected area is ideal due to availability of the data from the 1995 OD Survey for building the model.

Figure 4.1 Study Area

4.3 SELECTION OF TRAVEL MODES

The travel modes included in the 1995 OD Survey are auto drivers, auto passengers, transit, bike and walk. The travel model that people choose depends on many factors such as trip length, travel cost, travel time, place of residence and other socio-economic factors. The demographic characteristics for the core, urban, suburban and rural areas tend to be quite different from one another. As a result of these differing demographics, modal choice differs for various geographical areas analyzed. The modal share of the travel modes for the after noon peak period is as shown in the Table 4.1.

Table 4.1 Travel Modes

Travel Modes	Number of Trip Records	Modal Share
Auto Drivers	19196	62.2%
Auto Passengers	4886	15.6%
Transit	3423	11.1%
Bike	463	1.5%
Walk	2909	9.4%

As seen from the Table 4.1, the share of auto drivers and auto passengers is 62.2% and 15.6% respectively. The combined share of auto modes is 77.8%. The transit share is 11.1%. Hence the share of motorized mode comes out to be 89.9%. The share of non-motorized modes is 10.9% with bike and walk mode shares of 1.5% and 9.4%. Thus it can be seen that the motorized modes have a much larger modal share. The pie chart showing the modal share of auto, transit, bike and walk is shown in the Figure 4.2

Figure 4.2 Travel Modal Share for P. M. peak period

The modes selected for this research are Auto and Transit. Auto was further divided into:

- Single Occupant Vehicle (SOV)
- Two persons per Vehicle (2P)
- Three or more persons per vehicle (3P+)

There are several reasons for the selection of these modes. The selected study area falls within two provinces, Ontario and Quebec, both having unique transportation characteristics. The region of Ottawa and Hull is the fourth largest metropolitan area in Canada. The region's population is growing fast and there is increased pressure for efficient and cost-effective transport facilities. The public transit is provided by OC Transpo in Region of Ottawa-Carleton and by Société de transport de l'Outaouais (STO) in Quebec side of National Capital Region. There is great pressure on the transit agencies to increase the ridership.

The automobile is the major travel mode with 77.8 % modal share. The characteristics of trip making by automobile differs significantly due to auto occupancy. It has been found that the characteristics of people driving alone, two people (mostly husband and wife) and

more than two differs significantly in the region. Hence it was necessary to study the travel characteristics of SOV, two persons per vehicle and three or more persons per vehicle in the study area. Furthermore the TRANS model developed by the region did not give this information, thus increasing the value of the research undertaken.

4.4 SELECTION OF TRIP PURPOSE

It was decided at the onset of this research that the transportation models developed from this modeling exercise will constitute an important part of the TRANS Transportation Model Development Program. Hence the decision was made to follow the same general style as other TRANS models to make this model more compatible and useful. The trips selected are:

- Work trips from work to home
- Non-work trips consisting of non-home based trips, other home based trips and leave home trips except school to home trips

The work trip dominates peak period travel and has quite different mode choice characteristics compared to other trip purposes. In this modeling exercise, a nested logit model for auto and transit was developed for the work trips. All other trips apart from work and school trips were combined into non-work trips. The logit model was developed for the non-work trips for auto and transit mode.

4.5 SELECTION OF TIME PERIOD

The maximum number of travel trips occur in the morning and after-noon peak periods (A.M. peak period and P.M. period). The trips in the A.M. peak period are defined as starting between 7.00 hours to 9.29 hours in morning. On the other hand, P.M. peak period starts at 15.30 hours and ends at 17.59 hours. The experience has shown that the large volume of traffic occurring in A.M. peak has strong orientation towards work and school trips. The P.M. peak period has even greater proportion of travel trips and the

transportation network is heavily loaded during the P.M. peak period reflecting the more varied trip purposes and destinations. For planning purposes, it is useful to have both in the model. But it is found that it is better to develop model for the P.M. peak period due to more proportion of travel trips and more varied trip purposes than the A.M. peak period.

In developing the P.M. peak period model, the conclusions drawn regarding the model variables will be similar to those resulting from the A.M. peak period model. However, there could be notable difference in travel time. The travel time variable will be less powerful and less reliable in the afternoon than in the morning. This is because the commuter places a higher value on personal time in the morning (on their way to work) than in the afternoon (on their way home). Also shopping trips on the way home from work may distort the travel time compared with A.M. home to work trips which tend to be more direct.

4.6 TYPES OF VARIABLES

Disaggregate models allow us to choose variables that influence the mode choice. 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. But there are certain types of variables that must definitely be included to obtain a useful model. There are no standard guidelines, lists or procedures that explicitly prescribe the variables that should be included in a model. The appropriate variables should be included in the model based on the purpose and the need of the project. Horowitz [1986] suggests that the process of selecting variables for a practical mode choice model is as much an art as a science. In this section we will discuss the development of additional variables. The three types of variables that affect mode choice are:

- Policy variables
- Socio-economic variables

- Other variables

Policy Variables

Policy variables represent potential policy measures. These variables change with the changes in policy. Travel cost and travel time are two policy variables. If the transportation planner deliberately changes these variables, there will be a change in the modal share of various travel 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. This means that the policy variable cost plays an important role in travel mode choice. Similarly, if transit travel time increases, people will try to find an alternative travel mode which requires less time.

Policy variables must be included in the model to make it useful for predicting the effects of policy measures. In our modeling exercise, travel cost and travel time are the policy variables. Travel cost include fuel cost and parking cost. Travel time is the time taken to travel from the trip origin to the trip destination. 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.

Socio-economic Variables

Socio-economic variables should be included in the model to predict the effects of these variables on mode choice. Variables such as income, number of automobiles per household, number of persons per household, etc. influence the mode choice decisions greatly. 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.

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 model will give incorrect predictions. For example, in our modeling exercise the variable province is an important variable. This variable is unique, since the National Capital Region covers both Ontario and Quebec province. As a result, this variable should be included in the model so that the model predicts travel characteristics correctly.

4.7 SELECTION OF DATA SOURCE

The primary source of the data used in the modeling exercise is the 1995 Origin Destination Travel Survey. The 1995 OD Survey is the most recent and comprehensive travel survey carried out in National Capital Region by TRANS. The survey was undertaken between September and December of 1995.

In the 1995 OD Survey, 21,000 household were interviewed by telephone between September 6th and December 13th, 1995. An advance letter, in both official languages (English and French) was mailed to the sample household, one week prior to planned contact, outlining the purpose of the survey and the nature of questions that would be asked. The advance letter was crucial in encouraging a high response rate and acceptance of the legitimacy of information provided. One person in each household was asked to provide all of the information for that household, including the details of the trips made by each person on the proceeding weekday. The information collected [RMOC, 1996] can be divided into three categories as shown in Table 4.2.

Table 4.2 1995 O-D Survey Data

Household Data	Person Data	Trip Data
Location Dwelling type Number of people Number of autos	Gender Age Driver's license Employment Status Place of employment Pay to park at work Student status School location Start location of 1st trip	Origin location Destination location Purpose Start time Mode of travel Number of auto occupants Transit routes used

Employment status, place of employment, school and trip data were not collected for persons under 10 years of age. Age 10 was selected as the minimum at which children are likely to make unaccompanied trips of significant length or use public transit. The description of variables used in the models from the OD survey are as follows:

Number of Persons

All persons who lived in the housing unit are included in the number of persons in the household. The number of persons in the household is an important variable which influences the travel mode choice. From the data, there appears to be a strong relationship between the number of persons per household and the geographic area [RMOC, 1997]. For example, households in the downtown area tend to be smaller with a greater proportion of households with only one person. As one moves away from the downtown, the number of households with three or more persons increases. The data indicate that the number of households with 3 or more persons in the core area is only 20% while the number of households with 3 or more persons in the urban areas inside the green belt increases to 40 percent. The number of houses with three or more persons climbs to approximately 60 percent of the households for both suburban and rural areas.

Number of Vehicles per Household

The number of vehicles in the household is an important variable that influences the travel behavior. Mode choice decisions depend heavily on the number of vehicles in the house. If there are several vehicles in the house, then the household members are likely to travel by automobile instead of transit. If there are no additional vehicles in the house, then household members have to resort to another mode of transportation. In general, greater the number of licensed drivers in the household, the greater the probability of using the household automobile. This shows that the availability of a vehicle in the household influences the mode choice.

The level of automobile ownership varies according to where people choose to live. Residents of the downtown area are less likely to own a car than people living in other areas. Over 40 percent downtown area households reported not owning a vehicle. These are the single person households and persons in 65 plus age group. Also people in the downtown area are very close to their work, shop and places of leisure activities. Many of these trips are short in length and can be made by walking or cycling. For longer trips downtown residents make use of transit.

On the other hand, people living in the suburbs rely more heavily on cars to meet their mobility needs. The car may be required for commuting to work, driving children to day care or school and other social and personal trips. In the rural areas, less than 3 percent of the households do not own a vehicle. The car remains the primary travel mode in the region, due to a number of factors including longer trip distances and limited transit services.

Experience has shown that the number of vehicles in the household has significant effects on mode choice decisions when there are 0, 1 and 2 vehicles in the household. If the number of vehicles is more than two, it has less significant effect on the mode choice. Also, owning several vehicles increases the probability of owning a recreational vehicle in the household, the number of vehicles in the household has been coded as 0 for no

vehicles in the household, 1 for 1 vehicles per household and 2 for more than 1 vehicles per household.

Gender

The gender of person is an important variable that affects travel mode choice. Both males and females show different mode preferences. Statistical analysis of the survey results indicate that a relatively high proportion of males drive alone whereas females are more likely to share rides. This variable will differentiate the travel mode choice characteristics of two genders. This variable has been coded as 0 for female and 1 for male.

Work

The work variable shows the employment status of the person whether working full time, part time, work at home full time and work at home part time. The work variable has an important effect on mode choice. For a given household, the full time primary worker has generally greater claim to use the household vehicle than the other members of the household. On the other hand, the part time workers often have different travel needs and characteristics.

In the downtown area, almost 60 percent of the households have at least one full time worker [RMOC, 1997]. The trend is that as one moves outward from the downtown through the urban and suburban areas, the number of households with full time workers increases. The downtown has approximately 0.8 workers per household while the suburban areas have on average 1.3 workers per household. The high rate of full time workers in the suburbs is indicative of the larger household sizes in the areas. Only 5 percent of the workforce were identified as working at home on a full time or part time basis. People living in the urban, suburban and rural areas of Ottawa-Hull region have a higher reliance on the core area for employment. The traffic generated by these commuters has a significant impact on the transportation system.

Trip Purpose

The 1995 OD Survey classifies trips according to their purposes such as home based work, home based school, home based shopping, home based other and non home based trips. These trip purposes include trips for picking up or dropping off passengers, daycare trips and other for entertainment/social trips. These trip purposes were provided to give an exhaustive and mutually exclusive choice set for all people. For our model, the trips were grouped as:

- Work trips (home based work)
- Non-work trips (other home based, non-home based and leave home trips)

Mode of Travel

The travel modes included in the 1995 OD Survey are auto driver, auto passenger, public transit, walk and bicycle. In the work trip and non-work trip models developed in this research, only auto drivers, auto passengers and public transit modes are considered.

Number of Auto Occupants

This is the total car occupancy for auto driver trips. The total number of people in the vehicle at the start of the trip including the driver are recorded. If a significant detour was made to drop off a passenger then it was recorded as two trips with the first trip purpose classified as a facilitate passenger trip.

Expansion Factor

Once the information was collected, expansion factors were assigned to the data for each household to provide a one day snap shot of weekday travel behavior for the entire 375,000 households in the survey area.

4.8 DEVELOPMENT OF VARIABLES

To develop mode choice models, detailed information concerning all modes available to the traveler is necessary. To obtain this information, several new variables were generated

from the existing variables of the 1995 OD Survey and also from the EMME/2 model. The EMME/2 model was used to assign observed PM peak hour travel demand onto the auto and transit networks to estimate mode attributes such as travel cost and time. The specific variables developed for the model are outlined below.

Auto Cost

Auto travel cost consists of fuel costs and parking costs. The fuel cost was taken as 5 cents per kilometre. The fuel cost is based on fuel consumption cost averages reported by the Canadian Automobile Association for 1995. Here 5 cents per kilometre is based on an average fuel consumption rate of 9.2 liters per 100 kilometer and a fuel price of 55 cents per litre.

Parking costs were estimated by contacting major parking suppliers and finding out the monthly cost for parking all day. This amount was divided by 20 to get a daily rate. This amount 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 the variable to zonal level. After estimating the fuel and parking costs, the total auto cost was then divided by auto occupancy to obtain a cost per person. If auto occupancy was not available, it was estimated based on an analysis of vehicle occupancy rates.

This auto cost is consistent with other TRANS models, so that the models obtained through this research can be incorporated in to the TRANS Model Development Program.

Auto time

Auto in-vehicle travel time was estimated using the EMME/2 model. The travel time in minutes was measured from trip origin to trip destination. For the auto mode, out-of-vehicle time was assumed to be zero.

Transit time

Transit time was also obtained using EMME/2 model. The total travel time in minutes was measured from trip origin to trip destination. Both the out-of-vehicle time and in-vehicle time were estimated. Out-of-vehicle time included transit access time, transit wait time and transit transfer time.

Transit Fare

The transit fare data was not collected in the survey. Therefore this cost had to be estimated. Transit fare was estimated based on a fare matrix system. The areas with regular and premium transit service in the National Capital Region were identified. The transit fare required to travel between different 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. Transit fare is shown in Table 4.3.

In the transit fare matrix, the high fares of \$1.73 are for accessing green express bus routes. It is assumed that the green express route 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 travelers would have to go to the central area and then transfer to a green express route to complete their trip. The EMME/2 zones assumed outside of the Urban Transit Area (UTA) for 1995 are 132, 133, 135, 137-141, 177, 181-185, 186-200, 212-215, 227-230.

Table 4.3 Transit Fare Matrix

Origin Area		Destination Area								
Area #	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	45-56, 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

These 258 traffic zones are shown in Figure 4.3.

Dummy Variables

Several dummy variables were developed based on the TRANS 1995 OD Survey. These dummy variables are based on the geographic location of the trip's origin and destination zone. The dummy variables are the variables which are either zero or one in a given observation. They are typically used to measure the characteristics that are either true or false. These variables are important and can affect mode choice significantly. By incorporating these variables in the model, the model becomes more useful and reliable. The dummy variables included in the work trip and non-work trip models are described below.

Province

Since the National Capital Region includes parts of Ontario and Quebec, it was necessary to develop this variable to distinguish between residents of both provinces. If the person resided in Ontario, the variable was coded as 0 and if the person lived in Quebec, it was assigned the value 1.

Central Business District

The central business district (CBD) refers to the downtown region of Ottawa and Hull, commonly known as the core area. These districts consist of high density office, commercial and residential developments. The central area has typical characteristics of high traffic density and high parking cost. If the trip originates from the central zone, the trip is assigned a value of 1 otherwise it is given the value 0.

Transitway

The Transitway variable captures the impact on mode choice if the work place is located near the transitway. The transitway infrastructure provides an exclusive rapid transit facility to the transit mode. If the trip originates from a location near the transitway, it was assigned a value of 1 otherwise it was assigned the value 0.

4.9 LINKING OF TRIPS

4.9.1 Introduction

During the past twenty years, people's travel characteristics have changed significantly due to the changing job market and our modern life style. Today, people frequently combine travel to several destinations into a single linked trip. Trips have become more complex due to ride sharing as well as trips to school or day care before heading to work. A person starting from home may pick up passengers or drop off passengers before arriving at work. Similarly another person may drop their children off at school or day care before going to work, reversing the process in the evening. Hence it is necessary to study these trips and resolve the problem of reporting them as per their legitimate purpose. It is also necessary to develop the procedures to link these trips and include linked trip analyses in the existing modeling system. The inclusion of linked trips in urban transportation models will be valuable and will ultimately help in improving the overall quality of transportation models.

In the following sections, the concept of linked trips is discussed as well as the procedure for linking trips developed in this research.

4.9.2 Trip Linking Concepts

Linking of trips is an important technical issue that arises from the way trips are coded and reported in the origin-destination survey. In the TRANS transportation modeling, it had been the practice to report individual legs of a trip separately every time the traveler stops for a specific purpose on the way to an ultimate destination. This problem had to be resolved for several reasons.

The basic reason for linking of trips is to associate this trip with its true and legitimate purpose with the demographic, economic and land use variables at origins and destination. The home based trips, non-home based trips, other home based trips and

leave home based trips can be properly quantified to reflect the true and ultimate purpose, if the trips are linked. This will help us to predict the most correct and legitimate modal share and the true demographic and economic impacts. This will make our travel demand model development more efficient and reliable.

In linking of trips, we need to link a change travel leg of a trip to its preceding/succeeding legs until it is coupled with its most legitimate and ultimate trip purpose from origin to destination. The trips that need to be linked are those that have one of two trip purposes at either origin or destination: serve passenger and day-care trips. These trips are considered intermediate trips in a trip sequence and they are linked with other trips in the sequence. The linking is done in such a way that the ultimate purpose of the trip is not lost.

In the 1995 OD Survey, the trip from work to pick up a passenger (or drop off a passenger) is coded as a non-home based trip (NHB) and the trip to pick up a passenger (or drop off a passenger) is coded as other home based trip (OHB). The ultimate purpose of the trip is from work to home with intermediate trips. Hence the legitimate purpose of the trip is home based work (HBW). In the TRANS data, there were other cases of serve passenger which had two or more intermediate legs of trips in sequence. These trips were needed to be linked so that the ultimate trip purpose could be re-coded.

The trips from work to daycare and day-care to home were also reported as two separate trips. The trip from work to day-care was reported as a NHB and the trip from day-care to home is reported as OHB. This trip is actually from work to home with intermediate trip of the day-care. Hence this trip is linked from work to home and re-coded as Home based work trip (HBW).

4.9.3 Trip Linking Procedure

Macros were written to link the appropriate trips. All trips made by a member of a household were examined as a unit. The reported trips were classified into three categories:

- Unlinkable trips
- Potentially linkable trips
- Linkable trips

The unlinkable trips were written out unaltered and no changes were made in the data of these trips. The potentially linkable trips were examined further to determine whether the linking was feasible or not. If the linking is feasible, they will become linkable. If not then they are treated as unlinkable. Once they are identified as unlinkable, they are written unaltered back into the data. If the trips are identified as linkable, then they are placed and grouped with the linkable trips for linking.

Once the linkable trips were identified, the procedure for linking of trips was started. First of all those trips which had one intermediate leg of trips were identified. A macro was run to verify and match the household number, person number and trip number of the trip. This macro correctly identified and verified that it was the trip made by the same person in a sequence. Hence this trip could be linked with the preceding or the succeeding leg as the case may be. All the necessary details were retained and some variables were re-coded to correctly point out changes in the trip data. This is because linking involves combining several legs of a sequence. The variables for the linked trips come from the individual legs of the trip sequence.

The output file for the linked cases contains all the details of the linked trips. All the details of individual trip legs are also recorded using sequential numbers, thus one can immediately know what data applies to the first leg and what data applies to the second leg. Thus the output file has all the details of the input file plus additional details for the intermediate trips that have been linked.

4.9.4 Linked Trip Variables

The details of each specific variables in the output file are discussed in this section. The output file has the same layout as the input file. The linking of trips up to four sequential

trips was done. This means that there could be four trips and they are linked as one trip. For example:

- Trip 1: Work to pick up passenger (or drop off as the case may be)
- Trip 2: Pick up passenger to pick up passenger
- Trip 3: Pick up passenger to pick up passenger
- Trip 4: Pick up passenger to home

Now this trip is linked and combined as a work to home trip. The suffix numbers at the end of the variable describe the leg of the trips, for example, origin_zone1, origin_zone2, Origin_zone3, Origin_zone4. The variable origin_zone will take the value of origin_zone1. This procedure was adopted for all the variables of the input data file. This method of coding was chosen to reduce errors and eliminate need to look at the original input data file, since the output file gives explicit detail concerning the original trips as well as the new linked trips.

The variables which are affected by linking of trips are described below.

Origin Zone

The origin zone of the trip (org_zon) is the origin zone of the first leg of the trip sequence (org_zon1). The trip's origin zone are also include with the suffix as org_zon1, org_zon2, org_zon3 and org_zon4.

Origin Purpose

The origin purpose of the trip (org_purp) is the origin purpose of the first trip of the linked trip. The other purpose are recorded as org_pur1, org_pur2, org_pur3 and org_pur4.

Start Time

Start time (start_ti) is the start time of the first trip (st_ti1) of the linked sequence trip. The other start time of the trips are recorded as st_ti1, st_ti2, st_ti3 and st_ti4.

Destination Zone

The destination zone (des_zon) is the destination zone of the last trip (des_zon4) in the sequence. All the destination zones are recorded as des_zon1, des_zon2, des_zon3 and des_zon4.

Car Occupancy

Car Occupancy (car_occ) is recorded as the maximum car occupancy of all the trips in the sequence in the final linked trip. The car occupancy of the trips are recorded as car_occ1, car_occ2, car_occ3 and car_occ4.

Primary Mode

The primary mode of the trip is recorded as prim_mo1, prim_mo2, prim_mo3 and prim_mo4. If all the trips have prime_mode as auto driver (D), then prime_mode is entered as D. If the prime_mode is auto passenger for all trips then prime_mode is coded as P.

Auto Distance

The auto distance (a_dist) of the linked trip is the summation of distance of all the individual trips. The distances of all the trips are recorded as a_dist1, a_dist2, a_dist3 and a_dist4.

Auto Time

The auto time (a_time) of the linked trip is the summation of time of all the individual trips. The time of individual trips are recorded as a_time1, a_time2, a_time3 and a_time4.

Transit Distance

The transit distance (t_dist) of the linked trip is the summation of the distance of all the individual trips of the linked trips. The distances of the individual trips are recorded as t_dist1, t_dist2, t_dist3 and t_dist4.

Transit Time

The transit time (t_time) of the linked trip is the summation of the time of all the individual trips of the linked trips. The time of the individual trips are recorded as t_time1, t_time2, t_time3 and t_time4. In-vehicle transit time, out-of-vehicle transit time, transit wait time, transit transfer time, transit boarding time, transit access time are recorded in a similar fashion.

Trip Purpose

If the trip purpose is from work to home, it is recorded as a home based work trip (HBW). This variable is recorded as purp_mc. If the trip is from work to pick up (non-linked trip) then it is recorded as non-home based trip (NHB). If the trip is from home to market (non-linked trip) then it is recorded as leave home trip (LH). If the trip is from pick up to home (non-linked trip) then it is recorded as other home based trip (OH).

For linked trip, this trip purpose changes, as it depends on origin purpose and destination purpose. This could be written more specifically in the following manner:

- Trip from work to day care is recorded as non-home based trip (NHB)
- Trip from day care to home is recorded as other home based trip (OHB)
- Now this trip is combined and linked as work to home and hence it is recorded as Home based trip (HBW)

Thus it can be seen that the origin purpose and destination purpose of a trip changes when it is linked and hence the trip purpose is also changed and accordingly recorded. This means that in the output file, the purp_mc variable changes for the linked trip. The

purp_mc variable of individual trips of linked trip is recorded as purp1_mc, purp2_mc, purp3_mc and purp4_mc. Hence if there is any confusion about the trip purpose of the linked trip and its corresponding individual trips, then the data can be readily verified using the purp1_mc, purp2_mc, etc. variables.

4.10 DATA PREPARATION PROCESS

The data preparation process is necessary to eliminate the trip records that are not to be included in the model development exercise. The data preparation process carried out for this study is shown in Figure 4.4 and is discussed below.

Linked trips

The original P.M. peak period file contained 30,877 trip records. These records include all modes of travel such as automobile, auto passengers, transit, bike and walk. It was decided at the outset of this research that the model developed from this research will address the linked trip problem. The potentially linkable trips will be linked and reported with their legitimate new trip purpose and other variables. Accordingly, 2,487 potentially linkable trips were removed. These trips were combined and linked into 1,202 linked trips. Now in the original file, this 1,202 linked trip records were added. Thus the new P.M. peak period file now contains 28,399 trip records.

Trip Purpose

The trip records were grouped according to their trip purposes. The trips were classified as home based work trip (HBW) and non-work trips consisting of non-home based trip, other home based trip and leave home trip. There are 10,904 home based work trip. There are 16,468 non-work trips, consisting of 6,115 non-home based trips, 5,880 other home based trips and 4,473 leave home based trips.

Figure 4.4 Data Preparation Process

Modes

The travel modes selected for this research are auto and transit. Hence the trip records of other travel modes such as bike and walk have been eliminated. 653 trip records of bike and walk have been eliminated and hence total available for building the model are 10,251 trip records.

Non-UTA Trips

Transit service is only provided within the urban transit area. This means that transit is not available as travel mode option to people staying outside the urban transit area. Therefore it was necessary to eliminate the trip records which belong to the non-UTA area. Thus 2,614 trip records were eliminated and now there are 7,637 trip records within the urban transit area.

License

Finally all persons who did not have a driving license were filtered out. This was necessary because all individuals should have equal opportunity for choosing the alternative travel modes. Persons without driver's license can not drive alone and therefore need to be eliminated from the analysis. There are 369 trip records without license. Hence now the total cases available for building the model are 7,268 trip records.

This process of data preparation was repeated in the same fashion for the development of file for the non-work trip records. Once the data preparation process was completed, the file was ready for the next stage of the modeling exercise, developing the variables.

CHAPTER 5

HOME BASED WORK TRIP MODEL

5.1 INTRODUCTION

The estimation of modal splits is an important part of the overall transportation modeling process. This chapter describes the development of a three level modal split model comprising of single occupant vehicle, two persons per vehicle, three or more persons per vehicle and transit modes.

The primary emphasis of this chapter is the development of a nested logit model to estimate the modal split for work trips. Work trips represent the dominant trip purpose in the P.M. peak period. The use of a nested logit modal split model allows level of service and socio-economic factors to be incorporated, thus providing a very powerful and policy sensitive tool for transportation planning.

5.2 STRUCTURE OF THE HBW TRIP MODEL

Various model structures having several combinations of travel modes such as SOV, non-SOV, two persons per vehicle, three or more persons per vehicle were explored so that better simulation results could be obtained. The logit model enables us to analyze more than two travel modes simultaneously. Here various modes were simulated using either logit or nested logit models. The four structures examined are described below.

5.2.1 Structure I

The first attempt was to develop a logit model for single occupant vehicle, vehicle with more than one occupant and a transit at the same level. The structure of the model is shown in Figure 5.1.

Figure 5.1 Structure I - Logit model for HBW trips

Here it was found that a logit model with better simulation results could not be developed for the above structure. The problem was with the prediction of 2+ trips. The maximum percent correct trips predicted correctly for SOV, non-SOV and transit were 89%, 21% and 59% respectively. This shows that the percent correct predicted for the two or more persons per vehicle was extremely low, whereas for the transit it was moderate. Our objective was to predict the non-SOV in vehicle trips more correctly with better overall simulation results. The logit model developed was predicting more SOV trips and not the non-SOV and the transit trips. The problem with the prediction of non-SOV trips was that these trips are very complicated and there are number of assumptions involved with these kinds of trips. Since the model could not distinguish properly between transit and share ride trips, the model had to be abandoned.

5.2.2 Structure II

The next attempt was the development of a nested logit model for auto and transit. Auto mode was further divided into SOV and Share ride modes. The structure of the model is shown in Figure 5.2.

The lower model consists of SOV and Share ride. The logit model was developed for SOV and Share ride. The maximum prediction of percent correct trips for SOV and Share ride was 94% and 24% respectively.

Figure 5.2 Structure II - Nested Logit Model for HBW trips

This shows that the logit model was not able to predict the share ride trips more correctly. The reason is that the share ride trips are more complex and are based on many assumptions. Thus in the absence of good simulation results this model was abandoned.

5.2.3 Structure III

The third attempt was the development of a nested logit model for auto and transit. Auto was divided into SOV, two persons per vehicle (2P) and three or more persons per vehicle (3P+). Thus the higher model consists of auto and transit while the lower model contains SOV, two persons per vehicle and three or more persons per vehicle. The structure of the model is as shown in Figure 5.3.

Here a logit model was developed for the lower stage. The results of this logit model were then incorporated in the higher level logit model for auto and transit.

Figure 5.3 Structure III - Nested Logit Model for HBW trips

Several logit models were developed for the lower level. The maximum correct prediction for the SOV, two persons per vehicle, three or more persons per vehicle were 99.97%, 62% and 7.38% respectively. Thus this model was able to predict SOV and two persons in vehicle nicely but it was not able to predict the third alternative of three or more persons per vehicle. Since the third alternative had a low percent correct prediction, this model was not selected as the final model.

5.2.4 Structure IV

The next attempt was to develop a nested logit model with two nests. The lower nest consisted of two persons per vehicle and three or more persons per vehicle. The next nest was for SOV (1 person in vehicle) and non-SOV (more than 1 person in vehicle). The higher level was for auto and transit. The structure of the model is as shown in Figure 5.4.

Here a logit model was developed for the lower level consisting of two persons per vehicle and three or more persons per vehicle. The results of this model were represented by the “Inclusive Variable “ in the next upper level logit model. This next upper level logit model was of SOV and Non-SOV. The upper level consisted of auto and transit.

Figure 5.4 Structure IV - Nested Logit Model for HBW trips

The satisfactory results were obtained by this two level nested logit model. In subsequent sections, this model will be discussed in detail. The description of the model is written in the same order as the calibration process was carried out.

5.3 LOWER LEVEL MODEL

5.3.1 Overview

This is the lowest level model developed for the home based work trip purpose. This model is of great significance in terms of policy implications, since it can be effectively used to analyze the policy impacts involving high occupancy vehicle facilities. The model simulates home based work trips for two persons per vehicle and three or more persons per vehicle.

5.3.2 Available Sample Size

This lower level model consists of 2P and 3P+ modes. The number of cases for two persons per vehicle are 758 and for three or more persons per vehicle are 271. Thus the total number of cases are 1,029.

These two modes represent specific and very different travel characteristics. Two persons per vehicle is an ideal mode for car sharing between husband and wife or between two colleagues or two friends working very close to each other. Here, there is more control over time and other travel attributes associated with the car sharing arrangement. The other mode has three or more persons per vehicle. This mode has high occupancy and hence less control over its travel time but is more economical. Hence, the logit model developed for the sample size of two persons per vehicle and three or more persons per vehicle would provide more information on the possible impacts of transportation policies associated with high occupancy vehicle facilities and ride sharing.

5.3.3 Model Calibration

Model calibration is the process of estimating variable coefficients so as to simulate as closely as possible the existing sample data. Computer software is used to apply the statistical procedures to develop the model. Here we have used “Time Series Processor” software [TSP International, 1996] to estimate the coefficients of the model.

In order to have some appreciation of the procedure that the TSP software employs, a brief explanation is presented here. For more details, the TSP manual should be consulted [TSP, 1996]. The disaggregate approach for modeling assumes that the individual is the main decision making entity and he will choose the most desirable and suitable mode. The chosen mode is the mode with the highest utility based on the level of service of each mode (travel cost, travel time), socioeconomic characteristics (income, number of vehicles) and attitude variables. The computer software estimates the coefficients of these variables. These estimates indicate the relative importance or weight people attach to the

travel mode characteristics. The higher the importance attached to the variable, the greater is the influence of that variable on the mode choice decision. From these coefficients the probability of choosing a mode in relation to other modes is calculated. The mode selected is the mode with the highest probability. The results are aggregated and validated.

The variables to be included in the model are determined by the analyst. The analyst includes those variables which in his opinion are the most suitable and significant. In this model we have included cost, time, gender, number of persons per household, number of vehicles per household, employment status of persons whether working full time or part time, origin employment density and the constant.

The variable cost is taken as a conditional variable. This means that cost has two values, one for the mode 2P(cost1) and the other for the mode 3P+ (cost2). The reason for this is that the cost of traveling with two persons per vehicle is different than the cost of traveling when there are more than two persons per vehicle. The variable cost is choice-specific and the coefficient will be equal over all choices.

Number of persons per household, employment, and origin employment density are multinomial variables. These variables are chooser-specific and their coefficients vary over the choices. During the calibration process, it was found that time was significant only for the 2P mode, and therefore is also a multinomial variable in this model.

As discussed, there are two modes in our data file, namely two persons per vehicle and three or more persons per vehicle. The first mode is 2P. To calibrate the model, the coefficients of this mode are normalized to zero. The TSP output then gives the coefficients of second mode (3P+) with respect to the first mode (2P) along with the conditional variable (cost).

5.3.4 Developed Model For Home Based Work Trip

Results of the model developed for home based work trips are as follows:

Table 5.1 Lower Level HBW Model

Modes	Cost	Time	No. of Persons	Work	Origin emp. Density	Constant
2P	-1.9224 (-4.67)	-0.0313 (-4.41)				
3P+	*-1.9224 **(-4.67)		0.7225 (-9.57)	-0.8089 (-5.66)	-0.0000169 (-2.47)	-1.3931 (-3.71)

*	...	Coefficient of variable
**	...	t-statistic
2P	...	Two persons per vehicle mode
3P+	...	Three or more persons per vehicle mode
Cost	...	Travel cost of trip from trip origin to trip destination
Time	...	Travel time from trip origin to trip destination
No. of persons	...	Number of persons per household
Origin Emp. Density	...	Origin employment density

Summary Statistics

Number of modes	=2
Number of 2P trips	= 758 (73.66 %)
Number of 3P+ trips	= 271 (26.34 %)
Total number of trips	= 1029 (100 %)
Rhosq	= 0.2691
Rhobarsq	= 0.2621

5.3.5 Model Validation

The results of this model have been validated using two approaches:

- Macro validation
- Micro validation

In macro validation, the modal split as given by the developed model is compared with the actual modal share of the observed data. This shows the difference in predicted modal share versus actual modal share.

In micro validation, the modal prediction of every trip record is compared with the actual mode taken by the individual. This gives us the percent right prediction of the model.

Macro Validation

The modal split given by the developed model and the actual modal share of the data is recorded in Table 5.2.

Table 5.2 Macro Validation For Lower Level HBW Model

Modes	Number of Observed trips	Number of Predicted trips	Error
2P	758	928	+170
3P+	271	101	-170

As shown in above table, the number of predicted trips for the mode two persons per vehicle is 928 trips. The actual observed trips are 758 trips. Thus 170 trips are over predicted. Similarly the number of predicted trips for the mode 3P+ are 101 trips. The actual observed trips are 271 trips. Thus, there is prediction of 170 trips less here.

From these results, it can be seen that the model tends to under-predict 3P+ trips. This is likely due to the fact that 3P+ trips are more difficult to model due to the wide variety of factors which influence these trips. In addition, the sample size for 3P+ trips is relatively small, which may affect the modelling results.

Micro Validation

The number of trips predicted correctly for the mode two persons in vehicle and three or more than three persons in vehicle are shown in the Table 5.3. Here the probability of person taking the mode 2P and 3P+ is calculated from their utility function. The mode with the highest utility is assumed to be chosen by the individual.

Table 5.3 Micro validation For Lower Level HBW Model

Modes	Number of Observed trips	Number of trips Predicted correctly	Percent Correct Value
2P	758	712	93.93%
3P+	271	55	20.30%
Total	1029	767	74.54%

From the above table, we see that for two persons per vehicle mode, the number of trips predicted correctly are 712. The observed number of trips are 758. Thus the percent correct value is 93.93 %. Similarly, the number of trips predicted correct for three or more persons per vehicle mode are 55. The observed number of trips are 271. Hence the percent correct value is 20.30%. The overall number of correct predicted trips are 767 out of 1029 trips. Thus the overall percent correct value is 74.54 %.

Like the macro validation, the micro validation reveals that the model has some difficulty predicting 3P+ trips correctly. Such high-occupancy trips are influenced by many factors.

For example, it is unclear how ride-share passengers perceive travel cost and time. In addition, each trip has different characteristics. The time to pick up passengers for one trip might be significantly different compared to another trip. Similarly, the extra distance traveled to pick up and drop off passengers will vary from trip to trip. These factors are difficult to model, and may be affecting the results.

5.3.6 Correlation Matrix

The correlation matrix for the developed model for the 2P mode is shown in Table 5.4 while the 3P+ mode is shown in Table 5.5.

Table 5.4 Correlation Matrix For 2P Mode

Variables	Cost1	Time1	Number Of Persons	Work
Time1	0.3875			
Number of Persons	-0.0962	-0.0503		
Work	0.0228	-0.0070	0.3394	
Origin Emp. density	0.5999	0.1008	-0.0333	0.0080

Table 5.5 Correlation Matrix For 3P+ Mode

Variables	Cost2	Time1	Number Of Persons	Work
Time1	0.3966			
Number of Persons	-0.1180	-0.0503		
Work	0.0315	-0.0070	0.3394	
Origin Emp. density	0.5931	0.1008	-0.0333	0.0080

The correlation matrix in Tables 5.4 and 5.5 shows the correlation between various variables included in the model. The correlation should be in the range of 0 and 1. The

higher the value, the higher is the correlation. However a higher value of correlation is not considered for a good model. A correlation between a pair of variables greater than 0.8 indicates that a particular effect is being accounted for twice and the model should be re-specified [RMOC, 1998]. Also as per Gujarati [1995], if the pair wise correlation coefficient between two variables is high, say in excess of 0.8, then multi-collinearity is a serious problem. In the model developed, no correlation between a pair of variables is greater than 0.8. Also there is no problem of multi-collinearity in any of the variables. The variables have little or no correlation and hence the model satisfies the correlation criterion.

5.3.7 Model Evaluation

There are several approaches for evaluating the quality of a logit modal split model. But none of the approaches are more definite and complete for evaluation of the model. Hence an assessment based on individual judgement and on statistical measures should be done. The output of the logit estimation software includes estimated values of the coefficients of various variables, the t-statistics of those coefficients and the correlation among variables. This set of statistical indicators can be used to evaluate the quality of the model.

The coefficients and their signs along with t-statistics of the variables included in the model are described below.

Variables in the Lower Level Home-based Work Trip Model

All the variables in the lower level model have the expected sign and most of them are significant at the 99.5% confidence interval. All the variables have t-statistics greater than 1.0 or less than -1.0 indicating that all the variables contribute significantly to the ability of the model to describe or explain the data.

Cost is an important policy variable in the model. Cost has a t-statistic of -4.67, which shows that it is highly significant. Its estimated coefficient is -1.9224 and it is highly

significant at a 99% confidence interval. These results make sense considering the importance placed on the cost. The cost savings of traveling with two people per vehicle or of three or more people traveling per vehicle is obviously a motivation for ride sharing. A small saving done each day accumulates at the end of month and at the end of the year. This saving is the advantage gained from the share ride.

Cost is a conditional and policy variable. Conditional means we have two different values of cost for two modes. It is a policy variable meaning that it can be changed by changing the policy. The cost consists of parking cost and fuel cost. Parking cost can be changed by increasing the parking fee. This cost has negative sign meaning that it is a disutility in the model equation. If the cost is increased, more people will travel with three or more persons per vehicle mode.

Time is an important variable in the model. The time is taken as multinomial variable. The time has an estimated coefficient of -0.0313 with a t-statistic of -4.41. The high value of the t-statistic shows that the time is significant at 99% confidence interval. Time is a disutility in the equation and hence its value should be negative. The negative value shows that if the time for the two persons per vehicle mode increases the people will be more inclined to travel with more than two persons per vehicle mode. The high value of the t-statistic indicates that people attaches high value to time.

Number of person per household is also an important variable with an estimated coefficient of 0.7225 and a t-statistic of -9.57. This high t-statistic suggests that this variable is quite significant and contributes highly to modal choice. The positive sign indicates that the greater the number of people per household, the greater the probability of choosing three or more persons per vehicle mode compared to two persons per vehicle mode.

Work variable has an estimated coefficient of -0.8089 with a t-statistic of -5.66. This work variable shows the employment status of people, whether they work full time, part

time, work full time from home and work part time from home. The sign of the variable is negative, meaning that if more people work in different categories such as part time, they are more likely to choose two persons per vehicle mode than three or more persons per vehicle mode. This shows that due to a very different nature of their job, they can not afford to go for three or more people in vehicle. The work variable is highly significant at the 99% confidence interval as can be seen from its t-statistic value.

Origin employment density variable has an estimated coefficient of -0.0000169 with a t-statistic value of -2.47 indicating that this variable is highly significant at 99% confidence interval. Since we are modeling work trips in the afternoon peak period, the trips originate from work. If the origin employment density of the work trip is high, more people are attracted to travel in high occupancy mode such as three or more people per vehicle since there are many people available for travel. If the origin employment density is low, people will choose less occupancy mode, which in this case is two persons per vehicle. Thus employment density coefficient as well as its t-statistic is consistent with trend in travel demand.

The alternative specific constant has an estimated coefficient of -1.3931 with a t-statistic of -3.71. This shows that it is significant with a confidence interval of more than 99%. This shows that there are some variables which are important and influence the mode choice that have not been represented or included in the model. Variables such as comfort, reliability, safety and other variables which influence the mode choice but are difficult to measure and predict have not been included in the model. The effect of these unexplained and unknown variables have been included in this constant. This constant represents the average effects of variables not present in the model. The choice probabilities obtained with this constant variable is very different and more realistic than those obtained without the constants. Hence the constant should always be included to make the model more realistic and reliable.

Goodness of Fit Measures

The goodness of fit measure “Rho-squared” provides a measure to rank the goodness of fit of the model to the sample data. In theory, this value ranges between 0 (no fit) and 1 (perfect fit). According to Ortuzar and Willumsen [1994], although this rho square has limits between 0 and 1, it does not have an intuitive interpretation for intermediate values and a value around 0.4 may indicate an excellent fit. The inclusion of the modal alternative decreases the rho-square, while inclusion of socio-economic variables increases the rho-square.

In our case the value of rho-square and rho-bar-square comes out to be 0.2691 and 0.2621 respectively. According to Table 3.1, our model (with a modal share of 74% for the primary mode) should have a minimum rho-square value of around 0.13. Since the actual rho-square value is greater than 0.13, the model is acceptable.

5.3.8 Sensitivity Analysis

Sensitivity tests for the mode should be carried out to determine the effect of public policy changes on the travel behavior. The disaggregate detail on level of service and individual and household attributes can provide an improved understanding of the travel choices. Since the model was developed taking into consideration the behavior of the individual, the evaluation of public policy alternatives is enhanced. The model provides a natural framework for analyzing how policy alternatives as well as socio-economic factor affect the individual choice. If policy effects are analyzed as they affect the individual, the transportation analyst’s recommendations gain credibility because they are more intuitive. The sensitivity analysis is ideally suited to evaluating the impact of policies and socio economic factors on different market segments or interest groups.

Table 5.6 Sensitivity Analysis For Lower Level Model

Variables	2P mode	3P+ mode
2P cost +10% change	-4.56%	+4.56%
3P+ cost +10% change	+1.27%	-1.27%
2P time +10% change	-0.98%	+0.98%
Origin emp. den. +10%	0%	0%

From the sensitivity table, it is clear that the cost of travel (a conditional variable in the 2P mode) has a higher effect on the modal share of two persons per vehicle than three or more persons per vehicle mode. A +10% change in the cost of 2P mode decreases the modal share by 4.56% while the modal share of three or more persons per vehicle increases by 4.56%. This increase in the number of people traveling by the 3P+ mode seems reasonable considering the way cost is being perceived.

A +10% change in cost of 3P+ mode increases the modal share of 2P mode by +1.27% and decreases the modal share of 3P+ mode by 1.27%. This change in modal share by 10% increase in 3P+ cost is less than 10% increase in 2P cost. This shows that if the cost of 2P changes by 10%, more people will shift to 3P+ mode even though it is less convenient. But if the cost of the 3P+ mode increases, fewer people will shift to the 2P mode. As the number of passengers per vehicle increases, the cost borne by each vehicle occupant decreases.

Travel time is included in the 2P model as a multinomial variable and is not included in the 3P+ mode. A 10% increase in 2P time decreases the modal share of the 2P mode by 0.98%. Since the 2P mode share decreases by .98%, the 3P+ mode must indirectly increase by +0.98%.

If the employment density increases by 10%, the modal share of 2P mode and 3P+ mode remains the same i.e. 0% change in modal share. This shows that the employment density must change significantly if changes in modal share are to occur.

5.4 INTERMEDIATE LEVEL MODEL

5.4.1 Overview

This section describes the intermediate level model of the nested logit model developed for home based trips. The model simulates home based work trips for SOV (one person in vehicle) and non-SOV (more than one person per vehicle) mode. The lower model consisting of two person per vehicle (2P) and three or more persons in vehicle (3P+) is represented in this model through an independent variable called “Inclusive Value”. This model can be effectively used in policy studies involving SOV and non-SOV vehicle facilities.

5.4.2 Model Structure

The structure of the intermediate level model is shown in Figure 5.5.

Figure 5.5 Structure of Intermediate and Lower Level Model

This model structure helps in simulating travel characteristics of SOV and non-SOV modes. The SOV mode provides the traveler with more flexibility, comfort and control

over time and hence it is more attractive. The non-SOV mode appeals to the market segment which for economical or environmental reasons seeks a high occupancy automobile mode with all the convenience and comfort of SOV mode. The 2P+ mode is further divided into 2P and 3P+ mode.

5.4.3 Available Sample Size

The number of trip records for the SOV mode were 3961. For 2P+ mode 1,029 trip records were available. Thus in total there were 4990 trip records that could be used to develop the model.

The variables selected for this model were cost, time, province, number of persons per household, number of vehicles per household, employment, destination population density and the inclusive variable from the lower nest. Many of these variables were also used in the lower level model and are discussed in the section below with additional comments and assumptions applicable to this model.

Cost

The cost for the SOV mode consists of the fuel cost plus the parking cost. This cost is fully borne by the auto occupant. For the 2P+ mode, the cost was divided by two for two people per vehicle and for more than two people in vehicle the cost was divided by vehicle occupancy. Hence the final cost for the 2P+ is the average cost of 2P and 3P+ mode.

Time

Travel time was obtained from the EMME/2 model. For the SOV mode, the time was measured from the trip origin to the trip destination. For the 2P+ mode, the time was measured from the trip origin to the last trip destination including the intermediate origin and destination. A four minute penalty was added each time a passenger was picked up or drop off. Since 2P+ mode represents the lower model, the time is the average time of two person in vehicle mode and three or more persons per vehicle mode.

Inclusive value

The inclusive value represents the composite utility of the 2P and 3P+ mode. As explained in Chapter 2, the composite utility included the expected value of the maximum utility of the members of the 2P and 3P+ mode as given by

$$I_{2P, 3P+} = E [\max (U_i)] = \ln \sum_{i=1}^N \exp(V_i) \dots\dots\dots(4.1)$$

where $I_{2P, 3P+}$ is the expected maximum utility of the members of the 2P and 3P+ nest. This inclusive value is entered as independent variable in SOV and 2P+ mode.

Destination Population Density

The population density of the destination is important since it indicates whether ride sharing is feasible or not. If the population density is high, it is easier to form car-pool. Hence this variable was included in the model.

5.4.4 Developed Model

The home based work trip intermediate level model developed for the SOV and 2P+ modes is shown in Table 5.7.

Table 5.7 Intermediate Level HBW Model For SOV And 2P+ Mode

Modes	Cost	Time	Inclusive Value	Province	Number of Persons	Number of Vehicles	Work	Destination Population Density	Constant
SOV	-0.0551 (-0.18)	-0.0975 (-6.49)	0.2440 (1.30)						
2P+	*-0.0551 **(-0.18)	-0.0975 (-6.49)	0.2440 (1.30)	0.4875 (6.14)	0.3305 (5.62)	-0.7986 (-9.92)	0.1488 (1.99)	-0.000045 (-2.07)	-0.5613 (2.48)

* Coefficient of variable

** t-statistic

Cost	...	Total travel cost from trip origin to trip destination
Time	...	Total travel time of the trip from origin to destination in minutes
Inclusive value	...	The expected maximum utility of lower nest i.e. 2P and 3P+ mode
Province	...	coded as 0 for Ontario and 1 for Quebec
Number of vehicles	...	codes as 0 for no vehicles/household, 1 for one vehicles/household and 2 for two or more vehicles/household

Summary Statistics

Number of modes	= 2
Number of SOV trips	= 3961 (79.38 %)
Number of 2P+ trips	= 1029 (20.62 %)
Total number of trips	= 4990 (100 %)
Rhosq	= 0.3169
Rhobarsq	= 0.3146

Overall Measure of Goodness of Fit

The development of overall measure of goodness of fit for nested logit model is a complicated task. The overall measure equivalent to ρ^2 suggested by McFadden and Tardiff as mentioned by Sobel [1981] are as under:

$$\begin{aligned}\rho_{\text{overall}}^2 &= 1 - \{ [L_{\text{lower}}(\beta) + L_{\text{Intermediate}}(\beta)] / [L_{\text{lower}}(0) + L_{\text{Intermediate}}(0)] \} \dots (4.2) \\ &= 1 - 0.6912 \\ &= 0.3088\end{aligned}$$

Thus the overall measure equivalent to ρ^2 is 0.3088. Since this value is between 0.2 and 0.5 as recommended by Ortuzar and Willumsen [1994], it can be concluded that the model is reliable.

5.4.5 Model Validation

As with lower level model, the intermediate level model was validated using both macro and micro validations.

Macro Validation

The modal split given by the developed model and the actual modal share is recorded in the Table 5.8.

Table 5.8 Macro Validation For Intermediate Level HBW Model

Modes	Number Of Observed Trips	Number Of Predicted Trips	Error
SOV	3961	4880	+ 919
2P+	1029	110	- 919

From the table, it is seen that the number of predicted trips for the SOV mode are 4880. The number of observed trips are 3961 trips. Thus 919 trips over-predicted. Similarly, the number of predicted trips for more than one vehicle (2P+) mode is 110 trips. The observed trips are 1029 trips. Thus 919 trips are under-predicted.

The model significantly under-predicts non-SOV trips. This is because non-SOV trips are difficult to simulate due to the complicated nature of these trips. There are many factors which influence non-SOV trips which are difficult to capture in a model. Unlike SOV trips, non-SOV trips can involve several destinations and have differing levels of auto occupancy at different times during the trip. In addition, it is unclear how ride-share travelers perceive travel cost and time. It is likely that families travelling together will have different trip characteristics than business colleagues who ride-share. Since this is a nested logit model, it was necessary to use an average cost and travel time based on the 2P and 3P+ modes, which may not be experienced in reality. Finally, a problem with the model structure is that it only includes trips within the Urban Transit Area (UTA). However, many of the non-SOV trips have an origin or destination outside the UTA. Since we are working with a logit model, it is important that each individual have access to all the available modes. Thus, it was necessary to confine the study area to the UTA in order to model transit trips. However, by so-doing, the sample size of the non-SOV trips was decreased, which may affect the modelling results.

Micro Validation

The number of trips correctly predicted for SOV mode and 2P+ mode are shown in the Table 5.9.

Table 5.9 Micro Validation For Intermediate Level HBW Model

Modes	Number Of Observed Trips	Number Of Trips Predicted Correctly	Percent Correct Value
SOV	3961	3905	98.59%
2P+	1029	54	5.25%
Total	4990	3959	79.34%

From the table it is seen that the number of trips correctly predicted for the SOV mode are 3905 trips. The number of observed trips are 3961 trips. The percent correct value comes out to be 98.59%. Similarly the number of correctly predicted trips for the 2P+ mode are 54. The observed number of trips are 1029 trips. The percent correct value is 5.25%. The overall number of correct predicted trips are 3955 out of 4990. Hence, the overall percent correct value comes out to be 79.34%.

It appears that the model is unable to predict 2P+ trips correctly. As discussed in the previous section, non-SOV trips are difficult to model correctly since the trips tend to be more complicated in nature. Non-SOV trips can involve several destinations and have differing levels of auto occupancy. Moreover, ride-share travelers are likely to perceive travel cost and time differently depending on whether they are families travelling together or business colleagues. Average travel cost and travel time values used in the model may also affect results. Since it is not possible to capture all of these factors when modelling

modal choice, the model tends to under-predict non-SOV trips. However, the model is able to predict SOV trips with a high degree of accuracy.

5.4.6 Correlation Matrix

The correlation matrix for the developed model is shown for the SOV mode in Table 5.10 and for the 2P+ mode in Table 5.11. The correlation matrix shows the correlation between various variables. The correlation range is 0 and 1. Higher the correlation, higher is the value. But higher correlation between independent variables is not considered good for the model. A correlation between a pair of variables greater than 0.8 indicates that a particular effect is being accounted twice and hence the model should be re-specified [RMOC, 1998]. Also as per Gujarati [1995], if the pair wise correlation coefficient between two variables is high, say in excess of 0.8, then multi-collinearity is a serious problem. In our Tables 5.10 and 5.11, the correlation between any of the variables is not greater than 0.8. Also it is clear that there is no problem of multi-collinearity in any of the variables. Hence the model satisfies the correlation criterion.

Table 5.10 Correlation Matrix For SOV Mode

Variables	Cost1	Time1	Number Of Persons	Number Of Vehicles	Province	Work
Time1	0.4077					
Number Of Persons	-0.0036	0.0821				
Number Of Vehicles	0.0186	0.0866	0.2675			
Province	0.0299	0.0675	-0.0224	0.1009		
Work	-0.0004	0.0019	0.4064	0.3311	-0.0286	
Dest. Pop. density	-0.1192	-0.3044	-0.0884	-0.1461	-0.0843	-0.0455

Table 5.11 Correlation Matrix For 2P+ Mode

Variables	Cost2	Time2	Number Of Persons	Number Of Vehicles	Province	Work
Time2	0.4461					
Number Of Persons	-0.0082	0.0616				
Number Of Vehicles	0.0202	0.0748	0.2675			
Province	0.0256	0.1009	-0.0225	-0.0339		
Work	-0.0017	-0.0110	0.4064	0.3311	-0.0286	
Dest. Pop. density	-0.1215	-0.2722	-0.0884	-0.1462	-0.0843	-0.0455

5.4.7 Model Evaluation

The model output gives us the estimated values of the coefficients and a set of statistical indicators to judge the quality of the model. The value of the individual coefficients of the variables, the t-statistics of these coefficients and the correlation among the variables is examined in the following paragraphs.

Cost is an important conditional variable. It has an estimated coefficient of -0.0551 with a t-statistic of -0.18. This t-statistic of less than -1 indicates that the cost is not highly significant. The negative sign is the expected sign and it means that the cost is a disutility

in the model. Even though it is not highly significant, cost is retained in the model as it is a major factor influencing mode choice.

Time is an important policy variable in the model. The estimated coefficient of time is -0.0975 with a t-statistic of -6.49. The sign of the time coefficient is negative, which is the expected sign. This negative sign indicates that time is a disutility in the model. This means that if time increases, people will switch from the 2P+ mode to the SOV mode and vice versa. This behavior is expected and is consistent with the observed behavior. A t-statistic of -6.49 shows that it is highly significant at a confidence interval of more than 99%. This shows that people attach significant value to travel time in work trips.

Inclusive value has an estimated coefficient of 0.244 with a t-statistic of 1.30. This inclusive value should be between 0 and 1. A t-statistic of 1.30 shows that the variable is significant at a confidence interval of more than 95%.

Number of persons per household has an estimated coefficient of 0.3305 with a t-statistic of 5.62. The positive sign of this variable indicates that as the number of persons in the household increases, the likelihood of ride-sharing also increases.

Number of vehicles per household is another important variable. This variable has an estimated coefficient of -0.7986 with a t-statistic of -9.92. The negative sign shows that if the number of vehicles increases in the house, people are more likely to choose the SOV mode. This is observed in practice. If there are several vehicles in the house, then people tend to drive alone so that they have more flexibility in their schedule. A high t-statistic of -9.92 shows that this variable is significant at 99.99% confidence interval.

Province is an important variable with an estimated coefficient of 0.4875 and a t-statistic of 6.14. The positive sign of the coefficient shows that people in Quebec are more likely to share ride. This is consistent with the travel characteristics of the region. A high t-statistic value of 6.14 shows that it is significant at more than 99% confidence interval.

Work has an estimated coefficient of 0.1488 with a t-statistic of 1.99. The positive sign shows that if there are more workers in the house they will go for share ride. The high value of the t-statistic shows that work is an important variable with significant impact on travel mode choice behavior.

Destination population density has an estimated coefficient of -0.000045 with a t-statistics of -2.07. The t-statistic shows that it is significant at more than 99% confidence interval.

Constant has an estimated coefficient of -0.5613 with a t-statistic of 2.48. This constant variable represents the average effect of all variables which are not present in the model. Due to constraints, the important variables which influence the mode choice may have not been included. So this variable represents all such unexplained and unknown variables in the model.

Goodness of Fit Measures

The goodness of fit measures “**rhosq**” and “**rhobarsq**” provides a means to determine how well the model fits the sample data. The value of the rhosq varies between 0 (no fit) and 1 (perfect fit).

In our case, the value of rhosq and rhobarsq are 0.3169 and 0.3146. The rhobarsq takes into account the market share of the model which is 79.38% for SOV and 20.62% for more than one person per vehicle. According to Table 3.1, this model should have a minimum rho-square value of 0.28. Since the value obtained from the model is greater than this, the model is acceptable.

5.4.8 Sensitivity Analysis

The sensitivity analysis shows the changes in modal share of the SOV mode and 2P+ mode. The results of the sensitivity analysis are shown in the Table 5.12.

Table 5.12 Sensitivity Analysis For Intermediate Level Model

Variables	SOV mode	2P+ mode
SOV cost +10% change	-0.10%	+0.10%
Non-sov cost +10% change	+0.10%	-0.10%
SOV time +10% change	-2.25%	+2.25%
Non-sov time +10% change	+1.48%	-1.48%
Vehicle from 1 to 2+	+1.48%	-1.48%
Pop. density +10% change	-0.08%	+0.08%
Quebec rather Ontario	-1.63%	1.63%

From the sensitivity table, it can be seen that a 10% increase in the SOV cost decreases the SOV modal share by 0.10% and increases the 2P+ modal share by 0.10%. Likewise a 10% change in the non-SOV cost increases the modal share of the SOV mode by 0.10% and decreases the modal share of 2P+ mode by 0.10%. Thus, a 10% increase in 2P+ cost has the same effect as a 10% increase in SOV cost. This clearly indicates that increasing SOV cost by 10% has little impact on the modal shift to non-SOV mode. A significant increase in cost may be needed to decrease the number of SOV trips.

A 10% increase in SOV travel time decreases the SOV modal share by 2.25% and increases the 2P+ modal share by 2.25%. This shows that the time has an important role to play in work trips and in the selection of SOV and 2P+ modes. On the other hand, a 10% increase in travel time for the 2P+ mode increases the SOV modal share by 1.48% and decreases the modal share of 2P+ mode by -1.48%. Thus, increasing the travel time of the SOV mode has a greater impact than increasing the travel time of the non-SOV mode.

From the travel cost and time sensitivities, it is clear that travel time has greater influence on the modal shift compared to travel cost. It appears that people consider time savings in cost context. SOV persons spend more money on travel but if they are not able to save time, then they may start to explore other alternatives which offer better incentives.

If the number of vehicles per household are increased from one to two or more vehicles, the modal share of the SOV mode increases by 1.48% and the modal share of the 2P+ mode decreases by 1.48%. This shows that the number of vehicles in the household influences modal choice significantly. If there are more vehicles available, the number of SOV trips can be expected to increase.

A 10% change in population density decreases the SOV modal share by 0.08% and increases the 2P+ modal share by 0.08%. This shows that the population density has a minor effect on ride sharing. In general, if the population density increases, vehicle occupancy also increases.

The impact of place of residence is shown by the province variable. If the place of residence is Quebec rather than Ontario, there is drop of 1.63% in the SOV modal share and an increase of 1.63% in the 2P+ modal share. This indicates that people in Quebec are likely to go for higher occupancy vehicle compared to residents of Ontario.

5.5 HIGHER LEVEL MODEL

5.5.1 Overview

This section describes the higher level model of the nested logit model developed for home based work trips. This model simulates auto and transit trips. The intermediate level model simulating auto trips for SOV and non-SOV (2P+) modes as well as the lower level model simulating auto occupancy for two persons in vehicle (2P) and three or more persons (3P+) mode are represented in this higher level model in the auto mode.

This higher level model can be effectively utilized in policy studies involving auto and transit vehicle facilities.

5.5.2 Model Structure

The structure of the higher level model is shown in Figure 5.6.

Figure 5.6 Structure of Higher Level HBW Model

5.5.3 Available Sample Size

The number of auto trips in the sample was 5,836, representing a modal share of 80.30%. In contrast, the number of transit trips are 1,432 with a modal share of 19.70%. Thus, the total number of trips used to develop the model was thus 7,268.

The variables used in the model include cost, time, inclusive value, gender, province, number of persons per household, number of vehicles per household, work, origin

employment density, central business district and transit way. These variables were described in detail in section 3.8. Additional details specific to this model are presented below.

Cost

Travel cost is an important policy variable in the model. This variable is useful for predicting the effects of policy measures that could change the modal share of auto and transit. This variable helps us to predict the change in bus ridership that will occur if bus fares increase or auto travel becomes more expensive. The cost variable is taken as a conditional variable in this model, since the cost for the transit mode is quite different from the cost for the auto mode.

Cost1 is the cost of travel by automobile from the origin of trip to the destination of the trip. This cost includes cost for fuel and parking and is calculated in the same way as reported in lower level model. Cost1 is the average cost of SOV cost and non-SOV cost of the intermediate level model. This average cost is calculated based on the procedure mentioned by Kenneth Train [1986].

Cost2 is the cost to travel by transit from the trip origin to the trip destination. This cost is based on the transit fare charged by the transit company. Transit fares for 1995 were estimated by developing the fare matrix. The transit fare required to travel between the National Capital Region areas is the function of cash fares and monthly passes. The fare takes into account the dual fare structure of OC Transpo and STO for regular and express service.

Time

The time is the total travel time in minutes from the trip origin to the trip destination. This total travel time is estimated using EMME/2 model. Time is also a policy variable. The total travel time could be changed by the policy measures. The Time variable can help us in predicting change in modal share if the bus becomes faster or auto becomes slower.

Time was taken as a conditional variable in the model, implying that the time coefficient will be the same value in both the SOV and 2P+ utility functions. This is because time is an influential policy variable in the intermediate model as well as lower level. Both auto time and transit time are included in the model.

Auto time is the average time of SOV time and non-SOV time of the intermediate level model. This average time is calculated as per the procedure mentioned by Kenneth Train [1986].

Transit time is time from the trip origin to the trip destination. This time includes the in-vehicle time as well as the out-of-vehicle time. The transit out-of-vehicle time includes the access time required to walk to the bus stop, transfer time, wait time, boarding time and egress time. For the auto mode (time1), out-of-vehicle time was assumed to be 0.

Inclusive value

The inclusive value variable represents the intermediate model in the higher model. This intermediate model simulates SOV and non-SOV trip in the model. The composite utility of the intermediate model is used in the higher model. This composite utility includes the expected maximum utility of the SOV and non-SOV mode as given by the following formula

$$I_{SOV, 2P+} = E [\max (U_i)] = \ln \sum_{i=1}^N \exp(V_i) \dots\dots\dots(4.4)$$

where $I_{SOV, 2P+}$ is the expected maximum utility of the SOV and 2P+ members of the intermediate model.

Province

Province is an important variable in the model representing regional travel characteristics. Transit in Ontario is provided by OC Transpo while transit in Quebec is provided by

STO. Thus, the National Capital Region is served by two transit agencies, which ultimately influences regional travel behavior.

Central Business District

The central business district is the downtown area of the city. This central business center has high employment density as well as shopping opportunities. Ottawa, like many other North American cities, has much of its employment concentrated in the core. Also, many of the important cultural and political institutions of local and national importance are located in the core, thus strengthening the central business district's dominant role in the transportation activities of the metropolitan area's inhabitants. The central area is considered the main focal point. It has high concentration of employment and contains the Canadian House of Parliament among other prominent cultural and political institutions and business centers.

The travel characteristics of the central business district area are quite different. Parking costs are high during the weekday. A higher percentage of commuters prefer to take transit to work instead of driving. Also, many persons share ride in the downtown to reduce the travel costs. Hence, it is necessary to include this variable in the model to predict the mode choice of people working in the downtown area. This variable was coded as 1 for trips originating in the central business district and 0 for trips originating out-side of the central business district.

Transitway

Transitway variable is included in the model to capture the effect on modal choice if an individual's work place is located near the Transitway. The Transitway provides the exclusive rapid transit service to the transit riders. If an individual's work place is located near the transitway, then the transit becomes a more attractive option. The National Capital Region has an extensive network of Transitways. The ridership data indicate that of the 300,000 people who travel by bus each day within the region, 200,000 travel daily

on the Transitway[RMOC, 1994]. The transitway could be one of the unique factors in affecting modal choice decisions and hence it is included in the model.

5.5.4 Developed Model

The home based work trip model developed for the higher level part of nested logit model is shown in the Table 5.13. This higher level model includes auto and transit mode. Auto mode is further divided into SOV, two persons in vehicle and three or more than three persons in vehicle.

The conditional variables in the model are cost, time and the inclusive value. The other multinomial variables are gender, number of persons per household, number of vehicles per household, province, origin employment density, central business district, transitway and constant.

Table 5.13 Higher Level HBW Model for Auto and Transit

Modes	Cost	Time	Inclusive Value	Gender	Province	Number Of Persons	Number of Vehicles	Work	Central Business District	Transit-way	Constant
Auto	-0.6020 (-13.02)	-0.0172 (-6.47)	0.2515 (6.33)								
Transit	*-0.6020 **(-13.02)	-0.0172 (-6.47)	0.2515 (6.33)	-0.4600 (-5.88)	-1.048 (-10.70)	0.1411 (4.07)	-1.777 (-21.06)	0.1505 (2.51)	1.159 (12.63)	0.6327 (7.62)	0.049 (0.31)

*** coefficient of variable**

**** t-statistic of variable**

Cost	...	travel cost from trip origin to trip destination
Inclusive value	...	expected maximum utility of the SOV and non-SOV mode
Gender	...	Coded as 0 for female and 1 for male
Province	...	Coded as 0 for Ontario and 1 for Quebec
Number of vehicles	...	Coded as 0 for no vehicle, 1 for one vehicle/household and 2 for two or more vehicles/household
CBD	...	Coded as 0 for trips going out of CBD and 1 for trips coming in CBD

Summary Statistics

Number of modes	= 2
Number of auto trips	= 5,836 trips (80.30 %)
Number of transit trips	= 1,432 trips (19.70 %)
Total number of trips	= 7,268 trips (100 %)
Rhosq	= 0.5518
Rhobarsq	= 0.5498

Overall Measure of Goodness of Fit

The development of the overall measure of goodness of fit for nested logit model consisting of auto and transit is a complicated task. The overall measure equivalent to ρ^2 suggested by McFadden and Tardiff as mentioned by Sobel [1981] are as under:

$$\begin{aligned}\rho_{\text{Overall}}^2 &= 1 - \{ [L_{\text{Higher}}(\beta) + L_{\text{Intermediate}}(\beta)] / [L_{\text{Higher}}(0) + L_{\text{Intermediate}}(0)] \} \dots (4.7) \\ &= 1 - 0.5437 \\ &= 0.4563\end{aligned}$$

Thus the overall measure equivalent to ρ^2 is 0.4563. Since the value is within the recommended range [Ortuzar and Willumsen, 1994], the model can be assumed to be reliable.

5.5.5 Model Validation

The results of this developed model are validated by two approaches:

- Macro Validation
- Micro Validation

In macro validation, the modal split obtained from the model is compared with the actual modal share captured by the data. While in micro validation, the choice prediction of

every trip record is compared with actual mode taken by the individual. Thus both the approaches are good indicator of model reliability.

Macro Validation

The modal split obtained from the developed model and the actual modal share of the data is shown in Table 5.14

Table 5.14 Macro Validation For Higher Level HBW Model

Modes	Number Of Observed Trips	Number Of Predicted Trips	Error
Auto	5836	6190	+ 354
Transit	1432	1078	- 354

From the table, it is seen that the number of predicted trips for the auto mode are 6,190 trips. The observed number of trips are 5,836 trips. Thus, 354 trips are over-predicted. Similarly, the number of predicted trips for transit are 1,078 trips. The observed number of trips is 1,432. Thus, 354 trips are under-predicted. These results indicate that the model is able to predict auto and transit trips with reasonable accuracy.

Micro Validation

The number of correct predicted trips for auto and transit mode are shown in Table 5.15.

Table 5.15 Micro Validation For Higher Level HBW Model

Modes	Number Of Observed Trips	Number Of Trips Predicted Correctly	Percent Correct Value
Auto	5836	5535	94.84%
Transit	1432	777	54.26%
Total	7268	6312	86.85%

From the above table, it is seen that the number of correct predicted trips for auto mode are 5,535 trips. The observed number of trips are 5,836 trips. Thus the percent correct value is 94.84%. Similarly the number of correct predicted trips for transit mode are 777 trips. The observed number of trips are 1,432 trips. Hence the percent correct value of the transit trip is 54.26%. The overall number of correct predicted trips are 6,312. Thus, the overall percent correct value for the model is 86.85%.

These results indicate that transit trips are more difficult to model than auto trips. Assumptions in transit fare and travel time will certainly introduce error. The time spent waiting for the bus will be different depending on the passenger and the route frequency. In addition, some passengers may choose to pay a premium fare while others do not. Since auto cost and travel time are based on average values, the auto cost for SOV trips will be lower than that experienced in reality while the travel time is higher. Thus, the model may tend to predict some transit trips as auto trips.

5.5.6 Correlation Matrix

The correlation matrix for the developed model is shown in Tables 5.16 and 5.17. The correlation matrix shows the correlation between various variables included in the model. The correlation value ranges between 0 and 1. Higher the value, higher is the correlation. The correlation between a pair of independent variables should not be greater than 0.8. A correlation value greater than 0.8 indicates that a particular effect is being accounted for

twice and that the model should be re-specified [RMOC, 1998]. Also as per Gujarati [1995], if the pair wise correlation coefficient between two variables is high, say in excess of 0.8, then multi-collinearity is a serious problem. From our tables, the value of correlation are less than 0.8 and hence the model satisfies the criterion for the correlation and no effect in any of the variable is accounted for twice.

Table 5.16 Correlation Matrix For Auto Mode

Variables	Cost1	Time1	Gender	Number Of Vehicles	Province	Work	Number Of Persons	CBD
Time1	0.4134							
Gender	-0.0068	0.1766						
Number of Vehicles	-0.0461	0.1851	-0.0006					
Province	-0.0556	0.0297	-0.0387	-0.0139				
Work	-0.0299	-0.0172	-0.0506	0.3332	-0.0194			
Number of Persons	-0.0174	0.0630	0.0724	0.2670	-0.0077	0.4118		
CBD	0.5491	0.0057	-0.0804	-0.1140	0.0465	-0.0302	-0.0264	
Transitway	0.4452	0.0040	-0.0747	-0.0706	-0.0943	0.0039	-0.0037	0.4262

Table 5.17 Correlation Matrix For Transit Mode

Variables	Cost2	Time2	Gender	Number Of Vehicles	Province	Work	Number Of Persons	CBD
Time2	0.6539							
Gender	0.0138	0.0618						
Number of Vehicles	0.1547	0.1535	-0.0006					
Province	-0.1460	-0.0237	-0.0387	-0.0139				
Work	0.0486	0.0367	-0.0506	0.3332	-0.0194			
Number of Persons	0.0813	0.1189	0.0724	0.2670	-0.0077	0.4118		
CBD	0.0142	-0.0872	-0.0804	-0.1140	0.0465	-0.0302	-0.0264	
Transitway	0.0335	-0.0663	-0.0747	-0.0706	-0.0943	0.0039	-0.0037	0.4262

5.5.7 Model Evaluation

The output of the logit model gives us coefficients of variables, t-statistics and goodness of fit measures. These sets of statistical indicators help to judge the quality of the model. The value of individual variables will be investigated through an examination of their coefficients, t-statistics and correlation. Also, the goodness of fit measures will be discussed.

Higher Level Model Variables

All the variables in the higher level model of auto and transit have expected signs as well as significant t-statistics. A discussion of individual variables is as follows.

Cost is an important policy variable in the model. The estimated coefficient of cost is -0.6020 and its t-statistic is -13.02. This shows that cost is highly significant at a more than 99% confidence interval. This is consistent with the every day observation that people value the cost significantly and it has high influence on their mode choice. The auto cost includes fuel cost and parking cost. Since the parking cost tend to be high, the auto mode is more expensive then the transit mode. This is especially true in the central business district area. Thus the changes in fuel and parking costs can have significant effect on the mode choice decisions.

Time is also an important policy variable in the model. The estimated coefficient of time is -0.0172 with a t-statistic of -6.47. This high t-statistic shows that time is highly significant at more than 99% confidence interval. The negative sign indicates that it is a disutility in the model. If transit time increases, people will tend to switch to the auto mode.

Inclusive value has an estimated coefficient of 0.2515 with a t-statistic of 6.47. The high t-statistic shows that it is highly significant at more than 99% confidence interval. The inclusive value represents the composite utility of the intermediate model. The value of inclusive value should be between 0 and 1 and this condition is satisfied.

Gender has an estimated coefficient of -0.4600 and its t-statistic is -5.88. This shows that it is significant at more than 99% confidence interval. Gender is a dummy variable coded as 0 for female and 1 for male. The negative sign shows that males are more likely to use auto mode than females who tend to use transit.

Province has an estimated coefficient of -1.048 with a t-statistic of -10.70. This high t-statistic shows that it is highly significant at more than 99% confidence interval. This variable represents the different travel characteristics of the two provinces of Ontario and Quebec. The negative sign shows that people in Ontario are more likely to use transit than Quebec residents.

Number of persons per household is an important variable influencing mode choice. It has an estimated coefficient of 0.1418 with a t-statistic of 4.07. The high t-statistic suggests that it is highly significant at more than 99% confidence interval. The number of persons in the house influences the mode choice. The positive sign indicates that if there are more people in the house then the probability of taking transit increases.

Number of vehicles per household has an estimated coefficient of -1.773 and a t-statistic of -21.06. The high t-statistic suggests that this variable is highly significant at more than 99% confidence interval. This means that the number of vehicles per household is an important variable that affects mode choice. The negative sign shows if there are several vehicles available, people are more likely to choose the auto mode.

Work has an estimated coefficient of 0.1505 with a t-statistic of 2.51. The t-statistic shows that work is significant and it contributes to the model. The nature of employment has an effect on travel mode choice behavior. The positive sign shows that if there are more workers in the house, they are likely to take transit rather than auto.

Central Business District is an important variable that influences mode choice and has an estimated coefficient of 1.159 with a t-statistic of 12.63. The high t-statistic shows that

this variable is significant at more than 99% confidence interval. The positive sign indicates that people are more likely to take transit rather than auto, if working in core area. This is especially true since parking costs are high in the central business district. Moreover, due to the dense network of streets and traffic congestion, it may be easier to take transit to the central business district than auto.

Transitway is an important variable and has an estimated coefficient of 0.6327 with a t-statistic of 7.62. This shows that transitway variable is significant at more than 99% confidence interval. The positive sign indicates that if the work place is located near the transitway, then the person is likely to take transit rather than auto. The high significance value shows that the location of the work place with respect to transit facilities has an important effect on mode choice behavior.

Constant has an estimated coefficient of 0.049 with a t-statistic of 0.31. The constant represents the average effects of variables not present in the model. It should be as low as possible. Here the low estimate of the coefficient suggests that the variables in the model estimate mode choice with little random error.

Goodness of Fit Measures

The goodness of fit measures like rho-square, rho-bar-square provide a means to quantify the goodness of fit of a model compared to the sample data. These measures range between 0 (for no fit) and 1 (for perfect fit).

The rho-square and rho-bar-square of this higher level model are 0.5520 and 0.5498 respectively. Since the primary mode has a modal share of 80%, the minimum acceptable rho-square value is 0.28 as found in Table 3.1. Thus, the model has an acceptable goodness of fit to the observed data.

5.5.8 Sensitivity Analysis

The sensitivity Analysis for the auto and transit mode is shown in the table as shown below.

Table 5.18 Sensitivity Analysis For Higher Level HBW Model

Variables	Auto	Transit
Auto cost +10% change	-1.03%	1.03%
Transit cost +10% change	+0.71%	-0.71%
Auto time +10% change	-0.36%	+0.36%
Transit time +10% change	+0.53%	-0.53%
Incl. value +10% change	-0.48%	+0.48%
Male rather than female	+0.40%	-0.40%
Vehicles from 0 to 1	+0.60%	-0.60%
Vehicles from 1 to 2	+6.42%	-6.42%
Quebec rather than Ontario	+4.33%	-4.33%
CBD from yes to no	+4.35%	-4.35%
Transitway from yes to no	+1.37%	-1.37%

The sensitivity analysis shows the change in the modal shares for auto and transit. From the above table, it is seen that a 10% increase in auto cost decreases the auto modal share by 1.03% and increases the transit modal share by +1.03%. A 10% increase in transit cost increases the modal share of auto by 0.71% and decreases the modal share of transit by -0.71%. The increase in auto cost has more effect on the modal share than the increase in transit fare changes. This indicates people are more sensitive to auto cost than transit cost. If the transit routes are convenient, people are likely to consider transit mode for the work trips. Work trips are mandatory trips and have to be undertaken without any choice. People are likely to choose the mode which is less expensive and offers best service.

A 10% increase in auto time decreases the auto modal share by 0.36% and increases the transit modal share by +0.36%. A 10% increase in transit time increases the auto modal share by +0.53% and decreases the transit modal share by -0.53%. Thus the effect of 10% increase transit time is more on modal share than 10% increase in auto time. This is

because people perceive transit time differently than auto time. If the transit times are unacceptably long, people are likely to switch to auto mode.

A 10% increase in inclusive value lowers the auto modal share by 0.48% and increases the transit modal share by 0.48%. This inclusive value represents the coefficients of intermediate level model of SOV and 2P+ along with the lower model of 2P and 3P+.

If males are considered rather than females, the auto modal share increases by 0.40% and the transit modal share decreases by 0.40%. This shows that women tend to use transit more than auto.

If the number of vehicles per household is increased from 0 to 1, then the auto mode split increases by 0.60% while the transit mode split decreases by 0.60%. But if the number of vehicles are increased from 1 to 2+, then the auto mode split increases by +6.42% and the transit mode split decreases by -6.42%. This indicates that if there are additional vehicles in the house, people are likely to choose auto mode over transit. Thus, we see that the number of vehicles per household is an important variable that influences mode choice.

If the province variable is considered as Quebec rather than Ontario, then the auto mode split increases by +4.33% and transit modal share decreases by -4.33%. This shows that people in Ontario show a greater tendency to use transit than people in Quebec. People in Quebec are more likely to choose the auto mode and hence the auto modal share increases by 4.33%.

The change in central business district from yes to no increases the auto mode split by +4.35% and decreases the transit mode split by -4.35%. This shows that the central business district has a great impact on the auto mode. The parking costs are high in the central business district and hence it discourages people in taking auto more towards the core area. Although people tend to use transit more if they worked in central business

district but if they travel outside central business district, they have greater tendency to use auto mode.

If the transitway variable is changed from yes to no i.e. the work place is not located near the transitway, then the auto mode increases by +1.37% and transit mode decreases by 1.37%. This shows that if the work place is located near the transit way, people are more likely to use transit mode instead of auto mode. But if the work place is located away from the transitway, then people prefer to use auto mode and hence the auto modal share goes up. Thus, the location of the workplace with respect to transit facilities has an important impact on the modal share.

CHAPTER 6

NON-WORK TRIP MODEL

6.1 INTRODUCTION

In the previous chapter, the home based work trip model was discussed. This chapter deals with the non-work trip model. Non-home based trips, other home based trips and leave home trips were grouped together to build the non-work trip model for auto and transit modes. The logit model developed is described in detail in the following sections.

6.2 MODEL STRUCTURE

Various modes and model structures were explored so that a better model could be developed with acceptable results. The logit and nested logit models were the obvious choice, since these models enable us to analyze more than two modes simultaneously. The different modes tried were SOV, 2P, 3P+ and transit. Three alternative model structures were attempted as described below.

6.2.1 Structure I

The first attempt was the development of a nested logit model of auto and transit. Auto mode was further divided into SOV and share ride modes. The structure of the model is shown in Figure 6.1. A logit model for the SOV and ride share was developed. The maximum number of trips predicted correctly for SOV and share ride were 87% and 27% respectively. Due to the low percent correct prediction for the share ride mode, the model was abandoned.

Figure 6.1 Structure I - Nested Logit Model For Non-work Trips

6.2.2 Structure II

The second attempt was to develop a nested logit model for auto and transit, with auto mode further divided into SOV, two persons per vehicle and three or more persons per vehicle. The structure of the model is shown in the Figure 6.2.

Figure 6.2 Structure II - Nested Logit Model For Non-work Trips

Several logit models were developed for the SOV, 2P and 3P+ modes. The best percent correct prediction obtained for the lower level model for SOV, 2P and 3P+ were 96%, 4% and 11% respectively. Thus, the model was unable to predict the high occupancy vehicle modes correctly. As a result, the model was not selected.

6.2.3 Structure III

The next attempt was again a nested logit model with auto and transit at the higher level but with different nests for auto occupancy. The structure of the model is shown in the Figure 6.3.

Figure 6.3 Structure III - Nested Logit Model For Non-work Trips

First, a logit model was developed for the lower level 2P and 3P+ modes. This model correctly predicted 92% and 47% of the 2P and 3P+ trips respectively. Next an

intermediate model for the SOV and non-SOV (2P+) was developed. For the SOV mode, 87% of the trips were predicted correctly. However this value dropped to 27% for the non-SOV trips. Due to the low number of trips predicted correctly for the 2P, 2P+ and 3P+ mode, the models were not selected.

Finally it was decided to develop a model for auto and transit without taking vehicle occupancy into account.

6.3 AVAILABLE SAMPLE SIZE

The trip purposes included in the model are:

- Non-home based trips
- Other home based trips
- Leave home based trips

The number of trips for non-home based trips, other home based trips and leave home based trips are shown in Table 6.1

Table 6.1 Auto and Transit Trips

Trip Purposes	Auto	Transit	Total
Non-home based	4569	436	5005
Other home based	3622	322	3944
Leave home	2868	203	3071
Total	11059	961	12020

The variables used in this model include cost, time, gender, province, number of persons per household, number of vehicles per household, work and origin employment density. These variables are discussed in detail in section 3.7 and 3.8. Additional details relevant to the non-work trip model are discussed below.

Cost

The cost of auto travel includes fuel costs and parking costs. As discussed earlier, the fuel cost is taken as 5 cents per kilometre. Parking cost was taken as \$1 for an average stop time of one hour. This one hour time is sufficient considering the nature of non-work trips during weekday travel. Moreover, this parking cost was taken for the central business district which covers downtown Ottawa and Hull, where parking fees are in effect on weekdays from 7 AM to 7 PM.

Transit cost is based on the transit fare required to travel from the trip origin to the trip destination. Transit fare was estimated by developing a fare matrix. The transit fare is the function of cash fares and monthly pass. The fare takes into account the dual fare structure of OC Transpo and STO for regular and express service.

Time

Travel time represents the total time required to travel from the trip origin to the trip destination. This time was obtained from the EMME/2 model. Time is a policy variable, since the total travel time is influenced by the policy measures.

The auto time is the time from the trip origin to the trip destination. The out-of-vehicle time is considered to be zero. The transit time is time from the trip origin to the trip destination. It includes out-of-vehicle time and in-vehicle time. The out-of-vehicle time includes access time, wait time, boarding time, transfer time and egress time.

6.4 DEVELOPED MODEL

The developed model for auto and transit is shown in Table 6.2.

Table 6.2 Non-work Trip Model For Auto And Transit Mode

Modes	Cost	Time	Gender	Province	Number of Persons	Number of vehicles	Work	Origin Employment Density	Constant
Auto	*-0.8432 **(-8.48)	-0.0157 (-3.86)							
Transit	-0.8432 (-8.48)	-0.0157 (-3.86)	-0.3925 (-4.90)	-0.6569 (-6.10)	0.1395 (4.13)	-2.5745 (-30.47)	0.3328 (6.59)	0.000025 (8.16)	0.5904 (3.60)

* Coefficient of variable

** t-statistics

Cost	...	Total travel cost from trip origin to trip destination
Time	...	Total travel time from trip origin to trip destination in minutes
Gender	...	Coded as 0 for female and 1 for male
Province	...	Coded as 0 for Ontario and 1 for Quebec
No. of Vehicles	...	Coded as 0 for no vehicles, 1 for one vehicles and 2 for two or more vehicles per household.

Summary Statistics

Number of modes	= 2
Number of auto trips	= 11,059 (92%)
Number of transit trips	= 961 (8%)
Total number of trips	= 12,020 (100%)
Rhosq	= 0.7153
Rhobarsq	= 0.7142

6.5 MODEL VALIDATION

The results of the model are validated by two approaches:

- Macro Validation
- Micro Validation

Macro Validation

The modal split given by the developed model and actual modal share of the data is shown in the Table 6.3.

Table 6.3 Macro Validation for Non-work Trip Model

Modes	Number Of Observed Trips	Number Of Predicted Trips	Error
Auto	11059	11651	+ 592
Transit	961	369	- 592

From the table, it can be seen that the number of trips predicted for auto are 11,651. The actual number of observed trips are 11,059. Thus, there is an over-prediction of 592 trips.

Similarly the number of predicted trips for transit are 369. The actual observed trips are 961. Thus there is a under-prediction of 592 trips.

Auto trips are over predicted where as transit trips are under predicted. This is because non-work trips are difficult to simulate compared to work trips. Non-work trips are more complicated for a variety of reasons. In general, non-work trips are discretionary and are therefore considered to be more flexible. Also, non-work trips tend to be shorter than work trips. For shorter distances, travel cost and travel time by transit are relatively higher, making the auto mode more attractive. Hence, the model tends to predict more auto trips compared to transit trips.

Micro Validation

The number of correctly predicted trips for auto and transit mode are shown in Table 6.4.

Table 6.4 Micro Validation for Non-work Trip Model

Modes	Number Of Observed Trips	Number Of Trips Predicted Correctly	Percent Correct Value
Auto	11059	10970	99.20%
Transit	961	280	29.14%
Total	12020	11250	93.59%

As shown in Table 6.4, the number of trips correctly predicted for the auto mode is 10,970. The observed trips for the auto mode are 11,059. Thus the percent correct trips for auto mode are 99.20%. This indicates that the model is able to predict auto trips with great accuracy. The number of transit trips predicted correctly are 280. The number of observed trips for transit are 961. The percent correct value comes out to be 29.14%. The

overall correctly predicted trips are 11,250. Thus, the overall percent correct value is 93.59%.

From these results, the model shows a low percent correct prediction for transit trips. This is because transit trips are more difficult to predict compared to auto trips as discussed in Section 4.5.5. It should be noted that the work trip model is better able to simulate transit trips because non-work trips are more complicated in nature, and are thus more difficult to model. The other possible reason could be that travel cost and time are higher for short distance transit trips compared to auto trips and hence the model tends to predict more auto trips. However, it should be emphasized that the model is able to predict auto trips with a high degree of accuracy.

6.6 CORRELATION MATRIX

The correlation matrix for auto and transit mode are as shown in Table 6.5 and Table 6.6. The correlation matrix shows the correlation between various independent variables. As per Gujarati [1995], if the pair wise correlation coefficient between two variables is high, say in excess of 0.8, then multi-collinearity is a serious problem. From the tables, it is seen that none of the correlation value is greater than 0.8 and hence the model variables are not correlated. Moreover, there is no problem of multi-collinearity in any of the variables.

Table 6.5 Correlation Matrix For Auto Mode

Variables	Cost1	Time1	Gender	Number Of Persons	Province	Number Of Vehicles	Work
Time1	0.7598						
Gender	0.0452	0.0554					
Number of Persons	-0.0444	-0.0089	-0.0028				
Province	-0.0403	-0.0194	0.0066	-0.0009			
Number of vehicles	-0.0066	0.0764	0.0135	0.3417	0.0018		
Work	0.0615	0.0790	0.0227	0.4609	0.0009	0.3832	
Origin emp. density	0.5179	0.1367	0.0154	-0.0659	-0.0311	-0.0715	0.0056

Table 6.6 Correlation Matrix For Transit Mode

Variables	Cost2	Time2	Gender	Number Of Persons	Province	Number Of Vehicles	Work
Time2	0.5384						
Gender	-0.0016	0.0455					
Number of Persons	0.0273	-0.0304	-0.0028				
Province	-0.0850	-0.0215	0.0066	-0.0009			
Number of vehicles	0.0968	0.1095	0.0135	0.3417	0.0018		
Work	0.0268	0.0718	0.0227	0.4609	0.0009	0.3832	
Origin emp. density	0.0319	-0.0244	0.0154	-0.0659	-0.0311	-0.0715	0.0056

6.7 MODEL EVALUATION

The output of the logit model gives the estimated values of the coefficients of the variables and a set of statistical indicators to evaluate the quality of the model. In this section, individual variables are investigated by examining the coefficients of the variables and their t-statistics.

Cost is an important variable in the model. The estimated coefficient of cost is -0.8432 with a t-statistic of -8.48. This shows that cost is significant at more than 99% confidence interval. The cost variable has great influence on mode choice behavior. Cost is a policy variable and hence any changes in policy can affect the mode choice decisions. If parking is made more expensive, the auto mode will become less attractive. Hence, some people will switch to transit which would be economical. Cost has negative sign, which indicates people will switch to transit, if auto costs are increased.

Time is also an important policy variable in the model. The estimated coefficient of time is -0.0157 with a t-statistic of -3.86. This high t-statistic shows that time is significant at more than 99% confidence interval. People value time in their travel for other trip purposes on the weekday travel. If transit time increases, people will tend to switch to the auto mode. Thus during weekday travel, time is an important variable for other trip purposes also.

Gender has an estimated coefficient of -0.3925 with a t-statistic of -4.90. This high t-statistic shows that gender is an important variable that affects the mode choice. The negative sign indicates that males are more likely to use the auto mode and females will use transit mode.

Number of persons per household also affects the mode choice. This variable has an estimated coefficient of 0.1395 and a t-statistic of 4.13. The high t-statistic indicates that it is significant at more than 99% confidence interval. The positive sign indicates that if there are more people in the house then probability of using transit increases.

Number of vehicles per household has an estimated coefficient of -2.575 and a t-statistic of -30.47. This high t-statistics of -30.47 shows that this variable is an important variable that affects the mode choice and it is significant at more than 99% confidence interval. The negative sign indicates that if there are several vehicles then the people are more likely to choose the auto mode. This is obvious and consistent with day to day

observation. The non-work trips are discretionary and hence if a vehicle is available, an individual is unlikely to use transit.

Work has an estimated coefficient of 0.3328 with a t-statistic of 6.59. This high t-statistic value shows that it is significant at more than 99% confidence interval. The nature of work clearly has an effect on mode choice.

Origin employment density has an estimated coefficient of 0.0000251 and a t-statistic of 8.16. The high value of the t-statistic suggests that the variable is important. The positive sign indicates people are likely to use transit for non-work trip purposes in high employment density areas. High origin employment density is normally found in the central business district, where transit is readily available and auto costs are high. Hence the number of persons using transit increases.

The **Constant** has an estimated coefficient of 0.5904 with a t-statistic of 3.6. The value of the constant variable is small, which is desirable. This constant variable represents the average effect of all variables which are not included in the model. The high t-statistic suggests that there are some variables which are not represented but are significant. The constant takes care of these variables which explains unknown and unexplained variables in the model.

Goodness of Fit Measures

The goodness of fit measures such as rho-square and rho-bar-square are good statistical indicators to judge the quality of the model. They provide a means to measure the goodness of fit of the model to the sample data. The value of these measures range between 0 (for no fit) and 1 (for perfect fit).

The rho-square and rho-bar-square values for non-work trip model are 0.7153 and 0.7143 respectively. The primary mode has a modal share of 92%. Thus, according to Table 3.1,

the minimum acceptable rho-square value is approximately 0.55 (using interpolation). As a result, the model is acceptable.

6.8 SENSITIVITY ANALYSIS

The sensitivity analysis for the auto and transit mode for non-work trip purposes is shown in Table 6.7.

Table 6.7 Sensitivity Analysis For Non-work Trip Model

Variables	Auto	Transit
Auto cost +10%	-0.27%	+0.27%
Transit cost +10%	+0.44%	-0.44%
Auto time + 10%	-0.06%	+0.06%
Transit time +10%	+0.17%	-0.17%
Male rather than female	+0.25%	-0.25%
Vehicles from 0 to 1	+2.58%	-2.58%
Vehicles from 1 to 2	+0.48%	-0.48%
Origin emp. density +10%	-0.17%	+0.17%
Quebec rather Ontario	+1.37%	-1.37%

The sensitivity analysis shows changes in auto and transit modal share. From the table, it is seen that a 10% increase in auto cost decreases the auto modal share by 0.27% and increases the transit modal share by 0.27%. A 10% increase in transit fare increases the auto mode split by 0.44 percent and decreases the transit mode by 0.44 percent. Thus it is clear that increase in transit fare has more effect on the modal share than similar increase in auto cost. This indicates that people tend to be more sensitive to transit cost for non-work trips.

A 10% increase in auto travel time causes 0.06 percent reduction in auto mode split and increases the transit mode by 0.06%. Also a 10% increase in transit travel time increases

the auto mode by 0.17% and decreases the transit mode split by 0.17%. This indicates that the effect of increasing travel time has minimal effect on the modal shift.

If males are considered rather than female, the auto mode increases by 0.25% while transit mode split decreases by 0.25%. This shows that males tend to use auto mode more while females tend to use transit mode.

If the number of vehicles are increased from 0 to 1, then auto mode split increases by 2.58% and transit mode split decreases by 2.58%. If the number of vehicles are increased from 1 to 2+ then the auto modal share increases by 0.48% and transit modal share decreases by 0.48%. This indicates that 2.58% people will switch to auto mode, if they had chance to own a vehicle. But if there are several vehicles, the shift to transit mode is not that great.

A 10 percent increase in origin employment density increases auto trips by 0.48% and decreases transit trips by 0.48%. This indicates that if employment density increases, people tend to make more non-work trips using auto mode.

If the province variable is considered as Quebec rather than Ontario, the auto mode share increases by 1.37% and transit mode share decreases by 1.37%. This shows that people in Quebec tend to use more auto than transit.

CHAPTER 7

MODEL COMPARISON

7.1 INTRODUCTION

A summary of three nested models developed for home based work trips as well as the model developed for non-work trips for the National Capital Region is presented. For each model (work and non-work trips) several alternative combinations of variables were tested. The objective for each case was to develop a model that best explains mode choice and an explanatory model which is most appropriate to be used effectively as a predictive model. To the extent possible, it was the intent to develop models for simulation and evaluation of vehicle occupancy. The initial specification in each model was chosen so as to be very similar to a specification of the TRANS model which has produced consistent results. These specifications were chosen so as the models developed from this research could become a part of the overall TRANS model development program.

The study area covers the National Capital Region which includes both Ontario and Quebec. This region is the fourth largest metropolitan area in Canada and incorporates a higher level of transit system as compared to most North American cities. The area is growing quickly due to several factors, including an increase of high tech jobs and better living conditions. It was essential to develop a model incorporating high occupancy modes such as share ride and transit. The level of service of these modes is a composite of several elements that can be influenced by transportation policies with widely differing implications. It was therefore essential to analyze the individual level of service of each mode to determine their relative importance.

For the home based work trip model, the modes selected were SOV, 2P, 3P+ and transit. For the non-work trip model, the modes selected were auto and transit. A summary of the two models along with validation results is shown in Tables 7.1, 7.2 and 7.3.

The variables included in the models are policy variables such as cost and travel time. Other important socio-economic variables which influence the mode choice such as number of vehicles per household, employment, gender, province, central business district, origin employment density and population density have been included to increase the models explanatory capabilities.

7.2 COMPARISON SUMMARY OF MODEL COEFFICIENTS

7.2.1 Policy Variables

From Table 7.1, it is evident that *cost* followed by *travel time*, *number of vehicles per household*, *number of persons per household*, *gender*, *employment* and *employment density* are the most significant variables in both the work trip and non-work trip models. Some of these are also policy variables, since changes in policy measures affect mode choice significantly. Policy makers such as elected officials and transportation planners are interested in policy variables that can help in improving transportation facilities.

From the home based work trip model, it is clear that cost and travel time are important variables which compete with each other when vehicle occupancy is considered. This is because vehicle occupancy has a significant effect on these two variables. By analyzing these variables at each level of the home based work trip model, we find that cost is sometimes dominant while at other times, travel time becomes more important. The following paragraphs examine cost and travel time variables at all three levels of the home based work trip model.

In the higher level model for auto and transit, *cost* is significant with an estimated coefficient of -0.6020 and a t-statistic of -13.02. This high t-statistic shows that cost is significant at more than 99% confidence interval. The negative sign indicates that cost is a disutility in the model. If cost increases for the transit mode, people will switch to the auto mode. In a similar fashion, if the auto cost increases, more people will switch to the transit mode.

Time has an estimated coefficient of -0.0172 and a t-statistic of -6.47. The high t-statistic suggests that time is significant at more than 99% confidence interval. The coefficient of time is lower than the cost coefficient. While time does influence mode choice, cost has a greater impact on mode choice decisions.

In the intermediate level model, we find that *time* is significant with an estimated coefficient of -0.0975 and a t-statistic of -6.49. This high t-statistic shows that time is significant at more than 99% confidence interval. Time becomes an important issue when choosing between driving alone and ride sharing. When ride sharing, the travel time increases due to potentially longer routes and the time required to pick up and drop off passengers. At this juncture, cost becomes secondary. The *Cost* variable has an estimated coefficient of -0.0551 with t-statistic of -0.18. The lower t-statistic suggests that cost is less significant than time. The cost is a policy variable and hence it should be included in the model. However, for SOV mode and non-SOV mode choice decisions, time is more important than cost.

At the lower level of the home based work trip model, the modes analyzed are two persons per vehicle and three or more persons per vehicle. Because the modes are high occupancy modes, cost and time both become more significant. The coefficient and t-statistic suggests that *cost* is significant. This finding appears consistent with the every day practice. The cost of travel can become much cheaper when people share a ride. As well, when there are more than two persons, increases in travel time becomes

insignificant compared to cost saving, as people realize that there is going to be more delay due to the high vehicle occupancy.

For the 2P mode, time has an estimated coefficient of -0.0313 and a t-statistic of -4.41. The travel time is important and if travel time increases, people will switch to other modes that offer less travel time. But if an increase in travel time is compensated by more savings in cost, people will likely not mind the increase in travel time. But this increase in travel time should be within reasonable limits so as to keep the mode attractive in cost and time savings.

From the non-work trip model, it can be seen that both cost and time are significant. The cost is significant with an estimated coefficient of -0.8432 and a t-statistic of -8.47. The time has an estimated coefficient of -0.016 with a t-statistic of -3.86. Thus cost is more significant than time. This is true from the observation that cost of travel is important in the non-work trip model as these trips are not mandatory as with work trips.

Table 7.1 Summary of Developed Models

Models	Modes	Cost	Time	Incl. Value	Gender	Province	Number Of Vehicles	Number of Persons	Work	Origin Employ. Density	Dest. Pop. Density	CBD	T_way	Constant
HBW Higher Level	Auto	-0.6020 (-13.02)	-0.0172 (-6.47)	0.2515 (6.33)										
	Transit	-0.6020 (-13.02)	-0.0172 (-6.47)	0.2515 (6.33)	-0.4600 (-5.88)	-1.048 (-10.70)	-1.773 (-21.06)	0.1418 (4.07)	0.1505 (2.51)			1.159 (12.63)	0.6327 (7.62)	0.049 (0.31)
HBW Inter. Level	SOV	-0.0551 (-0.18)	-0.0975 (-6.49)	0.2440 (1.30)										
	2P+	-0.0551 (-0.18)	-0.0975 (-6.49)	0.2440 (1.30)		0.4875 (6.14)	-0.7986 (-9.92)	0.3305 (5.62)	0.1488 (1.99)		-0.000045 (-2.07)			-0.5613 (2.48)
HBW Lower Level	2P	-1.9224 (-4.67)	-0.0313 (-4.41)											
	3P+	-1.9224 (-4.67)						0.7225 (-9.57)	-0.8089 (-5.66)	-0.0000169 (-2.47)				-1.3931 (-3.71)
Non-Work Trip Model	Auto	-0.8432 (-8.48)	-0.016 (-3.86)											
	Transit	-0.8432 (-8.48)	-0.016 (-3.86)		-0.3925 (-4.90)	-0.6569 (-6.10)	-2.5745 (-30.47)	0.1395 (-4.13)	0.3328 (-6.59)	0.000025 (-8.16)				0.5904 (-3.6)

Cost & Time

Travel cost and travel time from trip origin to trip destination

Gender

Coded as 0 for female and 1 for male

Province

Coded as 0 for Ontario and 1 for Quebec

Number of vehicles

Coded as 0 for no vehicle, 1 for one vehicle/household and 2 for two or more vehicles/household

CBD

Coded as 0 for trips going out of CBD and 1 for trips coming in CBD

7.2.2 Other Variables

Inclusive Value

The inclusive value represents the composite utility of the lower nests. As reported by McFadden [NCHRP, 1983], it is clear that in a nested structure with more than two levels, the only condition is that the inclusive value should lie in the range of 0 and 1. More explanation of this constraint is presented in section 2.6.3.

The inclusive value in the higher level model represents the composite utility of the SOV and non-SOV modes. From Table 7.1, it is clear that the inclusive value for the higher level model has an estimated value of 0.2515 with a t-statistic of 6.33. Thus, the inclusive value is between 0 and 1, which satisfies the condition. The high t-statistic of 6.33 shows that it is significant. The inclusive value of 0.2515 indicates that the nest of SOV and non-SOV modes is valid and is satisfying the statistical criteria.

In the intermediate level model for the SOV and 2P+ modes, the inclusive value represents the composite utility of the lower modes of two persons per vehicle and three or more persons per vehicle. The inclusive value of the intermediate model has an estimated value of 0.2440 with a t-statistic of 1.30. As this value is between 0 and 1, it satisfies the condition.

As can be seen, the inclusive value for the higher level and intermediate level models is between 0 and 1. The inclusive value at the higher level is 0.2515 and at the intermediate level, it is 0.2440. Thus this inclusive value satisfies the condition of Ortuzar and Willumsen [1994], which states that in cases with several nesting levels, the inclusive value at each nest level should be greater than the inclusive value from the lower nest. This is written as

$$0 < \phi_1 \leq \phi_2 \leq \dots \leq \phi_s \leq 1 \quad \dots \dots \dots (6.1)$$

where ϕ_1 correspond to the most inclusive parameter and ϕ_s to that of the highest level.

From the Table 7.1, we see that the inclusive value for the nested model is

$$0 < 0.2440 \text{ (Intermediate level)} < 0.2515 \text{ (Higher level)} < 1 \quad \dots \dots (6.2)$$

This satisfies the Ortuzar's condition and proves that the nest of SOV and non-SOV modes as well as 2P and 3P+ are working as expected, justifying the nested logit model.

The non-work trip model is a logit model for auto and transit with no nests for vehicle occupancy. Hence there is no inclusive value in Table 7.1.

Gender

Gender is an important variable that captures the travel characteristics of the two genders. It is important to know how these two genders will behave in a given mode choice situation. As seen in the higher level model, the gender variable has an estimated coefficient of -0.4600 and a t-statistic of -5.88. The gender variable is coded as 0 for female and 1 for male. The negative coefficient sign means that females are more likely to choose transit compared to males, since auto is normalized to zero. This indicates that a significant number of women take transit to work compared to men.

At the intermediate and lower level model, the gender variable is not found significant. This indicates that gender becomes insignificant in mode choice when two or more people are traveling in the high occupancy auto mode.

In the non-work trip model, gender has an estimated coefficient of -0.3925 and a t-statistic of -4.90. The negative sign shows that females are more likely to use the transit mode for non-work trips. The high t-statistic suggests that the variable is quite significant.

Province

The area under study lies within two provinces Ontario and Quebec. The province variable captures differences in travel behavior between two regions.

The province variable in the higher level home based work trip model has an estimated coefficient of -1.048 and a t-statistic of -10.70. The negative sign indicates that the people in Ontario are more likely to use transit compared to Quebec residents.

In the intermediate level home based work trip model, the province variable has an estimated coefficient of 0.4875 and a t-statistic of 6.14. The positive sign shows that people in Quebec are more likely to ride-share than residents of Ontario.

The province variable was not found significant in the lower level home based work trip model. This indicates there could be no appreciable difference in travel characteristics between the two regions when the auto occupancy is two or more persons per vehicle.

In the non-work trip model, the province variable has an estimated coefficient of -0.6569 with a t-statistic of -6.10. The negative sign shows that people in Ontario are more likely to travel by transit for non-work trip purposes compared to residents of Quebec.

Number of Vehicles

The number of vehicles per household is an important variable that influences the travel behavior. If there are several vehicles in the household, then household members are more likely to use a vehicle then take transit. However, if there are no cars available, there may be no alternative but to use transit.

In the higher level home based work trip model, the number of vehicles per household has an estimated coefficient of -1.773 with a t-statistic of -21.06. The negative sign shows that if the number of vehicles increases, people have a strong preference to use the auto mode.

In the intermediate level home based work trip model, the number of vehicles per household has an estimated coefficient of -0.7986 and a t-statistic of -9.92. The negative sign shows that if the number of vehicles in the household increases, the probability of driving alone also increases.

In the lower level model, the number of vehicles per household is found to have t-statistic of less than 1. This indicates that the number of vehicles per household does not impact auto occupancy for the 2P and 3P+ mode. One of the reasons could be that the number of vehicles is coded as 0 for no vehicle per household, 1 for one vehicle per household and 2 for two or more vehicle per household. Hence if there are more than two vehicles, they are treated in the same way.

In the non-work trip model, the number of vehicles has an estimated coefficient of -2.575 and a t-statistic of -30.47. The negative sign shows that if the number of vehicles per household increases, so does the probability of selecting the auto mode. The t-statistic for this model is higher than for the home based work trip model. This indicates that the number of vehicles has more impact on the non-work trips. If there are several vehicles available in the household, household members are more likely to use auto for non-work trips than transit.

Number of Persons

The number of persons per household is an important socio-economic variable. As the number of people in the household increases, the probability of using transit or other high occupancy modes such as ride sharing increases.

In the higher level home base work trip model, the number of persons per household has an estimated coefficient of 0.1418 and a t-statistic of 4.07. The positive sign shows that if there are more people per household then the probability of using transit increases.

For the intermediate level home based work trip model, the number of persons per household has an estimated coefficient of 0.3305 and a t-statistic of 5.62. The positive sign shows that if there are more people in the home, the probability of using a non-SOV mode increases. This may be partially attributed to the fact that the household members are more likely to ride together in the larger household.

For the lower level home based work trip model, the number of persons per household has an estimated coefficient of 0.7225 and a t-statistic of -9.57. The positive sign shows that if there are more people in the household, then the household members are more likely to choose the higher auto occupancy mode i.e. three or more persons in vehicle.

For the non-work trip model, the number of persons in vehicle has an estimated coefficient of 0.1395 and a t-statistic of -4.13. The positive sign indicates that if there are more people in the household then the probability of using transit increases.

From the home based trip model, it can be seen that as the auto occupancy increases, the number of persons in the household variable becomes more significant.

Work

The work variable represents the number of persons per household working full time or part time at an office or at home. This variable captures the effect of employment opportunities in a home with respect to mode choice.

In the higher level home based work trip model, work has an estimated coefficient of 0.1505 and a t-statistic of 2.51. The positive sign indicates that if there are more workers in the house, then the probability of using transit increases.

For the intermediate level home based work trip model, work has an estimated coefficient of 0.1488 and a t-statistic of 1.99. This suggest that as the number workers per household increases, so does the likelihood of choosing a HOV mode.

In the lower level home based work trip model, work has an estimated coefficient of -0.8089 and a t-statistic of -5.66. The negative sign indicates that if the workers per household increases so does the probability of choosing the 2P auto mode.

For the non-work trip model, the work variable has an estimated coefficient of 0.1395 and a t-statistic of -4.13. This suggest that if there are more workers in the household, the probability of choosing transit over the auto mode increases.

From both the home based work trip and non-work trip model, it is found that if there are more workers in the household, the variable becomes more significant and the probability of choosing the high occupancy mode increases.

Origin Employment Density

This variable represents the employment density of the trip origin. If the origin employment density is high, people are likely to use high occupancy modes such as transit and ride-sharing.

For the higher level and intermediate model, origin employment density has a t-statistic less than 1. Hence the variable was not included in the models.

For the lower level home based work trip model, the origin employment density has an estimated coefficient of -0.0000169 with t-statistics of -2.47. This indicates that if the origin employment density is high, the use of high occupancy mode increases.

The non-work trip model has an estimated coefficient of -0.0000025 and a t-statistic of -8.16. This finding could be explained using the concept that a higher employment density implies that there is a high concentration of people in these areas to make shopping, social or recreational trips after work.

Destination Population Density

This variable represents the population density at the trip's destination. It captures the characteristics dependent on population which affect travel mode choice. The destination population density was found to be significant in the intermediate level model where it has an estimated coefficient of -0.000045 and a t-statistic of -2.07. This t-statistic shows that population density is significant and influences the modal choice between SOV and non-SOV modes. As destination population decreases, people are more likely to drive alone.

Central Business District

This variable represents the impact of the downtown area on mode choice decisions. The central business center has high employment density as well as numerous shopping opportunities. The central area is a focal point with many political and cultural institutions of local and national importance. Parking costs tend to be high and people's travel characteristics in this area differ compared to other areas in the region.

For the higher level home based work trip model, the CBD variable has an estimated coefficient of 1.159 and a t-statistic of 12.63. The positive sign shows that people travelling to and from the CBD have a greater probability of using transit. The signs of coefficients and its t-statistics are consistent with expectation. Due to high parking costs, probability of using a less expensive mode such as transit increases.

In the non-work trip model, the central business district variable was not found significant. Since its t-statistic was less than 1, the variable was dropped from the model.

Transitway

The transitway variable is used as an indicator of frequent and high speed transit service. Hence it is necessary to include the transitway variable so that its effect on mode choice can be modeled. The experience has shown that the proximity of the workplace to a transitway station is a very good descriptive variable for the PM peak period, while

proximity of the home to a transitway station is appropriate for explaining transit attractiveness in the morning [TRANS, 1993]. The system of express bus routes operated by OC Transpo in the morning peak period generally starts in residential suburban neighborhoods and offers a high level of service to the central business district mostly via transitway and ends at transitway stations or major workplace destinations after passing through central business district. In the afternoon, the opposite operational characteristics occur. However if the workplace is located near the transitway, it becomes more convenient to use transit to avoid paying high parking costs in areas as the CBD.

In the models described here, we have included a transitway variable which takes the proximity of transitway near the workplace into consideration. This transitway variable is found significant at the higher level of the home based work trip model. The estimated coefficient of transitway variable is 0.6327 with a t-statistic of 7.62. The positive sign shows that transit is more likely to be selected if an individual works near the transitway.

Constant

The constant variable represents the average effects of variables not present in the model. There are many factors such as comfort, reliability and safety which may cause one mode to have greater probability of being chosen than another even if the two modes have equal travel cost and time. The effects of these unexplained and unknown variables are represented by the constant.

From Table 7.1, we can see that the higher level home based work trip model has an estimated coefficient of 0.049 with a t-statistic of 0.31. The t-statistic shows that the constant variable is less significant. The model has a lower estimated coefficient which is desirable.

For the intermediate level home based work trip model, the constant has an estimated coefficient of -0.5613 with a t-statistic of 2.48. The value of the coefficient suggests that there are many variables which are significant but have not been included in the model.

This intermediate model simulates SOV and non-SOV trips and it is difficult to include all variables which influence the mode choice between SOV and non-SOV. Hence all these unknown variables have been indirectly included in the constant.

In the lower level home based work trip model, the constant has an estimated coefficient of -1.3931 with a t-statistic of -3.71. The high value of estimated coefficient shows that there are many unknown variables which affect the choice between two persons per vehicle and three or more persons per vehicle have not been included in the model.

The non-work trip model has an estimated coefficient of 0.5904 with a t-statistic of -3.6. The value of the estimated coefficient suggests that there are some factors which influence the mode choice but are not included in the model.

7.3 COMPARISON OF MODEL VALIDATIONS

A validation summary of home based work trip and non-work trip models is shown in Table 7.2. This table shows the macro validation as well as the micro validation.

The higher level home based work trip model simulates auto and transit. There are 5,836 observed trips for auto. The total number of trips predicted by the model for auto are 6,190. Out of these trips, the number of correctly predicted trips are 5,535 which constitutes 94.84%. The number of observed trips for transit are 1,432 and the total number predicted by the model is 1,078. The correctly predicted trips for transit are 777 giving the percent correct value of 54.26%. The overall percent correct value for the higher level home based work trip model is 86.85%.

The intermediate level home based work trip model simulates SOV and non-SOV (2P+) modes. There are 3,961 observed trips for the SOV mode. The total number of trips

Table 7.2 Summary Of Model Validations

Models	Modes	Macro Validation			Micro Validation			Overall Percent Correct Value
		No. Of Observed Trips	No. Of Predicted Trips	Error	No. Of Observed Trips	No. Of Correct Predicted trips	Percent Correct Value	
HBW Higher Level	Auto	5836 (80.30%)	6190 (85.17%)	+354 (+4.87%)	5836	5535	94.84%	86.85%
	Transit	1432 (19.70%)	1078 (14.83%)	-354 (-4.87%)	1432	777	54.26%	
	Total	7268 (100%)	7268 (100%)	(4.87%)	7268	6312	86.85%	
HBW Intermediate Level	SOV	3961 (79.38%)	4880 (97.80)	+919 (+18.42%)	3961	3905	98.59%	79.33%
	2P+	1029 (20.62%)	110 (2.20%)	-919 (-18.42%)	1029	54	5.25%	
	Total	4990 (100%)	4990 (100%)	(18.42%)	4990	3959	79.33%	
HBW Lower Level	2P	758 (73.66%)	928 (90.18%)	+170 (+16.52%)	758	712	93.93%	74.54%
	3P+	271 (26.34%)	101 (9.82%)	-170 (-16.52%)	271	55	20.30%	
	Total	1029 (100%)	1029 (100%)	(16.52%)	1029	767	74.54%	
Non-work Trip Model	Auto	11059 (92.00%)	11651 (96.93%)	+592 (+4.93%)	11059	10970	99.20%	93.59%
	Transit	961 (8.00%)	369 (3.07%)	-592 (-4.93%)	961	280	29.14%	
	Total	12020 (100%)	12020 (100%)	(4.93)	12020	11250	93.59%	

predicted by the model for the SOV is 4,880. The number of correctly predicted trips for SOV are 3,905 which constitutes 98.59%. The observed trips for 2P+ mode are 1,029. The total number of trips predicted by the model is 110. The correct predicted trips are 54 making percent correct value of 5.25%. The overall percent correct value for the intermediate level model is 79.33%.

The lower level home based work trip model simulates the 2P and 3P+ modes. The number of observed trips for the 2P mode is 758. The total number of trips predicted by the model is 928. The number of correct predicted trips are 712 which makes 93.93%. The observed trips for 3P+ mode is 271. The total trips predicted by the model for 3P+ mode is 101. The number of correct predicted trips are 55 constituting 20.30% correct percent value. The overall percent correct value for the lower level mode is 74.54%.

The non-work trip model simulates the auto and transit mode. The number of observed trips for auto are 11,059. The total number of trips predicted by the model is 11,651. The correct predicted trips are 10,970. Thus the percent correct predicted trips for auto mode is 99.20. The number of observed trips for transit mode are 961. The total number of predicted trips are 369. The correct predicted trips are 280, thus making 29.14% correct percent value. The overall percent correct value for the non-work trip model is 93.59%.

Based on the above findings, we see that both the home based work trip model and the non-work trip model have high overall percent correct values.

7.4 COMPARISON OF GOODNESS OF FIT MEASURES

Several statistical indicators are used to measure the “goodness of fit” of the model to the observed data. The “rho-squared ” statistic indicates the degree of certainty of the model, relative to zero information. In theory, the value ranges between 0 (no fit or zero information) to 1 (for perfect fit or full information). The “rho-bar-squared” statistics takes into consideration modal share of the model. Its value also ranges between 0 (for no fit) and 1 (for perfect fit).

Ortuzar and Willumsen [1994] has reported that the “rho squared” index varies between 0 and 1. However, although its meaning is clear in the limits (0 and 1), it does not have an intuitive interpretation for intermediate values. In fact the values around 0.4 may be excellent fits. Experience has shown that the model of our type returns a value between 0.2 to 0.5.

Table 7.3 Summary Of Rho-square And Rho-bar-square Values

Models	Rho-square	Rho-bar-square	Overall Rhosquare
HBW Higher Level	0.5518	0.5498	0.4563
HBW Intermediate Level	0.3169	0.3146	0.3088
HBW Lower Level	0.2691	0.2621	
Non-work Trip Model	0.7153	0.7142	

From Table 7.3, we see that the rho-square and rho-bar-square for the higher level home based work trip model are 0.5518 and 0.5498 respectively. The overall rho-square value for the lower nested models is 0.4563. These values of rho-square and rho-bar-square shows that model has quite high values. The goodness of fit of the model to the sample data are quite good.

For the intermediate level home based work trip model, the rho-square and rho-bar-square values are 0.3169 and 0.3146 respectively. The overall rho-square value of this intermediate model considering the lower nest model are 0.3088. These values are fairly

high considering the nature of modes involved such as SOV and non-SOV trips. The modal share of SOV and non-SOV trips are 79.38% and 20.62%.

The lower level home based work trip model has rho-square and rho-bar-square values of 0.2693 and 0.2595 respectively. These values are reasonably good, since the model attempts to simulate two persons per vehicle and three or more persons per vehicle. These modes are very difficult to simulate considering the nature of complications involved in simulating the high occupancy mode.

The non-work trip model has a rho-square value of 0.7153 and rho-bar-square value of 0.7142. The model has high values of rho-square and rho-bar square which shows a good fit to the sample data.

7.5 COMPARISON OF SENSITIVITY TEST ANALYSIS

Sensitivity tests for the modes were carried out to determine the effect on travel behavior resulting from changes in public policy for the various travel modes. Disaggregate detail on level of service as well as individual and household attributes can provide an improved understanding of travel choices. Since the model was developed taking into consideration the behavior of the individual, evaluation of public policy alternatives is enhanced. If policy effects are analyzed as they affect the individual, the transportation analyst's recommendations gain credibility, because they are more intuitive. Sensitivity analysis is ideally suited to evaluating the impact of policies and socio-economic factors on different market segments.

A summary of the sensitivity analysis performed for the home based work trip and non-work trip model is shown in Table 7.4.

Table 7.4 Summary of Sensitivity Analysis

Variables	Work Trip Model							Non-work Trip Model	
	Higher Level Model		Intermediate Level Model		Lower Level Model		3P+	Non-work Trip Model	
	Auto	Transit	SOV	Non-SOV	2P	3P+		Auto	Transit
Auto cost +10% change	-1.03%	+1.03%						-0.27%	+0.27%
Transit cost +10% change	+0.71%	-0.71%						+0.44%	-0.44%
SOV cost +10% change			-0.10%	+0.10%					
Non-sov cost +10% change			+0.10%	-0.10%					
2P cost +10% change					-4.56%	+4.56%			
3P+ cost +10% change					+1.27%	-1.27%			
Auto time +10% change	-0.36%	+0.36%						-0.06%	+0.06%
Transit time +10% change	+0.53%	-0.53%						+0.17%	-0.17%
SOV time +10% change			-2.25%	+2.25%					
Non-SOV time +10% change			+1.48%	-1.48%					
2P time +10% change					-1.27%	+1.27%			
Male rather female	+0.45%	-0.45%						+0.25%	-0.25%
Vehicles from 0 to 1	+0.60%	-0.60%						+2.58%	-2.58%
Vehicles from 1 to 2	+6.42%	-6.42%	+1.48%	-1.48%				+0.48%	-0.48%
Origin emp. density +10% change					0.00%	0.00%		-0.17%	0.17%
Quebec rather Ontario	+4.33%	-4.33%	-1.63%	+1.63%				+1.37%	-1.37%
CBD to non-CBD area	+4.35%	-4.35%							

The sensitivity analysis carried out for the various variables shown in Table 7.4 is discussed below.

Cost

From Table 7.4, it can be seen that a 10% increase in auto cost decreases the auto modal share by 1.03% and increases transit modal share by +1.03% for work trip model. For the non-work trip model, a 10% increase in auto cost decreases auto modal share by 0.27% and increases the transit modal share by +0.27%. This shows that increase in auto cost has more effect on work trips than non-work trips. There is more flexibility in taking non-work trips and they can be put off easily to some other convenient time. In addition, non-work trips such as shopping and visiting friends are often poorly suited to transit. In many cases, transit routes do not serve residential areas well, and week-end and evening routes tend to be infrequent. It is also very inconvenient to carry shopping packages on the bus, and for this reason, many travelers may prefer to use the auto mode for non-work trips.

A 10% increase in transit cost increases the auto modal share by +0.71% and decreases the transit modal share by -0.71% for the work trips. Similarly a 10% increase in transit cost for non-work trips increases the auto modal share by 0.44% and decreases the transit modal share by -0.44%. This indicates that transit users for the work trip are more sensitive to fare increases than for non-work trips.

The modal shift due to a 10% increase in transit cost is less than the shift due to a 10% increase in auto cost. This shows that people are more sensitive to auto cost than they are to transit cost. This could be due to the fact that some people who use transit are captive riders who have no choice but to use transit. These people may be too old or too young to drive or may have no car available.

For the work trip model, a 10% change in SOV cost decreases the SOV modal share by 0.10% and increases the non-SOV cost by +0.10%. If the non-SOV cost is increased by 10% percent, the change in modal share is +0.10% for SOV mode and -0.10% for the

non-SOV mode. Since the change in modal share is small, any attempt to decrease SOV trips by increasing travel cost may only have minimal impact unless the increase in cost is quite high.

If the cost of the 2P mode in the work trip model is increased by 10%, 2P modal share decreases by 4.56% and the modal share of 3P+ is increased by +4.56%. On the other hand, if the cost of the 3P+ mode is increased by 10%, the change in modal share of 2P is +1.27% while the change in modal share for the 3P+ mode is -1.27%. This indicates that changing the cost of the 2P mode has more effect on the modal share than changing the cost of the 3P+ mode. As the number of passengers per vehicle increases, the cost borne by each vehicle occupant decreases. Thus, as the cost of the 2P mode increases, there is more incentive for finding additional passengers to split the costs.

From the above sensitivity analysis, it is clear that the cost of travel has a significant effect on modal choice for work trips as well as non-work trips. Travelers are concerned about the cost of travel and they may shift to modes which are more economical and offer the same return for an equal amount of money.

Time

Travel time is another important variable that affects travel choice. For work trips, a 10% increase in auto travel time decreases the auto modal share by 0.36% and increases the transit modal share by +0.36%. For non-work trips, the 10% increase in auto time decreases the auto modal share by 0.06% and increases the transit modal share by +0.06%. Thus, travel time is more important for work trips than non-work trips; however, the change in modal share in both cases is quite small.

If the transit time is increased by 10%, the auto modal share for the work trips increases by +0.53% and transit modal share decreases by 0.53%. For non-work trips, the auto modal share increases by +0.17% and transit modal share decreases by 0.17%. This shows that the increase in transit time has more effect on work trips than non-work trips.

A possible explanation for this trend may be that people who use transit for work trips have more flexibility in switching to the auto mode should transit trips become significantly longer in duration than travel by auto. However, people using transit for non-work trips are more likely to be captive riders who are unable to switch modes. For these individuals, cost is more important than travel time.

For the work trip model, if SOV time is increased by 10%, the SOV modal share decreases by 2.25% while the non-SOV share increases by +2.25%. On the other hand if non-SOV time is increased by 10%, the SOV modal share increases by +1.48% and the non-SOV modal share decreases by 1.48%. From these results, it is clear that an increase in SOV time has more effect on modal choice than an increase in non-SOV time. This trend may be attributed to the fact that people who use the SOV mode value their travel time very highly. As a result, they may be convinced to ride-share if considerable travel time savings are possible. On the other hand, non-SOV travelers are less likely to switch to the SOV mode if travel times increase. This may be due to husbands and wives travelling together, or child passengers being dropped off at school or daycare. In these cases, SOV trips are not feasible, and thus, the non-SOV mode is used despite longer trip times.

It is also important to note that travel time has a much greater influence on SOV and non-SOV trips than travel cost. It appears that people perceive travel time as a significant cost in its own right.

A 10% increase in 2P time, decreases the modal share of the 2P mode by 0.98% and increases the modal share of the 3P+ mode by +0.98%. This result makes sense since travelling with three or more persons per vehicle becomes more attractive if travel time savings can be achieved, for example, through the use of HOV lanes. In addition to travel time savings, cost savings can also be achieved with higher vehicle occupancy, further increasing the attractiveness of the 3P+ mode. The 3P+ travel time was not found to be significant and hence it is not included in the model.

Gender

For work trips, if males are considered rather than female, the auto modal share increases by 0.45% and transit modal share decreases by +0.45%. This indicates that, for work trips, females have a higher probability of choosing transit compared to males. This may be because transit is more convenient for working women due to their different responsibilities and security needs. Males are more likely to drive than to take transit.

The gender is not found significant for the lower model of 2P and 3P+. The percent change in modal share is 0.0%.

For the non-work trips, if males are considered rather than females, the auto modal share increases by 0.25% and transit modal share decreases by 0.25%. This shows that for non-work trips, the probability of choosing the auto mode is higher for males than for females. This is consistent with every day observation.

Number of Vehicles

The number of vehicles per household is another important variable in the model. For work trips, if the number of vehicles is increased from 0 to 1, the auto modal share increases by 0.60% and the transit modal share decreases by 0.60%.

For non-work trips, if the number of vehicles increases from 0 to 1, the auto modal share increases by +2.58% and the transit modal share decreases by 2.58%. This shows that an increase in automobile ownership has more effect on non-work trips than work trips. This may be due to the greater convenience of automobiles for non-work trip purposes.

If the number of vehicles is increased from 1 to 2+ for work trips, the auto modal share increases by +6.42% and the transit modal share decreases by 6.42%. This indicates that if the number of vehicles increase, the probability of choosing the auto over transit also increases. Clearly, people are more likely to choose the auto mode if additional vehicles are available.

For the intermediate level home based work trip model, if the number of vehicles increases from 1 to 2+, SOV trips increases by +1.48% while 2P+ trips decreases by 1.48%.

For non-work trips, if the number of vehicles increases from 1 to 2+, auto modal share increases by +0.48% while transit modal share decreases by 0.48%. As extra vehicles become available, household members are able to take advantage of the vehicles for non-work trip purposes. However, this modal change is lower than the 6.42% modal change found in work trips. This may be due to the fact that work trips are mandatory trips whereas non-work trips are discretionary and can be combined with other trips at some other convenient time.

Origin Employment Density

If the origin employment density is increased by 10% for the lower level work trip model, the modal share of 2P mode and 3P+ has 0% change. Hence the model is not sensitive to origin employment density for the high occupancy mode.

If the origin employment density increases by 10% for non-work trips, the auto modal share decreases by 0.17% and transit modal share increases by +0.17%. This shows that the increase in employment density has more effect on non-work trips than the work trips.

Province

If an individual is considered to reside in Quebec rather than Ontario, the auto modal share for work trips increases by +4.33% while the transit modal share decreases by 4.33%. This indicates that people in Ontario are more likely to use transit than people in Quebec.

For the intermediate level home based work trip model, if province variable is changed to Quebec, the SOV modal share decreases by 1.63% and non-SOV modal share increases by +1.63%. This indicates that SOV trips decreases and non-SOV trips increases.

For non-work trips, if the province variable is taken as Quebec, the auto modal share increases by +1.37% while the transit modal share decreases by 1.37%. This modal change is less than the change observed in the work trip model.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

A nested logit modal split model sensitive to vehicle occupancy was developed for home based work trips. The model was divided into three levels. The higher level simulated auto and transit modes. At the intermediate level, the auto mode was divided into SOV and more than one person per vehicle (2P+). This model captures the characteristics of single occupant vehicle users and share ride users. At the lower level, the auto mode was further divided into two persons per vehicle and three or more persons per vehicle. The non-work trip model simulated the auto and transit mode directly, implying that the model did not include nests for SOV, 2P and 3P+ .

The research involved identification of linked trips and the development of procedures and concepts to link the potentially linked trips. In the TRANS database, the potential linkable trips were identified and linked as per their true and legitimate purpose. The unlinkable trips were written unaltered back into the data base.

From the results of both the work and non-work trip models, the following conclusions are drawn. These are grouped according to whether they are general conclusions applicable to both work and non-work trip models or whether they pertain specifically to one model or the other. Based on these results, statements are also made regarding the reliability of the model results and the usefulness of the disaggregate approach.

8.1.1 General Conclusions

- Travel cost and travel time have proved to be highly significant modal attributes affecting travel behavior in both the work and non-work trip models.

- Vehicle ownership was also found to be an important attribute affecting mode choice. The higher the level of automobile ownership in a household, the more likely an individual is to travel by automobile.
- The number of persons per household is an important attribute influencing the mode choice. The higher the number of persons per household, the higher the probability of travelling by high occupancy vehicle such as ride sharing and transit.
- The travel time for the three or more persons per vehicle mode was not found to be significant in the lower level model, possibly because the sample size was quite small. As a result, it is unclear how travel time in the National Capital Region impacts the use of HOV lanes. Unlike larger American cities where HOV lanes function successfully, the distance from the CBD to the suburbs in the NCR is relatively small. This implies that not enough time savings can be made to auto users based on trip distance and the relatively modest congestion levels in the NCR compared to large U.S. cities.
- The three or more persons per vehicle mode was difficult to simulate because of the small sample size available compared to other modes. Moreover, the development of the model was hindered by the limited data collected in the 1995 O-D Survey. In particular, information on auto occupancy, cost sharing, waiting time, and the additional travel time for ride-share trips was not specified precisely in the O-D Survey, thus affecting the model results.
- Due to their greater complexity, non-work trips are more difficult to simulate compared to work trips. In general, non-work trips are discretionary and are therefore considered to be more flexible. The greater number of trip purposes (recreation, entertainment, shopping, social visits, etc.) clearly impacts travel behavior, making the trips more difficult to model.
- Due to the model structure used in this research, the study area was confined to the Urban Transit Area. Logit models require that every individual have access to each of the travel modes studied. Thus, to model transit trips, it was necessary to work with trips that occurred within the UTA. Unfortunately, many non-SOV trips had either an origin or destination outside the UTA, limiting the sample size that could be used in

the analysis. In particular, long-distance non-SOV trips were eliminated from the sample data.

- The logit model developed here can be used to gain insight on how urban development and land use policies can alter auto occupancy, and ultimately, levels of congestion.

8.1.2 Usefulness of the Disaggregate Behavioral Approach

- The results of this study indicates that the disaggregate behavioral approach based on individual choice of mode is a useful technique for testing transportation policies within the urban transportation planning process
- Using the disaggregate behavioral modeling approach, it is possible to identify level of service attributes as well as socio-economic attributes that are most likely to have the greatest effect on mode choice
- Disaggregate models can be used to gain insight to people's behavior towards mode choice and vehicle occupancy
- Disaggregate models are consistent with intuitive expectations of traveler's preferences and rational behavior
- Logit models of disaggregate travel choice can be calibrated using readily available user oriented computer programs

8.1.3 Conclusions Relating to the Work Trip Models

- For the work trips, several alternative combinations of variables were tested. The objective for each case was to develop a model which best explains the observed mode choice. The model should be explanatory, consistent and reliable.
- A nested logit model sensitive to vehicle occupancy was developed for auto and transit mode. This model has three nests or levels. The higher level is of auto and transit. The intermediate level model consists of SOV mode and non-SOV modes. The lower level model is of two persons per vehicle and three or more persons per vehicle.

- Travel cost, travel time, gender, province, number of vehicles per household, number of persons per household, number of workers per household, origin employment density, central business district and transitway were found to be significant variables.
- In the higher level model of auto and transit, travel cost is more significant than travel time.
- In the intermediate level, travel time is more significant than travel cost for the SOV mode compared to the non-SOV mode. This indicates that people attach more importance to travel time, when driving alone.
- The inclusive value, which represents coefficients of lower nests in the model is between 0 and 1. This indicates that the nests of lower modes are justified.
- The central business district variable was found to be highly significant. People working in central business district are more likely to travel by transit than by auto.
- The destination population density was found to be significant for the 2P and 3P+ mode. This indicates that it could be a major factor in choosing car-pooling. The higher the population density, the higher the opportunities for car-pooling.
- The number of vehicles per household is an important variable in mode choice decisions. The greater the number of vehicles in the household, the greater the probability of taking a vehicle to work. The modal shift is higher if the number of vehicles is increased from 1 to 2+. The impact of vehicle ownership on mode choice is greater than any other variable including travel cost and travel time.
- The province variable was found to be significant in the work trip model. This indicates that Ontario residents are more likely to select transit as a mode of travel compared to Quebec residents.
- The intermediate work trip model indicates that more people go for ride sharing in Quebec than Ontario. In Ontario, the number of SOV trips are higher than Quebec.
- The number of employed persons in the house is highly significant. The higher the number of employed persons per household, the higher are the probability of choosing an auto mode rather than transit.

- Origin employment density was found to be significant in the lower level home based work trip model. If employment density is high, the likelihood of choosing a high occupancy vehicle mode increases.
- The Transitway variable was also found to be significant. If the work place is situated near the transitway, people are more likely to use transit than if their work place was located elsewhere. This may indicate that transit is more convenient than auto for travelling to work-places situated near the transitway station.

8.1.4 Conclusions Relating to the Non-work Trip Model

- The non-work trip model explains and predicts the choice an individual makes in using auto or transit for non-work travel.
- Vehicle ownership was found to be more significant than any other variable including travel cost and travel time.
- Travel cost, travel time, gender, province, number of vehicles, number of persons in the household, number of employed persons per household and origin employment density are found to be significant in mode choice decisions.
- Travel cost was found to be more significant than travel time.

8.1.5 Reliability of the Results

- The statistical indicators used to evaluate the reliability of the models confirm that the estimated coefficients of the variables are reasonable and have signs consistent with observed behavior.
- From the tests used in the model validation stage, it appears that the work and non-work trip models are able to predict an individual's mode choice reasonably well.
- Both the work and non-work trip models have sufficiently good percent correct statistics. Although a high percent correct value is desirable, such high values may result from a high degree of modal uniformity despite a poorly specified model. A study area with higher degree of modal variation among major travel corridors will

inevitably return a lower value. It is therefore not recommended that the percent correct statistic be rigorously used to evaluate alternative transportation models.

- The intermediate level work trip model for SOV and non-SOV trips significantly under-predicts non-SOV trips. This is because non-SOV trips are difficult to simulate due to the many factors which influence these types of trips. Unlike SOV trips, non-SOV trips can involve several destinations and have differing levels of auto occupancy at different times during the trip. Moreover, with the information collected in the 1995 OD Survey, it is difficult to measure how ride-share travelers perceive travel cost and time. Indeed, average cost and travel time were used in the model, which may not be experienced in reality. Despite these limitations, the variable coefficients and their t-statistics developed for the model appear reasonable and compatible with the other models developed in the NCR. Hence, the intermediate level model was retained in the analysis.
- Logit estimation software provides several indicators 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 modelling studies has indicated that a model of the type developed here generally returns a value of between 0.2 and 0.5. This is consistent with the findings of this research.

It is concluded that the models developed are useful tools to evaluate transportation policies sensitive to vehicle occupancy and affecting mode choice travel decisions.

8.2 RECOMMENDATIONS

Transportation modeling is never complete. Modeling is a never-ending process and requires continuous development with time. The following recommendations are made based on the experience gained through this model development exercise.

1. It can be stated that the results of the models developed in this research are useful in their present form. This model development and testing will be useful for policy testing and as predictive tools for short and long range planning.
2. It is suggested that the main objective of any further development be to improve the intermediate level home based work trip model for SOV and non-SOV modes.
3. The developed model has a lower percent correct prediction for three or more persons per vehicles. These predictions should be improved by collecting more thorough information on high occupancy vehicles in an OD survey.
4. A special survey should be carried out focused on the specific needs of high occupancy vehicles. This survey should identify the economic conditions and lifestyles variables which influence the changes in personal mobility.
5. In the present survey, detailed information on the auto passenger was not collected. Because of this, it is not possible to know how the travelers shared the cost of travel, or who they drove with. This information could help us in accurately assign cost based on the vehicle occupancy.
6. The information on in-vehicle-travel-time (IVTT) and out-of-vehicle-travel-time (OVTT) should be collected precisely in the survey. The wait time for the passenger should also be known, so that the travel time used in the model reflects the true time spent for travelling.
7. It is suggested that the non-work trip model should be developed for the SOV, 2P and 3P+ modes. This was attempted in the present research but without success. 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. This makes the model development difficult. Hence, this problem requires more research and further effort.
8. In order to apply the developed models in another city, the models must first be adjusted for known inter-regional differences.

Thus, the factors considered important to mode choice and sensitive to vehicle occupancy were identified and tested. The results indicate that travel cost, travel time, number of vehicles per household, number of persons per household, number of employed persons

per household, province, central business district, origin employment density and destination population density are all important variables in mode choice decisions. These variables were found to be significant and influenced the mode choice decisions greatly.

In conclusion, this research has illustrated the development of work and non-work trip models sensitive to vehicle occupancy using the disaggregate approach. The results achieved indicate that this approach has considerable potential for use by Canadian and other municipalities elsewhere in their transportation planning activities.

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APPENDIX A

ABBREVIATIONS

2P	Two persons in vehicle
2P+	Two or more persons in vehicle
3P	Three persons in vehicle
3P+	Three or more persons in vehicle
CBD	Central Business District
CUO	Communauté urbaine de l'outaouais
GTA	Greater Toronto Area
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	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'outaouais
TRANS	Joint Technical Committee on Transportation Systems Planning
TSP	Time Series Processor
UTA	Urban Transit Area

APPENDIX B

TSP SOFTWARE

Introduction

TSP is a general purpose computer language for econometric and statistical data processing and estimation on mainframe and personal computers. TSP is useful for:

- Applied econometrics, including teaching
- Macroeconomic research and forecasting
- Econometric analysis of cross section and panel data
- Sales forecasting
- Financial analysis
- cost analysis and forecasting

TSP was developed by economists and most of its uses 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.

The TSP Manual describes the basic syntax rules and gives a brief guide to understanding the command reference section. A summary of the command syntax as well as a detailed description for each TSP command. Finally there is a short index of commands grouped by function.

The basic data object within TSP is the series. Each series has a name, and you can request operations on all the observations just by mentioning the name of the series. TSP provides convenient ways to enter series, to create new series from existing ones, to display and print series, and to carry out statistical analysis of the relations among series.

Some of the most important TSP features are:

- Both data and commands are entered in free format.
- Data can be transformed by convenient algebraic format.

- Leads and lags are specified in a natural way.
- There are few restrictions on the order of the operations in a run.
- The output from one statistical procedure can easily be used as the input to another.
- All standard econometric techniques are available in an accurate and efficient form: ordinary least squares, two-stage least squares (instrumental variables), limited information maximum likelihood (LIML), polynomial and Shiller distributed lags, auto regressive correction, and weighted least squares.
- Advanced techniques are available, including nonlinear 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 nonlinear models.
- A full set of matrix operations and the analytic differentiation procedures makes it possible for you to program your own estimators easily.
- Panel and cross-section data sets can be handled by TSP as easily as time series.

Limited Information Maximum Likelihood: LIML

The LIML command computed maximum likelihood estimates for a linear model with endogenous variables on the right-hand side (and normally distributed disturbances). It is specified like the 2SLS command – instruments are given in the options list. The advantages of LIML over 2SLS are asymptotic efficiency and a more centered small sample distribution. The disadvantages of LIML is that the estimates are more sensitive to specification error in the lists of included and excluded variables. For the illustrative model, we have:

LIML(INST=(C,G,TIME,LM)) CONS C,GNP;

The only difference from the output for OLSQ and INST is the presence of the F-statistic for over identifying restrictions (two in this case, since there are three excluded

exogenous variables and only one right-hand side endogenous variable) and the estimate of k , the variance ratio.

Full Information Maximum Likelihood: FIML

FIML is the asymptotically efficient estimator for linear and nonlinear simultaneous models, under the assumption that the disturbances are multivariate normal. When this assumption fails, FIML may still be asymptotically efficient.

Because FIML operates on the model as a whole, the model must be complete – it must have as many equations as endogenous variables. Thus in addition to the behavioral equations containing unknown parameters, FIML must be supplied with any identities that involve the endogenous variables. Identities provide a convenient way of entering repeated sums and differences of endogenous variables into several equations; another way is the EQSUB command.

In FIML, the endogenous variables are listed in parentheses after the ENDOG= keyword. The corresponding instruments are then defined implicitly. For example, the illustrative model is estimated by FIML:

```
FIML(ENDOG=CONS,I,R,L,P,GNP))CONSEQ,INVEQ,INTRSTEQ,PRICEQ,GNPID;
```

The objective function for FIML is the (minus) log likelihood function, which involves the log of the determinant of the residual covariance matrix, and the log of the determinant of the Jacobian (the derivatives of the residuals with respect to the endogenous variables). If there no simultaneity and no nonlinear functions of the endogenous variables appear in the equations, the Jacobian term drops out, and the model is equivalent to multivariate regression.

FIML can be used to estimate nonlinear LIML models. In addition to the nonlinear equation of interest, FRMLs must be specified for each of the remaining endogenous

variables. To make this a LIML model, these FRMLs are linear in the instruments and there are no constraints among their parameters.

The standard errors for the FIML structural parameters are computed from the matrix of sums of squares of the outer products of the gradient of the likelihood function with respect to both the structural parameters and the unique elements of the inverse residual covariance matrix (the BHHH matrix). These standard errors are consistent and generally larger than those calculated in previous versions of TSP, which were computed from the submatrix for the structural parameters only.

Multinomial and Conditional Logit: 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 mode; estimates from the two models will be very similar (see below). There are different names for logit models, depending on whether the data or coefficients are choice-specific or chooser-specific. Multinomial logit has chooser-specific data and coefficients vary over the choices. Conditional logit has choice-specific data and coefficients equal over all choices. mixed logit involves both types of data and coefficients.

McFadden (1973, 1976, 1985) pioneered the use of the logit model in econometrics. The underlying model for most econometric applications involves latent value (utility) equations for each choice. For example, the following latent value equations apply to a model with three choices, the multinomial variable X that has coefficients (b_1, b_2, b_3) and conditional variables (Z_1, Z_2, Z_3) which have coefficients 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

$$Pr ob(i) = \exp(a_i + Xb_i + Z_i g) / \sum (\exp(a_j + Xb_j + Z_j g))$$

In this case, the likelihood function is computationally simple, and the estimation method converges rapidly.

The LOGIT command 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 “|”. For example, the model outlined above is estimated with the command:

LOGIT(NCHOICE=3,COND) Y Z | C X ;

When a multinomial variables are used, the model is identified by normalizing the multinomial coefficients of the first choice to zero. In the case of two alternatives; this provides compatibility to the PROBIT command, which effectively uses the same normalization; although the coefficients are larger in LOGIT by a factor of approximately 1.6, due to the larger standard deviation of the G.E.V. disturbances.

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, use one observation for each choice, 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. Incidentally, the constant C is not a legal conditional variable since it doesn't vary across choices.

Like the binary probit model, logit pertains to a set of mutually exclusive choices (exactly one must be chosen). It is theoretically possible to set up likelihood functions where several alternatives are chosen. It is also possible to extend the probit model to more than two alternatives, with correlations between the disturbances of each value function. However, the multivariate normal integrals required become difficult to compute when the number of choices is greater than four.

The multinomial probit model would be a useful alternative to logit, since 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. There are possible solutions to this problem within the logit framework.

The nested logit model is one way to structure the alternatives so that some are “closer” to each other than others. Although this model is not currently implemented in TSP, it can be consistently estimated by using the conventional LOGIT procedure in stages. The first stage would estimate the bottom branch of a set of choices, and the succeeding stages would include a predicted “inclusive value” based on the estimates of lower stages in the set of independent variables.

Another method to avoid the IIA problem uses the fact that logit models can be used to describe any set of choice probabilities, not just those implied by the utility model and the GEV distribution. In particular, to allow correlation among choices, include variables describing other alternatives in the V function for one alternative. The defect of this approach is that it does not specify how many or which variables should be added, and may estimate a large number of parameters. Having a model of the possible relationship among choices will help here.

General Maximum Likelihood Estimation: ML, EQSUB

This procedure provides a very general estimation method, where you write the likelihood function for an observation in a FRML statement, and TSP maximizes it with respect to the parameters it contains, using the data in the current sample. ML is quite powerful, because TSP can compute analytic first and second derivatives for iteration and standard errors.

For example, the following commands will estimate a binary probit model (although this should be re-coded as discussed later in this section):

```
FRML EQL LOGL = LOG ((1- WORKING)*CNORM(-A-B*X) + WORKING*(1-  
CNORM(-A-B*X)));  
PARAM A,B;  
ML EQL;
```

The automatic differentiation in ML is a greater advantage over coding the derivatives by hand in a FORTRAN subroutine (and especially debugging them). The disadvantage is that execution time is slower and numerical error handling more difficult, so take care when writing the likelihood function to minimize these problems.

Execution time can be reduced by simplifying the FRML as much as possible, and eliminating repeated terms. Repeated terms are best handled with the EQSUB (equation substitution) command, which guarantees that the repeated term will be evaluated only once. EQSUB is also useful for changing the list of explanatory variables in different parts of the likelihood function, so that it is not necessary to rewrite the general equation. Numerical errors are often reduced by simplifying the function, but careful to avoid operations like taking the log of zero. For example, the above probit could be rewritten in two ways. The first involves minimum execution time, but may fail because of an attempt to take the log of zero. It is the model above, with the CNORM(-A-B*X) term collected, and its coefficient WORKYN evaluated outside the FRML. The EQSUB command is

not strictly necessary here, but it is useful for changing the variables in the model and avoiding repeated evaluation.

```
WORKYN = (1-WORKING) - WORKING;
FRML CNXB CNORM(-A-B*X);
FRML EQL LOGL = LOG(WORKING + CNXB*WORKYN);
EQSUB EQL CNXB; ? Substitute the expression for CNXB into the model.
PARAM A,B;
ML(HCOV =N) EQL;
```

On a 386 16Mhz computer, this example took 98.1 CPU seconds, compared with 5.9 seconds for the PROBIT command, using a dataset with 385 observations and 8 variables.

The second way of writing the LOGL equations avoids the log of zero, but may take slightly more execution time. Generally, this approach is preferred for larger models where values can result in negative arguments to the LOG function. In this example, the function $LCNORM() = LOG(CNORM())$ and the relationship $CNORM(E) = 1 - CNORM(-E)$ are used.

```
NOWORK = WORKING .EQ. 0;
FRML XB A+B*X;
FRMLEQLLOGL=NOWORK*LCNORM(-XB)+ WORKING*LCNORM(XB);
EQSUB EQL XB;
PARAM A,B;
ML(HCOV= N)EQL;
```

As in LSQ, the likelihood function equation for the ML procedure may contain logical expressions (such as $WAGE > 0$ or $GAMMA*(1-BETA) <= 0$). However, be aware that if these logical expressions contain parameters to be estimated, the likelihood function

will not be differentiable over the whole parameter space, and will not satisfy the usual regularity conditions that guarantee the consistency and asymptotic normality of maximum likelihood estimates.

LOGIT

Function

LOGIT is used to estimate a conditional and /or multinomial logit model. The explanatory variables in the model may vary across alternative (choices) for each observation or they may be characteristics of the observation, or both. There is no limit on the number of alternatives.

Usage

There are three basic types of logit model: those where the regressors are the same across all choices for each observation, i. e., they are characteristics of the chooser, those where the regressors are characteristics of the specific choice, and mixed models, which have regressors of both kinds. In the first case (multinomial logit), a separate coefficient for each regressor is estimated for all but one of the choices. In the second case (conditional logit), the regressors change across the choices, and a single coefficient is estimated for each set of regressors. We describe the use of these three types of models in the LOGIT procedure in more detail below.

1. Binary or multinomial logit – just like OLSQ or PROBIT

LOGIT dependent variable multinomial variables;

LOGIT Y C X1 X2 XK;

Y can be 0/1 or ½ 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 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 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 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.

The multinomial logit procedure checks for “univariate complete and quasi-complete separation.”

2. Conditional Logit

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, use C as a multinomial variable in mixed logit. In this case, the example shown becomes

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

The CASE option allows you to use data organized with one choice per observation rather than with one case per observation. For example,

LOGIT (CASE=V) Y X Z;

where the variable V is a case ID which is equal for adjacent observations which belong to the same case. In this case, the variable names X and Z are used directly (not X1, X2, etc.). There need not be an equal number of observations per case. Only the first Y for each is examined for a valid choice number.

For multiple observations per case datasets, you can also use

LOGIT (NREC=W) Y X Z;

In this case, W specifies the number of records per case and you do not need to supply an ID variable with the CASE option.

3. Mixed Logit

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.

OLSQ

Function

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.

ML Examples

Multinomial Logit

? simulated data for Multinomial Logit (3 choices, 2 X's)

?

SET N = 500;

SMPL 1,N;

DOT 1 2; ?number of X's

 RANDOM(UNIFORM) X.;

ENDDOT;

DOT 1 2 3; ?number of choices

 RANDOM(UNIFORM) F; ? inverse distribution function for

 U. = -LOG(-LOG(F)); ? Type I Extreme Value

ENDDOT;

Y1 = U1; ? all coefs are 0

Y2 = -1+X1+X2+U2; ? coefs are -1,1,1

Y3 = -1+X1+X2+U3; ? coefs are -1,1,1

Y_1 = Y1>Y2 & Y1>Y3;

Y_2 = Y2>Y1 & Y2>Y3;

Y_3 = Y3>Y1 & Y3>Y2;

$$Y = 1*Y_1 + 2*Y_2 + 3*Y_3;$$

?

?Logit model

?

$$\text{FRML EQ1 LOG1} = Y_2*XB2 + Y_3*XB3 - \text{LOG}[1+\text{EXP}(XB2) + \text{EXP}(XB3)];$$

$$\text{FRML EQXB2 XB2} = B20 + B21*X1 + B22*X2;$$

$$\text{FRML EQXB3 XB3} = B30 + B31*X1 + B32*X2;$$

EQSUB(NAME=LOGIT3) EQ1 EQXB3 EQXB2; ? substitution order affects output

PARAM B20-B22 B30-B32;

ML(HITER=N,HCOV=NBW) LOGIT3;

Nested Logit

?Example of Nested Logit using ML.

?

?This example is for the simplest nested logit model, where the top branch is a choice between alternative 1 (with characteristics X1) and the lower branch. The lower branch is a choice between alternative 2 (with characteristics X2) and alternative 3 (with characteristics X3). Alternatives 2 and 3 are correlated, and the inclusive value parameter is denoted lambda. Note that the coefficients of the lower branch must be multiplied by lambda to obtain correct estimates.

?

?The likelihood for an individual observation can be written:

?

$$\text{?LOGL} = D(1 \text{ chosen}) L(1|X) + D(2 \text{ chosen}) L(2|X) + D(3 \text{ chosen}) L(3|X)$$

?

?where D(.) is a zero-one variable denoting which choice was made, and L(I| X) is the likelihood of that choice conditional on the X's.

?

$$D1 = \text{CHOICE}=1; D2 = \text{CHOICE}=2; D3 = \text{CHOICE}=3;$$

```

FRML X1BEQ X1B = BETA0 + X1*BETA1;
FRML X2BEQ X2B = (GAM0 + X2*GAM1)/LAMBDA;
FRML X3BEQ X3B = (GAM0 + X3*GAM1)/LAMBDA;
FRML SUM23EQ SUM23 = (EXP(X2B) + EXP(X3B));
FRML DENOM EXP(X1B)+SUM23**LAMBDA;
FRML NLOGEQ -LOG(DENOM) + D1*X1B + D2*((LAMBDA1)*LOG(SUM23)+X2B)
          + D3*((LAMBDA-1*LOG(SUM23)+X3B);
EQSUB NLOGEQ DENOM SUM23EQ X1BEQ X2BEQ X3BEQ ;
PARAM BETA0 BETA1 1 GAM0 1 GAM1 1 LAMBDA 1;
CONST NLOGEQ;
?
?Test for IIA
?
```

**For further information please refer to the Time Series Processor (TSP) Manual
Version 4.3.**

APPENDIX C

MACROS FOR LINKING OF TRIPS

Comment: File Sabn

```
GET FILE
"K:\POLICY\DataMF\Sabbir\sabn.sav"
.
EXECUTE
.
USE ALL.
COMPUTE filter_$=((orig_pur = "W" | dest_pur = "F") &( orig_pur = "F" |
  dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" | dest_pur = "F") &( orig_pur = "F"+
  ' | dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FREQUENCIES
  VARIABLES=orig_pur dest_pur .
```

Comment: File Sabwfh

```
GET FILE
"K:\POLICY\DataMF\Sabbir\sabwfh.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF(((orig_pur = "W" & dest_pur = "F") & ( car_occ >= 2) & (pay_park =
  "Y"))).
EXECUTE .
```

```
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\WFHC2PPY.sav'
  /COMPRESSED.
```

```
GET FILE
"K:\POLICY\DataMF\Sabbir\Sabwdh1.sav"
.
EXECUTE
.
```

```

FILTER OFF.
USE ALL.
SELECT IF(((orig_pur = "W" & dest_pur = "D") & (car_occ >= 2) &
( pay_park = "Y"))).
EXECUTE .

```

Comment: File PM peak period

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" & orig_pur = "W" & dest_pur = "F").
EXECUTE .
SORT CASES BY
  per_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\comb1.sav'
/COMPRESSED.

```

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF(prime_mo ="D" & orig_pur = "F" & dest_pur = "H").
EXECUTE .
SORT CASES BY
  per_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\comb2.sav'
/COMPRESSED.

```

Comment: File WFFHTRIAL

```
GET FILE
"K:\POLICY\DataMF\Sabbir\WFFHTRIAL.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "P" & orig_pur = "W" & dest_pur = "F").
EXECUTE .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\combp1sav.sav'
/COMPRESSED.
GET FILE
"K:\POLICY\DataMF\Sabbir\WFFHTRIAL.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "P" & orig_pur = "F" & dest_pur = "H").
EXECUTE .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\combp2.sav'
/COMPRESSED.
GET FILE
"K:\POLICY\DataMF\Sabbir\combp1.sav"
.
EXECUTE
.
ADD FILES /FILE=*
/FILE='K:\POLICY\DataMF\Sabbir\combp2.sav'.
EXECUTE.
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\combp12.sav'
/COMPRESSED.

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" & orig_pur = "W" & dest_pur = "H" & car_occ > 1).
```

```
EXECUTE .  
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\Twopas1.sav'  
/COMPRESSED.
```

```
GET FILE  
"K:\POLICY\DataMF\Sabbir\WFFHTRIAL.sav"
```

```
.  
EXECUTE
```

```
.  
FILTER OFF.
```

```
USE ALL.
```

```
SELECT IF(prime_mo = "D" & orig_pur = "F" & dest_pur = "F" & car_occ > 1).
```

```
EXECUTE .
```

```
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\Twops1 ff.sav'  
/COMPRESSED.
```

```
GET FILE  
"K:\POLICY\DataMF\Sabbir\WFFHTRIAL.sav"
```

```
.  
EXECUTE
```

```
.  
FILTER OFF.
```

```
USE ALL.
```

```
SELECT IF(prime_mo = "D" & orig_pur = "F" & dest_pur = "H" & car_occ > 1).
```

```
EXECUTE .
```

```
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\Twops1 fh.sav'  
/COMPRESSED.
```

```
GET FILE  
"K:\POLICY\DataMF\Sabbir\WFFHTRIAL.sav"
```

```
.  
EXECUTE
```

```
.  
FILTER OFF.
```

```
USE ALL.
```

```
SELECT IF(prime_mo = "D" & orig_pur = "W" & dest_pur = "F" & car_occ > 1).
```

```
EXECUTE .
```

```
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\Twops1 wf.sav'  
/COMPRESSED.
```



```

GET FILE
"K:\POLICY\DataMF\Sabbir\WFFHTRIAL.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" & orig_pur = "F" & dest_pur = "F").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" & orig_pur = "F" & dest_pur = "F" & car_occ > 1).
EXECUTE .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\TwopsP1.sav'
/COMPRESSED.

```

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "P" & orig_pur = "F" & dest_pur = "H" & car_occ > 1).
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "P" & orig_pur = "F" & dest_pur = "H" & car_occ > 1).
EXECUTE .

```

Comment: File Sabn

```

SORT CASES BY
  per_num (A) .

SORT CASES BY
  per_num (A) hh_num (A) .

SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .

USE ALL.

```

```

COMPUTE filter_$=(prime_mo = "D" | prime_mo = "P").
VARIABLE LABEL filter_$ 'prime_mo = "D" | prime_mo = "P" (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FILTER OFF.

```

```

USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.

```

```

USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
"H")).
EXECUTE .

```

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"

```

```

.
EXECUTE

```

```

.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.

```

```

USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.

```

```

USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
"H")).
EXECUTE .

```

```

FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" & dest_pur =
"H")).
EXECUTE .
GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE

```

```
.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .

FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" & dest_pur =
  "H")).
EXECUTE .
```

```
GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"

EXECUTE
```

```
.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" & dest_pur =
  "H")).
EXECUTE .
```

```
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
  dest_pur = "F") | (orig_pur = "F" & dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "F") | (orig_pur = "F"+
  ' & dest_pur = "F") | (orig_pur = "F" & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
```

```
GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"

EXECUTE
```

```

.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
  "F") | (orig_pur = "F" & dest_pur = "H")).
EXECUTE .

```

Comment: Run for deleting cases

```

SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
USE ALL.
COMPUTE filter_$=(prime_mo = "D" | prime_mo = "P").
VARIABLE LABEL filter_$ 'prime_mo = "D" | prime_mo = "P" (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
  dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
  ' & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" &
  dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" &
  ' & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
USE ALL.

```

```

COMPUTE filter_$=((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
  dest_pur = "F") | (orig_pur = "F" & dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "F") | (orig_pur = "F"'+
' & dest_pur = "F") | (orig_pur = "F" & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ = 0).
EXECUTE .

```

Comment: PMPKPD TN1 file macro

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
USE ALL.
COMPUTE filter_$=(prime_mo = "D" | prime_mo = "P").
VARIABLE LABEL filter_$ 'prime_mo = "D" | prime_mo = "P" (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
USE ALL.
COMPUTE filter_$=(prime_mo = "D" | prime_mo = "P").
VARIABLE LABEL filter_$ 'prime_mo = "D" | prime_mo = "P" (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
  dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "F") | (orig_pur = "F"'+
' & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).

```

```

FILTER BY filter_$.
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ = 0).
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" &
  dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "D") | (orig_pur = "D"'+
  ' & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ = 0).
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
  dest_pur = "F") | (orig_pur = "F" & dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "F") | (orig_pur = "F"'+
  ' & dest_pur = "F") | (orig_pur = "F" & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ = 0).
EXECUTE .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\pmpkpdTN1.sav'
  /COMPRESSED.

```

Comment: Sab31

```

USE ALL.
COMPUTE filter_$=(sab31_1 = 0).
VARIABLE LABEL filter_$ 'sab31_1 = 0 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .

```

Comment: Sab33

```
USE ALL.  
COMPUTE filter_$=(sab33_1 = 0).  
VARIABLE LABEL filter_$ 'sab33_1 = 0 (FILTER)'.  
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.  
FORMAT filter_$ (f1.0).  
FILTER BY filter_$.  
EXECUTE .
```

Comment: Merge files sab31ho and sab33ho

```
ADD FILES /FILE=*  
/RENAME (sab31_1 = d0)  
/FILE='K:\POLICY\DataMF\Sabbir\sab33H0.sav'  
/RENAME (sab33_1 sort2 = d1 d2)  
/DROP= d0 d1 d2.  
EXECUTE.
```

Comment: Merge files sab31 and sab33

```
ADD FILES /FILE=*  
/RENAME (sab31_1 = d0)  
/FILE='K:\POLICY\DataMF\Sabbir\sab33.sav'  
/RENAME (sab33_1 sort2 = d1 d2)  
/DROP= d0 d1 d2.  
EXECUTE.
```

Comment: Select file sab31, sab31_1

```
FILTER OFF.  
USE ALL.  
SELECT IF(sab31_1 = 1).  
EXECUTE .
```

```
FILTER OFF.  
USE ALL.  
SELECT IF(sab33_1 = 1).  
EXECUTE .
```

Comment: Merge files sab31H1 and sab33H1

```
GET FILE
"K:\POLICY\DataMF\Sabbir\sab31H1.sav"
.
EXECUTE
.
ADD FILES /FILE=*
/RENAME (sab31_1 = d0)
/FILE='K:\POLICY\DataMF\Sabbir\sab33H1.sav'
/RENAME (sab33_1 sort2 = d1 d2)
/DROP= d0 d1 d2.
EXECUTE.
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\cosab3133H1.sav'
/COMPRESSED.
```

Comment: Selecting cases in cosab3133H1 file

```
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
"H")).
EXECUTE .
```

Comment: File for eliminating cases

```
GET FILE
"K:\POLICY\DataMF\Sabbir\Copy of cosab3133.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" & dest_pur =
"H")).
EXECUTE .
```

Comment: Nlinkwdh file

```
GET FILE
"K:\POLICY\DataMF\Sabbir\cosab3133H0wd.sav"
.
EXECUTE
```



```
.
ADD FILES /FILE=*
/FILE='K:\POLICY\DataMF\Sabbir\co3133H1wdhv0.sav'
/RENAME (var_d1 = d0)
/DROP= d0.
EXECUTE.
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\Nlinkwdh.sav'
/COMPRESSED.
```

Comment: wfh file

```
GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
```

```
.
EXECUTE
```

```
.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
"H")).
EXECUTE .
```

```
GET FILE
"K:\POLICY\DataMF\Sabbir\cosab3133H1.sav"
```

```
.
EXECUTE
```

```
.
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
"H")).
EXECUTE .
```

```

GET FILE
"K:\POLICY\DataMF\Sabbir\cosab3133H0.sav"
.
EXECUTE
.
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
"H")).
EXECUTE .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\cosab3133H0wfh.sav'
/COMPRESSED.

```

```

GET FILE
"K:\POLICY\DataMF\Sabbir\co3133H1wfhv0.sav"
.
EXECUTE
.
ADD FILES /FILE=*
/RENAME (var_h1 = d0)
/FILE='K:\POLICY\DataMF\Sabbir\cosab3133H0wfh.sav'
/DROP= d0.
EXECUTE.
ADD FILES /FILE=*
/FILE='K:\POLICY\DataMF\Sabbir\sabwfhnotlink.sav'
/RENAME (wf_var = d0)
/DROP= d0.
EXECUTE.
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\Nlinkwfh.sav'
/COMPRESSED.

```

Comment: Deleting cases

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
EXECUTE
.
SORT CASES BY
per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.

```

```

USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
"H")).
EXECUTE .

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "F") | (orig_pur = "F"+
' & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
SORT CASES BY
  filter_$ (A) .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ =0).
EXECUTE .

SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\pppnew1.sav'
/COMPRESSED.
GET FILE
"K:\POLICY\DataMF\Sabbir\pppnew1.sav"
.
EXECUTE
.

```

```

USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" &
  dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "D") | (orig_pur = "D"'+
  ' & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
SORT CASES BY
  filter_$ (A) .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ = 0).
EXECUTE .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\ppdnew2.sav'
  /COMPRESSED.

```

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
USE ALL.
COMPUTE filter_$=(prime_mo = "D" | prime_mo = "P").
VARIABLE LABEL filter_$ 'prime_mo = "D" | prime_mo = "P" (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ = 0).
EXECUTE .
SORT CASES BY
  hh_num (A) .
SORT CASES BY
  hh_num (A) per_num (A) .
SORT CASES BY
  hh_num (A) per_num (A) trip_num (A) .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\pppbwt.sav'
  /COMPRESSED.

```

Comment: wffh file

```
GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
SORT CASES BY
  per_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
  "F") | (orig_pur = "F" & dest_pur = "H")).
EXECUTE .
```

Comment: wfh file

```
GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
  "H")).
EXECUTE .
```

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
  "H")).
EXECUTE .

SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\wfhmacro.sav'
/COMPRESSED.

```

Comment: File PPPnew1 file

```

GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
  dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "F") | (orig_pur = "F"+
  ' & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
SORT CASES BY
  filter_$ (A) .

```

```
FILTER OFF.  
USE ALL.  
SELECT IF(filter_$ =0).  
EXECUTE .
```

Comment: wffh file

```
GET FILE  
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
```

```
.  
EXECUTE
```

```
.  
SORT CASES BY
```

```
per_num (A) .
```

```
SORT CASES BY
```

```
per_num (A) hh_num (A) .
```

```
SORT CASES BY
```

```
per_num (A) hh_num (A) trip_num (A) .
```

```
FILTER OFF.
```

```
USE ALL.
```

```
SELECT IF(prime_mo = "D" | prime_mo = "P").
```

```
EXECUTE .
```

```
FILTER OFF.
```

```
USE ALL.
```

```
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =  
"F") | (orig_pur = "F" & dest_pur = "H")).
```

```
EXECUTE .
```

```
GET FILE
```

```
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
```

```
.  
EXECUTE
```

```
.  
SORT CASES BY
```

```
per_num (A) hh_num (A) trip_num (A) .
```

```
FILTER OFF.
```

```
USE ALL.
```

```
SELECT IF(prime_mo = "D" | prime_mo = "P").
```

```
EXECUTE .
```

```
FILTER OFF.
```

```
USE ALL.
```

```
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =  
"H")).
```

```
EXECUTE .
```

SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\wfhmacro.sav'
/COMPRESSED.

Comment: wffh file

```
GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
SORT CASES BY
  per_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" & dest_pur =
  "F") | (orig_pur = "F" & dest_pur = "F") | (orig_pur = "F" & dest_pur = "H"
  )).
EXECUTE .
```

Comment: ppp3fdr

Comment: The file having 3224 and 986 cases of w-f-h and w-d-h removed

```
GET FILE
"K:\POLICY\DataMF\Sabbir\pmpkpd01trial.sav"
.
EXECUTE
.
SORT CASES BY
  per_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) .
SORT CASES BY
  per_num (A) hh_num (A) trip_num (A) .
```



```

FILTER OFF.
USE ALL.
SELECT IF(prime_mo = "D" | prime_mo = "P").
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "F") | (orig_pur = "F" &
  dest_pur = "F") | (orig_pur = "F" & dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "F") | (orig_pur = "F"'+
' & dest_pur = "F") | (orig_pur = "F" & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
SORT CASES BY
  filter_$ (D) .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ = 0).
EXECUTE .
USE ALL.
COMPUTE filter_$=((orig_pur = "W" & dest_pur = "D") | (orig_pur = "D" &
  dest_pur = "H")).
VARIABLE LABEL filter_$ '(orig_pur = "W" & dest_pur = "D") | (orig_pur = "D"'+
' & dest_pur = "H") (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .
FILTER OFF.
USE ALL.
SELECT IF(filter_$ = 0).
EXECUTE .
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\ppp3fdm.sav'
  /COMPRESSED.

```

Comment: Merge Nlink files of wdh, wfh and wffh cases

```

GET FILE
"K:\POLICY\DataMF\Sabbir\Copy of Nlinkwdh.sav"
.
EXECUTE
.
ADD FILES /FILE=*
/FILE='K:\POLICY\DataMF\Sabbir\Nlinkwfh.sav'.

```

```
EXECUTE.  
ADD FILES /FILE=*  
/FILE='K:\POLICY\DataMF\Sabbir\Nlinkwffh.sav'  
/RENAME (wffh1_va wffh_var = d0 d1)  
/DROP= d0 d1.  
EXECUTE.  
SAVE OUTFILE='K:\POLICY\DataMF\Sabbir\Nlinkcodf2f.sav'  
/COMPRESSED.
```

APPENDIX D

DEVELOPMENT OF VARIABLES

Comment: 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: Development of transitway accessibility factor

```
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: 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: 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: 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: 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: Auto and transit higher file

```

COMPUTE sov = 0 .
EXECUTE .
COMPUTE two_per = 0 .
EXECUTE .
COMPUTE two_pper = 0 .
EXECUTE .
IF (carocc_n = 1) sov = 1 .
EXECUTE .
IF (carocc_n = 2) two_per = 1 .
EXECUTE .
IF (carocc_n > 2) two_pper = 1 .
EXECUTE .

```

Comment: File Ap9_23x1

```
COMPUTE sov_cost = 0 .
EXECUTE .
COMPUTE two_cost = 0 .
EXECUTE .
COMPUTE two_p_co = 0 .
EXECUTE .
COMPUTE sov_time = 0 .
EXECUTE .
COMPUTE two_time = 0 .
EXECUTE .
COMPUTE two_p_ti = 0 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) sov_cost = a_dist_s * 0.05
+ lk_spark .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s *1.9*
0.05 + lk_spark)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s *1.9 *
1.05 * 0.05 + lk_spark)
/2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s<= 5) sov_cost = (a_dist_s * 0.05)
*0.77 + lk_spark .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s<= 5) two_cost = (a_dist_s* 0.05 +
lk_spark)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s<= 5) two_p_co =( (a_dist_s * 0.05)
*1.05 + lk_spark)/2.8.
EXECUTE .
IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) sov_cost = a_dist_s *
0.05 + lk_spark .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s
*1.90 * 0.05 + lk_spark
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s
*1.90*1.05 * 0.05 + lk_spark
)/2.8 .
```

```

EXECUTE .
IF (two_per = 1 & mode = "link"& a_dist_s<= 5) sov_cost = (a_dist_s * 0.05
) * 0.77 +
lk_Spark .
EXECUTE .
IF (two_per = 1 & mode = "link" & a_dist_s<= 5) two_cost = (a_dist_s * 0.05
+ lk_Spark)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& a_dist_s<= 5) two_p_co =((a_dist_s * 0.05)
*1.05 + lk_Spark)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& a_dist_s<= 5) sov_cost = a_dist_s *
0.05 + lk_Spark .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s
*1.90* 0.05 +
lk_Spark)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s
*1.90 * 0.05 +
lk_Spark)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& a_dist_s<= 5) sov_cost = (a_dist_s * 0.05
)*0.77 +
lk_Spark .
EXECUTE .
IF (two_pper = 1 & mode = "link" & a_dist_s<= 5) two_cost = ((a_dist_s *
0.05)*0.96 +
lk_Spark)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& a_dist_s<= 5) two_p_co = (a_dist_s * 0.05
+ lk_Spark)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10)) sov_cost =
a_dist_s * 0.05 + lk_Spark .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10)) two_cost =
(a_dist_s *1.7* 0.05 + lk_Spark)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10)) two_p_co =
(a_dist_s *1.7 * 1.05 * 0.05 + lk_Spark)

```

```

/2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_cost =
(a_dist_s * 0.05) * 0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_cost =
(a_dist_s * 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park) / 2.8.
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_cost = (a_dist_s * 1.70 * 0.05 + lk_$park
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_p_co = (a_dist_s * 1.70 * 1.05 * 0.05 + lk_$park
)/2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_cost =
(a_dist_s * 0.05) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_cost =
(a_dist_s * 0.05 + lk_$park) / 2 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_cost = (a_dist_s * 1.70 * 0.05 + lk_$park) / 2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_p_co = (a_dist_s * 1.70 * 0.05 + lk_$park) / carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_cost =
(a_dist_s * 0.05) * 0.77 +

```

```

lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_cost =
((a_dist_s * 0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s > 5 & a_dist_s <= 10)) two_p_co =
(a_dist_s * 0.05+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) sov_cost =
a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) two_cost =
(a_dist_s * 1.5* 0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) two_p_co =
(a_dist_s * 1.5 * 1.05 * 0.05 + lk_$park)
/2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) sov_cost =
(a_dist_s * 0.05)*0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) two_cost =
(a_dist_s* 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) two_p_co = (
(a_dist_s * 0.05 )*1.05+ lk_$park)/2.8.
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15))
two_cost = (a_dist_s*1.50 * 0.05 + lk_$park
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15))
two_p_co = (a_dist_s*1.50*1.05 * 0.05 + lk_$park
)/2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s > 10 & a_dist_s <= 15)) sov_cost =
(a_dist_s * 0.05 ) * 0.77 +

```

```

lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) two_cost =
(a_dist_s * 0.05 + lk_$park)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s > 10 & a_dist_s <= 15)) two_p_co =(
(a_dist_s * 0.05)*1.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& (a_dist_s > 10 & a_dist_s <= 15))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15))
two_cost = (a_dist_s * 1.50 * 0.05 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15))
two_p_co = (a_dist_s * 1.50 * 0.05 +
lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s > 10 & a_dist_s <= 15)) sov_cost =
(a_dist_s * 0.05)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) two_cost
= ((a_dist_s * 0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s > 10 & a_dist_s <= 15)) two_p_co =
(a_dist_s * 0.05+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_cost =
a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost =
(a_dist_s * 1.3 * 0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co =
(a_dist_s * 1.3 * 1.05 * 0.05 + lk_$park)
/2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_cost =

```

```

(a_dist_s * 0.05)*0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost =
(a_dist_s * 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co = (
(a_dist_s * 0.05 ) * 1.05 + lk_$park) / 3 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_cost = (a_dist_s * 1.30 * 0.05 + lk_$park
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_p_co = (a_dist_s * 1.30 * 1.05 * 0.05 + lk_$park
)/2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_cost =
(a_dist_s * 0.05 ) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost =
(a_dist_s * 0.05 + lk_$park) / 2 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_cost = (a_dist_s * 1.30 * 0.05 +
lk_$park) / 2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_p_co = (a_dist_s * 1.30 * 0.05 +
lk_$park) / carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_cost =
(a_dist_s * 0.05) * 0.77 +
lk_$park .

```

```

EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost
= ((a_dist_s * 0.05) * 0.96 +
lk_$spark) / 2 .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co =
(a_dist_s * 0.05 + lk_$spark)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 20)) sov_cost = a_dist_s * 0.05
+ lk_$spark .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 20)) two_cost = (a_dist_s * 1.1 *
0.05 + lk_$spark) / 2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 20)) two_p_co = (a_dist_s * 1.1 *
1.05 * 0.05 + lk_$spark)
/ 2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 20)) sov_cost = (a_dist_s * 0.05)
* 0.77 + lk_$spark .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 20)) two_cost = (a_dist_s * 0.05 +
lk_$spark)
/ 2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 20)) two_p_co = ((a_dist_s * 0.05 )
* 1.05 + lk_$spark) / 2.8 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 20)) sov_cost = a_dist_s *
0.05 + lk_$spark .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 20)) two_cost = (a_dist_s
* 1.10 * 0.05 + lk_$spark
) / 2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 20)) two_p_co = (a_dist_s
* 1.10 * 1.05 * 0.05 + lk_$spark
) / 2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 20)) sov_cost = (a_dist_s * 0.05
) * 0.77 +

```



```

lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s>20)) two_cost = (a_dist_s *
0.05 + lk_$park)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s>20)) two_p_co=((a_dist_s * 0.05
)*1.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& (a_dist_s>20)) sov_cost = a_dist_s *
0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s>20)) two_cost = (a_dist_s
*1.10* 0.05 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s>20)) two_p_co = (a_dist_s
*1.10 * 0.05 +
lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s>20)) sov_cost = (a_dist_s *
0.05)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s>20)) two_cost = ((a_dist_s *
0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s>20)) two_p_co = (a_dist_s *
0.05+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90 + 1
* 4 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90
*1.05+ 4 * ( 2.8-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .

```

```

IF (sov = 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& a_dist_s<=5) two_p_ti = a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90
+ 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90
*1.05 + 4* (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) two_p_ti = a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90
*1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s * 0.96
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) two_p_ti = a_time_s + 4 *
( carocc_n-1) .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s<=10)) sov_time =
a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s<=10)) two_time =
a_time_s*1.70 + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s<=10)) two_p_ti =
a_time_s*1.70 *1.05+ 4 * (2.8-1) .

```

```

EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_time = a_time_s*1.70 + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_p_ti = a_time_s*1.70*1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_time = a_time_s*1.70 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_p_ti = a_time_s*1.70 *1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
a_time_s + 4 * ( carocc_n-1) .

```

EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) sov_time = a_time_s .

EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) two_time = a_time_s * 1.50 + 4 * 1 .

EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) two_p_ti = a_time_s * 1.50 * 1.05 + 4 * (2.8 - 1) .

EXECUTE .

IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) sov_time = a_time_s .

EXECUTE .

IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) two_time = a_time_s + 4 * 1 .

EXECUTE .

IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) two_p_ti = a_time_s + 4 * (2.8 - 1) .

EXECUTE .

IF (two_per = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) sov_time = a_time_s .

EXECUTE .

IF (two_per = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) two_time = a_time_s * 1.50 + 4 * 1 .

EXECUTE .

IF (two_per = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) two_p_ti = a_time_s * 1.50 * 1.05 + 4 * (2.8 - 1) .

EXECUTE .

IF (two_per = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) sov_time = a_time_s * 0.77 .

EXECUTE .

IF (two_per = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) two_time = a_time_s + 4 * 1 .

EXECUTE .

IF (two_per = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s <= 15)) two_p_ti = a_time_s + 4 * (2.8 - 1) .

EXECUTE .

IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) sov_time = a_time_s .

EXECUTE .

IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s <= 15)) two_time = a_time_s * 1.50 + 4 * 1 .

EXECUTE .

```

IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
    two_p_ti = a_time_s*1.50 *1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time
    = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_time
    = a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_p_ti
    = a_time_s + 4 * (carocc_n-1) .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time
    = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s >15 & a_dist_s<=20)) two_time =
    a_time_s*1.30 + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti
    = a_time_s*1.30 *1.05+ 4 * (2.8-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time =
    a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time =
    a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& (a_dist_s > 15 & a_dist_s<=20)) two_p_ti =
    a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    two_time = a_time_s*1.30 + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    two_p_ti = a_time_s*1.30 *1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time =
    a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time =

```

```

a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti =
a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s >15 & a_dist_s<=20))
two_time = a_time_s*1.30 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
two_p_ti = a_time_s*1.30*1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time
= a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time
= a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti
= a_time_s + 4 * (carocc_n-1) .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & a_dist_s>20) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s>20) two_time = a_time_s*1.10 + 4
* 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s >20) two_p_ti = a_time_s*1.10
*1.05 + 4 * (2.8-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s >20) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s >20) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& a_dist_s >20) two_p_ti = a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s >20) sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s >20) two_time = a_time_s*1.10
+ 4 * 1 .
EXECUTE .

```

```

IF (two_per= 1 & mode = "non_link" & a_dist_s >20) two_p_ti = a_time_s*1.10
* 1.05 + 4 *( 2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s >20) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s >20) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s >20) two_p_ti = a_time_s +4 *( 2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s >20) sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s >20) two_time = a_time_s*1.10
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s >20) two_p_ti = a_time_s
*1.10 * 1.05 + 4 *( 2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s >20) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s >20) two_time = a_time_s * 0.96
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s >20) two_p_ti = a_time_s + 4 *
(carocc_n-1) .
EXECUTE .

```

```

COMPUTE cost1 = two_cost .
EXECUTE .
COMPUTE cost2 = two_p_co .
EXECUTE .
COMPUTE time1 = two_time .
EXECUTE .
COMPUTE time2 = two_p_ti .
EXECUTE .

```

Comment: AP9_12x3

GET FILE

"G:\POLICY\DataMF\Sabbir\Folder2\Auto\Auto2\AP9_12x3.sav"

.

EXECUTE

.

COMPUTE sov_cost = 0 .

EXECUTE .

COMPUTE two_cost = 0 .

EXECUTE .

COMPUTE two_p_co = 0 .

EXECUTE .

COMPUTE sov_time = 0 .

EXECUTE .

COMPUTE two_time = 0 .

EXECUTE .

COMPUTE two_p_ti = 0 .

EXECUTE .

IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) sov_cost = a_dist_s * 0.05
+ lk_\$spark .

EXECUTE .

IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s * 1.9*
0.05 + lk_\$spark)/2 .

EXECUTE .

IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s * 1.9 *
1.05 * 0.05 + lk_\$spark)
/2.9 .

EXECUTE .

IF (sov = 1 & mode = "link" & a_dist_s<= 5) sov_cost = (a_dist_s * 0.05)
* 0.77 + lk_\$spark .

EXECUTE .

IF (sov = 1 & mode = "link" & a_dist_s<= 5) two_cost = (a_dist_s * 0.05 +
lk_\$spark)
/2 .

EXECUTE .

IF (sov = 1 & mode = "link" & a_dist_s<= 5) two_p_co = (a_dist_s * 0.05)
* 1.05 + lk_\$spark)/2.9.

EXECUTE .

IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) sov_cost = a_dist_s *
0.05 + lk_\$spark .

EXECUTE .

IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s
* 1.90 * 0.05 + lk_\$spark
)/2 .


```

EXECUTE .
IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s
*1.90*1.05 * 0.05 + lk_$park
)/2.9 .
EXECUTE .
IF (two_per = 1 & mode = "link"& a_dist_s<= 5) sov_cost = (a_dist_s * 0.05
) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & a_dist_s<= 5) two_cost = (a_dist_s * 0.05
+ lk_$park)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& a_dist_s<= 5) two_p_co = ((a_dist_s * 0.05)
*1.05 + lk_$park)
/2.9 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& a_dist_s<= 5) sov_cost = a_dist_s *
0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s
*1.90* 0.05 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s
*1.90 * 0.05 +
lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& a_dist_s<= 5) sov_cost = (a_dist_s * 0.05
)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & a_dist_s<= 5) two_cost = ((a_dist_s *
0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& a_dist_s<= 5) two_p_co = (a_dist_s * 0.05
+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10)) sov_cost =
a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10)) two_cost =

```

```

(a_dist_s * 1.7 * 0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_co =
(a_dist_s * 1.7 * 1.05 * 0.05 + lk_$park)
/2.9 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_cost =
(a_dist_s * 0.05) * 0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_cost =
(a_dist_s * 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park) / 2.9 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_cost = (a_dist_s * 1.70 * 0.05 + lk_$park
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_p_co = (a_dist_s * 1.70 * 1.05 * 0.05 + lk_$park
)/2.9 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_cost =
(a_dist_s * 0.05) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_cost =
(a_dist_s * 0.05 + lk_$park) / 2 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park)
/2.9 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
two_cost = (a_dist_s * 1.70 * 0.05 + lk_$park) / 2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))

```

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two_p_co = (a_dist_s*1.70 * 0.05 + lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 5 & a_dist_s<=10)) sov_cost =
(a_dist_s * 0.05)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s> 5 & a_dist_s<=10)) two_cost =
((a_dist_s * 0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 5 & a_dist_s<=10)) two_p_co =
(a_dist_s * 0.05+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15)) sov_cost =
a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15)) two_cost =
(a_dist_s *1.5* 0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15)) two_p_co =
(a_dist_s *1.5 * 1.05 * 0.05 + lk_$park)
/2.9 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) sov_cost =
(a_dist_s * 0.05)*0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) two_cost =
(a_dist_s* 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) two_p_co = (
(a_dist_s * 0.05 )*1.05+ lk_$park)/2.9.
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
two_cost = (a_dist_s*1.50 * 0.05 + lk_$park
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
two_p_co = (a_dist_s*1.50*1.05 * 0.05 + lk_$park

```

```

)/2.9 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s> 10 & a_dist_s<=15)) sov_cost =
(a_dist_s * 0.05 ) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) two_cost =
(a_dist_s * 0.05 + lk_$park)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s> 10 & a_dist_s<=15)) two_p_co =(
(a_dist_s * 0.05)*1.05 + lk_$park)
/2.9 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& (a_dist_s> 10 & a_dist_s<=15))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
two_cost = (a_dist_s * 1.50* 0.05 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
two_p_co = (a_dist_s*1.50 * 0.05 +
lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 10 & a_dist_s<=15)) sov_cost =
(a_dist_s * 0.05)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) two_cost
= ((a_dist_s * 0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 10 & a_dist_s<=15)) two_p_co =
(a_dist_s * 0.05+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s> 15 & a_dist_s<=20)) sov_cost =
a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 15 & a_dist_s<=20)) two_cost =
(a_dist_s * 1.3* 0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 15 & a_dist_s<=20)) two_p_co =

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(a_dist_s * 1.3 * 1.05 * 0.05 + lk_$park)
/2.9 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_ccost =
(a_dist_s * 0.05) * 0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost =
(a_dist_s * 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park) / 2.9 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_cost = (a_dist_s * 1.30 * 0.05 + lk_$park)
/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_p_co = (a_dist_s * 1.30 * 1.05 * 0.05 + lk_$park)
/2.9 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_cost =
(a_dist_s * 0.05) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost =
(a_dist_s * 0.05 + lk_$park) / 2 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park)
/2.9 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_cost = (a_dist_s * 1.30 * 0.05 +
lk_$park) / 2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_p_co = (a_dist_s * 1.30 * 0.05 +
lk_$park) / carocc_n .

```

```

EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_cost =
(a_dist_s * 0.05) * 0.77 +
lk_spark .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost
= ((a_dist_s * 0.05) * 0.96 +
lk_spark) / 2 .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co =
(a_dist_s * 0.05 + lk_spark)
/carocc_n .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s > 20)) sov_cost = a_dist_s * 0.05
+ lk_spark .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 20)) two_cost = (a_dist_s * 1.1 *
0.05 + lk_spark) / 2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 20)) two_p_co = (a_dist_s * 1.1 *
1.05 * 0.05 + lk_spark)
/ 2.9 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 20)) sov_cost = (a_dist_s * 0.05)
* 0.77 + lk_spark .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 20)) two_cost = (a_dist_s * 0.05 +
lk_spark)
/ 2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 20)) two_p_co = ((a_dist_s * 0.05 )
* 1.05 + lk_spark) / 2.9 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 20)) sov_cost = a_dist_s *
0.05 + lk_spark .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 20)) two_cost = (a_dist_s
* 1.10 * 0.05 + lk_spark
) / 2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 20)) two_p_co = (a_dist_s
* 1.10 * 1.05 * 0.05 + lk_spark

```

```

)/2.9 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s>20)) sov_cost = (a_dist_s * 0.05
) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s>20)) two_cost = (a_dist_s *
0.05 + lk_$park)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s>20)) two_p_co = ((a_dist_s * 0.05
)*1.05 + lk_$park)
/2.9 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& (a_dist_s>20)) sov_cost = a_dist_s *
0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s>20)) two_cost = (a_dist_s
*1.10* 0.05 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s>20)) two_p_co = (a_dist_s
*1.10 * 0.05 +
lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s>20)) sov_cost = (a_dist_s *
0.05)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s>20)) two_cost = ((a_dist_s *
0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s>20)) two_p_co = (a_dist_s *
0.05+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90 + 1
* 4 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90

```

```

*1.05+ 4 * ( 2.9-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& a_dist_s<=5) two_p_ti = a_time_s + 4 * (2.9-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90
+ 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90
*1.05 + 4* (2.9-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) two_p_ti = a_time_s + 4 * (
2.9-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90
*1.05 + 4 * (2.9-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s * 0.96
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) two_p_ti = a_time_s + 4 *
( carocc_n-1) .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s<=10)) sov_time =
a_time_s .
EXECUTE .

```



```

IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
  a_time_s * 1.70 + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
  a_time_s * 1.70 * 1.05 + 4 * (2.9 - 1) .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
  a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
  a_time_s + 4 * (2.9 - 1) .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  sov_time = a_time_s .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  two_time = a_time_s * 1.70 + 4 * 1 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  two_p_ti = a_time_s * 1.70 * 1.05 + 4 * (2.9 - 1) .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
  a_time_s * 0.77 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
  a_time_s + 4 * (2.9 - 1) .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  sov_time = a_time_s .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  two_time = a_time_s * 1.70 + 4 * 1 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  two_p_ti = a_time_s * 1.70 * 1.05 + 4 * (2.9 - 1) .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
  a_time_s * 0.77 .
EXECUTE .

```

```

IF (two_pper= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s<=10)) two_time =
  a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s<=10)) two_p_ti =
  a_time_s + 4 * ( carocc_n-1) .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time
  = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15)) two_time =
  a_time_s*1.50 + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15)) two_p_ti
  = a_time_s*1.50 *1.05+ 4 * (2.9-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time =
  a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& (a_dist_s > 10 & a_dist_s<=15)) two_p_ti =
  a_time_s + 4 * (2.9-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
  sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
  two_time = a_time_s*1.50 + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
  two_p_ti = a_time_s*1.50 *1.05 + 4 * (2.9-1) .

```

```

EXECUTE .

```

```

IF (two_per= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time =
  a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_p_ti =
  a_time_s + 4 * (2.9-1) .

```

```

EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
    sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s >10 & a_dist_s<=15))
    two_time = a_time_s*1.50 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
    two_p_ti = a_time_s*1.50 *1.05 + 4 * (2.9-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time
    = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_time
    = a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_p_ti
    = a_time_s + 4 * (carocc_n-1) .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time
    = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s >15 & a_dist_s<=20)) two_time =
    a_time_s*1.30 + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti
    = a_time_s*1.30 *1.05+ 4 * (2.9-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time =
    a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time =
    a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& (a_dist_s > 15 & a_dist_s<=20)) two_p_ti =
    a_time_s + 4 * (2.9-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    two_time = a_time_s*1.30 + 4 * 1 .
EXECUTE .

```

```

IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    two_p_ti = a_time_s*1.30 *1.05 + 4 * (2.9-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time =
    a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time =
    a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti =
    a_time_s + 4 * ( 2.9-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s >15 & a_dist_s<=20))
    two_time = a_time_s*1.30 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    two_p_ti = a_time_s*1.30*1.05 + 4 *( 2.9-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time
    = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time
    = a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti
    = a_time_s + 4 * (carocc_n-1) .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & a_dist_s>20) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s>20) two_time = a_time_s*1.10 + 4
    * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s >20) two_p_ti = a_time_s*1.10
    *1.05 + 4 * (2.9-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s >20) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s >20) two_time = a_time_s + 4 * 1 .
EXECUTE .

```

```

IF (sov = 1 & mode = "link" & a_dist_s > 20) two_p_ti = a_time_s + 4 * (2.9-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s > 20) sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s > 20) two_time = a_time_s*1.10
+ 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s > 20) two_p_ti = a_time_s*1.10
* 1.05 + 4 * (2.9-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s > 20) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s > 20) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s > 20) two_p_ti = a_time_s + 4 * (
2.9-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s > 20) sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s > 20) two_time = a_time_s*1.10
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s > 20) two_p_ti = a_time_s
*1.10 * 1.05 + 4 * (2.9-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s > 20) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s > 20) two_time = a_time_s * 0.96
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s > 20) two_p_ti = a_time_s + 4 *
(carocc_n-1) .
EXECUTE .

SAVE OUTFILE='G:\POLICY\DataMF\Sabbir\Folder2\Auto\Auto2\AP9_12x3.sav'
/COMPRESSED.

```

Comment: AT_hi_5x

GET FILE

"G:\POLICY\DataMF\Sabbir\Folder2\Auto\Auto2\AT_hi_5x.sav"

.

EXECUTE

.

COMPUTE sov_cost = 0 .

EXECUTE .

COMPUTE two_cost = 0 .

EXECUTE .

COMPUTE two_p_co = 0 .

EXECUTE .

COMPUTE sov_time = 0 .

EXECUTE .

COMPUTE two_time = 0 .

EXECUTE .

COMPUTE two_p_ti = 0 .

EXECUTE .

IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) sov_cost = a_dist_s * 0.05
+ lk_\$park .

EXECUTE .

IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s * 1.9*
0.05 + lk_\$park)/2 .

EXECUTE .

IF (sov = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s * 1.9 *
1.05 * 0.05 + lk_\$park)
/2.8 .

EXECUTE .

IF (sov = 1 & mode = "link" & a_dist_s<= 5) sov_cost = (a_dist_s * 0.05)
*0.77 + lk_\$park .

EXECUTE .

IF (sov = 1 & mode = "link" & a_dist_s<= 5) two_cost = (a_dist_s* 0.05 +
lk_\$park)
/2 .

EXECUTE .

IF (sov = 1 & mode = "link" & a_dist_s<= 5) two_p_co =((a_dist_s * 0.05)
*1.05 + lk_\$park)/2.8.

EXECUTE .

IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) sov_cost = a_dist_s *
0.05 + lk_\$park .

EXECUTE .

IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s
*1.90 * 0.05 + lk_\$park
)/2 .

```

EXECUTE .
IF (two_per = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s
*1.90*1.05 * 0.05 + lk_$park
)/2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link"& a_dist_s<= 5) sov_cost = (a_dist_s * 0.05
) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & a_dist_s<= 5) two_cost = (a_dist_s * 0.05
+ lk_$park)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& a_dist_s<= 5) two_p_co =((a_dist_s * 0.05)
*1.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& a_dist_s<= 5) sov_cost = a_dist_s *
0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & a_dist_s<= 5) two_cost = (a_dist_s
*1.90* 0.05 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & a_dist_s<= 5) two_p_co = (a_dist_s
*1.90 * 0.05 +
lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& a_dist_s<= 5) sov_cost = (a_dist_s * 0.05
)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & a_dist_s<= 5) two_cost = ((a_dist_s *
0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& a_dist_s<= 5) two_p_co = (a_dist_s * 0.05
+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10)) sov_cost =
a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10)) two_cost =

```

```

(a_dist_s*1.7* 0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10)) two_p_co =
(a_dist_s*1.7 * 1.05 * 0.05 + lk_$park)
/2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 5 & a_dist_s<=10)) sov_cost =
(a_dist_s * 0.05)*0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 5 & a_dist_s<=10)) two_cost =
(a_dist_s* 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 5 & a_dist_s<=10)) two_p_co = (
(a_dist_s * 0.05 )*1.05+ lk_$park)/2.8.
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10))
two_cost = (a_dist_s*1.70 * 0.05 + lk_$park
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10))
two_p_co = (a_dist_s*1.70*1.05 * 0.05 + lk_$park
)/2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s> 5 & a_dist_s<=10)) sov_cost =
(a_dist_s * 0.05 ) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s> 5 & a_dist_s<=10)) two_cost =
(a_dist_s * 0.05 + lk_$park)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s> 5 & a_dist_s<=10)) two_p_co =(
(a_dist_s * 0.05)*1.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& (a_dist_s> 5 & a_dist_s<=10))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10))
two_cost = (a_dist_s *1.70* 0.05 +lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s> 5 & a_dist_s<=10))

```



```

two_p_co = (a_dist_s*1.70 * 0.05 + lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 5 & a_dist_s<=10)) sov_cost =
(a_dist_s * 0.05)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s> 5 & a_dist_s<=10)) two_cost =
((a_dist_s * 0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 5 & a_dist_s<=10)) two_p_co =
(a_dist_s * 0.05+ lk_$park)
/carocc_n .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15)) sov_cost =
a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15)) two_cost =
(a_dist_s * 1.5* 0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15)) two_p_co =
(a_dist_s * 1.5 * 1.05 * 0.05 + lk_$park)
/2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) sov_cost =
(a_dist_s * 0.05)*0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) two_cost =
(a_dist_s* 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) two_p_co = (
(a_dist_s * 0.05 )*1.05+ lk_$park)/2.8.
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
two_cost = (a_dist_s*1.50 * 0.05 + lk_$park
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
two_p_co = (a_dist_s*1.50*1.05 * 0.05 + lk_$park

```

```

)/2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s> 10 & a_dist_s<=15)) sov_cost =
(a_dist_s * 0.05 ) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) two_cost =
(a_dist_s * 0.05 + lk_$park)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s> 10 & a_dist_s<=15)) two_p_co =(
(a_dist_s * 0.05)*1.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& (a_dist_s> 10 & a_dist_s<=15))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
two_cost = (a_dist_s *1.50* 0.05 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s> 10 & a_dist_s<=15))
two_p_co = (a_dist_s*1.50 * 0.05 +
lk_$park)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 10 & a_dist_s<=15)) sov_cost =
(a_dist_s * 0.05)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s> 10 & a_dist_s<=15)) two_cost
= ((a_dist_s * 0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 10 & a_dist_s<=15)) two_p_co =
(a_dist_s * 0.05+ lk_$park)
/carocc_n .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s> 15 & a_dist_s<=20)) sov_cost =
a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 15 & a_dist_s<=20)) two_cost =
(a_dist_s *1.3* 0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s> 15 & a_dist_s<=20)) two_p_co =

```

```

(a_dist_s * 1.3 * 1.05 * 0.05 + lk_$park)
/2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_cost =
(a_dist_s * 0.05) * 0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost =
(a_dist_s * 0.05 + lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park) / 3 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_cost = (a_dist_s * 1.30 * 0.05 + lk_$park)
/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_p_co = (a_dist_s * 1.30 * 1.05 * 0.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) sov_cost =
(a_dist_s * 0.05) * 0.77 +
lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_cost =
(a_dist_s * 0.05 + lk_$park) / 2 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s <= 20)) two_p_co = (
(a_dist_s * 0.05) * 1.05 + lk_$park)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_cost = (a_dist_s * 1.30 * 0.05 +
lk_$park) / 2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s <= 20))
two_p_co = (a_dist_s * 1.30 * 0.05 +
lk_$park) / carocc_n .

```

```

EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 15 & a_dist_s<=20)) sov_cost =
(a_dist_s * 0.05)*0.77 +
lk_$park .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s> 15 & a_dist_s<=20)) two_cost
= ((a_dist_s * 0.05)*0.96 +
lk_$park)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s> 15 & a_dist_s<=20)) two_p_co =
(a_dist_s * 0.05+ lk_$park)
/carocc_n .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s>20)) sov_cost = a_dist_s * 0.05
+ lk_$park .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s>20)) two_cost = (a_dist_s *1.1*
0.05 + lk_$park)/2 .
EXECUTE .
IF (sov = 1 & mode = "non_link" &(a_dist_s>20)) two_p_co = (a_dist_s *1.1 *
1.05 * 0.05 + lk_$park)
/2.8 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s>20)) sov_cost = (a_dist_s * 0.05)
*0.77 + lk_$park .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s>20)) two_cost = (a_dist_s* 0.05 +
lk_$park)
/2 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s>20)) two_p_co = ((a_dist_s * 0.05 )
*1.05+ lk_$park)/2.8.
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s>20)) sov_cost = a_dist_s *
0.05 + lk_$park .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s>20)) two_cost = (a_dist_s
*1.10 * 0.05 + lk_$park
)/2 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s>20)) two_p_co = (a_dist_s
*1.10*1.05 * 0.05 + lk_$park

```

```

)/2.8 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s>20)) sov_cost = (a_dist_s * 0.05
) * 0.77 +
lk_Spark .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s>20)) two_cost = (a_dist_s *
0.05 + lk_Spark)/2 .
EXECUTE .
IF (two_per = 1 & mode = "link"& (a_dist_s>20)) two_p_co = ((a_dist_s * 0.05
)*1.05 + lk_Spark)
/2.8 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link"& (a_dist_s>20)) sov_cost = a_dist_s *
0.05 + lk_Spark .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s>20)) two_cost = (a_dist_s
*1.10* 0.05 +
lk_Spark)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s>20)) two_p_co = (a_dist_s
*1.10 * 0.05 +
lk_Spark)/carocc_n .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s>20)) sov_cost = (a_dist_s *
0.05)*0.77 +
lk_Spark .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s>20)) two_cost = ((a_dist_s *
0.05)*0.96 +
lk_Spark)/2 .
EXECUTE .
IF (two_pper = 1 & mode = "link"& (a_dist_s>20)) two_p_co = (a_dist_s *
0.05+ lk_Spark)
/carocc_n .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90 + 1
* 4 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90

```

```

*1.05+ 4 * ( 2.8-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& a_dist_s<=5) two_p_ti = a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90
+ 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90
*1.05 + 4* (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s<=5) two_p_ti = a_time_s + 4 * (
2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) two_time = a_time_s*1.90
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s<=5) two_p_ti = a_time_s*1.90
*1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) two_time = a_time_s * 0.96
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s<=5) two_p_ti = a_time_s + 4 *
( carocc_n-1) .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s<=10)) sov_time =
a_time_s .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
  a_time_s * 1.70 + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
  a_time_s * 1.70 * 1.05 + 4 * (2.8 - 1) .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
  a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
  a_time_s + 4 * (2.8 - 1) .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  sov_time = a_time_s .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  two_time = a_time_s * 1.70 + 4 * 1 .
EXECUTE .
IF (two_per = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  two_p_ti = a_time_s * 1.70 * 1.05 + 4 * (2.8 - 1) .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
  a_time_s * 0.77 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (two_per = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) two_p_ti =
  a_time_s + 4 * (2.8 - 1) .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  sov_time = a_time_s .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  two_time = a_time_s * 1.70 + 4 * 1 .
EXECUTE .
IF (two_pper = 1 & mode = "non_link" & (a_dist_s > 5 & a_dist_s <= 10))
  two_p_ti = a_time_s * 1.70 * 1.05 + 4 * (2.8 - 1) .
EXECUTE .
IF (two_pper = 1 & mode = "link" & (a_dist_s > 5 & a_dist_s <= 10)) sov_time =
  a_time_s * 0.77 .
EXECUTE .

```

```

IF (two_pper= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s<=10)) two_time =
  a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 5 & a_dist_s<=10)) two_p_ti =
  a_time_s + 4 * ( carocc_n-1) .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time
  = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s >10 & a_dist_s<=15)) two_time =
  a_time_s*1.50 + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15)) two_p_ti
  = a_time_s*1.50 *1.05+ 4 * (2.8-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time =
  a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& (a_dist_s > 10 & a_dist_s<=15)) two_p_ti =
  a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
  sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
  two_time = a_time_s*1.50 + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
  two_p_ti = a_time_s*1.50 *1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time =
  a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_p_ti =
  a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))

```



```

    sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s >10 & a_dist_s<=15))
    two_time = a_time_s*1.50 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 10 & a_dist_s<=15))
    two_p_ti = a_time_s*1.50 *1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) sov_time
    = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_time
    = a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 10 & a_dist_s<=15)) two_p_ti
    = a_time_s + 4 * (carocc_n-1) .
EXECUTE .

IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time
    = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s >15 & a_dist_s<=20)) two_time =
    a_time_s*1.30 + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti
    = a_time_s*1.30 *1.05+ 4 * (2.8-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time =
    a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time =
    a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& (a_dist_s > 15 & a_dist_s<=20)) two_p_ti =
    a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    two_time = a_time_s*1.30 + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
    two_p_ti = a_time_s*1.30 *1.05 + 4 * (2.8-1) .

```

```

EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time =
  a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time =
  a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti =
  a_time_s + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
  sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
  two_time = a_time_s*1.30 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & (a_dist_s > 15 & a_dist_s<=20))
  two_p_ti = a_time_s*1.30*1.05 + 4 * (2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) sov_time
  = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_time
  = a_time_s * 0.96 + 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & (a_dist_s > 15 & a_dist_s<=20)) two_p_ti
  = a_time_s + 4 * (carocc_n-1) .
EXECUTE .

```

```

IF (sov = 1 & mode = "non_link" & a_dist_s>20) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s>20) two_time = a_time_s*1.10 + 4
  * 1 .
EXECUTE .
IF (sov = 1 & mode = "non_link" & a_dist_s >20) two_p_ti = a_time_s*1.10
  *1.05 + 4 * (2.8-1) .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s >20) sov_time = a_time_s .
EXECUTE .
IF (sov = 1 & mode = "link" & a_dist_s >20) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (sov = 1 & mode = "link"& a_dist_s >20) two_p_ti = a_time_s + 4 * (2.8-1) .
EXECUTE .

```

```

IF (two_per= 1 & mode = "non_link" & a_dist_s >20) sov_time = a_time_s .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s >20) two_time = a_time_s*1.10
+ 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "non_link" & a_dist_s >20) two_p_ti = a_time_s*1.10
* 1.05 + 4 *( 2.8-1) .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s >20) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s >20) two_time = a_time_s + 4 * 1 .
EXECUTE .
IF (two_per= 1 & mode = "link" & a_dist_s >20) two_p_ti = a_time_s +4 *(
2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s >20) sov_time = a_time_s .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s >20) two_time = a_time_s*1.10
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "non_link" & a_dist_s >20) two_p_ti = a_time_s
*1.10 * 1.05 + 4 *( 2.8-1) .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s >20) sov_time = a_time_s * 0.77 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s >20) two_time = a_time_s * 0.96
+ 4 * 1 .
EXECUTE .
IF (two_pper= 1 & mode = "link" & a_dist_s >20) two_p_ti = a_time_s + 4 *
(carocc_n-1) .
EXECUTE .

IF (transit = 1) sov_cost = a_dist_s * 0.05 + lk_$park .
EXECUTE .
IF (transit = 1) two_cost = (a_dist_s * 0.05 + lk_$park)/2 .
EXECUTE .
IF (transit = 1) two_p_co = (a_dist_s * 0.05 + lk_$park)/2.8 .
EXECUTE .
IF (transit = 1) sov_time = sov_t .
EXECUTE .
IF (transit = 1) two_time = sov_t + 4*1 .
EXECUTE .
IF (transit = 1) two_p_ti = sov_t + 4*2.8 .
EXECUTE .

```

```
IF (transit = 1) two_p_ti = sov_t + 4*(2.8 -1) .  
EXECUTE .  
  
COMPUTE cost1 = (sov_cost + two_cost + two_p_co) / 3 .  
EXECUTE .  
COMPUTE cost2 = t_fare .  
EXECUTE .  
COMPUTE time1 = (sov_time + two_time + two_p_ti) / 3 .  
EXECUTE .  
COMPUTE time2 = t_time_s .  
EXECUTE .  
SAVE OUTFILE='G:\POLICY\DataMF\Sabbir\Folder2\Auto\Auto2\AT_hi_5x.sav'  
/COMPRESSED.
```

APPENDIX E

MODEL OUTPUT

HIGHER LEVEL HOME BASED WORK TRIP MODEL

TSP Version 4.3A

(10/26/95) DOS/Win 15MB
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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='AT_hi_5S.xls'), choice cost1 cost2 time1 time2
| 3 incl1 incl2 sex_v n_veh_hh num_pers province
| 3 wk_fphj cbd_flag tway_o ;
| 4 logit(cond,nchoice=2) choice cost time incl | sex_v
| 4 province num_pers n_veh_hh wk_fphj
| 4 cbd_flag tway_o 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-10)/y);
| 10 print y,x,@logl,rhosq,rhobarsq;
| 11 msd (all, corr, print) choice cost1 cost2 time1 time2
| 11 sex_v n_veh_hh province wk_fphj
| 11 num_pers cbd_flag tway_o
| 11 ;
| 12
EXECUTION

```

Current sample: 1 to 7268

Equation 1
 =====

MIXED LOGIT ESTIMATION

CHOICE	FREQUENCY	PERCENT	
1	5836	80.2972	(COEFFICIENTS NORMALIZED TO ZERO)
2	1432	19.7028	

Working space used: 247507

STARTING VALUES

	COST	TIME	INCL	SEX_V2
PROVINC2				
VALUE	0.00000	0.00000	0.00000	0.00000
0.00000				

TWAY_O2	NUM_PER2	N_VEH_H2	WK_FPHJ2	CBD_FL A2
VALUE	0.00000	0.00000	0.00000	0.00000
0.00000				

	C2				
VALUE	0.00000				
F= 5037.8	FNEW= 2603.2	ISQZ= 0	STEP= 1.0000	CRIT=	
4328.1					
F= 2603.2	FNEW= 2306.0	ISQZ= 0	STEP= 1.0000	CRIT=	
496.01					
F= 2306.0	FNEW= 2260.1	ISQZ= 0	STEP= 1.0000	CRIT=	
81.651					
F= 2260.1	FNEW= 2258.1	ISQZ= 0	STEP= 1.0000	CRIT=	
3.9984					
F= 2258.1	FNEW= 2258.1	ISQZ= 0	STEP= 1.0000	CRIT=	
0.12287E-01					
F= 2258.1	FNEW= 2258.1	ISQZ= 0	STEP= 1.0000	CRIT=	
0.13058E-06					

CONVERGENCE ACHIEVED AFTER 6 ITERATIONS

12 FUNCTION EVALUATIONS.

DEPENDENT VARIABLE: CHOICE

LOG OF LIKELIHOOD FUNCTION = -2258.06
NUMBER OF CASES = 7268
NUMBER OF CHOICES = 14536

Standard	Parameter	Estimate	Error	t-statistic
	COST	-.601988	.046241	-13.0184
	TIME	-.017237	.266249E-02	-6.47384
	INCL	.251464	.039703	6.33355
	SEX_V2	-.460069	.078196	-5.88356
	PROVINC2	-1.04756	.097883	-10.7021
	NUM_PER2	.141824	.034820	4.07311
	N_VEH_H2	-1.77329	.084190	-21.0629
	WK_FPHJ2	.150520	.059939	2.51121
	CBD_FL A2	1.15938	.091814	12.6274
	TWAY_O2	.632718	.083069	7.61679
	C2	.049289	.159050	.309900

Standard Errors computed from analytic second derivatives
(Newton)

Class	Name	Description
-----	----	-----
LIST	@LHV	1 members
	@RNMS	11 members

	Y	X	@LOGL	RHOSQ
RHOBARSQ				

Value	-5037.79371	5559.46869	-2258.05936	0.55178
0.54979				

Results of Covariance procedure

Number of Observations: 7268

	Mean	Std Dev	Minimum	Maximum
CHOICE	1.19703	0.39778	1.00000	2.00000
COST1	0.99618	1.09397	0.00000	4.30083
COST2	1.60078	0.43723	1.35000	3.10000
TIME1	23.10045	13.21852	0.00000	75.83643
TIME2	45.86673	27.24855	0.00000	180.00000
SEX_V	0.54224	0.49825	0.00000	1.00000
N_VEH_HH	1.51720	0.54252	0.00000	2.00000
PROVINCE	0.26692	0.44238	0.00000	1.00000
WK_FPHJ	1.94854	0.73864	0.00000	7.00000
NUM_PERS	3.09865	1.22091	1.00000	10.00000
CBD_FLAG	0.34026	0.47383	0.00000	1.00000
TWAY_O	0.30435	0.46016	0.00000	1.00000

	Sum	Variance	Skewness	Kurtosis
CHOICE	8700.00000	0.15823	1.52373	0.32184
COST1	7240.26689	1.19678	1.17129	-0.013967
COST2	11634.44008	0.19117	2.56473	6.15979
TIME1	167894.05761	174.72932	-0.0043853	-0.32184
TIME2	333359.38616	742.48345	1.42484	2.59938
SEX_V	3941.00000	0.24825	-0.16960	-1.97178
N_VEH_HH	11027.00000	0.29432	-0.48718	-0.93551
PROVINCE	1940.00000	0.19570	1.05402	-0.88928
WK_FPHJ	14162.00000	0.54558	0.95879	2.28939
NUM_PERS	22521.00000	1.49061	0.39391	0.057677
CBD_FLAG	2473.00000	0.22451	0.67444	-1.54555
TWAY_O	2212.00000	0.21175	0.85060	-1.27684

	Median	1st Qrt	3rd Qrt	IQ Range
CHOICE	1.00000	1.00000	1.00000	0.00000
COST1	0.51715	0.22099	1.53121	1.31023
COST2	1.35000	1.35000	1.73000	0.38000
TIME1	23.78333	14.42333	32.08333	17.66000
TIME2	40.15000	27.20590	56.98812	29.78223
SEX_V	1.00000	0.00000	1.00000	1.00000
N_VEH_HH	2.00000	1.00000	2.00000	1.00000
PROVINCE	0.00000	0.00000	1.00000	1.00000
WK_FPHJ	2.00000	2.00000	2.00000	0.00000
NUM_PERS	3.00000	2.00000	4.00000	2.00000
CBD_FLAG	0.00000	0.00000	1.00000	1.00000
TWAY_O	0.00000	0.00000	1.00000	1.00000

Correlation Matrix

	CHOICE	COST1	COST2	TIME1
CHOICE	1.00000			
COST1	0.50418	1.00000		
COST2	-0.023223	0.15833	1.0000	
TIME1	0.025725	0.41343	0.37371	1.00000
TIME2	-0.12717	0.13299	0.65389	0.61664
SEX_V	-0.063521	0.0068164	0.013847	0.17664
N_VEH_HH	-0.27587	-0.046102	0.15469	0.18511
PROVINCE	-0.11592	-0.055573	-0.14599	0.029732
WK_FPHJ	-0.055879	-0.029957	0.048600	-0.017235
NUM_PERS	-0.047962	-0.017436	0.081386	0.062992
CBD_FLAG	0.42035	0.54914	0.014228	0.0057406
TWAY_O	0.34144	0.44523	0.033526	0.0039595

	TIME2	SEX_V	N_VEH_HH	PROVINCE
TIME2	1.00000			
SEX_V	0.061839	1.00000		
N_VEH_HH	0.15359	-0.00065162	1.0000	
PROVINCE	0.023683	-0.038673	-0.013970	1.0000
WK_FPHJ	0.036678	-0.050554	0.33325	-0.019444
NUM_PERS	0.11891	0.072437	0.26700	-0.0077413
CBD_FLAG	-0.087199	-0.080414	-0.11404	0.046544
TWAY_O	-0.066274	-0.074685	-0.070580	-0.094256

	WK_FPHJ	NUM_PERS	CBD_FLAG	TWAY_O
WK_FPHJ	1.00000			
NUM_PERS	0.41183	1.00000		
CBD_FLAG	-0.030174	-0.026395	1.00000	
TWAY_O	0.0039782	-0.0037273	0.42623	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 :    386156      3.6
CURRENT VARIABLE STORAGE :    110720

```

INTERMEDIATE LEVEL HOME BASED WORK TRIP MODEL

TSP Version 4.3A

(10/26/95) DOS/Win 15MB
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 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='AP9_12Sl.xls'), choice cost1 cost2 time1 time2
|      3  incl1 incl2 num_pers n_veh_hh province wk_fphj
|      3  de_p_den ;
|      4  logit(cond,nchoice=2) choice cost time incl |
|      4  num_pers n_veh_hh province wk_fphj de_p_den 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-((@log1-8)/y);
|     10  print y,x,@log1,rhosq,rhobarsq;
|     11  msd (all, corr, print) choice cost1 cost2 time1 time2
|     11  num_pers n_veh_hh province wk_fphj de_p_den ;
|     12
      EXECUTION
*****
*****

```

Current sample: 1 to 4990

Equation 1

MIXED LOGIT ESTIMATION

CHOICE	FREQUENCY	PERCENT	
1	3961	79.3788	(COEFFICIENTS NORMALIZED TO ZERO)
2	1029	20.6212	

Working space used: 149991

STARTING VALUES

	COST	TIME	INCL	NUM_PER2
N_VEH_H2				
VALUE	0.00000	0.00000	0.00000	0.00000
0.00000				
	PROVINC2	WK_FPHJ2	DE_P_DE2	C2

VALUE	0.00000	0.00000	0.00000	0.00000
F= 3458.8 1955.9	FNEW= 2404.9	ISQZ= 0	STEP= 1.0000	CRIT=
F= 2404.9 76.182	FNEW= 2363.6	ISQZ= 0	STEP= 1.0000	CRIT=
F= 2363.6 1.5978	FNEW= 2362.7	ISQZ= 0	STEP= 1.0000	CRIT=
F= 2362.7 0.97592E-03	FNEW= 2362.7	ISQZ= 0	STEP= 1.0000	CRIT=
F= 2362.7 0.38327E-09	FNEW= 2362.7	ISQZ= 0	STEP= 1.0000	CRIT=

CONVERGENCE ACHIEVED AFTER 5 ITERATIONS

10 FUNCTION EVALUATIONS.

DEPENDENT VARIABLE: CHOICE

LOG OF LIKELIHOOD FUNCTION = -2362.74
NUMBER OF CASES = 4990
NUMBER OF CHOICES = 9980

Parameter	Estimate	Standard Error	t-statistic
COST	-.055056	.305315	-.180326
TIME	-.097515	.015035	-6.48599
INCL	.244025	.188282	1.29606
NUM_PER2	.330466	.058780	5.62205
N_VEH_H2	-.798555	.080468	-9.92385
PROVINC2	.487459	.079419	6.13779
WK_FPHJ2	.148792	.074678	1.99245
DE_P_DE2	-.446907E-04	.215518E-04	-2.07364
C2	-.561339	.226493	-2.47839

Standard Errors computed from analytic second derivatives
(Newton)

Class	Name	Description
LIST	@LHV	1 members
	@RNMS	9 members

	Y	X	@LOGL	RHOSQ
RHOBARSQ				
Value	-3458.80443	2192.12894	-2362.73996	0.31689
0.31458				

Results of Covariance procedure

Number of Observations: 4990

	Mean	Std Dev	Minimum	Maximum
CHOICE	1.20621	0.40463	1.00000	2.00000
COST1	1.25810	1.40113	0.0022200	6.62600
COST2	0.63929	0.60451	0.0018454	2.93591
TIME1	18.36098	10.76800	0.00000	64.09000
TIME2	31.05167	11.64229	5.60000	83.69000
NUM_PERS	3.11623	1.21778	1.00000	10.00000
N_VEH_HH	1.63427	0.48251	0.00000	2.00000
PROVINCE	0.28176	0.44990	0.00000	1.00000
WK_FPHJ	1.95271	0.73849	0.00000	7.00000
DE_P_DEN	2492.18248	1843.26527	9.39882	20016.24805

	Sum	Variance	Skewness	Kurtosis
CHOICE	6019.00000	0.16372	1.45273	0.11046
COST1	6277.93772	1.96316	1.71913	2.06004
COST2	3190.06763	0.36544	1.66256	1.94873
TIME1	91621.28540	115.94987	0.66642	0.091355
TIME2	154947.80959	135.54284	0.22735	-0.085928
NUM_PERS	15550.00000	1.48298	0.39532	0.12136
N_VEH_HH	8155.00000	0.23282	-0.56843	-1.64809
PROVINCE	1406.00000	0.20241	0.97054	-1.05848
WK_FPHJ	9744.00000	0.54537	0.95323	2.26761
DE_P_DEN	1.24360D+07	3397626.86734	1.48484	7.64047

	Median	1st Qrt	3rd Qrt	IQ Range
CHOICE	1.00000	1.00000	1.00000	0.00000
COST1	0.68901	0.37021	1.44715	1.07694
COST2	0.43205	0.26217	0.70810	0.44592
TIME1	16.83000	10.16000	24.94850	14.78850
TIME2	31.08587	22.72969	38.81051	16.08082
NUM_PERS	3.00000	2.00000	4.00000	2.00000
N_VEH_HH	2.00000	1.00000	2.00000	1.00000
PROVINCE	0.00000	0.00000	1.00000	1.00000
WK_FPHJ	2.00000	2.00000	2.00000	0.00000
DE_P_DEN	2323.62183	1098.09302	3612.48462	2514.39160

Correlation Matrix

	CHOICE	COST1	COST2	TIME1
CHOICE	1.00000			
COST1	0.13678	1.00000		
COST2	0.12522	0.99735	1.00000	
TIME1	0.083283	0.40774	0.42489	1.00000
TIME2	0.056877	0.41635	0.44613	0.96718
NUM_PERS	0.11935	-0.0036421	-0.0081574	0.082079
N_VEH_HH	-0.088972	0.018578	0.020233	0.086612
PROVINCE	0.078248	0.029978	0.025583	0.067468
WK_FPHJ	0.069539	-0.00036029	-0.0016687	0.0019674
DE_P_DEN	-0.051690	-0.11916	-0.12145	-0.30439

	TIME2	NUM_PERS	N_VEH_HH	PROVINCE
TIME2	1.00000			
NUM_PERS	0.061632	1.00000		
N_VEH_HH	0.074819	0.26748	1.00000	
PROVINCE	0.10087	-0.022471	-0.033961	1.00000
WK_FPHJ	-0.011027	0.40641	0.33114	-0.028658
DE_P_DEN	-0.27216	-0.088381	-0.14616	-0.084324

	WK_FPHJ	DE_P_DEN
WK_FPHJ	1.00000	
DE_P_DEN	-0.045534	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 :      235372      3.0
CURRENT VARIABLE STORAGE :      66318

```

LOWER LEVEL HOME BASED WORK TRIP MODEL

TSP Version 4.3A

(10/26/95) DOS/Win 15MB
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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='AP9_23x1.xls'), choice cost1 cost2 time1
|      3  sex_v num_pers n_veh_hh wk_fphj or_e_den ;
|      4  logit(cond,nchoice=2) choice cost 1
|      4  num_pers wk_fphj or_e_den time1 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-((@log1-5)/y);
|     10  print y,x,@log1,rhosq,rhobarsq;
|     11  msd (all, corr, print) choice cost1 cost2 time1
|     11  sex_v num_pers n_veh_hh wk_fphj
|     11  or_e_den ;
|     12
      EXECUTION
*****
*****
Current sample: 1 to 1029

```

Equation 1
 =====

MIXED LOGIT ESTIMATION

CHOICE	FREQUENCY	PERCENT	(COEFFICIENTS NORMALIZED TO ZERO)
1	758	73.6638	
2	271	26.3362	

Working space used: 20745

STARTING VALUES

	COST	NUM_PER2	WK_FPHJ2	OR_E_DE2
TIME12				
VALUE	0.00000	0.00000	0.00000	0.00000
0.00000				
	C2			
VALUE	0.00000			

F= 713.25	FNEW= 529.32	ISQZ= 0	STEP= 1.0000	CRIT=
339.36				
F= 529.32	FNEW= 521.43	ISQZ= 0	STEP= 1.0000	CRIT=
14.575				
F= 521.43	FNEW= 521.29	ISQZ= 0	STEP= 1.0000	CRIT=
0.28652				
F= 521.29	FNEW= 521.29	ISQZ= 0	STEP= 1.0000	CRIT=
0.14913E-03				
F= 521.29	FNEW= 521.29	ISQZ= 0	STEP= 1.0000	CRIT=
0.42259E-10				

CONVERGENCE ACHIEVED AFTER 5 ITERATIONS

10 FUNCTION EVALUATIONS.

DEPENDENT VARIABLE: CHOICE

LOG OF LIKELIHOOD FUNCTION = -521.285
NUMBER OF CASES = 1029
NUMBER OF CHOICES = 2058

Parameter	Estimate	Standard Error	t-statistic
COST	-1.92244	.411391	-4.67302
NUM_PER2	.722509	.075506	9.56894
WK_FPHJ2	-.808869	.142956	-5.65816
OR_E_DE2	-.169517E-04	.685682E-05	-2.47224
TIME12	-.031346	.710015E-02	-4.41480
C2	-1.39314	.375687	-3.70824

Standard Errors computed from analytic second derivatives
(Newton)

Class	Name	Description
-----	----	-----
LIST	@LHV	1 members
	@RNMS	6 members

	Y	X	@LOGL	RHOSQ
RHOBARSQ				
Value	-713.24845	383.92619	-521.28536	0.26914
0.26213				

Results of Covariance procedure

Number of Observations: 1029

	Mean	Std Dev	Minimum	Maximum
CHOICE	1.26336	0.44067	1.00000	2.00000
COST1	0.92134	0.81463	0.017870	3.26653
COST2	0.65424	0.57352	0.013402	2.36418
TIME1	30.26450	12.03754	4.00000	82.09000
SEX_V	0.61613	0.48656	0.00000	1.00000
NUM_PERS	3.40136	1.13111	1.00000	9.00000
N_VEH HH	1.55005	0.49773	1.00000	2.00000
WK_FPHJ	2.05345	0.60804	0.00000	5.00000
OR_E_DEN	9556.63866	15204.79172	4.01054	65606.38281

	Sum	Variance	Skewness	Kurtosis
CHOICE	1300.00000	0.19419	1.07608	-0.84370
COST1	948.05821	0.66362	1.07662	-0.094889
COST2	673.21353	0.32892	1.08975	-0.012521
TIME1	31142.17003	144.90227	0.34583	0.19316
SEX_V	634.00000	0.23674	-0.47829	-1.77469
NUM_PERS	3500.00000	1.27941	0.41946	0.34769
N_VEH HH	1595.00000	0.24774	-0.20150	-1.96322
WK_FPHJ	2113.00000	0.36971	0.98812	3.54665
OR_E_DEN	9833781.18284	2.31186D+08	2.33053	5.12899

	Median	1st Qrt	3rd Qrt	IQ Range
CHOICE	1.00000	1.00000	2.00000	1.00000
COST1	0.55344	0.32996	1.43975	1.10979
COST2	0.40359	0.23798	0.99509	0.75710
TIME1	30.24640	21.77750	37.80360	16.02610
SEX_V	1.00000	0.00000	1.00000	1.00000
NUM_PERS	3.00000	3.00000	4.00000	1.00000
N_VEH HH	2.00000	1.00000	2.00000	1.00000
WK_FPHJ	2.00000	2.00000	2.00000	0.00000
OR_E_DEN	2229.91504	868.76263	8560.10059	7691.33795

Correlation Matrix

	CHOICE	COST1	COST2	TIME1
CHOICE	1.00000			
COST1	-0.071887	1.00000		
COST2	-0.13288	0.99332	1.00000	
TIME1	-0.099739	0.38754	0.39659	1.00000
SEX_V	-0.036167	0.040962	0.042892	0.099932
NUM_PERS	0.27172	-0.096277	-0.11799	-0.050346
N_VEH_HH	0.044070	0.022786	0.025323	0.061501
WK_FPHJ	-0.081631	0.022818	0.031530	-0.0070274
OR_E_DEN	-0.015569	0.59996	0.59310	0.10082

	SEX_V	NUM_PERS	N_VEH_HH	WK_FPHJ
SEX_V	1.00000			
NUM_PERS	-0.045005	1.00000		
N_VEH_HH	-0.12745	0.28653	1.00000	
WK_FPHJ	0.075996	0.33935	0.28847	1.0000
OR_E_DEN	0.0058429	-0.033305	-0.0085583	0.0080311

	OR_E_DEN
OR_E_DEN	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	:	35690	2.2
CURRENT VARIABLE STORAGE	:	11524	

NON-WORK TRIP MODEL

TSP Version 4.3A

(10/26/95) DOS/Win 15MB
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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='OHdpt6.xls'), choice cost1 cost2
|      3  time1 time2 sex_v num_pers province
|      3  n_veh_hh wk_fphj or_e_den ;
|      4  logit(cond,nchoice=2) choice cost time | sex_v
|      4  province num_pers n_veh_hh wk_fphj
|      4  or_e_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-8)/y);
|     10  print y,x,@logl,rhosq,rhobarsq;
|     11  msd (all, corr, print) choice cost1 cost2
|     11  time1 time2 sex_v num_pers province
|     11  n_veh_hh wk_fphj or_e_den
|     11  ;
|     12

```

EXECUTION

Current sample: 1 to 12020

Equation 1
 =====

MIXED LOGIT ESTIMATION

CHOICE	FREQUENCY	PERCENT	
1	11059	92.0050	(COEFFICIENTS NORMALIZED TO ZERO)
2	961	7.9950	

Working space used: 336851

STARTING VALUES

	COST	TIME	SEX_V2	PROVINC2
NUM_PER2				
VALUE	0.00000	0.00000	0.00000	0.00000
0.00000				

VALUE	N_VEH_H2 0.00000	WK_FPHJ2 0.00000	OR_E_DE2 0.00000	C2 0.00000
F= 8331.6	FNEW= 3231.8	ISQZ= 0	STEP= 1.0000	CRIT=
9095.4				
F= 3231.8	FNEW= 2562.5	ISQZ= 0	STEP= 1.0000	CRIT=
1085.5				
F= 2562.5	FNEW= 2393.9	ISQZ= 0	STEP= 1.0000	CRIT=
283.50				
F= 2393.9	FNEW= 2372.5	ISQZ= 0	STEP= 1.0000	CRIT=
38.973				
F= 2372.5	FNEW= 2372.0	ISQZ= 0	STEP= 1.0000	CRIT=
1.0193				
F= 2372.0	FNEW= 2372.0	ISQZ= 0	STEP= 1.0000	CRIT=
0.80511E-03				
F= 2372.0	FNEW= 2372.0	ISQZ= 0	STEP= 1.0000	CRIT=
0.53538E-09				

CONVERGENCE ACHIEVED AFTER 7 ITERATIONS

14 FUNCTION EVALUATIONS.

DEPENDENT VARIABLE: CHOICE

LOG OF LIKELIHOOD FUNCTION = -2372.00
NUMBER OF CASES = 12020
NUMBER OF CHOICES = 24040

Parameter	Estimate	Standard Error	t-statistic
COST	-.843160	.099433	-8.47971
TIME	-.015718	.407186E-02	-3.86006
SEX_V2	-.392528	.079958	-4.90917
PROVINC2	-.656918	.107708	-6.09908
NUM_PER2	.139512	.033758	4.13267
N_VEH_H2	-2.57456	.084499	-30.4683
WK_FPHJ2	.332848	.050462	6.59597
OR_E_DE2	.250771E-04	.307192E-05	8.16332
C2	.590396	.163958	3.60089

Standard Errors computed from analytic second derivatives
(Newton)

Class	Name	Description
-------	------	-------------

LIST	@LHV	1 members
	@RNMS	9 members

	Y	X	@LOGL	RHOSQ
RHOBARSQ				
Value	-8331.62911	11919.25068	-2372.00377	0.71530
0.71434				

Results of Covariance procedure

Number of Observations: 12020

	Mean	Std Dev	Minimum	Maximum
CHOICE	1.07995	0.27123	1.00000	2.00000
COST1	0.50649	0.49476	0.00085500	2.92550
COST2	1.44289	0.29106	1.35000	3.10000
TIME1	10.29577	8.18979	0.00000	60.16000
TIME2	28.65236	20.19486	0.00000	163.39000
SEX_V	0.45682	0.49815	0.00000	1.00000
NUM_PERS	3.04135	1.32624	1.00000	9.00000
PROVINCE	0.21955	0.41396	0.00000	1.00000
N_VEH_HH	1.43228	0.58505	0.00000	2.00000
WK_FPHJ	1.56431	0.96659	0.00000	6.00000
OR_E_DEN	4950.63780	11373.69029	2.16020	65606.38281

	Sum	Variance	Skewness	Kurtosis
CHOICE	12981.00000	0.073564	3.09792	7.59836
COST1	6088.03467	0.24479	1.35332	1.40623
COST2	17343.49024	0.084719	4.56899	22.58430
TIME1	123755.20642	67.07268	1.36464	2.12508
TIME2	344401.35748	407.83222	1.80688	4.98903
SEX_V	5491.00000	0.24816	0.17338	-1.97027
NUM_PERS	36557.00000	1.75892	0.49970	-0.029216
PROVINCE	2639.00000	0.17136	1.35519	-0.16350
N_VEH_HH	17216.00000	0.34228	-0.46126	-0.69357
WK_FPHJ	18803.00000	0.93429	0.30967	0.67387
OR_E_DEN	5.95067D+07	1.29361D+08	3.65116	13.95724

	Median	1st Qrt	3rd Qrt	IQ Range
CHOICE	1.00000	1.00000	1.00000	0.00000
COST1	0.31450	0.12351	0.72800	0.60449
COST2	1.35000	1.35000	1.35000	0.00000
TIME1	8.09000	3.99000	14.46750	10.47750
TIME2	24.05000	15.46447	36.46750	21.00304
SEX_V	0.00000	0.00000	1.00000	1.00000
NUM_PERS	3.00000	2.00000	4.00000	2.00000
PROVINCE	0.00000	0.00000	0.00000	0.00000
N_VEH_HH	1.00000	1.00000	2.00000	1.00000
WK_FPHJ	2.00000	1.00000	2.00000	1.00000
OR_E_DEN	869.06232	348.04758	2826.68506	2478.63748

Correlation Matrix

	CHOICE	COST1	COST2	TIME1
CHOICE	1.00000			
COST1	0.15790	1.0000		
COST2	-0.023422	0.34313	1.00000	
TIME1	0.041878	0.75988	0.43912	1.00000
TIME2	-0.029101	0.60648	0.53837	0.84165
SEX_V	-0.049883	0.045174	-0.0015534	0.055498
NUM_PERS	-0.073261	-0.044425	0.027251	-0.0089003
PROVINCE	-0.062239	-0.040361	-0.085037	-0.019428
N_VEH_HH	-0.34418	-0.0066272	0.096779	0.076428
WK_FPHJ	-0.057538	0.061508	0.026806	0.079033
OR_E_DEN	0.21948	0.51791	0.031957	0.13673

	TIME2	SEX_V	NUM_PERS	PROVINCE
TIME2	1.0000			
SEX_V	0.045537	1.0000		
NUM_PERS	0.030411	-0.0027757	1.00000	
PROVINCE	-0.021525	0.0066358	-0.00092698	1.00000
N_VEH_HH	0.10954	0.013518	0.34165	0.0017913
WK_FPHJ	0.071872	0.022701	0.46091	0.00099545
OR_E_DEN	-0.024498	0.015477	-0.065932	-0.031117

	N_VEH_HH	WK_FPHJ	OR_E_DEN
N_VEH_HH	1.0000		
WK_FPHJ	0.38325	1.0000	
OR_E_DEN	-0.071501	0.0055718	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 :    529720     4.2
CURRENT VARIABLE STORAGE :    145752

```