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FACTORS AFFECTING PUBLIC TRANSIT RIDERSHIP

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**A Thesis Submitted to
the Faculty of Graduate Studies and Research
in Partial Fulfilment of the Requirements
for the Degree of**

Master of Engineering

**Department of Civil and Environmental Engineering
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ABSTRACT

The shrinking road space due to traffic congestion is a major problem being felt by all. Both supply of infrastructure as well as demand management strategies seem to work to a certain extent to combat this problem. But to achieve any tangible result, it is necessary to ensure that a sustained effort continues on both these fronts. One such effort is to promote ridership of High Occupancy Vehicles (HOV) like bus during peak periods of travel. For example, each fully occupied bus during peak periods replaces at least 40 to 60 single occupancy cars from the streets, thereby releasing road space. But the real challenge lies with the question of how this switch from car to bus can be made possible. Some of the important factors that determine this are: the level of service (LOS) , fare, information on time of arrival and departure, safety and security. However, a behavioural study, based on OC Transpo's 1995 attitude survey questionnaire elicited a large number of responses that are useful. But such questions and responses may be tainted with repetitions and correlation. Therefore, a factor analysis approach has been taken up in this study to remove such anomalies and to produce clusters of uncorrelated factors using the large number of observed variables. The result is a significantly reduced number of underlying factors. For example, from 47 observed variables only 7 underlying factors have emerged and are interpreted. These seven factors have been used as independent variables with ridership as the dependent variable in an analysis using logistic regression. The odds of ridership occurring has been explained by means of the regression model that emerged. To this model conventional socio-economic variables like age, education, occupation, income, sex etc. have been added to see the odds of ridership happening or not.

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To start graduate studies at this juncture in my life, 30 years after graduation, had been an emotionally draining, but at the same time thrilling and exciting experience. I had been sitting in the graduate class with my classmates who are about half my age but who, nevertheless, treated me well and accepted me in their midst with unadulterated friendliness.

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TABLE OF CONTENTS

ABSTRACT.....	iii
ACKNOWLEDGMENT	iv
TABLE OF CONTENTS	v
LIST OF FIGURES	x
LIST OF TABLES	xi
LIST OF APPENDICES	xiii
GLOSSARY OF ACRONYMS & SYMBOLS	xiv

CHAPTER 1 : INTRODUCTION

1.0 Background -----	1
1.1 General Problem Identification	2
1.2 Defining the Problem	4
1.3 Ottawa Scenario	10
1.4 Traffic Congestion	13
1.5 Solution Generation.	15
1.5.1 Short Term Solution: Supply Side.	15
1.5.1.1 Transportation Systems Planning	16
1.5.1.2 Trip Generation	17
1.5.1.3 Trip Distribution	18
1.5.1.4 Modal Split	19

1.5.1.5 Trip Assignment	20
1.5.1.6 Supply of Road Space	20
1.5.2 Long Term Solution	21
1.5.2.1 Demand Management	21
1.6 Factors Analysis: A Step Towards Understanding Ridership	23
1.6.1 Solution Generation.	24
1.6.2 Impact of the Factors on Ridership	26
1.7 Study Plan	28

CHAPTER 2: CURRENT KNOWLEDGE

2.1 Current State of Knowledge	30
2.1.1 Literature Review	30
2.1.2 OC Transpo Operations	35
2.2 Performance of Bus Services	36
2.2.1 Urban Transport : Key Performance Indicators	36
2.3 OC Transpo's Attitude Survey	42
2.3.1 Weighted Frequency Method	42
2.3.2 Recommendation	47
2.4 Application of Statistical Methodologies	48
2.4.1 Human Values as Factor	48
2.4.1.1 Methodology	48
2.4.1.2 Findings	49

2.4.1.3 Recommendation	50
2.4.2 Behavioral Studies: Relating to Traffic Engineering	50
2.5 Factor Analysis Rationale	52
2.5.1 Importance of the Knowledge of Factors	54
2.5.2 What is Known About Factors ?	55

CHAPTER 3 : DATA AND METHODOLOGY

3.1 Survey Data: 1988-1995	58
3.2 Reliability of Data	60
3.3 Alternate Forms of Analysis	61
3.4 Methodology of Analysis	63
3.5 The Critical Ratio or T-Test	65
3.6 Sampling	65

CHAPTER 4 : CONCEPTUAL FRAMEWORK AND EXAMINING THE UNDERLYING DIMENSIONS OF RIDERSHIP

4.1 Factor analysis: Why and How	67
4.2 Hypotheses	70
4.2.1 Formulation of Hypotheses	70
4.3 Scale Development	73
4.3.1 Scale Reliability	73

4.4 Examining the Underlying Dimensions of Ridership	74
4.4.1 Sample Adequacy	74
4.4.2 Factor Extraction	76
4.4.3 Communality	76
4.4.4 Eigenvalues and Scree Plot	77
4.4.5 Factor Loadings	83
4.5 Final Solution	83
4.5.1 Factor Rotation	83
4.5.2 Orthogonal rotation.....	85
4.5.3 Output : Varimax Rotation	89
4.5.4 Oblique rotation	89

CHAPTER 5 : DESCRIPTIVE RESULTS

5.1 Factor Analysis: Correlation Matrix: 1995: Correlation Matrix	90
5.2 Rotated Factor Matrix	90
5.3 Varimax Rotated Solution	91

CHAPTER 6 : FACTORS INFLUENCING FREQUENCY OF USING BUS

6.1 Ridership with Factors or Hypothetical Variables	106
6.1.1 Logistic Regression Models Using Factors	107
6.1.2 Goodness of Fit of the Model	109

6.1.3 Determining the Relative Importance of the Variables	117
6.2 Models with Various Socio-Economic Variables	118
6.3 Discussions	121
6.4 Discussions with Socio-economic Variables	123
CHAPTER 7 : CONCLUSION AND RECOMMENDATIONS	
7.1 Summary and Conclusions	126
7.2 Recommendations.	130
REFERENCE	133
APPENDICES	

LIST OF FIGURES

Figure 1.0	Flow Chart of Study Plan	09
Figure 4.1	Factor Scree Plot	82

LIST OF TABLES

Table 1-1	Traffic on Ottawa's Roadways	12
Table 1-2	Modal Utility Equations: AM Peak	19
Table 1-3	Modal Utility Equation: PM Peak	20
Table 2-1	Private and Public Bus Service Operating in the same city, World Bank Survey : OC Transpo Data.	37
Table 2-2A	Operational Performance Indicators: World Bank Study	39
Table 2-2B	Quality of Service Indicators: World Bank Study	41
Table 4-1	Typical Factor Example: Sorted, Rotated and Blanked	68
Table 4-2	Initial Statistics: From actual Output	78
Table 4-3	Unrotated Factor Matrix	80
Table 4-4	[Eigenvalues ≥ 1] Final Statistics	81
Table 4-5	Factor Extraction: Varimax Rotated Solution	87
Table 5-1	Factor 1 Cluster	92
Table 5-2	Factor 2 Cluster	95
Table 5-3	Factor 3 : Cluster	96
Table 5-4	Factor 4: Cluster	97
Table 5-5	Factor 5 : Cluster	98

LIST OF TABLES continued

Table 5-6	Factor 6 : Cluster of observed variables:	100
Table 5-7	Factor 7 : Cluster of observed variables (Combined)	101
Table 5-8	Factor 10 : Cluster of observed variables	103
Table 5-9	Interpreted Factors and Labels	104
Table 6-1	Model 1: Ridership with Bus Information	109
Table 6-2	Model 2: Model 1 plus On-Street Service	110
Table 6-3	Model 3: Model 2 plus Customer Service	111
Table 6-4	Model 4: Model 3 plus Cleanliness	112
Table 6-5	Model 5: Model 4 plus General Attitude	113
Table 6-6	Model 6: Model 5 plus Safety on Transitway	114
Table 6-7	Model 7: Model 6 plus Safety en Route	115
Table 6-8	Model 8: Model 7 plus Reduced Fare	116
Table 6-9	Combined Models: Model 8 plus Socio-Economic Variables	120

LIST OF APPENDICES

APPENDIX A : SPSS Programming for Factor Analysis	140
APPENDIX B : Correlation Matrix	147
APPENDIX C : Miscellaneous SPSS Output	153
APPENDIX D : 1995 Attitude Survey Questionnaire (OC Transpo)	156

GLOSSARY OF ACRONYMS

AADT	Average Annual daily Traffic
Aam _{rmoc}	Trips attracted during AM peak at the RMOC area
ATIS	Advanced Traffic Information System
ATMS	Advanced Traffic Management System
AVCS	Advanced Vehicle Control System
CBD	Central Business District
GPS	Global Positioning System
ELF	Employed Labour Force
HHLD	Household
HOV	High Occupancy Vehicle
INFO	Information Services relating to Bus
ITS	Intelligent Transportation System
IVTT	In Vehicle transit Time
KMO	Keiser Meyer Olkin value
LOS	Level Of Service
MIT	Massachussetts Institue of Technology
OC TRANSPO	Ottawa Carleton Regional Transit Commission
OVTT	Out of Vehicle transit Time
Pam _{rmoc}	Production of trips during AM peak at RMOC area
POP _{x-y}	Population of x-y age cohort

continued GLOSSARY OF ACRONYMS

ROW	Right of Way
RMOC	Regional Municipality of Ottawa Carleton
SOV	Single Occupancy Vehicle
TAC	Transportation Association of Canada
TRWY	Transitway
TV	Television
Var xx	Variable xx

GLOSSARY OF SYMBOLS

LOS A	Free Flow condition
LOS B	Stable Flow: Speed restricted slightly by traffic
LOS C	Stable Flow : Speed controlled by traffic: used for urban hwy design
LOS D	Approaching Unstable Flow
LOS E	Unstable flow
LOS F	Forced Flow
AT	Auto Travel Time
TT	Transit Travel Time
$f(R_{ij})$	A functional measure of spatial separation between zones i and j
T_{ij}	Total trips from origin i to destination j
O_i	Total trips produced by origin i
D_j	Total trips attracted to destination j
$e(u)$	Exponential function of Utility, U_1 , U_2 etc.
$P(m_1)$	Probability of auto driver, auto passenger or transit passenger modes

CHAPTER 1

INTRODUCTION

1.0 Background

Since time immemorial when dinosaurs roamed the pristine earth, there were no human beings to inhabit the planet. The giant creatures depended on their feet to transport themselves for food and shelter and did not have the intelligence or capability to do better until their mysterious extinction in an apocalyptic disaster sixty-five million years ago. Eons passed when a new species, believed to have evolved from apes, emerged as the human beings and started dominating the earth. These human beings also used their feet to take them from one place to another. But evolving into modern men and women, they did even better by using their brain as well as hands to make tools and ultimately to develop the machines to revolutionize the concept of transporting themselves from one place to another. Today, with the help of the machine we, the modern human being, are striving to go from one place to another in the shortest possible time with the best possible comfort and convenience. The modern human being has invented the railway, tram, metro, bus and the automobile which took over as the principal mode of transportation. The world of transportation eventually covered sea and air apart from land based transportation modes. Moreover, the twentieth century saw the breakthrough in all these three fields of transportation and even space travel became a reality to add another dimension to the travel mode.

From this general transportation scenario, if we zoom into urban transportation in particular,

we find highways, arterials, service roads criss-crossing a modern metropolis and on these thoroughfare cars, buses, trucks etc. are moving briskly in all directions at all times of day and night. It may appear that we have achieved great progress and have fulfilled our goal of moving from one place to another virtually unimpeded. But this euphoria is short lived as we eventually find out that at certain times or at certain places the urban roads are at a virtual standstill with cars, buses and various other modes of transportation throbbing and pulsating in a traffic gridlock, creating traffic congestion, sometimes of epic proportions. To be caught up in such congestion is a nightmare with anxiety, frustration and delay wreaking havoc. Unless we find ways and means to overcome this malaise, transportation systems will become increasingly inefficient.

1.1 General Problem Identification

To be stuck in traffic congestion during morning and afternoon hours in an urban highway is a common experience for most of us. The bumper to bumper traffic, moving with frustratingly crawling pace, occasionally coming to a standstill in a traffic gridlock are the common stories being repeated everyday. The implications are far reaching and adverse. The resulting delays cause important appointments to pass by or personal emergencies to remain unattended. For many it may even be worse with missing flights or trains on way to very important business. The total effect is that society suffers an economic as well as a social output loss.

Thus congestion has been a major concern to our society. It has been identified as a major problem by the transportation planners as well and strategies have been devised to minimize its adverse impacts. For example, a comprehensive solution of traffic congestion on the supply side include building of new roads or new lanes and on the demand side include the Transportation Demand Management (TDM) strategies such as promoting high occupancy vehicle use. However,

in spite of numerous other strategies, as we shall be discussing later in this chapter, congestion still persists. What then is the problem? The answer lies in the fact that none of these strategies seem to be fully effective or easy to implement. For example, to provide additional road space by infrastructure expansion proves ineffective in the long run. Though this strategy produces immediate relief from congestion, in a short period of time congestion returns to the expanded facility in full force. This is because of the traffic being induced by the expanded and improved facility resulting in a fresh outbreak of congestion. *This phenomenon has been attributed to the four principles, namely: (1) The Principle of Triple Convergence. (2) Dual Swamping by Growth. (3) The Imperviousness to growth to Local Public Policies. (4) One Hundred Small Cuts [Downs, 1992].*

The principle of triple convergence nullifies the effect of new and improved facilities that are designed to combat congestion due to spatial, temporal as well as modal convergence. The effort to reduce congestion by building a road may become useless as the new facility induces an increase in car ownership. The new improved facility also induces a commercial and residential boom which increases traffic load. The policy of curbing new growth to contain congestion has been proved to be counterproductive in the long run as it affects employment related benefits to the area under such policy.

In summary, although a strategy of building new facilities, a **supply policy**, can facilitate combating the congestion problem in the short run, it is inefficient and ineffective in the long run. The problem of congestion cannot be solved with a single policy or action or measure. It must be confronted from all possible directions, both from supply and **demand management** perspectives. The supply of infrastructure may be well suited in the short run, but if the situation deteriorates, the strategy of implementing suitable demand management policies should be undertaken.

Therefore, in the long run, the strategy of demand management has been conceived of as the appropriate approach to a solution which involves, among other things, a subtle intervention into the demand side of the traffic scenario. One such demand management strategy is to encourage people to travel by bus during rush hours instead of cars. But how are the potential riders encouraged to do so ? This will be dealt with later. First, we proceed with illustrating the various demand management strategies in general.

1.2 Defining the Problem

There had to be something missing from the definition of the transportation systems planning process because there is a huge gap between the actual peak period traffic volume generated and the volume predicted. The road space that has been designed for 20 to 25 years at a certain level of service (LOS), predicting peak hourly traffic volumes, becomes congested in a matter of a few years. Therefore, in the transportation system planning the problem has now been redefined to include demand management strategies in addition to the supply of road space according to the predicted demand volume only. Numerous strategies and remedial measures have been devised from the demand management perspective. However, the scope of this research is limited to only one of those numerous remedial measures for peak period congestion relief, namely, finding of the factors that increase the odds of bus ridership to occur.

The objective of this research, therefore, is to identify the factors that affect public transit ridership. This objective has been met through analyzing the direct responses from a representative sample of the population of Ottawa-Carleton region.

The constraints in defining the problem of congestion originate from the 'vicious cycle' scenario of supply and demand that exists in the transportation system planning process itself.

Therefore, this problem had to be redefined by the transportation system planners to include transportation demand management strategies to make it a fully defined process.

There has been a major departure from conventional input in this research. Instead of using quantitative data as used in the origin-destination survey, this research analysis has used a response oriented database which translates attitude into behaviour patterns through interpreted factors that originate from the people in the community. In fact the outputs are the factors that are the offsprings of behavioural responses.

The value function in this study cannot be quantified through conventional approach. The scale is qualitative, probabilistic and explanatory in nature. No dollar value could be assigned to the qualitative scaling technique used in behavioural research studies as in social sciences. These are 'rank ordered' according to their relative importance measured statistically.

The 'degree of fit' of the model has been statistically obtained, for example, from the Pseudo R square values as well as R values of the logistic regression models.

In generating the solution, this research defines the alternative as "Do Nothing" which means allowing for a supply of road space according to the demand of traffic volume generated. We know the dangerous consequences of do nothing strategy from the resulting peak period congestion if such an option is chosen. The other options are transportation demand management strategies that have been discussed in this thesis.

In the analysis phase, we have formulated hypotheses, calibrated logistic regression models, explained the probable odds of ridership occurring due to individual factors in the model. The postulated hypotheses have been accepted or rejected according to the impacts they produce.

Defining the problem in terms of its objectives, inputs, outputs, constraints and value functions are very important elements of solving problems. The well known example of defining a problem as “crossing the bridge” [Braaksma, J.P, 1990] instead of a broader and comprehensive definition of “crossing the river” may serve as an example. If the problem is defined as river crossing, then jumping into a solution instead of looking into alternative possibilities may be avoided. For example, building a tunnel, taking a hovercraft or crossing by ferry may offer anyone of them a better solution. When we confront the problem of congestion, a question naturally comes to mind as to why this happens. However, it did not take long for the transportation system planners to identify the problem. They concluded that it lies with the incomplete definition of the transportation systems planning (TSP) which has defined only a part of the problem. It has not taken into account the behaviour of the people that use transportation. The design of road space at a certain level of service for a long period of 20 to 25 years could not be sustained after only a short period because of the principles of triple convergence which are triggered mostly by deeply rooted behavioural patterns of the people. Therefore, in a bid to come out of the never ending loop of supply and demand, the transportation planners found out the demand management strategies. These strategies will be discussed along with the TSP process in this chapter in order to put into perspective, the complete and comprehensive definition of the problem and to suggest solution to one of the strategies already recognized by the planners.

To switch from car to bus, one strategy would be to make car use more expensive. It is an indisputable fact that a single occupancy vehicle, during peak hours, keeps four other seats empty and takes unnecessary road space. These SOV drivers should pay the equivalent social price in real dollar value for such misuse of road space. One study in California’s San Francisco Bay [Bay Area

Economic Forum] has estimated that if a single car enters the highway during peak period, it will create an additional delay of one hour to the entire traffic in the congested route. The notion of introducing Peak-Hour road pricing came as a demand management strategy under such circumstances. Intervention may include also shifting of peak hours by staggering the work hours. Work-at-home strategy in this era of computer and world wide web is a feasible option and should contribute towards lessening traffic congestion. Attempts have been made in cities like Singapore to allow cars with odd or even registration numbers to ply on alternate days. The party not allowed driving on a particular day may arrange ride-share or use public transit bus. The raising of gasoline tax or car registration fees, though politically unpopular and difficult to implement, are also included in the strategies to deter car use. Parking costs in city core may be raised to discourage car users in going to work in their cars. The strategies discussed above are all designed to discourage car use during peak periods. But this should also be matched with genuine efforts to attract people to bus. This is a difficult task and to do it requires unfolding the underlying factors that impact upon ridership of transit bus.

It is undoubtedly a formidable task to change people's perception of comfort and convenience in driving a car alone instead of using the transit service. Also, people will not be attracted to a public transit service which does not come up to the expected service standards. Any intervention to persuade people to ride public transit buses should be matched with raising the level of service (LOS) standards so that the shift to public transit is spontaneous. The responses obtained from a comprehensive questionnaire served on a cross section of the target population, may closely reflect peoples' perception and attitude towards bus ridership. These responses are in fact the observed variables in a large database and appropriate analysis can bring out the underlying factors

that could be used to formulate strategies for making urban transit buses popular. Our problem will be to focus on transit bus ridership and find out these factors. A systematic study of factors affecting public transit ridership calls for the use of scientific methods. **Figure 1** presents the flow chart of such a study plan.

With the myriad aspects of the congestion management problems identified and the particular strategy defined, we can now turn our attention to the congestion scenario in Ottawa because our database to be analyzed involves Ottawa-Carleton residents. This will enable us to understand the more specific aspect of the problem.

FIGURE 1:
THESIS RESEARCH PLAN

1.3 Ottawa Scenario

Ottawa is the nation's capital and a thriving metropolis of medium size. On its highways, service roads and arterials, a stream of traffic flows all round the year. In the course of a typical week day, this flow varies from light to heavy depending upon the time of day. Though the flow is unimpeded most of the time, twice in the day the traffic grows denser and denser until it approaches congestion and sometimes gridlock. This phenomenon is commonplace in most of the vibrant urban areas of North America. The pattern is similar because the historical evolution of the cities in North America are similar, with a central business district (CBD) connected to the sprawling suburbs by sleek highways. Ottawa's central business district is connected by highway 417 or Queensway to the suburbs of *Orleans* and *Kanata* in the East and West ends respectively and residential areas like *Gloucester*, *Nepean* and *Barrhaven* lying in-between. Most of the people live in these suburbs and go to the city core for work and business. The city arterial within the residential areas mentioned are also congested with a Level of Service (LOS) at forced flow conditions as shown in Table 1.1. During the morning hours of 7:00 am to 9:30 am parts of highway 417 and highway 17, that pass longitudinally through the city of Ottawa, are found to be congested with heavy traffic. Similar patterns can be seen in the afternoon hours from 3:30 pm to 6:00 pm. On an hourly basis the AM peak hour has been defined to be from 7:30 to 8:30 A.M. and the PM peak hour has been determined to be from 4:00 to 5:00 PM. This peak period traffic is generated mainly because people go from their home to work at about the same time to the CBD. The reverse flow occurs from the places of work (CBD) to the respective homes, shopping malls or the neighborhoods in the evening hours. These flows, concentrated in narrow time spans of AM and PM peak periods, are a source of considerable concern because congestion

occurs during these periods mainly. A variety of modes occupy the road space, namely, private cars, vans, urban transit buses, trucks, motor bikes and bicycles etc. but most of the traffic stream consist of cars. In the absence of metro or light rail transit in Ottawa , transit bus service is the main public transit. But every year the trend is such that increasing number of cars, mostly single occupancy vehicles (SOV), are coming onto the traffic stream with the transit bus losing ground to the private cars. The comfort, convenience, freedom and speed of operating cars on a road have made cars to thrive as a popular and attractive mode. Therefore, cars are on the streets accounting for 80% of traffic according to some studies, creating traffic jams and delays. This situation is not uncommon. Table 1.1 shows the 1981 conditions of some of the city streets:

Table 1.1 - TRAFFIC ON OTTAWA'S ROADWAYS

(Environmental Assessment : highway 416)

Name of Roadway	1981 A A D T	Number of Lanes	Level Of Service Peak Hour
Prince of Wales Drive	18000	2	F (Forced Flow)
Fisher Avenue	12100	2	F (Forced Flow)
Merivale Road	39100	4	F (Forced Flow)
Woodroffe Avenue*	18900	2	F (Forced Flow)
Greenbank Road	28150	4	D-E (Unstable Flow)
Moodie Drive	14750	4	C (Stable Flow)

Source: Environmental Assessment of Highway 416, 1985, RMOC

* Woodroffe Avenue has since been widened to 4 lanes with corresponding LOS improvement.

Studies by the US Federal Highway Administration have revealed that from the base year of 1989, in spite of planning highway lanes with sophisticated forecasting techniques, congestion on cities will be rising between 200% to 400% by the year 2005 AD. However, even if Ottawa has a smaller traffic growth potential compared to the larger metropolis like Toronto and other large cities in the USA, the roads in this city are nevertheless getting congested. Delays, environmental pollution, accidents and loss of fuel and energy are the outcome of such congestion. The condition for the city of Ottawa is also critical so far as the future traffic conditions are concerned. The Average Annual Daily Traffic (AADT) for 1981 and Level of Service (LOS) on some of Ottawa's major roadways shows forced flow conditions on some of the major roads [MTO Highway 16 Study, 1985]. The measure of LOS has been defined according to the range of A to F. LOS A denotes free flow conditions, whereas, LOS F denotes forced flow conditions and is tantamount to traffic congestion and deadlock. Roadways have not been considerably expanded since 1981 and it is highly unlikely that traffic conditions have improved. In fact, they may have deteriorated.

1.4 Traffic Congestion

The congestion scenario in Ottawa, as depicted above, is not unique. It is a world-wide phenomenon and results in huge financial as well as environmental losses. According to a study in 39 US cities in 1987, congestion related losses have been calculated to the tune of 41 billion dollars. There are studies in Europe, North America and Asia to understand the trend and impact of congestion. The findings suggest that congestion increases by leaps and bounds and the resulting costs and implications are tremendous. Apart from the material loss, the behavior and mood of the people are also affected due to congestion related delays resulting in *'negative impact on*

productivity at work and on personal relationship' [Papacostas, 1993]. Therefore, it reinforces the contention that there is a necessity to combat traffic congestion effectively so that its impacts are minimized. But to reduce traffic congestion, especially by means of making people switch from cars to bus is not an easy task. According to a study by the Brookings Institute, the think tank based in Washington D.C., “ *The main causes of peak-hour traffic congestion are deeply rooted in American desires and behavior patterns. Some are even built into the basic physical and social structures of US metropolitan areas. Policy makers hoping to reduce congestion therefore must persuade millions of Americans to alter some of their most cherished social goals and comfortable personal conduct.* ” [Downs, 1992]. The same argument should apply to cities in Canada including this city of Ottawa. It is not practical to provide dedicated traffic lanes for actual demand during peak hours. The costs will be enormous, the infrastructure expansion cannot be done indefinitely due to Right of Way (ROW) limitations, natural environment concerns and scarce resources like money and material. Therefore, there has to be a balance between the road space provided and the traffic generated. Normally, transportation system planning uses the four stage process to derive the equilibrium traffic volume in a network.

The design of the road space is determined from the volume of traffic generated and predicted from the calibrated models. Even though it is assumed that the transportation planning models yield reasonably acceptable predictions of traffic volumes, it should be borne in mind that these volumes are generated through proxy variables like population, employed labor force and number of dwelling units in the area under study. The congestion in peak periods is not understood through these models as they do not take into account peoples' behaviour patterns that lead to the choice of a mode of travel. Therefore, we see a chronic imbalance between transportation demand

and the infrastructure space provided through the conventional process. In an effort to understand and confront this problem, we are adding the dimension of behavioral studies towards solving a particular aspect of the demand management strategy, without jeopardizing the transportation planning process itself which is being used by the transportation planners all over the world.

1.5 Solution Generation

The use of transit by a consumer or user is a matter of choice depending upon *'(1) what alternative choices consumers perceive. (2) What consequences of these alternatives they consider important (3) How they make their choices from among the perceived alternatives.'* [Mannheim, 1979].

The answer to the above questions can be obtained by means of analysis of **user behaviour**. Unlike engineering problems, this study of human behaviour involves a blend of engineering, statistics, economics and the attitude traits of individuals. Only engineering number crunching and economic analysis of costs and contingencies cannot solve problems like congestion. To influence an individual's choice of transit mode or to promote the ridership of transit buses, transportation planners should widen their vision to include behavioural studies. The *generic transportation vision*, formulated by the Transportation Association of Canada which goes a long way to guide the future direction states that *'to provide transportation systems that better serve the economic and social needs of urban residents and protect the environment.'* and that should be economically competitive, socially desirable, environmentally friendly to ensure greater mobility, easier access to a wider choice of transportation options while recognizing, economic realities and the constraints of the existing urban structure. [TAC, 1993].

1. 5.1 Short Term Solution: Supply Side

Urban congestion could be reduced by expansion of transportation systems from the perspective of:

1. Increasing the capacity of existing facilities by means of :

- broadening city streets - widening of existing roads.
- using one way street systems.
- prohibiting parking and stopping in peak hours.
- rapid removal of accidents.
- improving highway maintenance.

2. Building new transportation facilities

- building new off-road transit systems and or expanding existing ones.
- building new roads without HOV lanes.
- adding HOV lanes to existing facilities.

The above solutions, though meant for long term, are in fact short term solutions due to factors discussed earlier in this chapter.

1.5.1.1 Transportation Systems Planning:

The supply of infrastructure and other related options as described above, are carried out by means of a process called transportation systems planning. But in transportation systems planning (TSP) the literature has been entirely devoted to deriving the equilibrium traffic flow volumes in the network in a four stage predictive model. The following models have been formulated by (Delcan,1993) on behalf of TRANS, the joint technical committee on Transportation Systems Planning (TSP) directed by Dr.Louis Shallal and participated by Ottawa-Carleton Region, OC Transpo, STO, MTO, Transports Quebec, NCC. This will generate a comprehensive understanding

of the systems planning process of road space design. The Transportation Planning Process involves the following stages:

1. Trip Generation 2. Trip distribution 3. Modal Split 4. Trip Assignment

The models are calibrated from data collected for : Total Population, Age cohorts, Employed Labor Force, Dwelling Units, Enrollment in Post Secondary Schools, Shopping Center Leasable Floor Area, Origin Destination (OD) survey, Trip Production & Trip Attraction, Auto as well as Transit travel time and distance between Origin and Destination.

1.5.1.2 Trip Generation

From the OD survey data the trip attraction and trip production models can be calibrated using sophisticated statistical regression models.

(1) Home- to-Work trip Generation Equation in the AM peak period:

$$P_{am_{RMOc}} = (0.3051 * POP_{15-24} + 0.4319 * POP_{26-44} + 0.3553 * POP_{45-64}) * ELF_{future} / ELF_{RMOc}$$

where, $P_{am_{RMOc}}$ = Production of trips during AM peak at the RMOc area.

POP_{x-y} = Population for x-y age cohort ELF = Employed Labor Force

(2) Work-to-Home trips Generation Equation in the PM peak period:

$$A_{am_{RMOc}} = (0.3731 * POP_{15-24} + 0.2606 * POP_{26-44} + 0.1977 * POP_{45-64}) * ELF_{future} / ELF_{RMOc}$$

where, $A_{am_{RMOc}}$ = Trips attracted during AM peak at the RMOc area.

POP_{15-24} = Population for x-y age cohort. ELF = Employed Labor Force

These models are predictive ones with number of trips by households gathered through survey procedures.

1.5.1.3 Trip Distribution

Differentiated by trip purposes, the trip distribution models may be formulated through gravity model calibration using the origin destination trips generated. The generalized cost function includes inter zonal auto travel time and auto travel distance. It is expressed through an exponential function derived as follows:

$$f(R_{ij}) = e^{-f(AT)} + e^{-f(TT)}, \quad \text{where,}$$

$$R_{ij} = (AT_{ij} + 4AD_{ij}) / 5$$

$$At_{ij} = \text{auto times between zones I and j} \quad Ad_{ij} = \text{distance between zones I and j}$$

$$AT = \text{Auto travel time} \quad \text{And} \quad TT = \text{Transit travel time}$$

The typical trip table from the OD survey data is derived on origin destination basis by the relation:

$$T_{ij} = O_i D_j f(R_{ij}) / \sum_j A_j f(R_{ij}) \quad \text{where,}$$

T_{ij} is the total trips from origin I to destination j.

O_i is the total trips produced at the origin I.

D_j is the total trips attracted to destination j.

R_{ij} is a measure of inter zonal impedance between I and j.

[PR Stopher and AH Meyburg, Urban Transportation Modeling and Planning, Lexington Books,1975,p143}

The observed and simulated trips are compared for the two cases of generalized cost functions in addition to trip generation models. Although, the observed screen line trips are not distinguished by purpose, they indicate the goodness of fit for the distribution models.

1.5.1.4 Modal Split

The next step, after trip generation and trip distribution, is the modal split. The focus of interest is the AM and PM peak period work trips. The split in individual modes are determined from the Logit model through probability of Auto Driver, Auto Passenger and Transit Passenger trips. These models are as follows:

$$P(m_1) = \frac{e^{(U_1)}}{e^{(U_1)} + e^{(U_2)} + e^{(U_3)}} \quad [\text{Equation 1.1}]$$

Where, $P(m_1)$ = Probability of a person choosing mode alternative 1.

U_1, U_2, U_3 = Utility equations for modes 1, 2 and 3 respectively. These utility equations are each functions of trip cost, in-vehicle-travel-time (IVTT), out-of-vehicle-travel-time (OVTT), number of vehicles in the household, transitway proximity etc. generalized into a cost function. As an example, the calibrated models, using equilibrium modeling software with the 1986 OD survey data for the Ottawa-Carleton region, are:

Table 1.2 : MODAL UTILITY EQUATIONS : am PEAK PERIOD

U_{driver}	$= -0.5472 - 0.5691 \times \text{cost-a} - 0.0161 \times \text{IVTT-a} + 0.7520 \text{ numveh}$
U_{pasngr}	$= -2.282 - 0.5691 * \text{cost-p} - 0.0161 * \text{IVTT-a} - 0.0261 * \text{OVTT-a} + 0.4529 * \text{numveh}$
U_{transit}	$= -0.5691 * \text{cost-t} - 0.0161 * \text{IVTT-t} - 0.0261 * \text{OVTT-t} + 1.0746 * \text{trwy} - 0.9784 * \text{region}$

Source: Technical Report: A Joint Technical Committee on Transportation System Planning

Table 1.3 : MODAL UTILITY EQUATIONS : pm PEAK PERIOD

$U_{\text{driver}} = -0.4103 - 0.6138 \cdot \text{cost-a} - 0.0051 \cdot \text{IVTT-a} + 0.5963 \cdot \text{numveh}$
$U_{\text{passgr}} = -2.049 - 0.6138 \cdot \text{cost-p} - 0.0051 \cdot \text{IVTT-a} - 0.0164 \cdot \text{OVTT-a} + 0.2229 \cdot \text{numveh}$
$U_{\text{transit}} = -0.6138 \cdot \text{cost-t} - 0.0051 \cdot \text{IVTT-t} - 0.0164 \cdot \text{OVTT-t} + 1.2511 \cdot \text{twywrk} - 1.1431 \cdot \text{region}$

Source: Technical Report: A Joint Technical Committee on Transportation System Planning

cost-t, cost-p and cost-a indicate transit fare for zone to zone, passenger's share of parking cost in employment zone and total auto travel cost respectively.

numveh = Average number of vehicles per household in the home zone.

Trywrk = A dummy variable with '1' coding if the employment zone is within a transitway catchment area and '0' coding if not.

The utility models as shown above are used in the Logit model in equation 1.1 to obtain the probability of mode choice.

1.5.1.5 Trip Assignment

Trip assignment is done through an iterative process with the minimum travel time as the determinant of flow through a particular route with higher time required in other routes. These assigned volumes are normally used for the design of road space like number of lanes required, lane width and other requirements for the network.

1.5.1.6 Supply of Road Space

The supply of road space based on Transportation Systems Planning (TSP) will, in turn, result in reduction of traffic density due to increased capacity which also will reduce congestion. Expanded transportation system will increase the rate of flow of traffic. Users of an expanded system will

experience higher speed and therefore a shorter travel time with higher rate of flow. The Level of Service or LOS will be better as a result. Major investment in transportation infrastructure creates a net increase in development as a whole within the area concerned and also brings more employment opportunities to the adjoining areas. The better LOS will ensure that damage caused by delay in transportation is reduced and valuable or perishable commodities will be spared destruction. However, the above benefits are only to be effective in the **Short Term**. The principle of **triple convergence** plays a vital role in nullifying the initial successes of the infrastructure expansion. Spatial convergence occurs on newly built infrastructure due to improved conditions. The Temporal or Time convergence are brought in by the car drivers who switch from non-peak hour driving strategy to the peak hours. The modal convergence are brought about by those who switch from bus to car because of the improved LOS in the new facilities.

1.5.2 Long Term Solution

Demand Management policies may be examined as a **long term** solution to reduce congestion. The demand management strategies are described next.

1.5.2.1 Demand Management

1. Flexible work hours: most of the government institutions are working now with a flexible schedule to decrease the peak during rush hours.
2. Parking Policy: to control parking in Central Business District (CBD) by increasing the parking fare or reducing parking supply.
3. Encourage car pooling and other forms of ride-sharing. Average vehicle occupancy in Ottawa-Carleton is not different from other typical urban areas and is as low as 1.2 persons per car.

4. **To make public transit more attractive by increasing the number of buses, lowering fares, and expanding the transitways etc.**
5. Designating HOV lanes on busy streets to complement ride-sharing.
6. Motivate workers towards telecommuting or to work at home.
7. New land use planning: concentrating jobs in areas of new growth zones of high density residential or commercial property in close proximity to transit way stations.

The first three options are already being used with limited success. The notion of telecommuting is a relatively new one influenced by the advent of the Internet in the cyber space and is limited to the nature of the work. The question of dealing with urban congestion by intervention into land use planning and development can produce long run benefits in congestion relief. Intervention into land use planning can limit development in potentially congested areas. This intervention will be able to monitor and preserve natural ecosystem and topographical patterns. It would decrease the physical impacts of fuel emissions and noise pollution and will enable the planners to locate work area sites so as to minimize all travel to and from the sites and help an energy efficient system. It will prevent intrusion of through traffic in problematic and strategic areas. But it is unrealistic to propose far-reaching land use schemes that will affect the urban life, only for the sake of reducing peak period congestion. The fourth and fifth options are closely associated with our objective to make buses more attractive. However, the individual travel behavior has to undergo a radical change to make this happen. We should understand the merits of dealing with urban congestion by changing individual travel behavior. Urban congestion can be reduced significantly by taking up strategies so that Single Occupancy Vehicle (SOV) operation could be

minimized by providing incentives for High Occupancy Vehicles (HOV) including **ridership of public transit bus**. By making public transit bus more attractive through taking demand management strategies and encouraging HOV, the benefits will be enormous. The resulting release of road space should considerably improve the traffic flow because of reduced congestion.

Although it is desirable to enhance public transit ridership, difficulties are being encountered in achieving this goal in Canada and possibly elsewhere in North America. What are the reasons? Among other reasons, it is possible that the transportation planners and managers do not have the required knowledge of “factors” that affect public transit ridership. One of the best ways to obtain knowledge of these factors would be to analyze the data on attitude related surveys using advanced statistical methods like factor analysis.

1.6 Factor Analysis: A step towards understanding Bus ridership

Our study approach will be to show how response from a target sample population can blend with the factor analysis to produce some interesting interpretations. *‘The role of factor analysis to theory construction has been well pointed out by Cattell (1957) and Kelly (1955). It is the means by which the vicious cycle of armchair theorizing versus scientific theory building may be broken. Through the factor analytic methodologies, logically conceived hypothetical constructs may be derived, tested empirically and modified with additions or deletions according to explicit standards.’* [Jarrett, Irwin and Brady, edited by, 1976].

However, the interpretation of the factors will be subtle and delicate because of the diverse categories of the response framework and the different scales involved. For each of the observed variables we should look into the frequencies of each response category and their bias before we ponder about giving a label to their interpretable meaning.

1.6.1 Solution generation

The Human mind is a paradox. It is ever fluctuating, complex and difficult to comprehend. However, even in complexity and incomprehensibility, there is a pattern of response to stimulus which is discernible. This phenomenon of behaviour pattern has been used, by means of qualitative explanatory research analysis, in the fields of Psychology, Sociology, Biology and studies relating to Economics to assess intelligence or to explain concepts. There is a built-in limitation to all such scientific explanation. Moreover, there is the narrowness of the frame of reference. For example, the spectroscope cannot describe the radiance of a sunset or the theory of refraction cannot describe the beauty of a rainbow. We can talk a great deal about the glass and steel as well as light spectrum in describing a Planetarium. But if we do not describe the function of the Observatory to see the planets and stars, the main purpose is missed. Likewise in factor analysis, the description of Mathematics or Statistics alone cannot bring out the meaning and essence of the factors. Because of this we have tried to interpret and describe the factors with the labels that are commonly used in other studies.

This study may raise some eyebrows for the use of statistics for social science related studies to find the factors affecting ridership of buses. But we should not forget that we are social beings and our activities are influenced by our social behavior or vice versa. A study by the Brookings [Downs.A, 1992] Institute, the Washington D.C. based think tank observes that “ *Peak hour traffic congestion is deeply rooted in behavior patterns that reflect certain cherished goals held by most Americans.* ”

But this aspect of human behavior has not been given due importance in the studies related to traffic congestion or more precisely to the study of ridership related topics. The attitude survey and factor

analysis is able to bring the missing dimension of human behavior into the process where decisions are made conscientiously to decide on which mode to take and why to take it. We already know that Transportation Demand Management is an effective technique to intervene into the demand side of the traffic equilibrium equation, by taking certain policy decisions to force and produce effective outcomes or impacts. But this intervention is not easy. Policy decisions are to be made that may have far reaching consequences to the population they intend to serve. The study of factors and their impacts can go a long way in understanding the response process and minimize the possible adverse or negative impacts for a particular situation or a particular population. Better understanding of user attitude by the transportation planners and managers have stressed the need to pinpoint the specific factors to target in the demand management strategies being planned. For example, OC Transpo has taken steps to understand ridership by initiating annual Attitude surveys. Their effort at supply side, through Transitway expansion, has already started. Now that the behavioural studies has been progressing briskly, the Demand management scenario is being addressed too. However, the road space during peak periods are still found to be insufficient at many roadway sections. Links from Place D'Orleans to Blair can serve as such an example. The eastward direction does not have any reserved lane for bus and infrastructure expansion is not encouraged due to already much discussed reasons of cost, environmental impact and various other compelling reasons. Even if infrastructure expansion takes place, the effect of triple convergence , as discussed will cause a resurgence of congestion in the long run. Therefore, we must make serious efforts to understand and implement the remedial measures being recommended. In this study we take up the seemingly simple task of understanding the factors that affect ridership of urban transit bus.

What sets this research analysis apart from other studies in transportation is that it takes

us into the realm of the unknown by means of exploratory research through the technique of factor analysis. It has been a challenging but at the same time an exciting experience to deal with such a large data matrix and to manipulate it to extract underlying factors that has been imagined to float in a hypothetical Universe-in-miniature, like the clusters of stars in the galaxies in our actual Universe. We feel we are in control of these clusters floating in what has been termed *sub-spaces* and *hyper planes* [Thurstone,1947], using hypothetical axes both orthogonal and oblique to locate them. All these actions produce *simple structures* [as envisaged by Thurstone,1947], which has been our aim for simplicity of interpretation and explanation of the central concept. This central concept may be as lofty a philosophy as *human values* or as mundane as *ridership* of urban bus. Research analysts since Galton (1876) have concluded that correlation matrices reveal underlying common factors which explain the correlations significantly. The factors in turn produce a relatively smaller number of hypothetical constructs called hypothetical variables. Galton, who has been the first person to formulate the correlation matrix in order to study Darwin's theory of co-variation amongst species, had largely contributed to the future development of the theory of common factor analysis. By means of this common factor analysis a considerably reduced number of hypothetical variables help explain a concept or phenomenon which is related to human behaviour or attitude.

1.6.2 Impact of the Factors on Ridership

Various underlying factors are expected to emerge after the analysis of a relatively large number of variables in the attitude survey database which will explain the bus **ridership**. Ridership, on the other hand, is a concept which is defined by the frequency of person-trips made through the urban transit buses. This index of 'ridership' is construed from a single observed

variable (var.10) with binary coding. It is only a concept and we will not try to predict its numerical value or size. We are going to explain the concept as a dependant variable with the factors in a logistic regression model.

There is no definitive answer to the question of why some people like to ride bus and why some do not. The question of **why** can best be explained by a systematic study of responses to a series of related questions prepared by persons experienced in the field. The questionnaires are designed to reflect the attitude, belief, values, lifestyle, egos, motives, drives etc. of an individual in the target population being questioned. In contrast to the conventional information like age cohorts, time-to-travel, income groups and also questions like education level, occupation etc. the typical questions that are designed to assess attitude towards a particular concept are equally important for assessing the causes of particular phenomenon like ridership of transit buses.

Our research has been greatly benefited by the questionnaire as well as response oriented databases that are available through the good offices of the OC Transpo from the Carleton University's Data Center under the School of Journalism. Using these databases, we have embarked upon the task of extracting the underlying factors from the vast array of observed variables. After extraction of these underlying factors, we shall use them to develop multiple regression models and through a series of hypotheses test them for statistical significance. We derived the hypotheses by specifying certain conditions upon which the impact on attitude towards riding a bus is deemed to be important and tested them, for example, by using the logistic regression analysis to see what are the odds of ridership occurring in the event of their inclusion into the models.

Several hypotheses will be formulated based on certain known or obvious factors affecting bus service ridership and will be tested through these models and the significance, relative

importance and impacts of these factors upon the concept of ridership will be discussed. For example, a fare increase contemplated by the region to overcome the budgetary constraints may prove to be counterproductive, as it may drive the transit users away from bus to private cars. The competition from cars and other modes have made bus fare increase very sensitive and it may impact negatively upon the bus ridership. However, to counteract this phenomenon, there are ways open to the transit authority. Improved LOS can keep the users into the fold of urban transit and also may attract non-users into the fold. After all, the car users also have their problems in the form of higher gasoline cost, parking fees, traffic congestion, cost of maintenance, insurance etc. Therefore, the transit authority should target the most appropriate factors that affect ridership. In order to attract people to the mass transit service like buses, the transit authority should have the required knowledge of factors that affect public transit ridership. May be the underlying factors will be useful guides to the transit planners and managers to implement policies to relieve congestion.

1.7 Study Plan

Chapter 2: Literature Review : In this chapter we will further explore the current knowledge of factors related to public transportation performance [e.g. Armstrong-Wright, 1985]. We also plan to include a detailed discussion of OC Transpo's study of the 1988-1995 database, including their weighted frequency analysis. Also, we will include brief descriptions of some behavioural studies relating to traffic engineering and a related paper on human values as Factor, demonstrating procedures involved in factor analysis. Data analysis will be pursued in order to explore the performance indicators and underlying factors that determine an urban transit system to be viable and providing excellent service standards to foster ridership of urban transit.

Chapter 3: Data and Methodology: Here all aspects of data will be described. For example, what

are available for analysis, the variables, the questionnaire and the method of acquiring the data etc. will be included in a brief and concise manner.

Chapter 4 : Conceptual Framework: Examining the underlying Dimensions of Ridership: The approach to this study will be to extract underlying factors that affect ridership from the observed variables. We will highlight the importance of the knowledge of factors, what is presently known about these, previous studies on factors, their findings, recommendations and applications. On the basis of OC Transpo's studies, the World Bank Policy studies and other factual experience, several hypotheses will be formulated in this chapter to see if they are acceptable from the point of view of the research outcome. This chapter will also include a description of the **methodology** with the mathematical procedures involved in the Factor analysis.

Chapter 5: Descriptive Results: In this chapter, the output of the actual factor analysis, using the 1995 Attitude Survey database, will be discussed. The factors extracted will be identified and tabulated individually with the clustered observed variables shown and then each of the factors will be interpreted and accordingly labelled.

Chapter 6 : Factors Influencing the Frequencies of Using Bus: The index of ridership will be regressed with the derived Factors as the independent variables and the resulting model will be discussed in light of the impacts, positive or negative, on the ridership of urban buses. The hypotheses formulated earlier in chapter 3 will be discussed within the framework of the models developed, as will be shown in this chapter.

Chapter 7: Conclusion and Recommendations: The conclusions will revolve round the possible impacts of the factors affecting ridership and several recommendations will be made so that a better understanding of user attitudes can lead to developing strategies, tactics and operational measures.

CHAPTER 2

CURRENT KNOWLEDGE

2.1 CURRENT STATE OF KNOWLEDGE

2.1.1 Literature Review

To continue the coverage of literature, in this section, available knowledge in bus transit service effectiveness and acceptance by potential users is reviewed. Advocates of sustainability in urban transportation indicate that a greater support for public transportation is necessary (Soberman 1997). It is now well recognized that dependency on the automobile to a high degree leads to the well known “vicious cycle” effect. This cycle starts with more demand for roadways, availability and low parking charges, and expectations of low-density land use in suburban areas. In turn, these create further dependency on the automobile and increased costs to provide transit services to low density outlying areas. This results in lack of growth in transit service coverage and availability, leading to the declining transit use (Environment Canada 1998).

As a part of setting new visions in urban transportation, a Symposium was held in 1994. The participants discussed ways of providing higher quality transit service in order to make such services attractive to potential customers in relation to the private automobile. Among other ideas, those related to this research are: investigating needs of all groups of current and potential transit users, providing and marketing services to meet these needs, and integration of public transit with other related modes of transportation, and initiating public education campaigns that aim to change behaviour and attitudes beginning with young persons (Transportation Association of Canada 1994).

Some analysts have argued that for successful urban transit, increased government subsidy may be required. On the other hand, it has also been pointed out that subsidies without innovation cannot lead to positive results. For example according to Kanji (1996), over the last two decades, increased government subsidies have not resulted in “new” ridership. Instead, these subsidies have simply assisted the core riders, thus making the entire operation increasingly inefficient.

Conventional management philosophies and practices cannot be relied upon to provide cost-efficient high quality services under current fiscal squeeze. There is need for the application of modern management concepts and methods, namely total quality management (TQM) and reengineering in order to enhance the probability of success in enhancing service quality, increasing ridership, and improving financial picture (Khan and Ugee 1995). The New Transportation Association of Canada (TAC) Vision for Urban Transportation stresses the importance of achieving a higher quality of transit service. According to the Vision Statement, it is necessary to provide higher quality transit service to make it competitive with the private automobile. Some of the attributes that noted for improvement are: comfort, security, frequency, on time reliability, geographic coverage, access for the physically challenged, and public information services (Transportation Association of Canada 1993). The Canadian Urban Transit Association (CUTA) has completed a study on Modal Shift to Transit. This study describes a number of challenges that Canadian cities and transit companies should respond to. These include changes in the market due to economic, demographic and land use trends. This study points that increasing car ownership and perception of lack of security are having an adverse impact on the transit’s share of the market (Therrien 1994).

The U.S. Transit Cooperative Research Program identified research topics in 1997 that could lead to new approaches in transit management and new vision for transit's future. Some of the research topics include increased customer convenience using new technology, training for new technology, and better integration of transit services and social services (Transportation Research Board 1997).

Numerous innovations are required to make public transit more effective. These cover technological, planning, marketing and management measures. Holloway (1995) cites four specific strategies for improving travel time and increasing speed. These include transit vehicle signal priority, transit vehicle queue jumpers, proof of payment on transit vehicles and the introduction of a regulation that would require motorists to yield to buses pulling from bus stops. On the planning side, there are many innovations that can be practiced.

Cape (1995) highlights the role of bus-based park and ride, an innovation that is increasing in importance. The practice of intermodalism is growing in the Ottawa-Carleton Region. OC Transpo is cooperating with other agencies in implementing the following services: rapid transit services to the Ottawa MacDonald-Cartier International Airport in association with Transport Canada and the National Capital Commission, better connection with Voyageur Colonial's intercity bus services (Gault 1995).

Numerous service innovations have been suggested in the literature. Welch (1991) suggested the application of out-of-direction (OOD) bus route segments. The OOD is a deviation from the main

line of fixed route. This practice can be beneficial provided that it does not result in adverse effects for through riders.

Studies have been carried out on the theoretical aspects of service and system design . For example, Janson (1992) reported an analysis of the joint optimization of prices, frequency, vehicle size, taking into account a variety of passenger groups. The constraints used were budget and a flat fare . Such studies are highly theoretical in nature and their results reflect limiting assumptions.

On the marketing side, an understanding of the various segments of the market are stressed in the literature. Over the years, the study of the sensitivity of demand to changes in price and service attributes have been investigated. There is considerable amount of literature on the subject of short term as well as long term elasticities . For example see Goodwin 1992, Khan 1981, Ramjerdi 1997, Schipper 1998a,b, White 1995. Additionally , an annotated bibliography is available on demand elasticities (Goodwin et. al 1992). A knowledge of elasticities has been helpful for making pricing and service decisions. Elasticities of demand in the Ottawa-Carleton Region have been under investigation by Carleton University researchers (Khan 1981, Zargari and Khan 1998).

Information systems for the use of customers and the operators of public transit have been under investigation around the world. For example, in Europe, officials have recognized that in a customer driven market economy, excellence of service as perceived by customers is the only way for a successful public transit business. Intelligent transportation system (ITS) technologies are enabling transit systems to provide a service with a difference. London Transport officials have come to

realize that real time information is necessary and also it is cost-effective. An example cited in the literature is that of real-time bus arrival information provided in Hampshire County (U.K.) using LED displays (Eno Transportation Foundation 1998).

The U.S. Department of Transportation studies also highlight the importance of traveller information systems. According to a recent publication, “the most frequent complaint from travelers - information is not current or reliable. “When Traveller Information and Transit Management Systems are linked, travellers can receive ‘real time’ transit information on arrivals, departures, and delays (U.S. Department of Transportation 1996)”. In the U.S.A. there is now a new trend which will help transit agencies that are hoping to reduce traffic congestion. Subscriber companies are keen on providing subscriber information services. In some case, transit agencies could be the source for traffic information and may result in new revenues for the transit companies (Urban Transport News 1998).

In Japan, a call for innovations was made to improving the market acceptance of public transit. These include: development of new transport services through the use of information systems, such as ITS, improvement of technology, and development of urban “travel demand management (TDM) suitable for a mature society” (Harata 1994).

The importance of marketing is frequently stressed in the literature. In addition to developing a mix of improvements that offer a range of opportunities to travellers, there is the need to sell the services to the public. Modern marketing concepts and techniques are required. These include market

segmentation, understanding the characteristics and needs of various segments of the market, developing the required services and then selling these services to the market segments (Black 1995, Deka 1996). Given the attraction of the private automobile to choice riders, the marketing challenge to public transit is enormous (Deka 1996).

2.1.2 OC Transpo Operations

The Ottawa-Carleton Regional Transit Commission (OC TRANSPO) provides public transit services for the 625,000 persons in the Regional Municipality of Ottawa-Carleton. Regular transit services are offered with a fleet of 825 buses (164 60-ft articulated buses, 4 low floor community buses, and the remaining are standard buses) (1995 statistics). In 1994, 73.5 million passengers were carried. The bus rapid transit system is based on the Transitway, an exclusive bus roadway. In 1995 it was 25 kms long and had 18 stations. The Transitway operations enable travelers to minimize the number of transfers through the extensive use of suburban express services in peak periods. This attribute of the system is attractive to “choice” riders. Transitway stations are designed to provide a comfortable, sheltered and secure environment for passengers while they are waiting for buses. Public information, although not as advanced as available in some other urban areas, is available at the stations. These are based on printed schedules and maps, automated television screens and through direct dial access to OC Transpo’s public information office (Gault 1995). Although in recent years, OC Transpo has installed on selected routes an automatic vehicle location and control (AVLC) system, the information provided by this system is not available to potential users through state-of-the art advanced traveller information system.

OC Transpo's regular transit services have an annual operating budget of approximately \$160 million, a little over half of which is collected through fares, 28% is covered through local taxes and 19% is funded by the Province of Ontario (1995 figures) (Gault 1995).

2.2 Performance of Bus Services

In Chapter 1, we have identified ridership of urban transit bus to be one of the focii of attention to combat congestion. But the major challenge lies in how to make people to take the bus instead of driving alone in their cars. In order to attract people to the fold of urban transit buses, it is natural that people will expect a high standard of service and good performance among other factors. There are a wide variety of urban transit bus services across the globe, both in developing as well as in developed countries. The sustained and increasing trend in ridership of these services depend on the operational performances and various level of service incentives given to the prospective riders by these transit services. In addition to literature quoted in the previous sections other studies are referenced. Examples are the World Bank study on urban transport [Armstrong-Wright, 1986] and OC Transpo's analysis of the Attitude Survey. This is intended to provide the context of our approach with the aid of advanced statistical analysis using the attitude survey database prepared for OC Transpo. These studies are relevant to congestion related problems because of the simple fact that public transit buses are high occupancy vehicles and increasing ridership help relieve congestion.

2.2.1 Urban Transport: Key Performance Indicators

A World Bank study has compiled and analysed a comprehensive database on what have been termed as the key performance indicators for urban transit services in some of the major cities of the world.

Table 2.1: Private and Public Bus Services Operating in the same city : 1983/1985 Data

City	Owned By	Bus Type	Fleet	Staff/Bus ratio	Cost pass/km US cents	Revenue cost ratio
London	Public		4901	6.8	17	0.48
Sao Paulo	Public	Large	3280	7.6	-	-
	Private	Large	5850	5.1	-	-
Bangkok	Public	Large	4400	6.2	1.9	0.74
	Private	Large	550	-	1.2	1.10
	Private	Mini	12000	-	-	1.20
Chicago	Public		2275	3.1	8	0.52
Istanbul	Public	Large	1500	7.5	2.0	0.88
	Private	Large	960	-	1.7	1.10
	Private	Mini	3800	-	2.2	1.40
Jakarta	Public	Large	1940	14.5	1.8	0.50
	Private	Large	550	7.25	0.9	1.20
	Private	Mini	3365	5.5	1.2	1.45
Karachi	Public	Large	790	12.4	2.8	0.49
	Private	Regular	1320	6.4	1.0	1.15
	Private	Mini	3980	5.7	1.3	1.30
Khartoum	Public	Large	74	18.1	1.5	0.80
	Military	Large	141	8	0.7	1.00
	Private	Trucks	720		0.6	1.10
Mexico City	Public	Large	6500	5.7	1.6	0.12
	Private	Large	DK	-	-	-

Source: World Bank surveys and studies: 1983 data for London & Chicago and others 1985 data

Ottawa	Public	Midsize Standard Articultd	55 631 284	2.58 ('90)	1.75 (apprx.)	0.56
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Source: OC Transpo's Strategic Plan for the 1990s, OC Transpo, Ottawa, Ontario, 1991.

The study covers ten major cities across the continents [Table 2.1] and compares the private and public transport systems co-existing in each of these cities. The items of comparison include : cost and quality of services and safety. It goes on to discuss the public bus corporations and bus companies in mixed ownership and the size of the undertakings.

The Operational Performance Indicators, according to the World Bank study, include acceptable ranges for: (1) Passenger volume per bus per day in each of the mini, standard or articulated buses. (2) Fleet Utilization in percent of total fleet. (3) Average distance travelled per bus per day in kilometres. (4) Breakdown in number of services as a percentage of Operating buses. (5) Fuel Consumption in litres per 100 kilometres: as per types of buses in use. (6) Staff per operating bus ratio: differentiated by administrative and maintenance staff. (7) Accident rate indicated by accident per 100,000 bus-kilometre. (8) Percentage of bus journeys not earning revenues. (9) Total cost per passenger-kilometre in mixed traffic and also in Transitways. (10) Revenue-Cost Ratio [Table 2.2A]. The study also gives acceptable ranges for some **Quality of Service Indicators** which include: (1) Average Waiting time at bus stops (2) Walking distance to Bus Stop. (3) Number of Transfers to and from Work: average and maximum. (4) (i) Journey times : average and maximum (ii) Journey Speed of Buses: dense areas, Transitways/lanes, low-density areas. (5) Travel Expenditure: Household expenditure on travel as a percentage of household income. [Table 2.2B]. The expressed purpose of the above study had been to “ *set out the circumstances found to be likely to result in viable bus services and lead to reduced costs and raised standards.*” [Armstrong-Wright, 1985]. The purpose of this study incidentally, has also been to seek the answers to the questions like: Why bus services in some cases succeed and in others accrue huge losses and what are the factors that

Table 2.2A

(A) OPERATIONAL PERFORMANCE INDICATORS

No	Description	World Bank Range for good Operating service level	* Service levels of OC Transpo. (1990,s data)
1	Passenger Volume: per op.bus per day		
	Type of Bus	Capacity	
	Standard: 567	40 crush 80	1500 - 1800
	Articulated: 164	90 160	2000 - 2400
	Equiv. Std: 858		2000 - 2400
2	Fleet Utilization: Buses in service during the peak, as a percentage of total fleet:	80% -90%	1376* 1376* 1376* 91%*
3	Distance Traveled by Buses: Average Kilometres per Bus per Day:	210-260	135*
4	Breakdown in Service:As a % of Buses in Operation	8-10	9*
5	Fuel Consumption: Litres per 100 km:		
	Minibuses:	20-25	-
	Buses:	25-50	40.24*

Table 2.2A Continued

(A) OPERATIONAL PERFORMANCE INDICATORS

No	Description	World Bank Range for good Operating service level	* Service levels of OC Transpo. (1990,s data)
6	Staff Ratios: Staff per Operating Bus		
	Total Staff:	3-8	2.58*
	Administrative:	0.3-0.4	0.34*
	Maintenance:	0.5-1.5	0.47*
7	Accident Rate: Accident per 100,000 Bus kilometers	1.5-3	1.42*
8	Dead Mileage: Percentage of Bus journeys not earning Revenues:	0.6-1.0	-
9	Cost of Bus Service:per passenger-km		
	Mixed Traffic:	Usc2-5	0.88*
	Transitways :	5-8	-
10	Operating Ratio: Total Revenue divided by Operating Cost:	1.05-1.08	0.56*

Source: Armstrong-Wright, Alan : World Bank Policy Study, 1986

* Obtained from the Strategic Plan for the 1990's, OC Transpo, Ottawa, Ontario, 1991.

Table 2.2B

(B) QUALITY OF SERVICE INDICATORS

No	Description	World Bank Range for Quality of Service	Quality of Service : OC Transpo Policy
1	Waiting Time: Waiting Time at Bus Stop Average: Maximum:	5 -10 minutes 10-20 minutes	10 minutes*
2	Walking Distance to Bus Stops Dense Urban Areas: Low-density Urban Areas:	300- 500 m 500-1000 m	400 m* 400 m
3	Interchanges between Routes & Services: Number of Transfers to & From Work: Average: Maximum:	0-1 2	1 2
4	Journey Times Hours To & From Work: Average: Maximum: Journey Speed of Buses Dense Areas: Transitways/Bus lanes: Low-density Areas:	1.0-1.5 2-3 10-12 kph 15-18 kph 25 kph	1 1.5 50 kph* 40 kph
5	Travel Expenditure Household Expenditure on Travel as a percentage of Household Income:	10	7.25

Source: Armstrong-Wright, Alan : World Bank Policy Study, 1986

*Strategic plan for the 1990's, OC Transpo, Ottawa, Ontario, 1991

determine ridership. In our study we shall seek the answers to the same questions through indicators obtained through data analysis using statistical technique of Factor Analysis. We shall be using the 1995 data used by OC Transpo for their Attitude survey on ridership of buses. In the following section the methodology used by OC Transpo is described.

2.3 OC Transpo's Attitude Survey

The following attitude survey by OC Transpo, to explain ridership of transit buses, uses a weighted frequency approach. This attitude survey analysis will be discussed in a little more detail because our analysis will use the same data but with a different technique.

2.3.1 Weighted Frequency method

Attitude surveys are being conducted every year by the Ottawa-Carleton Regional Transit Commission (OC TRANSPO) since the 1980's, to track attitudes of the Region's residents towards transit. According to OC Transpo : *"The survey is used to track attitudes, to help formulate policies and to better plan and market services."* [OC Transpo, Attitude Survey, 1995]

Through analysing the data set, the results are given, with numerous comparisons of weighted frequencies in the form of several Exhibit tables as shown in the report [OC Transpo, Attitude Survey, 1995]. Let us review OC Transpo's study and its results so that we can compare them with the outcome of our study. We begin with the questionnaire [Appendix D], which is a mixed set of questions designed for various purposes. Some deal with subjects like age cohorts, income range, education etc. while others are arranged in such a way that the responses reflect certain attitudes towards a certain service or facilities provided by the transit authority. The response criteria of the questions have been prepared in an uni-dimensional scale format with the objective of scaling the respondents and their attitudes with respect to a concept.

OC Transpo has opted to examine the weighted frequencies of the responses, corrected for population etc.

The Attitude Survey report 1995 studies the ridership on the basis of an attitude related index and views the impacts through twelve main issues of importance like : Casual Users and Non-Users, Trip Characteristics, On-Street Service, Easier Access Program, Service Planning, Fare, Public Information Services, Customer Service, Transit way Service, Vehicles and Facilities, Security and General Attitude,

Casual and Non-users : Market insight:

It discusses the percentage of the casual users , percentage of non-users who had previously been regular users of urban transit bus but have drifted out of its fold. Effort had been directed towards explaining this shift from the available frequency tables and from the questions therein that had been answered.

Trip Characteristics

OC Transpo report defines trip characteristics as being reflected by variables like Var14 : Transpo to work or school and finds that urban transit bus has been used mainly for going to work purposes followed by school, shopping, pleasure etc. Ridership has also been influenced by high parking fees and bus fare (Var14, 24 and 30, 17 and 27 respectively).

On-Street Service

This factor, as has been defined in the OC Transpo report, relates to the reliability of service in the urban transit route, conditions prevailing in the service bus, transfers, driver courtesy , standing in

the rush hour bus, status of service over previous years etc. denoted by the respective observed variables in the data matrix. According to the OC Transpo report : *'There is a slight decrease in the attitude towards the idea that it is reasonable to stand sometimes on rush hour buses[Var84]'* The report has grouped together variables like Var71: frequency of bus service, var72 transfers are convenient, var78: drivers are courteous, var87 status of service over previous years etc into **on-street service** category.

The OC Transpo report includes **Easier Access Program** as a significant factor. The impact of Easier access program (Var56) which provides for on-bus facilities like **kneeling** buses (Var57), extra grab rails, lighting, benches, calling **stop** names on PA system (var58) have been examined under this heading.

The next topic of discussion has been the **Service Planning** and included in its fold are var63: Buses are easy to use, var67: route changes are too frequent. The observation of OC Transpo suggests that the users and non-users are complacent about route changes which means that it has little or no impact on ridership of transit bus.

The important question of **FARE** reduction has been examined in the light of var75: peak hour fare too expensive, var76: bus pass good buy, var30: pay fare, var31: know that tickets are cheaper, var32: type of pass. Although, the conclusion about peak hour fare has been positive, ironically no fare increase has taken place during those years of study between 1988 and 1995. The years after 1995 have seen a steady increase in fare and it will be interesting to see the effect of **reduced fare** through our models.

Public information services are described on the report as indicated by var47: telidons, var48: information accuracy, var49: bus stop schedules, var50: accuracy of information, var51/var52: time

table leaflets, var53: call customer service, var55: system map use, var39: bus information, var40: pick up other information, var41: use 560 telephone system, var42: how often, var43: called info centre, var44: if yes, it was easy to get through. All these variables represent **public information** which is an inseparable part of bus service and it is important to keep this service so that the users stay in the urban transit system. However, how much these factors can contribute towards increasing ridership is unknown. Ordinarily, information upgrade may not contribute to ridership increase but the impact of pre-arrival display of information by means of electronic sensors like GPS receivers and computer translation with digital display contribute towards an increase in the level of service. Therefore, information related services should be considered as an integral part of the urban transit system and should be one of the most important contributors towards ridership.

Customer Service

Customer Service has been defined by the Report through the variables like var46: Information staff courteous and var54: customer service staff courteous. According to OC Transpo's study the positive attitude with regard to the above factor is on the rise. The relative importance of customer service can be ascertained through a model envisaged through our study.

Transitway Service

This service has been an unique feature of OC Transpo and the impact of this service have been tested by means of var59: transitway bus roadway investment good/poor investment, var60: use transitway stations, var61 transitway stations safe, var62: why not , meaning gangs, poor lighting, lack of emergency phone, loneliness etc. in transitway stations as categories, var69: Transitway stations are clean. According to OC Transpo's weighted frequency studies, bus passengers agree that transitway has improved bus service . *'Nearly seventy percent of frequent bus users agree or*

strongly agree that the transitway has improved bus service for them. [OC Transpo, Attitude Survey]]

Vehicles & Facilities

This has been represented by variables that state whether var74: the buses are not kept clean, var69: transitways are kept clean or not, var81: taking bus benefits environment, var86: OC Transpo should buy more air-conditioned buses. According to the report although the attitude towards cleanliness or air-conditioned buses remained unchanged during the years of study, the environmental benefit has been strongly agreed to by the respondents, The report further states: *‘ Respondents continue to strongly agree that taking the bus benefits the environment. ’*

Personal Security

Questions on personal security have been explained through the observed variables like: var61/var62: Transitway stations safe, var68: personal security, var69: personal security at night in the neighbourhood, var85: personal security at night in multi storied parking lots. These are all relevant questions dealing with ridership and has since been addressed by OC Transpo. The results show that majority of the issues have been favourably considered by the respondents, particularly with respect to poor lighting, phone service, security etc. According to OC Transpo *‘ a comprehensive lighting review was undertaken in 1993 and the lighting was upgraded at many of the stations. Emergency telephones with simple push buttons are now being installed rather than the handset variety. ’*

These projects have since been completed under the supervision of the writer of this paper. It will be heartening to see if this emerges as a significant factor to explain ridership index later in our

research study. OC Transpo says that: *'no Lighting and lack of emergency phones was only raised by 2% of these people'* [OC Transpo, Attitude Survey,1995].

General Attitude

This has been attributed to variables like var82 Taking bus is frustrating, var83: Always avoid taking bus, var80: Behaviour of other passengers unpleasant, var87: status of bus service over last year, var81: taking bus benefits environment, var88: one thing to improve service. The last variable relating to improvement of service has been considered as an important variable as it has posed questions in the categories within the question about service delivery, additional service provision like more buses, reduction of fare, etc. According to the outcome in the report: *'overall the two most frequently mentioned items were reducing fares and more frequent service.'*

Differences in responses by gender via var98 : sex, has been found to be evenly distributed .

2.3.2 Recommendations

The conclusions of OC Transpo's attitude survey report is quoted in full to understand the significance of the study so far as the ridership is concerned:

'There was less overall travel in Ottawa-Carleton in the year since the last survey. This is reflected in the lower percentage of people using both cars and buses for work trips. This years' survey results show that we are continuing to lose ground with casual riders. This is a market which must be developed if OC Transpo is to turn the tide on ridership.' [OC Transpo's Attitude Survey, 1995]

2.4 Applications of Statistical methodologies: There are numerous research papers using factor analysis in the social sciences, medicine and psychology. From this vast array of literature the following paper has been chosen for discussion because the procedure applied in this research is largely identical to it .

2.4.1 Human Values as factors

In this publication, there are a number of *papers presented at a Conference Jointly sponsored by The Illinois Regional Medical Program and the Southern Illinois University School of Medicine* [Jarrett and Brady].

Factor Analysis may be defined as the statistical technique *‘used to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables.’*

Factor Analyses within the scope of *‘human behaviour in an organizational or social mode’* have been carried out. One of the papers deals with *“Human values as key Factors”*. This is an interesting example of how the complex subject has been empirically studied by use of statistical factor analysis. *‘The intent of the study was to sharpen the definition of the concept “human values” by empirically deriving its factor structure.’* Nellie Del Mar McClure in her study approach has shown how response from a target sample population can blend with the factor analysis to produce some interesting interpretations.

2.4.1.1 Methodology

The study sample consisted of 430 College Students , 53 % male, 42 % female . The ethnic distribution has been Caucasian (45 %), Mexican American (26 %), Asian (3 %), Am. Indian (0.9 %), Black (0.9 %), Jewish (0.7 %) and in the remaining responses 3 % as other and 22 % as no response. For sample adequacy this paper follows a different scale [Comrey, 1973] in

contrast to the Keiser-Meyer-Olkin (KMO)values employed in this study. The study in McClure's paper used Varimax method of orthogonal rotation , the same as has been done in our study. Missing data have been treated by computer program used and only a few variables were deleted because of data inadequacy. The Common Factor Analysis method of factor extraction have been employed and the squared multiple correlation (SMC) estimates have been used for analysis of the correlation matrix. The number of common factors have been determined by studying the scree plot with Factors in the x-axis and eigenvalues in the ordinate or Y-axis. Because of the fact that the scree plot had more than one clearly distinguishable points of scree or straightening of the curve from a gradually sloping one, the author thought it wise to consult two other experts in the field to interpret the exact location of the scree in the plot. They all agreed to the same location , thereby, removing controversy. There is a widely acceptable thumb rule to calculate the latent roots or eigenvalues of the variables and values 1.00 or greater are considered to be the number of factors to be taken as representing a reasonable number of factors.

2.4.1.2 Findings

The factor extraction procedure was followed by the actual analysis. The process yielded eight latent variables to explain *Human Values* and of these the Factor 1 was loaded with forty-four observed variables, factor 2 with thirty-two variables, thirty-five in factor 3, twenty-two in factor 4, fifteen in factor 5, twenty-five in factor 6, five variables in factor 7 and four variables in factor eight. Therefore, one hundred and eighty two variables have been reduced to only eight hypothetical variables to explain human values. *Human values* is a very high profile concept that, as men and women are prone to thinking, separates mankind from other mortals. The study of such a topic by means of factor analysis , using a set of selective questions, is a formidable

undertaking. The application of the same method for explaining a more down-to-earth concept like ridership of urban transit buses should be an interesting one.

2.4.1.3 Recommendation

The paper recommends to create an instrument to vary the response frame so that interaction between scoring method and response pattern can be further assessed. The samples of subjects should include other than college students only. It recommends to include more items similar to those loading on Factor (viii) which has been defined as Individualism. It also recommends comparing the factor structure derived with the results from another method of study. Finally, it recommends to assess the effects on a systematically varying positive versus negative statements of the same value .

The above study has been reviewed briefly because of the fact that in this research we will follow a similar procedure for factor analysis to extract underlying factors explaining ridership.

2.4.2 Behavioural Studies: relating to traffic engineering

Although sociologists and economists have used the technique of statistical factor analysis to explain concepts for the explanation of attitudes in the social, political and economic context, the engineering studies lack such an approach.

In the field of transportation engineering , although there have been attempts at explaining public behaviour or attitude towards traffic related problems, there are relatively few research studies using factor analysis. For example, some of the **Behavioural** studies in traffic engineering include:

The Analysis of Public Attitudes to Road-Use Pricing: [Thorpe, Neil: Research Associates, Transportation Operations Research Group, University of New Castle Upon Tyne, United Kingdom]

The concept revolves round managing travel demand to relieve traffic congestion by road-use pricing directly, via toll-rings, traffic restraint or other appropriate strategies. The paper refers to *" the on-going research program to investigate public attitudes to the changes that can be expected in the economic and social costs and benefits of travel that would arise following the implementation of a road-use pricing policy."* A stated preference survey has been suggested to predict range of user response to different schemes.

Driver Attitudes and Traffic Accidents : [Terju Assum & Kari Midtland, Research officers, Institute of Transport Economics, Oslo, Norway]

In this paper two investigations have been made to derive the relationship between (1) attitude and behaviour and (2) between attitude and accidents.

The first study observed speed of drivers from 1433 driver samples and behaviour data were obtained by means of questionnaire and response from the same persons. The hypothesis was that there is a positive relationship between drivers' attitude and behaviour.

The second hypothesis stated that there is a negative relationship between drivers' attitudes and risk of accidents. 15,000 Norwegian driver's license holders had been served with a specifically designed questionnaire.

A Framework For The Prediction Of User Feedback To Road Safety Measures: [Wiel Janssen, TNO Institute for Perception, Soesterberg, The Netherlands] : The study involved three dimensions in the feedback analysis:

- (1) Engineering Estimate of accident reduction without behavioural feedback.
- (2) The rate or degree of penetration of the safety measures amongst the users.
- (3) Response of road users to the implementation of safety measures.

The third one deals with user response to seat belt use. It studies the application of behavioural models to user feedback and indicated that those users who disliked the use of mandatory seat belts had been the ones who profited mostly from the said safety measure.

All these topics could have been analysed also by using the statistical method of factor analysis. Whether such a study could have yielded better results, is not the point in question. The crux of the matter is that attitude surveys by means of questionnaire designed specifically for the purpose using statistical analyses, facilitate traffic related problem identification and policy formulation. A further refinement of such studies could possibly have been achieved through Factor Analysis.

2.5 Factor Analysis: Rationale

The topic of our research, is a challenging one. It tries to fathom the minds of the population through the responses from a cross section of the population. Studies like this are commonly done in social sciences. However, in transportation engineering, as we have seen during our brief discussion of the TSP in Chapter 1, it is a process of number crunching with the use of pure prediction models calibrated for the prediction of flow in a proposed network. On the basis of such flows the road space planning is done. But we now know that these predictions are not sufficient enough to ensure free flow conditions in a network for an indefinite period of time. The phenomenon of triple convergence outpaces the predictions and creates congestion. Such failure to predict congestion during peak periods on the road space designed should be addressed through a different approach. Congestion

is a phenomenon resulting from matters which are both complex and difficult to comprehend through the predictive models described above. Also, to use purely predictive models for the purpose of explanation may be fraught with contradiction and danger of undesirable impacts. For example, if certain luxury goods are used to predict certain related achievement like **TV in household** to predict **verbal achievement**, it should not mean that every household should be supplied with TV sets to enhance verbal achievement. Researchers are prone to falling into such a trap when they use purely predictive studies for the purpose of explaining phenomenon. We know that prediction of a phenomenon is possible without explaining whereas explanation requires just more than correlating. In the transportation planning process described in the previous chapter, the trip generation and trip distribution are based on prediction models with the utility models calibrated through multiple regression analysis. The modal split figures are obtained from the probability of using a particular mode. The trip assignment being an iterative process yielding the equilibrium traffic volumes based on travel time in a particular origin destination route with several alternatives. The process neither explain the reason for the ever increasing peak period volume of traffic nor the ever increasing phenomenon of congestion. Prediction is done on the basis of well established empirical generalization. For example, in the trip generation model, prediction is done from the sample survey of actual number of OD trips in typical households. The goal has been to optimize prediction of number of trips through an iterative process. The choice of variables are determined by contribution of selected observed variables towards prediction of the criteria. If correlation is high between the predicted and predictor the procedure is a success. Predictor or in this case the volume of traffic is a cause or symptom in forecasting. We do not seek to nullify the established process. What we want to do is to intervene, after the fact, into those specific but underlying causes that

make road space so scarce during those peak periods. We will proceed to unravel this unknown realm of knowledge through explanatory research using attitude survey database being used by OC Transpo.

2.5.1 Importance of the Knowledge of Factors

Factor analysis is an efficient performer of data analysis. It actually achieves variable reduction. This is done by creating a new set of variables extracted from the common factors. The new variable is the dependent variable as in a regression model with the factors and their factor loadings as independent variable. The factors are added to each of the original variables with factor loadings associated with each factor. For example, in a three factor model :

$$V. = C_1 F_1 + C_2 F_2 + C_3 F_3 \quad \text{where,}$$

V. is the first variable explained by the three factors namely F_1, F_2, F_3 ,

which are distinguished by the co-efficient C_1, C_2, C_3 respectively.

Before discussing the analytical procedure of Factor Analysis, it is felt that a semantic perception of the whole *concept* of factor analysis should be discussed. Let us assume that the index of ridership, which represents a *concept*, is a hypothetical point in space. Let us conceive that in a multi-dimensional space this *concept* is explained by variables or indicators scattered all around like the stars in a galaxy. These indicators lie in clusters around the *concept*. But many variables are not at all related to the hypothetical point in space and are irrelevant. As will be seen during our analysis, these remote points in the hypothetical space will be dropped from the Factor model with the theoretical application of variance, communality and eigenvalues, all of which are being explained below.

2.5.2 What is Known About Factors ?

In a factor model, the factor loadings and their signs are important determinants of the factor model analysis. The highest loaded factor indicator should explain the concept best. The indicator variables that have the highest loadings are retained in the model structure and the lightly loaded are discarded. The threshold for such retention or discarding depend on the percentage of variance explained by the respective indicators. Also, these 'eigenvalues' are plotted with the variables as abscissae with the eigenvalues as y-coordinate in a two-dimensional plot called the 'scree' plot. The cut-off point indicated by the scree plot determines the number of factors that should be included in the factor extraction. Factor analysis is also a multivariate analysis suggested by the examination of correlation matrices of the original variables. Linear combination of variables are used to predict the variance of the variate. The technique of factor analysis uses the correlations between the variables to create a new set of more closely related set of variables. 'The basic assumption of factor analysis is that the correlation between variables is due to sharing of common factors'. Factors may be orthogonal i.e. they are located in an axis perpendicular to each other or they may be oblique in which case their axes are not perpendicular with one another. In this research study orthogonal analysis has been done using Varimax rotation method. Factor analysis has been used to add several new dimensions, extracted from the common factors shared by each of the variables, to the domain of the observed variables. These factors are related to the original variables like in a regression model, each factor having been multiplied by a coefficient called the factor loading and added numerically in the model. The correlation matrix is changed after factor extraction. The original correlation matrix, in a model of 3 factors for example, becomes for variables i and j :

$$r_{ij} = r_{i1} \times r_{1j} + r_{i2} \times r_{2j} + \dots + \dots + r_{ik} \times r_{kj}$$

where,

r_{ij} = correlation between variables i and j

k = number of common factors.

If there is a difference between this estimated correlation and the actual correlation, then the difference will be the residual. In a correlation matrix the residuals are above the diagonal, the correlations are below the diagonal and the communalities are on the diagonal. The smaller magnitude of residuals are the indicators of good 'model fit'. How many factors will be considered for inclusion into the model will depend on the magnitude of the proportion of the total variance explained by each factor or eigenvalues. It is a practice to include those factors having eigenvalue of greater than or equal to one.

To make factor analysis, the following four steps are necessary:

(1) The **correlation matrix** of all the variables are computed. The matrix is examined in the light of the factor model. The observed variables must have to be highly correlated to create common factors in the factor model. But the factors should not themselves be correlated to one another in the factor structure.

(2) The next step in the factor analysis will be the **Factor Extraction** to determine the factors. There are several methods of this extraction, namely, the Principal Component Analysis, the Common Factor Analysis, the method of unweighted least square, the maximum likelihood analysis etc. In the principal component analysis, the variables are standardized to have mean '0' and standard deviation '1' and each will have a variance of '1'. Thus the total variance will be equal

to the sum of all the variables being considered in the analysis. For example, if there are 10 variables with communality equal to '1', then the total variance will be 10. The total variance explained by each factor is termed **Eigenvalue**. The Eigenvalues are obtained from the correlation matrix solving for 'latent roots' and 'vectors'. These latent roots, arranged in descending order denote variance of a new set of variables, say, $y_1 \dots y_n$. These variables are not correlated. Mostly the eigenvalues for several components add up to account for a large proportion of the total variance of the original variants, $x_1 \dots x_n$. The squared multiple correlation coefficient between a variable and all other variables or **Communality** indicates the strength of linear association among the variables. In the case of Principal Component Analysis the proportion of variance accounted for by the common factors or communality will be equal to '1' for all variables.

(3) The third step involves **Rotation** of the factor matrix, which can be orthogonal or oblique with their sub-branches.

(4) In the 4th step the **factor scores** are used for analysis like in a regression model as independent variables.

In the following chapter we will describe the salient features of the database and the methodology to be used for Factor Analysis.

CHAPTER 3

DATA AND METHODOLOGY

3.1 Survey Data: 1988-1995

The OC Transpo data base on attitudes towards transit in Ottawa-Carleton resulted from opinion poll of public transportation . The study was designed and conducted by the Carleton University Survey Centre and was based on 2000 completed telephone interviews. The survey was carried out between 1988 and 1995 (OC Transpo: 1995 Attitude Survey).

The sample was extracted from telephone numbers. Birthday selection method or the person whose birthday in the household is nearest is selected to ensure a representative sample across age group. The selection of these people are done randomly *from listed telephone numbers on the CD, CanadaPHONE*. Also, care is taken so that people from cities of Ottawa, Kanata, Nepean, Gloucester, Cumberland and Vanier are given proper representation. Only persons with age equal to and older than 18 years have been included. Random selection technique were used and the sample was stratified by six municipalities served by OC Transpo.

The School of Journalism was used as the site to conduct interviews. The experienced bilingual survey crew was trained prior to the first night of interviewing. An information session was held to

familiarize the interviewers with the questionnaire and to instruct the crew on answering questions. Interviews were conducted in the evening or during the weekends. Call-backs were made according to well established survey techniques. The interviewers worked under constant supervision.

The questionnaire was an updated version of the questionnaire used in 1994. As in the past, it was designed by OC Transpo in association with the Carleton University Survey Centre. The English as well as French versions of the questionnaire were used. Prior to actual use, each version was pre-tested. [For the 1995 data survey questionnaire, please see Appendix D]

The outcome was 49% gave complete response, 25% refused to respond, 24% were not available and 2% telephones were not in service.

The Urban Transit Area was represented as follows:

- . the Central Area (35.70 % of respondents)
- . the inner suburbs (24.10 % of respondents)
- . the outer suburbs (40.10% of respondents)
- . Refused (0.10% of respondents)

In order to obtain final results, the sample was weighted to correctly represent the actual of the region. In order to interpret results, the following definitions are useful to know. Frequent users are those “who use the bus at least once a week”. Casual users are those “who have used the bus in the last six months but who use the bus less than a week”. Non-users are those “who have not used the bus in the last six months.”

For the final results, the population figures of the six municipalities were weighted for age and sex to ensure that the sample reflected the true proportions of the population, as indicated by Statistics Canada census data. In addition, because the 1995 results were skewed in area distributions when compared to previous surveys, this years results were weighted by the 1994 area distribution. After careful analysis, it was determined that this skew was a factor of the telephone number selection and response rates.

The weighting of the data does not affect the accuracy in a sample of this size

Sample Size and Error. A sample of this size is deemed accurate within 1.8 percentage points 19 times out of 20. When only bus users are considered, the standard error is 22.7 percentage points 19 times out of 20. When individual groups of users are broken down the error estimate rises. “

3.2 Reliability of Data

According to the Survey Centre, the sample was representative of residents within the Urban Transit Area and is claimed to be accurate to 3% nineteen times out of twenty. A statistical approach was taken in this research to check the reliability of the 1995 database.

3.3 Alternative Forms of Analysis

Market Segmentation

Sophisticated marketing emphasizes segmentation of the market. This is normally done by analyzing clientele and dividing it into segments. The segments are defined on the basis of different characteristics and behaviour. This enables the targeting of services to attract individual segments of travelers.

In the context of this study, this approach is already covered by the weighted frequency approach used by OC Transpo to analyze the data. For example, market segments have been defined on the basis of: frequent users, casual users, non-users, gender, age, spatial segments (central, inner suburbs, outer suburbs), etc.

Factor Analysis

Given the large number of variables and correlations between independent variables, it is necessary to use a statistical method to scientifically analyze the data base. Also, it is essential to investigate the behavioural aspects of the potential users of bus services. Factor analysis meets these requirements.

Although Factor Analysis is frequently used in social sciences and medical research work, very few applications in transportation planning and engineering have been reported. At Carleton University, three doctoral thesis research endeavors have applied this technique. For example, Shallal (1979) used Factor Analysis for the identification of factors and ultimately variables for inclusion in developing regression equation that predict peak-hour traffic. He also discussed the TSP models in the light of three generations of development: The first generation models being based on trend analysis, the second generation being the four stage TSP models and the third being the econometrics and the desegregate stochastic models. The third generation models have been described as consumer behaviour models and that they can be developed for peak hour traffic conditions. According to Shallal, “ for short range planning peak hour models are necessary since peak hour volumes are used as an input to functional planning and design.”

However, the behavioural aspect of the above models are indirectly derived behaviour from the origin destination surveys etc. whereas in the attitude surveys like OC Transpo's, the direct responses from a sample population are used to explain behaviour. The above mentioned models predict peak hour volumes to design road space. The philosophy is to supply road space according to demand during peak hour or during 24 hour period. These are widely accepted procedures being used by transportation planners and made more sophisticated during generations of research and development.

The nature of study in this research does not deal with the above planning process. It deals with the other aspect of the problem, the management of the demand. The OC Transpo's effort at understanding the behaviour of the people it serves is an important step towards studying one aspect of the demand management strategies. OC Transpo's attitude survey and its analysis is discussed in detail in literature review with a view to highlight the complexity of the problem and to formulate hypotheses for this research to see if the outcome accepts or rejects OC Transpo's conclusions.

3.4 Methodology

The 1995 data has been analyzed by Factor Analysis with the help of SPSS software in the following chapters. The 1995 database questionnaire format has been slightly altered, although, the central theme of the questions have been the same. There are 98 variables in the data set. Of these there are 24 variables that are of ordinal type with 5 categories of responses like 'strongly agree', 'agree', 'neither agree or disagree', 'strongly disagree' frame. We have also included some of the higher category (8) and lower (2) and three (3) category responses.

In surveys involving direct questions on attitudes and in this case the survey of urban bus ridership, it is difficult to measure the actual responses. Also, there are questions asked that might be construed as self deceiving like 'Do you use bus?', 'Why not use bus?', 'Bus is frustrating.' etc. The question setter in such cases knowingly or unknowingly forces an answer which will be based on the tone of the question rather than on true feelings of the person asked. There may also be overlapping questions, questions that can be misinterpreted and conversely there can be answers that are reflections of vagueness, absentmindedness and so on and so forth, meaning that highly correlated responses may result in incomprehensible results.

The **ridership** index has been selected from the variable indicating frequency of riding buses. Variable 10 in the database is a dichotomous variable with question asking : Do you ride OC Transpo buses?. The responses are “Yes” or “No”. As we are dealing with a single variable with binary coding, it will be necessary to recode it as a dummy variable for use in a Logistic Regression model as the dependent variable.

The most appropriate approach for analysis of the observed variables stated above would be the **Likert** approach, which scales the **respondents** not the **items**. In Likert scaling, *‘a set of items, composed of approximately an equal number of favorable and unfavorable statements concerning the attitude object, is given to a group of subjects. They are asked to respond to each statement in terms of their own degree of agreement or disagreement. Typically, they are instructed to select one of five responses: strongly agree, agree, undecided, disagree, or strongly disagree. The specific responses to the items are combined so that individuals with the most favorable attitudes will have the highest scores while individuals with the most unfavorable (or most unfavorable) attitudes will have the lowest scores.’* [Kim Jae-On, 1981]..

Items in the variables selected for our analysis mainly consist of three-choice to five-choice ‘continuum for recoding response categories’. There are a 24 variables with a five category response frame .There are a few with larger category frame like : var39 and var58 are eight category responses, var42 and var52 are seven category responses. There are smaller category response frames like: 6 variables with four category and the 12 variables with three category responses. There are no dichotomous variables as their inclusion might have undermined interpretability. **Internal consistency** criteria have been modified to account for differences in subgroup size as well as different distributions of responses between subgroups.

3.5 The critical ratio or T-Test

It is an indicator of an item differentiation between low and high sub-groups affording evaluation of mean differences. The critical ratio is:

$$t = (X_H - X_L) / \sqrt{[(S_H^2/n_H) + (S_L^2/n_L)]}$$

X_i is the mean item response of subgroup I, S_i^2 is the item variance of subgroup I, and n_i is the size of the subgroup I. [McIver, 1981]. The subscripts H and L indicating high and low sub-groups respectively. The t-test supports our scaling technique used in this study.

The stage has now been set for the study of the underlying dimensions of ridership.

3.6 Sampling

Sampling is a technique of gathering information about an entire population by obtaining it from only a representative part of the same. Statisticians draw conclusion about the entire population through the sample population. This approach is known as the statistical induction. In statistical enquiries the investigators meet the challenge to describe an entire population by taking the appropriate sampling techniques.

The concept of sampling is not new. In our daily life we take samples unawares to test the quality of a thing we are going to buy. For example, sometimes we taste a fruit or a food before we decide to buy the entire quantity we need. We assume that the entire quantity we are buying will be reflected by the sampling we tasted. This day to day practice is rooted in our psyche and there is hardly anyone who has not done this sampling practice.

The research worker has a lot of options to choose from a numerous available sampling techniques. The choice depends on the merit of each case. In this research, the data used has been

obtained from a systematic survey questionnaire as has been discussed. The size of the sample, two thousand in number, has been reasonably adequate. The data has been tested for reliability and validity. The sampling error has been investigated through its attributes like standard error, mean, standard deviation etc. of variables. We calculate the mean, standard deviation etc. of the variables to estimate the corresponding values of the population.

In the next chapter we shall discuss the conceptual framework for examining the underlying dimensions of ridership and this will also include the factor analysis output using the data from OC Transpo as described here in this chapter.

CHAPTER 4

CONCEPTUAL FRAMEWORK FOR EXAMINING THE UNDERLYING DIMENSIONS OF RIDERSHIP

4.1 FACTOR ANALYSIS : Why and How ?

The review of literature in chapter 2 clearly indicates how behavioural studies can be used to explain a concept through statistical analysis. In this chapter, we present a discussion of the theoretical underpinnings of the relationship between ridership and several important factors that emerged in the OC Transpo's study as well as from the Performance Indicators found in the World Bank study on ridership of transit buses. There are several major hypotheses to explain the relationship between Ridership and the attitude related factors as well as some of the categorical variables with dummy coding.

The attitude towards ridership of transit is dependent upon variables that in the original version may be tainted with shallow perception of the questions answered, indifference or mere capitulation to a 'sought after' question clearly manipulated. Some of these questions answered may simply be vague and absentminded. Factor analysis is expected to overcome these anomalies by creating uncorrelated clusters of observed variables.

By rule of thumb, the factors with eigenvalues equal to or greater than '1' are taken in the factor model and their factor loadings are calculated. Another procedure to determine the number of factors for a factor model is by drawing a plot of eigenvalues as ordinate with the respective variables as the abscissa. There will be a noticeable break or scree with a horizontal leveling off

followed by another slope downwards. This corresponding number of factors are taken into the factor model. Next, a factor matrix is created with all the variables sharing these factors. The factor matrix may not always be interpreted easily. The factor loadings cannot be distinguished, looking at their magnitude and they cannot be interpreted. But if the same coordinates are rotated orthogonally, say, 45 degrees, they are simpler to interpret.

From the rotated table, If we sort the loadings in order of magnitude and blank out the **lower values** of loadings the following distinguishable clusters should emerge :

Table 4.1: Example: Rotated factor loadings of the above table with lower values blocked.

VARIABLES	FACTOR-1 LOADING	FACTOR-2 LOADING
X1	0.7	
X3	0.9	
X5	0.7	
X2		-0.6
X4		0.85

Source: Nil: Hypothetically made up as an example only.

It can be seen from the above table that X1, X3 and X5 form a cluster under Factor-1 and X2 and X4 create a second set with Factor-2 loadings. The variables X1, X3 and X5 are explained by the factor-1, and the variables X2 and X4 are explained by factor-2. Thus five observed variables have been explained by two factors. Oblique rotation can also be achieved by rotating both axes simultaneously, forming any oblique angle.

Factor Analysis has been used as an aid in the formation and refinement of empirically useful concepts. Ridership is such a concept and will be explained in the same way. *However, the real research problem at hand is almost always more complex than the factor analysis model*

assumes to be true. For instance, (1) it may be that the level of measurement of some or all variables does not meet the measurement requirements of factor analysis. (2) some aspects of the model, such as independence of measurement error, may be unrealistic for one's data, or (3) one may have minor factors whose identification is not the primary concern but whose presence affects the identification of major common factors. The crux of the matter is that the researcher must in the end make some discretionary extra statistical decisions. [Lawley, 1971]

The intent of this study has been to sharpen the concept of ridership by deriving factor structures of the 47 numbers of ordinal type of variables. These variables are representing the value categories on a *likered scale*.

The topic of review of literature in chapter 2 dealing with human values explained in a factor analytic procedure shows: (1) the benefit and effectiveness of using factor analysis to reduce a large number of observed variables by a comparatively smaller number of hypothetical variables and (2) shows how the interpretation of a major theoretical concept like *human values can be made* by a very small number of hypothetical variables.

The topic review in chapter2 involving OC Transpo's study has used weighted frequencies to show direct relationship between attitude towards urban bus ridership and twelve other constructs shown as Exhibits, apparently created through judgement and experience instead of using high-tech tools. The objectives in both these studies, however, have been the same. The Exhibits are groups of ridership related responses on services like **On-street-service, customer service, Security, Public Info, Fares etc** . However, there are inclusions of the same observed variables in more than one exhibit box to explain these constructs or hypothetical factors. The close correlation amongst the Exhibits in OC Transpo's study are, in this case, highly visible through use of same

observed variables in different constructs and may result in erroneous interpretation and impact evaluation. However, the twelve items of Exhibits portray a general picture of what the transit service perceives to be significant factors affecting ridership. The important thing to observe in our study will be to see if a factor analytic approach will bring out the statistically uncorrelated factors which explain ridership of public transit. This will create a recognised statistical process of data analysis removing data anomalies.

4.2 Hypotheses

In this chapter, we would like to further present the theoretical underpinnings of the various models that should explain ridership. This study formulates and tests a series of hypotheses to explain the index of ridership with respect to the hypothetical as well as some socio-economic variables. To facilitate this objective, the following broad types of models have been proposed :

- (1) A logistic regression model: **Ridership** as a binary dependent variable with the significant **hypothetical variables** or **Factors** as independent variables.
- (2) A logistic regression model: **Ridership** versus **Factors** plus some **socio-economic variables** like income, education, occupation, age, sex etc. coded into categorical dummy variables.

4.2.1 Formulation of Hypotheses

In the sample survey, information is collected from the representative cross-section of the same population. It makes the estimation of population parameters from the sample values. As the sampling fluctuations are natural, sampling errors are commonplace. This sampling error is called standard error and by use of standard error and the probability theory, the probability of locating the population value between the standard error limits can be found. In testing the reliability of estimate between the acceptable limits from the knowledge of the sample is known as test of hypothesis. In

this analysis hypotheses have been formulated on the basis of the transit commission's questionnaire based estimates and weighted frequencies as well as from the outcome of the important studies like World Bank's operational performance and quality of service indicators. Through this research we will either accept or reject these hypotheses on the basis of the odds ratio, R values and their levels of significance in an algorithm of logistic model development.

A dynamic bus arrival information to the waiting passengers in addition to the conventional information are thrilling future possibilities by use of Intelligent Transportation System (ITS). It will be of interest to see in our analysis what will be the impact of such an introduction.

On-Street service has been conceived of as the combination of the Operational performance indicators suggested by the World bank study and the OC Transpo's Attitude survey. These services are pivotal to any transit service and improving such services should have a positive impact on Ridership of transit buses.

The overall Safety and Security concerns should be addressed by the Transit Authority, so that the people do not have an attitude which will translate into a negative impact against riding transit buses. A reduced fare should induce people to take to public transit. Any kind of reduction of fare, for example, monthly bus pass, off-peak reduced fare, Senior pass, Student pass, Unipass, Transpass, Econopass, is expected to boost ridership. Therefore, a significant fare reduction should have positive impact on ridership. Also, conventional socio-economic variables like age cohorts, education, occupation, income, gender and language groups should conceivably have some impact on ridership.

Based on the experiences of previous research as discussed above, we begin by hypothesising that

ridership is explained by a series of factors like fare reduction, excellent service, dynamic bus information, safety and security etc. provided by the transit service. In our literature review we have discussed, among other topics, OC Transpo's analysis of attitude survey data and also World Bank study of important service indicators for a viable bus service. Working within the framework we would like to focus on a statistical analysis approach to accept or reject the following hypotheses:

Hypothesis 1: Providing accurate and dynamic *Information & Customer Service* should have a **positive** impact on transit ridership.

Hypothesis 2 : *On-Street-Service* improvement would be a very important factor impacting positively upon ridership.

Hypothesis 3 : The increased *Safety and Security* inside the bus as well as in the stations of access and egress will positively impact upon ridership.

Hypothesis 4 : The *reduced fare* will have a strong and positive impact on ridership of bus.

Hypothesis 5: *Cleanliness* of bus routes, passenger terminals as well as of vehicle should have a positive impact on ridership.

Hypothesis 6: General attitude on riding buses are reflected by various concerns like environmental, social and economic ones.

Hypothesis SH1 : The impact of **age** on ridership would depend on different age groups: positive impact for younger age group between 18-22 gradually decreasing with increasing age. Depending on coding the impact should be negative with increasing age group cohorts.

Hypothesis SH2: The impact of *education* on ridership of urban transit buses will be negative.

Hypothesis SH3: The impact of *occupation* on ridership will be negative with higher categories

of job classification.

Hypothesis SH4: The impact of **sex**: male or female will have equal impact on ridership.

Hypothesis SH5: The language groups: Both **French** and **English** speaking groups should have negative impact on ridership while other language groups will have positive impact on ridership.

Hypothesis SH6: The impact of **income** on ridership should be negative with increasing income.

The above hypotheses when tested in our research analysis will give us the probability of occurring any value of the statistic. If the odds of occurring of the observed value of such statistic is small according to null hypothesis, we shall reject the hypothesis and in the reverse case we shall accept it. The level of demarcation or the level of significance, generally 5% or 1%, determines the acceptance or rejection of the null hypothesis. When the null hypothesis falls within these limits, for example 5%, we accept our corresponding hypothesis with 95% confidence. The results of the testing of our hypothesis will be discussed in detail in chapter 6 of this research analysis.

4.3 Scale Development

The ridership scale has been developed empirically and indexed from the variable 10, with responses relating to frequency of bus ridership. It is a binary coded variable with 'yes' or 'no' response framework. A Logistic regression analysis will indicate the odds of occurring ridership according to the odds ratio obtained from the evaluation of the logistic model incorporating the factors or the socio-economic variables.

4.3.1 Scale reliability

Items in the variables selected for our analysis mainly consist of three-choice to five-choice continuum for recoding response categories. There are 24 variables with a five category response

frame. There are a few with larger category response frames, e.g. : var39 and var58 are eight category, var42 and var52 are seven category responses. There are smaller category response frames like: 6 variables with four category and the 12 variables with three category responses. Also, questions that do not require responses involving human traits have not been included for factor analysis, like income, age, education, occupation, travel time, language, sex etc. A separate analytical procedure with coding , categorizing and making dummies and regressing these with ridership index have been shown. The ridership index has been analysed for reliability and shows a 89 % scale of reliability. This has ensured adequate scale reliability. Any scale anomalies could ultimately result in non-interpretability of factor indicators. The respondents evaluated the importance of each category on a mostly 5 point scale *through to a minimum of three point scale of response. These responses were factor analysed in order to reveal the areas of interdependence and independence, in other words to reveal the factor structure... Through the factor analytic methodologies, logically conceived hypothetical constructs may be derived, tested empirically, modified with additions or deletions according to explicit standards.* [Lawley, 1971]

4.4 Examining the Underlying Dimensions of Ridership

4.4.1 Sample Adequacy

We start our factor analysis by deriving the correlation matrix of all the forty-seven variables under our study plan. The **correlation matrix** of all the variables have been computed. [Appendix B]. The matrix is examined in the light of the factor model. To share **common factors**, the correlation between the observed variables must be high. It is difficult, from a relatively large array of correlation like this, to assess by visual examination, if the sample is adequate for factor

analysis or not. The **Kaiser-Meyer-Olkin (KMO)** measure of sample adequacy is an index which can show if the data are suitable for Factor Analysis or not. This is a ratio of the sum of squares of the simple correlation between variables over the sum of the squares of the simple correlation coefficient plus the sum of the partial correlation coefficients between all the variables and the expression for that is as follows:

$$KMO = \frac{\sum_{J \neq 1} \sum r_{ij}^2}{\sum_{J \neq 1} \sum r_{ij}^2 + \sum_{j \neq 1} \sum a_{ij}^2}$$

where, r_{ij} = Simple correlation coefficient between variables I and j

and a_{ij} = Partial correlation coefficient between variables I and j

'Kaiser (1974) characterizes measures in the 0.90's as marvelous, in the 0.80's as meritorious, in the 0.70's as middling, in the 0.60's as mediocre, in the 0.50's as miserable, and below 0.50 as unacceptable.' An examination of the partial correlation matrix or its negative called Anti-image correlation should show very small values amongst the pair of variables. The Kaiser-Meyer-Olkin values for sampling adequacy for each pair of variables have been shown on the diagonals of the Anti-image correlation matrix shown in [Appendix B]. The following result has been obtained in our analysis:

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = **.79589**

Bartlett Test of Sphericity = 12835.641, Significance = **.00000**

As the Kaiser-Meyer-Olkin measure of sampling adequacy shows to be greater than 0.79589 in this study, this is acceptable with *merit* for Factor Analysis. The pair-wise KMO values as shown in the anti-image correlation matrix are the indicators of respective strengths of the variable relationship. With this view in mind we have dropped out a number of variables with the lowest KMO values and found the analysis by means of forty-seven (47) variables. It should also be noted that the pair-wise KMO values in the diagonals are between 0.97045 to 0.47715, an average of which has reached to 0.79589 which is *meritorious* according to Kaiser and acceptable for factor analysis. Also the **Bartlett Test of Sphericity**, testing the Hypothesis that the correlation matrix is an identity matrix with diagonal as '1' and off-diagonal values as '0' has been proved to be not true with the Sphericity = 12835.641 and significance as 0.0000 as can be seen in the output table. Therefore, Factor Analysis will be feasible with the 1995 database.

4.4.2 Factor Extraction

Now, the Factor extraction procedure has been discussed to find out the underlying factors that are responsible to explain the index of **Ridership**.

4.4.3 Communalities

With mean as "0" and Standard. Deviation of each variable as "1", the **communality** or the proportion of variance accounted for by the common factor should be "1" for each of the variables. **Communality** of a variable has been calculated by squaring the factor loadings of the concerned variable and adding them together. The factor loading on the other hand has been obtained by squaring the correlation coefficient of the variable concerned which denotes the variance of the variable. In Table 4.3 the results of the **Principal Component Analysis** have been shown. In the

case of **principal component analysis** the total variance is given by the sum of variances which is '1' for each variable and is the sum total of the number of variables involved. Please note that after factor extraction the communalities have been recalculated for finding the actual variance.

4.4.4 Eigenvalue and Scree-plot

The **Eigenvalue** or the total variance explained by each of the factors individually have been calculated from the factor matrix by squaring and adding the loadings under each factor [Table 4.2]. All these operations have been done using the Statistical Package for Social Sciences (SPSS) software which can handle the database as large and as complicated as this one. As a thumb rule, the number of factors have been determined by the number corresponding to **Eigenvalue** equal to or greater than '1' as shown in the **initial statistics** table [Table 4.2]. In the final factor extraction, we have used Cattell's Scree Test [Figure 4.1] which is a plot of unrotated factors versus the proportion of total variance or **Eigenvalues**. It is to note that in the scree plot there is a negative slope, decreasing from factor no.1 through to factor no.6 and then it seemed to have leveled off and sloped further down and leveled off again. The point corresponding to the first scree may initially determine the number of factors that should emerge.

'The random error factor when plotted resembles scree, the debris that has fallen or been eroded from a mountain and that lies at its base.' [Kim Jae-On and Mueller, 1981]

However, there may be the necessity sometimes to employ subjective judgement to determine the level-off point and to overcome this the scree plot should be reviewed by some other experts in the field to reach a consensus. Next, we start the **Initial Factor Extraction** procedure to determine the factors. There are several methods of this extraction, namely, The Principal Component Analysis, The Common Factor Analysis, The method of unweighted Least Square, The

Table 4.2 [Eigenvalues ≥ 1] Initial Statistics

This table only shows eigenvalues greater than "1"					
<i>Variables</i>	<i>Communality</i>	<i>Factor</i>	<i>Eigenvalue</i>	<i>Percentage of Variance</i>	<i>Cumulative Percentage</i>
<i>Var39</i>	1.00000 *	1	10.38162	22.1	22.1
<i>Var40</i>	1.00000 *	2	5.10286	10.9	32.9
<i>Var41</i>	1.00000 *	3	2.65026	5.6	38.6
<i>var42</i>	1.00000 *	4	2.00358	4.3	42.8
<i>Var43</i>	1.00000 *	5	1.66328	3.5	46.4
<i>Var44</i>	1.00000 *	6	1.50926	3.2	49.6
<i>Var45</i>	1.00000 *	7	1.45470	3.1	52.7
<i>Var46</i>	1.00000 *	8	1.43355	3.1	55.7
<i>Var39</i>	1.00000 *	9	1.30502	2.8	58.5
<i>Var48</i>	1.00000 *	10	1.20653	2.6	61.1
<i>Var49</i>	1.00000 *	11	1.15550	2.5	63.5
<i>Var50</i>	1.00000 *	12	1.10245	2.3	65.9
Var51	1.00000 *	13	1.04050	2.2	68.1

Maximum Likelihood Analysis etc. In this study, principal component analysis has been chosen and each variable has been standardized to have mean '0' and standard deviation '1' and each have a variance of '1'. Thus the total variance has been equal to the sum of all the observed variables being considered in the analysis. For example, in our study, there are Forty-seven variables with **communality** of each equal to '1'. This means that the total variance of these variables will be equal to 47. As the total variance explained by each factor is the 'Eigenvalue'. The Eigenvalues are obtained from the correlation (or covariance) matrix solving for the 'latent roots' and 'vectors'. These latent roots, arranged in descending order denote variance of a new set of variables, for example, $y_1, \dots, y_n$. The squared multiple correlation coefficient between a variable and all other variables are the 'Communality'. They indicate the strength of linear association among the variables. In the case of Principal Component Analysis, at first, the proportion of variance accounted for by the common factors or 'communality' will be equal to '1' for each of the variables. The eigenvalues have been obtained by the sum of the squared correlations in the **initial statistics table** and communalities are obtained by the process of Principal Component Analysis as shown in Table 4.2. We have the number of factors extracted to be thirteen (13) from a total of forty-seven (47) observed variables. These are based on orthogonal rotation with an assumed **rule of thumb** to determine the number of factors from the eigenvalues to be equal to or greater than one (1). In the initial solution the first factor accounted for 22.1 % of the total variance and the subsequent factors explained by gradually diminishing percentages of variance and the thirteenth factor explains 2.3 % of variance. Also, from the above table the first thirteen factors which have an eigenvalue greater than '1', explain 68.1 % of the total variance. The remaining factors, representing the remaining percent of variance have eigenvalue less than 1 and are not included. Therefore, the

first thirteen factors are taken in the factor model and their factor loadings are calculated

Next, an **unrotated factor matrix** has been created with all the variables sharing these factors, as shown in Table 4.3.

Table 4.3 Unrotated Factor Matrix

<i>Variables</i>	<i>Factor 1</i>	<i>Factor 2</i>	<i>Factor 3</i>	<i>Factor 4</i>	<i>Factor 5</i>
<i>Var53</i>	.95156		-.12856		
<i>Var55</i>	.90726				
<i>Var51</i>	.90203	.12935	-.13476		-.11638
<i>Var58</i>	.89702	.13037	-.11862		
<i>Var49</i>	.87568				
<i>Var47</i>	.87002				-.16771
<i>Var56</i>	.85854	.14321			-.13161
<i>Var41</i>	.85097				-.11950
<i>Var40</i>	.83853	.15363	-.20216		-.12268
<i>Var43</i>	.83046	.11190	-.31808	.38228	
<i>Var39</i>	.78252				
<i>Var57</i>	.63622			.11131	.25157
<i>Var50</i>	.62469	.22954		.16446	.12506
<i>Var42</i>	.52579	.11162			.16652
<i>Var48</i>	.48839	.19669		.15673	.36769
<i>Var70</i>		.62461			
<i>Var82</i>	-.23762	.58894			
<i>Var78</i>		-.58154			-.16761
<i>Var63</i>	-.33885	.57384	-.12658	-.12128	

'At this stage of the analysis one should not be too concerned with whether the underlying factors are orthogonal or oblique - all initial solutions are based on orthogonal solution. Nor one should be too concerned with whether the factors extracted are interpretable or meaningful. The chief concern is whether a smaller number of factors can account for a much larger number of variables.' [Kim Jae-On and Mueller, 1981]

Table 4.4 [Eigenvalues ≥ 1] Final Statistics

This table only shows eigenvalues greater than "1"					
<i>Variables</i>	<i>Communality</i>	<i>Factor</i>	<i>Eigenvalue</i>	<i>Percentage of Variance</i>	<i>Cumulative Percentage</i>
<i>Var39</i>	.65556	1	10.38162	22.1	22.1
<i>Var40</i>	.79445	2	5.10286	10.9	32.9
<i>Var41</i>	.86915	3	2.65026	5.6	38.6
<i>var42</i>	.72106	4	2.00358	4.3	42.8
<i>Var43</i>	.95897	5	1.66328	3.5	46.4
<i>Var44</i>	.73285	6	1.50926	3.2	49.6
<i>Var45</i>	.85972	7	1.45470	3.1	52.7
<i>Var46</i>	.84664	8	1.43355	3.1	55.7
<i>Var39</i>	.86622	9	1.30502	2.8	58.5
<i>Var48</i>	.66884	10	1.20653	2.6	61.1
<i>Var49</i>	.80736	11	1.15550	2.5	63.5
<i>Var50</i>	.61291	12	1.10245	2.3	65.9
Var51	.90648	13	1.04050	2.2	68.1

Figure 4.1

In the extracted factor solution process, the variance of all the variables have not been explained. Therefore, the actual communalities are calculated by squaring the correlations of the factors retained. The other values in the initial statistics table remain unchanged.

4.4.5 Factor Loadings

The Factor loadings have been obtained by considering a linear relationship amongst the factors so that a multiple linear regression model can be assumed. The **loadings** are the same as the **coefficients** of the factors as independent variable and the observed variable as the dependent variable.

4.5 Final Solution

4.5.1 Factor Rotation

The aim of the final solution has been to obtain a **simple structure** solution by means of rotation, either orthogonal or oblique . Simple structure has been variously defined by a large array of scholars in the field, especially the sociologists like Thurstone [1947] and Mulaik [1972]. The definition mostly favored by the scholars is that of Thurstone who used hyper planes and subs spaces to rotate the structure matrix so that, according to the simpler description of Mulaik :

(r refers to the number of common factors and V is the reference structure matrix consisting of a reference axis.)

- (1) *Each row of the reference structure matrix V should have at least one zero.*
- (2) *For each column k of the reference matrix V there should be a set of at least r linearly independent observed variables whose correlations (as found in the k th column of V) with the k th reference-axis variable are zero.*
- (3) *For every pair of columns of V there should be several zero entries in one column*

corresponding to nonzero entries in the other.

(4) When four or more common factors are obtained, each pair of columns of V should have a proportion of corresponding zero entries. This requirement assures that each reference axis is pertinent to only a few of the observed variables and thus guarantees a separation of the observed variables into distinct clusters.

(5) For every pair of columns of V there should be only a small number of corresponding entries in both columns which do not vanish. This criterion further ensures the simplicity of the variables.

The above statement can be written in a more precise manner: To rotate the structure matrix so that :

(a) There will be one zero in each Row

(b) There will be as many zeros as there are common factor for each column.

(c) On the other hand, for every pair of columns there should be at least as many pairs of variables with zero regression weight as there are common factors.

With the above framework in mind rotation of the matrix structure had been done.

First, VARIMAX orthogonal rotation has been carried out. This means that the original reference axes [90 deg.] have been rotated in the hypothetical space in such a manner that they seek out and pass through the clusters. An ideal or perfect case would be to absorb all the variables within each axes as the case may be. But the variables are with variance and in reality what has happened is that the groups of clusters have formed a simpler Factor matrix [Table 4.5] after such orthogonal rotation. Compared to the unrotated matrix, this rotated matrix has created a more interpretable set of constructs or hypothetical variables under the factors. This has been possible by means of Varimax rotation which has converged in fifteen (15) iterations.

The set of loadings obtained from a factor analysis , when the number of common factors exceeds

one, is not unique and that other equivalent sets can be derived by orthogonal transformations of it. This fact is frequently utilized in an effort to simplify the results of an analysis, and to make them more meaningful, even if it does allow different interpretations of the same data to be given [Lawley and Maxwell 1971].

It has been clear from looking at the unrotated factor matrix that it is extremely difficult to isolate the factors with high loadings in a group of variables in their respective threshold of loading magnitude. Therefore, to give the clusters a meaningful interpretation and also to remove any negative sign problem, the VARIMAX rotation has been carried out at first. The rotated output has been obtained after sorting in ascending order and blanking out the loadings lower than 0.39. This has produced, what can be termed, the structure closest to a **simple structure**.

4.5.2 Orthogonal Rotation

Orthogonal Varimax rotation that has been performed has converged in 15 iterations. The Varimax rotation used maximization of the variance of squared loadings for each **factor**, given by the expression :

$$V = \sum_{j=1}^r v_j = \left[\sum_{j=1}^r n \sum_{i=1}^n b_{ij}^4 - \left(\sum_{i=1}^n b_{ij}^2 \right)^2 \right] / n^2$$

Where, n is the number of variables b_{ij} is the factor loading of variable i on factor j .

However, normalized factor loadings have been used by replacing b_{ij}^2 by b_{ij}^2 / h_{ij}^2 and b_{ij}^4 by b_{ij}^4 / h_{ij}^4 In the above equation for use in the iterative process.

The rotated table is shown in Table 4.5 for **Varimax rotation**.

Application of quartimax , contrary to Varimax , maximizes the squared loadings of each variable.

The overall measure of simplicity is given by q from the expression:

$$q = \sum_{i=1}^n q_i = \sum_{i=1}^n \left\{ \sum_{j=1}^r (b_{ij}^4) - \left(\sum_{j=1}^r b_{ij}^2 \right)^2 / r \right\}$$

q is the factorial complexity of a variable i , b_{ij} is the factor loading of variable i on factor j ,

r is the number of columns in a pattern matrix. The maximization of q above is attained by rotating the above.

But this is achieved by rotating the first term in the equation, as the latter term is a constant, which is:

$$Q = \sum \sum b_{ij}^4$$

which denotes a **quartimax** solution, with $i = 1$ to n and $j = 1$ to r number of rows and columns in a pattern matrix. This uses the maximization of the variance of squared loadings of the variables.

Table 4.5: EXTRACTED FACTORS USING VARIMAX METHOD

FACTORS EXTRACTED : VARIMAX METHOD													
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>	<i>13</i>
V53	.938												
V51	.915												
V43	.892												
V58	.882												
V47	.875												
V55	.874												
V40	.870												
V56	.870												
V41	.863												
V49	.855												
V39	.704												
V50	.595												
V57	.548												
V42	.418												
V70		.737											
V71		.730											
V64		.588											
V82		.582											
V63		.573											
V72		.468											
V45			.872										
V46			.870										
V44			.736										

Table 4.5 continued with extracted factors using varimax method

	1	2	3	4	5	6	7	8	9	10	11	12	13
V74				.746									
V69				.696									
V73				-.67									
V78				-.41									
V81					.801								
V84					.595								
V83					-.51								
V65					.422								
V61						.830							
V62						.800							
V85							.666						
V68							.633						
V79							.564						
V59								.759					
V77								.512					
V52									.800				
V75										.755			
V76										-.43			
V66										.390			
V48											.599		
V86												.789	
V54												-.45	
V67												.39	
V80													.66

4.5.3 Output: Varimax Rotation

The final step has been to calculate the factor scores. This is done by the product of the standardized value of a variable by its factor score coefficient and summing them up separately under each factor for each variable. The factor scores are only estimated approximations, as exact scores cannot be calculated. In our study we derived the **regression factor scores** by the squared multiple correlation between the estimated factor scores and the actual factor values. They are shown on the diagonals of the covariance matrix for estimated regression factor scores.

4.5.4 Oblique Rotation

Direct Oblimin method, based on the criterion developed by Jennrich and Simpson (1966), has also been used during the analysis phase of this research effort. However, no appreciable changes were noticed in the overall results. The oblique rotation is done following the expression:

$$D = \sum [\sum b_{ij}^2 b_{ik}^2 - d (\sum b_{ij}^2 \sum b_{ik}^2) / n]$$

where, b_{ij} are factor loadings in a pattern matrix . The values of d in the equation are varied to obtain the obliqueness of the solution. The greater values of d produce more obliqueness and the negative value tend to more orthogonality while $d=0$ identifies the correct pattern.

Now that the procedure of factor analysis, as described above, has been accomplished , it will be interesting to interpret these factors in the following chapter and label them and fit them into a model which explains the factors affecting ridership.

CHAPTER 5

DESCRIPTIVE RESULTS

5.1 Factor Analysis: 1995: Correlation Matrix

During analysis of the 1995 data, the **correlation matrix** of the variables relevant to the ridership index have been computed as shown in the Table in [Appendix B]. The two dimensional data matrix for the 1995 Attitude survey represents persons interviewed through questions in rows and the variables represented in the columns. These variables have been found to be correlated to each other and their acceptability have been verified through the Kaiser-Meyer-Olkin (KMO) values, and have been found to be within the 'meritorious' range for factor extraction to be carried out. Therefore, we proceeded with the analysis on the basis of the KMO values indicative of a high degree of correlation amongst the independent variables. On Table 4.3 of the output we have the **unrotated factor matrix**. This is an initial matrix, which shows the 13 extracted factors on an orthogonal axis. But no attempt has been made to interpret the factors from this matrix.

5.2 Rotated Factor Matrix

The aim in pursuing procedures like rotation , orthogonal or oblique , has been to attain a *simple structure* so that the interpretation of such factors extracted are easier. This has been done, first by means of orthogonal rotation like **Varimax** and later with **Oblique rotation** like **Direct Oblimin**. These rotations, however, did not change the *degree of fit between data and factor structure*. This structure has been obtained by following the definition of the *simple structure* as discussed before. The lower magnitude (≤ 0.39) loadings have been blocked out in the rotated

matrix table for showing the clusters more distinctly.

5.3 Varimax Rotated Solution

The Varimax rotated factor matrix has yielded the following Factors which will first be interpreted and later used later for calibrating the logistic regression models:

Factor 1

The rotated Factor Matrix gives the following 14 **observed variables** under **Factor 1** :

- ◆ **Call Customer Service,**
- ◆ **Use Time Table Leaflets,**
- ◆ **Called OC Info Center,**
- ◆ **Drivers Describe Stops,**
- ◆ **Use TV Screen,**
- ◆ **Have System Map,**
- ◆ **Pick Up Other Info,**
- ◆ **Heard of Easier Access Program,**
- ◆ **Use 560 Telephone System,**
- ◆ **Use Printed Schedule at Bus Stop,**
- ◆ **Bus Information,**
- ◆ **Information Accurate**
- ◆ **Yes -Seen Bus Kneeling,**
- ◆ **How Often: Use 560 System?**

It is obvious that the above observed variables are the outcome of OC Transpo's questionnaire designed to extract feedback of user attitude towards the numerous information

facilities provided for the potential customers of Ottawa-Carleton region.

In the following table, Factor 1 cluster consisting of the original observed variables are given:

Table 5.1: Factor 1 Cluster

Original Variable Number	Factor Loading	Description
Var53	0.93805	Do You Call customer Service ?
Var51	0.91546	Do You Happen to Use Time Table
Var43	0.89160	Called OC Information Center
Var58	0.88163	Drivers Describe Stops
Var47	0.87487	Use TV Screen
Var55	0.87453	Have System M ap
Var40	0.87021	Pick Up Other Info
Var56	0.87012	Heard of Easier Access Program
Var41	0.86284	Use 560 Telephone System
Var49	0.85484	Use Printed Schedule at Stops
Var39	0.70452	Bus Information
Var50	0.59465	Information Accurate
Var57	0.54846	Yes--Seen Bus Kneeling
Var42	0.41828	How Often (560)

The first factor accounts for 22.1 percent of variance according to the Final Statistics table. The factor loadings are all positive within the cluster. A close look at the responses of each of the observed variables reveal the attitude of the respondents towards the bus information related services provided. It is clearly apparent that OC Transpo wanted to know the impact of its various bus information related services like information center, time tables displayed at different bus terminals, transitway stations and even at the small bus stops. It also wanted to know the impact of TV screens or teledons, 560 system etc. In the process it also wanted information regarding some new services like Easier Access Program and kneeling bus program ostensibly to find their impact. But as can be easily seen from the table 5.1, there are 14 observed variables that have clustered together to produce a single factor because of the high correlation amongst themselves. They constitute a single underlying entity. The 14 observed variables may not be important individually and in the general sense to explain bus ridership. But they acted like proxy variables to produce a very important factor explaining ridership. In the subsequent chapters the role of information services using intelligent transportation system (ITS) technology in promoting bus ridership will be discussed more in detail. Therefore, in accordance with the clustered variables we interpret and label the factor as **BUS INFORMATION**. The impact of this service will be examined later in light of the logistic regression models to find its impact and significance upon the concept of ridership.

Factor 2

From the rotated factor matrix, **Factor 2** is found to consist of the following six observed variables :

- ◆ **Bus service is unreliable**
- ◆ **Bus frequency is adequate**
- ◆ **Bus route well planned**
- ◆ **Buses are frustrating**
- ◆ **Bus not easy to use**
- ◆ **Bus transfers are convenient**

The percentage of variance explained by the second factor is 10.9 %. A look back into the OC Transpo's 1995 report reveals that the observed variables under Factor 2 are common to the OC Transpo's **On-Street Service** criterion as well as **route planning** criterion based on weighted frequency studies. The variables under those criteria include all these variables plus some other variables like bus driver courtesy, standing during rush hour and another criterion of service compared to the last year, which did not cluster into the fold of the factor 2. Obviously, those are not highly relevant to the concept. The following table shows the Factor 2 cluster with description of the observed variables concerned:

Table 5.2 : Factor 2

Original Variable Number	Factor Loading	Description
Var70	0.73673	Bus Service Unreliable
Var71	0.73021	BUS frequency adequate
Var64	0.58765	Bus Routes Well Planned
Var82	0.58233	Taking Bus Frustrating
Var63	0.57367	Bus Not Easy To Use
Var72	0.46835	Transfers are Convenient

From the table above it is observed that most of the respondents do not agree that bus service is unreliable or buses are not easy to use. Therefore, they have a positive attitude towards bus service. About the notion that taking bus is frustrating, the response is about even. The other responses relate to adequate frequency of bus, well planned routes and convenient transfers. It is reasonable to label this factor as **On-Street Service**. The myriad dimensions of this factor will be discussed in the light of the broader meaning it conveys to the urban transit ridership.

Factor 3

The third factor explains 5.6 percent of the total variance. It includes three observed variables in its fold and conveys the perception of bus users towards the customer service provided by the transit authority. This factor is similar to factor 1. In a typical factor analysis applied sociological study like *Human Values as Key Factors* [Jarrett, Irwin and Brady, Patricia edited by, 1976], under similar circumstances, the two factors have been combined numerically by adding the factor loadings to create yet another new factor. But because we find in OC Transpo's study, customer service has been described as a separate entity, we find this factor to be a suitable candidate for such a label. The following table gives us the cluster of **Customer Service**:

Table 5.3: Factor 3

Original Variable Number	Factor Loading	Description
Var45	0.87169	Info Accurate
Var46	0.86992	Info Courteous
Var44	0.73616	Info Center Easy To Get Through

Factor 4

Under the Factor 4, there are three variables loaded. They include:

- ◆ **Transitway stations are not kept clean.**
- ◆ **Bus shelters are clean.**
- ◆ **Buses not kept clean.**

Factor 4 is about cleanliness within the bus, along the transitway stations and bus shelters. Though, routes are not included, the clearing of snow is of great importance in all the above places plus the bus route. Therefore, this factor should be considered in a broader perspective to include general cleanliness including snow clearing. OC Transpo's exhibits dealing with the factors do not include this feature as an indicator of ridership. The following table gives the Factor Analysis result:

Table 5.4: Factor 4

Original Variable Number	Factor Loading	Description
Var69	0.69639	Transitway Stations are Not Kept Clean
Var73	-0.66766	Bus Shelters Clean
Var74	0.74036	Buses not kept Clean

The overall notion is that of Cleanliness. Therefore, the Factor is labeled **Cleanliness**. The variable var78 has been dropped from the cluster as it is found to be closely correlated also with factor 2 as well as factor 4 in the factor structure matrix making interpretation difficult. The contribution of factor 4 explains 4.2 % of total variance.

Factor 5

There are four observed variables that cluster around factor 5. These variables are described as:

- ♦ **Taking bus benefits the environment.**
- ♦ **Standing on Rush-hour is reasonable.**
- ♦ **Always avoid taking bus.**
- ♦ **Services have been improved.**

Table 5.5: Factor 5

Original Variable Number	Factor Loading	Description
Var81	0.80120	Taking Buses benefits the Environment
Var84	0.59456	It is Reasonable for People To Stand Sometimes on Rush Hour Buses
Var83	-0.5090	No Matter Where I Live, I Will Always avoid Taking Bus
Var65	0.42273	The Transitway has Improved Bus Service For Me

The first, second and fourth variables have positive overtone supported by positive response frequencies and positive loading signs. The third variable, though negatively connotated, the response frequency disagrees with this bias. The factor loading is also negatively loaded. These are variables that relate to certain Attitude towards the urban bus service in general and therefore, may be labeled as **General Attitude**. We should appreciate the fact that if the general attitude towards

urban transit bus is such that people recognize the adverse impacts on environment and do not mind standing on rush-hour buses, they perceive the fact that transit authority provides improved service and therefore, they do not avoid taking buses..

Factor 6 and Factor 7

We have combined the factor 6 and factor 7 together, because they represent Safety and Security in general, although, factor 6 relates to the very important feature of safety in the transitway stations. In Sociological studies like Human Values as Key factors [Jarrett, Irwin M .. Edited by, 1976], Nellie Del Mar McClure has shown how two similar factors could be added numerically and interpreted as a single factor. We have done the same thing and obtained **Safety and Security** as a factor.

OC Transpo has put added emphasis on transitway security and put emergency telephones at some of the stations, improved lighting in the existing stations by upgrading. Also, security mirrors have been installed in some remote stations. Video cameras scan a few of the station premises especially in stations with Park and Ride facilities like Place D'Orleans to improve safety and security of the cars parked. Therefore, Transitway Safety and General Safety are different dimensions of the same factor. Factor 6 consists of the following observed variable cluster:

Factor 6

◆ **Transitway Stations Safe**

◆ **Why not ?**

The variable with " Why Not?" needs some further clarification because of the ambiguity and incompleteness of the question. A review of the frequency table shows that the complete question is: Why not use transitway station? This has a six category response frame with : **Gangs, Few People Around, No Security, No Phones, All of the Above, Poor Lighting and Other.**

Table 5.6: Factor 6

Original Variable Number	Factor Loading	Description
Var61	0.83010	Transitway Stations Safe
Var62	0.80022	Why Not ?

The first variable refers to safety in the transitway with majority of the responses with a positive bias. The next variable only categorizes the safety related questions. Before we label this factor, let us look into the next factor loaded with three more variables relating to safety in general.

Factor 7

- ◆ **Personal Security**
- ◆ **Personal Security at Night in the Multistory Parking Structures**
- ◆ **Personal Security at Night in the Neighborhood**

Table 5.7: Factor 7

Original Variable Number	Factor Loading	Description
Var85	0.66647	Personal Security At Night in Multistoried Parking Lots.
Var68	0.63321	Taking Bus at Night no threat to Security.
Var79	0.56441	Personal Security At Night while walking in Neighborhood

Combined Factor 6A: [Factor 6 + Factor 7]

The above three variables actually denote the security and safety in general.

Safety and Security should be the appropriate label for these two factors, namely factor 6 and factor 7, combined together. The Factor 6 accounts for 3.2% of variance and factor 7 accounts for 3.1% of the variance. The total variance being 5.3% for both factors.

Factor 8

This factor loads two observed variables. They are:

- ◆ Transitway Bus Roadways Good/Poor Investment
- ◆ Bus route maps difficult to understand.

The above observed variables are difficult to interpret. Therefore, this has been dropped from the factor analysis scenario.

Factor 9

This factor is loaded with only one variable, namely **Var52**: relating to from where timetables have been obtained. This factor also has been dropped because of its lack of importance as single entity factor impacting upon ridership.

Factor 10

Under this factor, three observed variables have been found to have clustered. They include:

- ◆ **Peak Hour Trip Too Expensive,**
- ◆ **Bus Pass Good Buy,**
- ◆ **Good Deal During Off-Peak Hours.**

They all relate to the **Bus Fares**. Riders are profoundly concerned about Bus Fare. In fact ridership of bus is one of the most positively impacted by a reduced Fare be that during the peak hours or off-peak or general pass related. The following table illustrates the clustered observed variables:

Table5.8 : Factor 10

Original Variable Number	Factor Loading	Description
Var75	0.75583	Peak-Hour Trip Too Expensive.
Var76	0.42952	Bus Pass Good Buy.
Var66	0.39000	Good Deal During Off-Peak Hours.

The above variables are indicative of reduction in Fare. Therefore, the proper label for this Factor should be **Reduced Fare**.

Factor 11

This factor loads only one original variable, namely **Var48:Info Accurate**. We drop this factor in favor of factor 1, which already includes this dimension.

Factor 12

This factor includes three variables, namely:

- ♦ **OC Transpo should buy more Air-conditioned Buses**
- ♦ **Staff courteous (meaning Information service staff)**
- ♦ **Route Changes too Frequently.**

There is a difficulty in interpretation of the above cluster. Similar difficulties have been confronted in other factor analysis studies by Sociologists as well as by psychologists or Physicians alike. We follow suit and drop this factor from our model.

Factor 13

This is also loaded with one variable, namely: **Var80: Behavior of other Passengers Unpleasant**. This factor has also been dropped from our study.

5.4 Interpreted Factors

The following Table gives a summary of the retained factors after interpretation and will be used in a Logistic regression analysis to find the odds of ridership occurring or not for each of the factors:

Table 5.9 : Interpreted Factors

Factor	Loading %	Interpretation
Factor 1	22.1	BUS INFORMATION
Factor 2	10.9	ON-STREET SERVICE
Factor 3	5.6	CUSTOMER SERVICE
Factor 4	4.3	CLEANLINESS
Factor 5	3.5	GENERAL ATTITUDE
Factor 6 + Factor 7= Factor 6A	6.3 (3.2 + 3.1)	SAFETY & SECURITY
Factor 10	2.6	REDUCED FARES

The odds will be obtained by raising the following linear function as a power of the exponential function e :

$$\begin{aligned} Z = & \text{CONSTANT} + k_1 (\text{BUS INFORMATION}) + k_2 (\text{ON -STREET SERVICE}) \\ & + k_3 (\text{CUSTOMER SERVICE}) + k_4 (\text{CLEANLINESS}) + k_5 (\text{GENERAL ATTITUDE}) \\ & + k_6 (\text{TRANSITWAY SAFETY}) + k_7 (\text{GENERAL SAFETY}) \\ & + \dots \dots \dots + \dots \dots \dots + k_{10} (\text{REDUCED FARES}) . \end{aligned}$$

Maximum Likelihood method will be used to find the coefficients for the factors in the above function.

The calibrated models will be presented and the possible impacts discussed on ridership in the following chapters. The impacts will be discussed on the basis of their signs and significance in the models and the hypotheses will be accepted or rejected.

CHAPTER 6

FACTORS INFLUENCING THE FREQUENCIES OF USING BUSES

6.1 Ridership with Factors or Hypothetical variables

The exclusive domain of behavioural responses signifying ridership of urban transit bus lie in the seven underlying factors that have been obtained from forty seven observed variables through factor analysis as has been discussed in the previous chapter. Like human values, love and similar other qualitative concepts, ridership cannot be quantified. While reducing interrelated observed variables into the reduced number of underlying factors, qualitative explanation of the concept is made possible by using these factors in a logistic regression model. However, the factors themselves are linear combination of observed variables. *'The mathematical model for factor analysis appears somewhat similar to a multiple regression equation. Each variable is expressed as a linear combination of factors which are not actually observed.'* [Pedhazur,1982]. This linear combination has been achieved by calculating the factor score coefficients.

In the beginning, when we want to build a model using the factors as independent variables, the Multiple Linear Regression Analysis and the Discriminant Analysis are two related techniques that comes to mind. However, these techniques pose difficulties when dependent variable is a binary.' [Norusis, 1990]. Therefore, Logistic Regression has been chosen as the appropriate technique in our analysis. Now, these factors, represented by the factor score coefficients, have been treated as if they are independent variables in a logistic regression model with ridership as the binary dependent variable. Ridership has only two probable values, one of ridership occurring coded

as one and the other of ridership not occurring coded as zero in this analysis.

6.1.1 Logistic Regression Models Using Factors

The models have been developed and tested through the Likelihood -ratio by introducing one factor at a time to the logistic regression model and noting the change in the log likelihood when each factor or variable is entered into the model. The likelihood-ratio tests the null hypothesis that the coefficients for the last variable added to the model is '0'. This is obtained by dividing the likelihood of the reduced model by the likelihood for the full model.

As a first step towards calibrating the logistic regression models, the 7 interpretable factors have been added one by one to the logistic regression model as independent variables to derive their respective unique contribution to ridership. The following tables give the factor models with their odds ratio and their R co-efficient. The odds ratio is used to assess the effect of independent variable on the dependent variable in terms of likelihood of the event that is coded as '1' and in this case it is ridership. The logistic regression model dependent variable thus has been coded in terms of the odds of an event occurring. This in turn is the ratio of the probability that it will occur to the probability that it will not. It suggests that the ridership variable does not affect the dependent variable. The value that is greater than one indicates positive effect of an independent variable on the dependent variable. The value that is less than one indicates negative effect. The R co-efficient gives the partial correlation between the dependent variable with the factors or other variables. The positive R indicates increasing likelihood of, say, ridership of bus increasing and a negative value indicating ridership decreasing. The small or large R value indicate corresponding small or large partial contribution to the model by an independent variable. In the following logistic models the probability of ridership of bus occurring will be examined by establishing the relationship between

the dependent variable ridership with the variables that have been interpreted through this research.

The Logistic model of the following form has been formulated:

$$\text{Prob (event)} = 1 / (1 + e^{-z})$$

The probability of ridership not occurring is expressed by : $\text{Prob (no event)} = 1 - \text{Prob (event)}$.

z is the linear combination of factors or any other socio economic variables and is expressed as:

$$z = B_0 + B_1 X_1 + B_2 X_2 + \dots + B_p X_p$$

The Maximum Likelihood method has been used to derive the co-efficient for the logistic model.

The Logistic model in terms of the odds (Logit) will be of the form:

$$\text{Log [Prob (event) / Prob (no event)]} = B_0 + B_1 X_1 + B_2 X_2 + \dots + B_p X_p$$

The above model can be written as:

$$\begin{aligned} [\text{Prob (event) / Prob (no event) }] &= e^{B_0 + B_1 X_1 + B_2 X_2 + \dots + B_p X_p} \\ &= e^{B_0} \cdot e^{B_1 X_1} \cdot e^{B_2 X_2} \cdot \dots \cdot e^{B_p X_p} \end{aligned}$$

The exponential e is the factor by which odds change when the i th factor increases by one unit. When i is positive, this factor will be greater than '1' which means increasing the odds of ridership happening. Negative value, whereas, will mean decreased odds and when $B_i = 0$, the factor odds remain unchanged.

The following models evolved after logistic regression with one factor added to the model one by one:

Table 6.1 : Model 1 :Dependent Variable: RIDERSHIP

INTERPRETED FACTOR LABEL	ODDS RATIO	R VALUE
BUS INFORMATION	61.3993**	0.3844
Initial LL Function-2 LL	379.719	
Model Chi-square	286.131	
-2 Log Likelihood	93.589	
Pseudo R square	0.7535	
R_L²	0.508	

* p<.10

** p<.05 ; two-tailed t test.

In the above table using one of the factors, namely, Bus-Information, we get a very high odds ratio. As well as R co-efficient. It is also significant with p<.05; in a two tailed t-test.

6.1.2 Goodness of Fit of the Model

The null hypothesis is tested on the premise that the model will have the observed likelihood of '1' to fit perfectly. The goodness of fit can be examined by deriving the following:

Pseudo R square = Model Chi-square / Initial Log Likelihood- 2 Log Likelihood

=286.131/379.719

= 0.7535

R_L²= Model Chi-square / Model Chi-square + N

= 0.508

As we proceed with the development of the models the same tests will be repeated to examine the model fit as well as to see the improvement, if any, to the models due to inclusion of other variables.

Table 6.2: Model 2: Dependent Variable: RIDERSHIP

INTERPRETED FACTOR LABEL	ODDS RATIO	R VALUE
BUS INFORMATION	78.949**	0.3795
ON-STREET SERVICE	2.2701**	0.1323
Initial LL Function-2 LL	379.719	
Model Chi-square	297.185	
-2 Log Likelihood	82.534	
Pseudo R square	0.780	
R_L²	0.502	

* p<.10

** p<.05 ; two-tailed t test.

The inclusion of On-Street Service factor shows that the odds ratio and the R co-efficient are significant in the model at p<.05 level. It should also be noted that Pseudo R square and R_L² both have registered increases after inclusion of On-Street Service variable to the model. In the next model Customer Service variable has been added. The following table illustrates the model:

Table 6.3: Model 3 : Dependent Variable: RIDERSHIP

INTERPRETED FACTOR LABEL	ODDS RATIO	R VALUE
BUS INFORMATION	76.5028**	0.3826
ON-STREET SERVICE	2.1137**	0.1156
CUSTOMER SERVICE	1.6485	0.0305
Initial LL Function-2 LL	379.719	
Model Chi-square	299.368	
-2 Log Likelihood	80.352	
Pseudo R square	0.789	
R_L²	0.519	

* p<.10

** p<.05 ; two-tailed t test.

In the above model the odds of the three factors all show positive impacts. The R value shows the extent of partial correlation between ridership and the respective factors. The inclusion of Customer Service also increases in the Pseudo R square as well as R_L² values. Therefore, it can be safely concluded that the above model with the three independent variables increase the odds of ridership occurring. We proceed with the next model by adding the variable Cleanliness. The following table illustrates the results:

Table 6.4: Model 4: Dependent Variable: RIDERSHIP

INTERPRETED FACTOR LABEL	ODDS RATIO	R VALUE
BUS INFORMATION	77.090**	0.3824
ON-STREET SERVICE	2.148**	0.1156
CUSTOMER SERVICE	1.613	0.0161
CLEANLINESS	0.862	0.0000
Initial LL Function-2 LL	379.719	
Model Chi-square	299.610	
-2 Log Likelihood	80.110	
Pseudo R square	0.789	
R_L²	0.519	

* p<.10

** p<.05 ; two-tailed t test.

In the above table, the variable cleanliness shows an odds ratio of less than one, indicating that it's inclusion into the model does not increase the odds of bus ridership. The odds ratio and the R coefficients are still significant at p<.05 level and the Customer Service variable along with Bus Information and On-Street Service show positive impacts upon ridership. However, Cleanliness does not seem to show any significant effect on ridership. However, its presence in the model is not detrimental. Pseudo R square and R_L² are found to be 0.791 and 0.520 respectively, which again shows a slight improvement to the previous model due to addition of the variable to the model, though, this factor does not add to the probability of ridership odds increasing.

Table 6.5: Model 5: Dependent Variable: RIDERSHIP

INTERPRETED FACTOR LABEL	ODDS RATIO	R VALUE
BUS INFORMATION	78.020**	0.3789
ON-STREET SERVICE	2.1283*	0.1133
CUSTOMER SERVICE	1.6621	0.0241
CLEANLINESS	0.8970	0.0000
GENERAL ATTITUDE	0.7471	0.0000
Initial LL Function-2 LL	379.719	
Model Chi-square	300.389	
-2 Log Likelihood	79.330	
Pseudo R square	0.799	
R_L²	0.523	

* p<.10

** p<.05 ; two-tailed t test.

The inclusion of General Attitude variable shows an odds ratio of less than one. Therefore, it does not increase the odds that ridership will occur due to adding this variable to the model. However, Pseudo R square and R_L² are found to be 0.7999 and 0.523 respectively, which again show slight improvement to the previous model. In the next model we add Transitway Safety variable and the results are shown in the following table:

Table 6.6: Model 6**Dependent Variable: RIDERSHIP**

INTERPRETED FACTOR	ODDS RATIO	R VALUE
LABEL		
BUS INFORMATION	85.7445**	0.3761
ON-STREET SERVICE	2.2630**	0.1204
CUSTOMER SERVICE	1.6535*	0.0232
CLEANLINESS	1.0100	0.0000
GENERAL ATTITUDE	0.7184	0.0000
SAFETY: TRANSITWAY	1.6985*	0.0511
Initial LL Function-2 LL	379.719	
Model Chi-square	303.760	
-2 Log Likelihood	75.957	
Pseudo R square	0.799	
R_L²	0.523	

* p<.10

** p<.05 ; two-tailed t test.

The inclusion of Transitway safety variable shows that the odds ratio is greater than one. This can be interpreted that transitway safety variable increases the odds that ridership will occur. This is also a significant factor in the model. The next model include another safety related variable which is the general safety in the bus route. The results are:

Table 6.7: Model 7**Dependent Variable: RIDERSHIP**

INTERPRETED FACTOR LABEL	ODDS RATIO	R VALUE
BUS INFORMATION	85.652**	0.3758
ON-STREET SERVICE	2.261**	0.1199
CUSTOMER SERVICE	1.6470*	0.0144
CLEANLINESS	1.0127	0.0000
GENERAL ATTITUDE	0.7195	0.0000
SAFETY: TRANSITWAY	1.6989*	0.0508
SAFETY: EN ROUTE	1.0163	0.0000
Initial LL Function-2 LL	379.719	
Model Chi-square	303.766	
-2 Log Likelihood	75.954	
Pseudo R square	0.800	
R_L²	0.526	

* p<.10

** p<.05 ; two-tailed t test.

The results show that inclusion of safety in bus route makes the odds ratio greater than one.

Therefore, it can be concluded that the inclusion of safety features will increase the odds that ridership will occur. We finally add Reduced Fare variable to the model and the results are shown in the following table:

Table 6.8: Model 8**Dependent Variable: RIDERSHIP**

INTERPRETED FACTOR LABEL	ODDS RATIO	R VALUE
BUS INFORMATION	91.221**	0.3725
ON-STREET SERVICE	2.1712**	0.1146
CUSTOMER SERVICE	1.6885*	0.0290
CLEANLINESS	1.0769	0.0000
GENERAL ATTITUDE	0.7376	0.0000
SAFETY: TRANSITWAY	1.7356*	0.0523
SAFETY: EN ROUTE	1.0814	0.0000
REDUCED FARE	1.3611	0.0000
Initial LL Function-2 LL	379.719	
Model Chi-square	303.766	
-2 Log Likelihood	75.954	
Pseudo R square	0.800	
R_L²	0.523	

* p<.10

** p<.05 ; two-tailed t test.

The Reduced fare variable shows odds ratio greater than one. Therefore, the odds that ridership will occur due to reduced fare can be concluded. In the above model all the 7 interpreted variables have been included and except cleanliness all the factors are positively impacted upon ridership. Though cleanliness would not increase the odds of ridership occurring, the presence of this factor contributes to the overall model.

6.1.3 Determining the Relative Importance of the Variables

To assign relative importance to the newly created factors a thumb rule is to look into the partial correlation coefficients between ridership and the individual factors. The larger the absolute value of the coefficient the more important will be the factor. But in a combined model the determination will not be that simplistic because of possible existence of inter correlation amongst factors themselves. However, the relative importance are generally assigned in a somewhat acceptable manner in two ways:

(1) from the magnitude of the partial correlation co-efficient (R) which is given by the expression:

$$R = \sqrt{\{(\text{Wald Statistic} - 2K) / (-2LL_{(0)})\}}$$

This shows the partial correlation between the dependent variable and the Factors used as independent variables. R has a range between -1 and +1. Positive values indicate the likelihood of ridership occurring and increasing it at the same time, the negative value indicates the reverse scenario. The magnitude of R denotes the contribution of the particular variable to the model.

(2) from the changes in **Pseudo R²** due to inclusion of a particular factor in to the model.

The factors in this study that follow in order of their magnitude of (R), from Table 6.1 through to table 6.8, are : **Bus Information, On-Street Service, Safety (combined), Customer Service, Reduced Fare, Cleanliness and General Attitude.**

The change in **Pseudo R²** , due to inclusion of a factor into the regression model, is an indicator of the unique information provided by that variable. Models 1 to 8 in this analysis tabulate these changes. These can also be considered as indicators of relative importance of the respective factors as per their magnitudes. In this context the factors that can be ranked in order of relative importance as follows:

Reduced Fare and On-Street Service

These two factors contributed mostly to the value of **Pseudo R²**. The contribution of other factors

in the models are small. In such a scenario, the relative importance of the factors have been assigned, keeping in view both the results as follows:

Bus Information, On-Street Service, Safety (combined), Customer Service, Reduced Fare, Cleanliness and General Attitude.

It should be pointed out that the importance of a particular factor may have originated from the survey questionnaire. For example, Bus Information related questions dominated the OC Transpo's attitude survey ostensibly because of their desire to know about the impact of some of the new services provided by them. While there should not be any objection to such a strategy, it may have contributed to the relative importance of that factor in an exaggerated manner. But from the study of current knowledge the factors are indeed in order of importance that have emerged from this research outcome.

6.2 Models with various Socio-Economic Variables

Now, in formulating model 9, we are introducing to the factor model 8 various socio-economic variables for the purpose of studying their impact on the dependent variable. Initially, socio-economic variables have been added one by one to the model with factors. But after seeing that the related Pseudo R square changes are very small, we have abandoned the process. Therefore, we added all the variables in the model simultaneously. The table 6.9 shows the factors and the socio-economic variables in a logistic regression model. The logistic regression analysis uses observed variables like age, education, sex, language, income and occupation after recoding them into distinct categories and converting them, for example, education, occupation and language into multi category dummy variables with a reference group chosen for each. Sex has been converted into a dichotomous dummy variable with female as the reference category. The unique contribution made by each of the variables have been ascertained by the calculated R values as has

been done with the factors. The table 6.9 shows odds ratio, R coefficients, Significance of t values for the Model 9. The model parameters for the dummy variables denote the difference in ridership index with respect to the reference category.

In the model stated, the Age cohorts have been recoded into a three tiered categorical variable with the groups as young, middle-aged and the old. The age groups are 18-24: 25-34, 35-44:45-54 and 55 and above. The impact on ridership should be read from a younger to gradually older age group.

The Education variable has been first recoded into a three category continuum. Later it has been converted into a dummy categorical variable. The reference group for education, in the above model, is the lowest educated category.

The Occupation category has been recoded into categories with professional and blue collar employees as dummy variables, each with the unemployed group as the lowest employed labour force as the reference category.

In the combined model [model 9], **DSex** is the indicator or dummy variable representing male category with the female category as reference, controlling other variables in the model. The difference between the log odds of male and female will be the outcome.

In model 9, language groups have been recoded into three distinct groups: English, French and Bilingual with Other as reference. If only English speaking people are considered, controlling rest of the variables, the log odds difference in ridership index with the 'other' as reference will be obtained

COMBINED TABLE FOR MODEL 8 AND MODEL 9

DEPENDENT VARIABLE : RIDERSHIP

INDEPENDENT VARIABLES	MODEL 8		MODEL 9	
	ODDS RATIO	R VALUE	ODDS RATIO	R VALUE
BUS-INFORMATION	91.2210**	0.3725	5.36 E +15*	0.0575
ON-STREET SERVICE	2.1712**	0.1146	5.69E +1	0.0000
CUSTOMER SERVICE	1.6885	0.0290	0.2780	0.0000
CLEANLINESS	1.0769	0.0000	0.9004	0.0000
GENERAL ATTITUDE	0.7376	0.0000	0.0206	0.0000
SAFETY: TRANSITWAY	1.7356*	0.0523	7.13E +3*	0.0502
SAFETY: EN ROUTE	1.0814	0.0000	2.4395	0.0000
REDUCED FARE	1.3611	0.0000	2.34E +4	0.0000
AGE GR: YOUNG [OLD AS REF.]			2.07E +3	0.0000
AGE: MIDDLE [OLD AS REF.]			5.45E +6	0.0221
EDUCATION: `VARSITY [EL. REF]			0.0017	0.0000
EDUCATION: SECONDARY[EL.R]			0.0000	0.0000
OCCUPATION: PROF.[UNEMP.REF]			0.0000	0.0000
OCCUPATION: BLUE C[UNEMP.R]			0.5094	0.0000
MALE : FEMALE AS REF.			0.3388	0.0000
ENGLISH SPEAKING GROUP			4.73E +15*	0.0487
BILINGUAL GROUP			4.90E +09	0.0000
FRENCH SPEAKING GROUP			9.01E +05	0.0000

* p< .10 ** p< .05 ; two-tailed t test

Combined Table (continued)

STATISTICS	FOR MODEL 8	FOR MODEL 9
Initial LL Function-2 LL	379.719	379.719
Model Chi-square	303.766	371.236
-2 Log Likelihood	75.954	8.484
Pseudo R square	0.800	0.977
R_L^2	0.526	0.573

6.3 Discussions

The hypotheses in Chapter 2 are now examined on the basis of the results of the above models derived through logistic regression.

We proposed in our hypothesis that *bus information and customer services* should have *positive impact* upon ridership and this has been confirmed through model 8. It should be noted that Bus Information is perceived by the people as an integral part of the transit service, though, most of the people questioned seem to have a passive attitude towards Information related services. Our model suggests that information services have positive impact upon ridership and its relative importance with respect to other factors in the model will be examined in this chapter. The hypothesis 1, as postulated in Chapter 2, has been accepted in this analysis.

On-Street Service is an important factor to promote bus ridership. This service has been traditionally used by transit organizations around the world as a yardstick of performance evaluation and service standards. The World Bank study, referred to earlier in this paper, proposed some acceptable ranges of values as performance indicators to compare different bus transit services. In the Chapter 2 [Table 2.2A], we compared OC Transpo's performance relating to On-Street Service, as obtained from their strategic plan

for the 1990's and other relevant publications, with the yardstick set by the World Bank evaluated standard values. It should be useful for a transit company to know where it stands in the light of its overall effort from the *on-street service* perspective or the performance indicators as stated. As seen in the model, this service is *positively impacted* upon ridership and through the model our hypothesis proposed in chapter 2 has been accepted.

Safety in the newly built transitway stations, especially at off-peak periods or at lonely places at odd hours are a concern to all and improvement of safety shows a positive impact on ridership. Installation of push-button emergency telephones and cameras, mirrors as well as security patrols are steps in the right direction to improve ridership. This has also a significant positive impact upon ridership as could be seen from the positive impact in the model. The hypothesis is accepted through our model above.

The factor concerning *Reduced fare* shows significant positive impact upon ridership in all concerned models. If the fare is reduced, the impact on ridership will be positive or the ridership will increase and our previously formulated hypothesis has been accepted through the models.

Cleanliness of bus stations, stops, bus routes etc. constitute a very important level of service criteria. The results, though, fail to show probability of ridership improvement due to Cleanliness factor. A considerable amount of money and effort are devoted towards cleaning of transitways, important bus routes, especially clearing of snow from the roadways and transitway platforms in addition to normal janitorial cleaning of the stations. Even if the factor do not show a favorable odds ratio, it is contributing to the model and it can act as a proxy variable from the transit authority's perspective to ensure that the bus routes are cleaned regularly. A review of the questionnaire should be done to put this factor in proper perspective. The original hypothesis says that cleaning is positively impacted upon ridership and could not be accepted straight forward through this research.

The hypothesis referring to the *attitude in general* towards transit service held by the population shows that these attitudes are shaped by a multifarious array of concerns of the people. For example, by environmental concerns of individuals, by a spirit of sacrifice by standing during rush hour or by other attitudes in general towards the new services provided by the bus company. It has been seen through the model that general attitude do not make the odds positive for ridership to happen. Probably, people take or do not take bus even with a negative attitude. Our hypothesis, therefore, is not accepted through this study.

6.4 Discussions with Socio-economic variables

The first hypothesis in this category of variables sought to test the relationship between ridership across the three broad age groups in the framework of a categorical variable. From Model 9 it is seen that the probable odds or impact of ageing on ridership is positive on young and middle aged with reference to the old group.. However, in order to examine this hypothesis, we should look into the categorical impacts on the three groups. While recoding the age cohorts into 3 distinct groups of young, middle and old categories, the model shows a positive impact with decreasing age groups. However, both young and middle age groups are positively impacted upon ridership. The positive impact should be on the relatively youngest and the oldest should have negative impact. The medium age group consisting of the majority of the employed labour force who mostly own cars have a negative impact on ridership.

Education does not have a significant effect on ridership. Results presented in table 9 generally reveal that University groups do not have a significant impact upon ridership with reference to the lowest educated group, other variables being controlled. The next level of education or the secondary level also do not improve the odds of ridership occurring. There is a negative impact, with the highest education category on ridership of urban transit bus. The education category with High School, Technical or Business School completed has a 0.000 value for R. While the highest educated has a negative impact upon ridership, the

medium educated have a negative probable odds of ridership happening . The model confirms the impact of education on ridership as per our hypothesis, namely, it has a negative impact upon ridership with increasing education level. It is possible that those with lesser education who are usually blue collar employees, unemployed, students or under employed, will be more inclined to use public transit bus service. The positive impact of lesser income on ridership, which has been our hypothesis, has been accepted through our study.

In the model 9, we coded the highest professional categories to the lower occupational category, with the lowest occupation as reference. Impact of both higher occupational categories have been negative upon ridership. According to our hypothesis, higher occupation categories will have better income and will have the negative odds of bus ridership happening with them. The effect of the difference between the reference group of unemployed, the highest professional group in the employed labour force has a negative impact upon ridership. Blue collar employees on the other hand has a lesser differential with respect to the unemployed, though, with a negative impact. The hypothesis has been accepted.

Model 9 suggests that male has negative odds of ridership occurring with female as the reference category in a dummy coding. We hypothesized that men have higher positive impact upon ridership as against women. This contradicts our hypothesis.

The main language groups, French and English as well as the Bilingual group, have been recoded into dummy variable with ‘**other**’ as the reference group. The English group has a higher probability of ridership occurring and therefore a higher impact on ridership over **other** as reference, controlling for the rest of the variables in the model. Both the French and the Bilingual groups, on the other hand, have lower impact on ridership with reference to the **other** group, controlling for all other variables including the English group. This does not conform to the hypothesis regarding the attitude of main language groups.

Before we turn our attention towards the concluding remarks and recommendations in the next chapter, let us summarize what has been done in the previous chapters:

The large database has been analyzed and tested for reliability and validity. Each individual variable has been coded, missing values discarded and response oriented variables identified. In the process, 47 variables have been obtained. By use of factor analysis, these variables have been reduced into seven individual entities called factors and they have been given labels to suit the current knowledge regarding bus service. The newly labelled factors have then been used as independent variables with the binary variable of ridership as the dependent variable. Then Logistic regression analysis produced several models that illustrate the odds of bus ridership occurring or not due to inclusion of these variables into the model. A step has been taken towards understanding a part of the missing definition of systems planning that allowed traffic congestion to grow unchallenged.

CHAPTER 7

CONCLUSIONS AND IMPLICATIONS

7.1 Summary and Conclusions

We are on the threshold of the 21st century. As we look back, we see that the current century has witnessed a tremendous progress in science and technology including the field of transportation. However, benefit from this progress is not without costs. For example, in the field of transportation, there has been the problem of congestion, resulting in delays, environmental pollution and onslaught on our natural environment. To make things worse, the phenomenon of urban traffic congestion is increasing by quantum leaps on our roadways resulting in huge losses of fuel, of time and of mental stress related problems. The new century will be confronted with this burgeoning problem headlong unless remedial measures are taken. It has been argued by transportation planners that the problem can be mitigated by undertaking different strategies based on supply and demand management policies. This thesis has dealt with only one aspect from numerous other demand management strategies. Within the framework of these strategies this thesis uncovers the underlying factors of making urban transit bus ridership more attractive to the people. Such a strategy proves to be a very effective and simple way to combat congestion. It is not difficult to figure out that a high occupancy bus has the potential to replace 40 to 60 single occupancy cars from the road space. But a successful implementation of the strategy -- by making people to switch from car to bus -- is a difficult task. Our study has analyzed the responses, based on a survey of attitudes of transit riders and non-riders alike, from a cross section of Ottawa-Carleton residents, using advanced statistical methods, and derived underlying factors from the large OC Transpo database (1995). These are

unique entities that could be used to develop strategies, tactics and operational measures to enhance ridership. In essence we have been able to identify the major factors based on many observed variables that enhance ridership and explain the concept of ridership to a great extent.

There may be a hundred ways to increase bus ridership, but this research employed factor analysis to identify seven key factors that are most important in the domain of ridership. They are:

- ◆ **Bus Information**
- ◆ **On-Street Service**
- ◆ **Safety & Security**
- ◆ **Customer Service**
- ◆ **Reduced Fare**
- ◆ **Cleanliness**
- ◆ **Attitude towards bus service in General**

Bus information service is the most important compared to the other factors as per this study. The information services have the potential to generate a dynamic feature into the urban transit service based on Intelligent Transportation System (ITS) technology. A prompt accident removal, immediate replacement of a bus which has broken down en route, dynamic arrival time displayed in all remote routes are possible by use of AVL/C through GPS receiver installation in all the transit buses. Nevertheless, it should be realized that without a first category bus information system, it will be difficult even to keep the regular bus users into the fold of bus transit. Traffic management information by providing real time route guidance, in fact may affect other factors like on-street service, safety as well as attitude in general towards riding buses.

On-Street Service: This is the next most important one in order of relative importance. It includes reliability of service, adequate bus frequency, well planned routes, service reliability, convenience at transfers and level of service etc. Potential riders, though unconsciously, will assess the conditions of the various components of this service, before switching from cars to bus. The other quality of service and operational indicators, that could be included from the perspective of the World Bank study, are the types and variety of buses in service, ensuring an optimum number of passengers per bus per day, an acceptable fleet utilization with excellent maintenance, minimal fuel consuming buses in service, a very acceptable and productive staff ratio per bus, trained operating staff who can ensure a very low accident rate. Also, the on-street buses should run within an acceptable threshold of travel time both out-of-vehicle and in-vehicle.

Safety and Security concerns should be addressed in the transitway stations, in the access and egress routes and inside the bus itself especially during the night and this will help boosting ridership.

Customer Service is perceived by the people in a way similar to information services. It may have little or no bearing on increasing ridership, but an excellent customer service is a necessity to make riders happy and to improve general attitude towards bus transit service.

Reduced Fare: It is accepted that a typical consumer desires to consume goods and services of high quality with lower price. Therefore, after maintaining a reasonably good level of service, the most effective way to bring ridership back to the fold of urban transit should be fare reduction. Simple as it may sound, the implementation of fare reduction is a very difficult task. According to the World Bank study *subsidized services fall short of demand because demand increases faster than budget revenue , .. and subsidies cannot go on increasing*. In such a scenario fare reduction is a distant

dream. More subsidy may not be necessary. Organizational change can do the same thing. Organizational inefficiency can cause the cost of providing services high. There is a *fat cat* problem. As could be seen from the said study for several large cities, the privately owned companies running parallel with the public bus company, are doing better financially. The privately owned bus company costs half as much as a publicly owned company and thus for a private bus company, fare reduction is easier to attain. In the case of Ottawa, however, this particular solution may not be a feasible option. But it deserves a closer examination. Reduced fare should improve ridership considerably and its impact has been reflected in our models.

Cleanliness: Riders conjure up the vision of traveling in a bus which is sprightly clean inside. Also, it should be plying on roads that are kept clean from snow, dust and dirt. Also, buses should be perceived of as environmentally clean. In summary, it means keeping buses clean as well as bus routes, transitway and passenger platforms free from accumulated snow, water logging, broken and damaged surface conditions etc. This is important for keeping existing riders and also to attract new riders into the fold of transit service.

The General Attitude is a behavioural response of the peoples from the feedback they get from their general surroundings. This feedback can be positively influenced through carefully designed advertisements which portray the numerous benefits of using public transit. The benefit that comes to the forefront is the environmental one. The General Attitude of the people is also influenced by, among other things, comfort and convenience and other level of service (LOS) features. For example, if people perceive that using mass transit not only frees road space but also removes emissions, noise and accident hazards, the ridership should get a boost.

7.2 Recommendations

- The above factors, from a larger perspective, can be conceived of as proxy variables representing the respective factors. Numerous related observed variables may fit into one of the underlying factors. Appropriate inclusion of other related and relevant questions to the questionnaire may produce responses that may be embraced by any of these factors or may result in an entirely new factor explaining ridership of urban transit bus.
- A dynamic information service in advance of expected arrival of buses at a particular terminal can relieve stresses caused by waiting and uncertainty. This can be achieved using Intelligent Transportation System (ITS) technology based on the Global Positioning System (GPS) receivers or roadside beacon or any advanced sensors. Digital real time information panels should be introduced at the selected bus stops or terminals including the remote ones.
- To provide an excellent on-street service, the bus company should increase its fleet of bus so that adequate frequency of service can be maintained. All these new purchases should include a variety of buses to suit different demands at different times and places. Travel time should be within a threshold of a maximum limited time, determined through the questions and their responses. Technological and institutional concerns, operational and environmental performance, financial performance, standard of service including passenger waiting time, walking distance to stops, the need to interchange between route to services, passenger journey time, passenger travel expenditure and affordability are to be incorporated into the on-street service structure planning. The ITS technology like ATMS, ATIS, AVCS that are being applied for combating traffic congestion related problems should also be

incorporated into the bus-only routes as well.

- The bus operators, the ticket sellers, the telephone operators and all those responsible for Customer service, should be courteous to the passengers. The customer service should be geared up accordingly. Customer service is a newly emerged concept which is also an offspring of this study. It should be given its due place while planning strategies to enhance bus ridership.
- The efforts at snow clearing of transitway and other routes should be geared up. The snow clearing is of utmost importance in all the routes including transitways to make buses to ply smoothly and on time.
- The general attitude of people cannot be changed easily. For this, direct intervention will be necessary. For example, advertising the benefits of using public transit can motivate people to use public transit. Also, the information services can incorporate some advertisement features through the ITS technology. A negative attitude towards public transit can also be turned around by imposing indirect fees on single occupancy vehicle users who must pay for the luxury of occupying space more than they deserve. Appropriate area wide toll has been introduced in cities like Singapore. A modified version of such a toll suited to Ottawa can be studied for possible impacts. This will promote HOV usage and will reduce congestion.
- The Safety concerns in the transitways and inside buses and in the neighborhoods can be further improved by implementing in full, the measures like emergency push button telephones at all stations, vigilant security patrols at night in remote areas, improving street as well as platform lighting and adding new ones at places not served.
- Fare reduction can be achieved effectively by many ways and one such measure may be by

allowing privately run transit services. The following steps may be very cautiously examined in this regard, with the ultimate objective of fare reduction:

- a. allowing private companies to operate with government regulations to ensure standard level of service and safety.
- b. allowing public entity to co-exist and compete with private entities as has been done in many other major cities starting with Hongkong all the way to the Mexico City,
- c. to operate a very truncated and smaller version of public transit to run on subsidy only for remote and lonely routes which privately owned companies will abandon as a losing concern.

Although, our results are derived from attitude survey, they provide some powerful insight into the inherent problems that beset a bus transit service. The study also identifies the most important factors that are key to enhance bus ridership. As we have noted in the previous chapter, the matter of relative importance is a matter of judgement in concert with the statistical methods of comparing beta values or changes in r square. It is recognized through this study that **Reduced Fare** and **On-Street Service** and **Bus Information Services** are the most important determinants of bus ridership. In turn, this knowledge of the factors can be used to develop strategies, tactics and operational measures to enhance ridership.

It can be safely concluded that by incorporating the results of behavioural studies like this into the mainstream transit planning process, ridership of urban transit buses can be enhanced. This in turn will contribute to reduction in traffic congestion to a great extent.

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APPENDIX A

SPSS programming for Factor Analysis

A.1 SPSS programming: missing values, coding , ridership index

```

get file='a:\oct.sav'.
execute.
missing values var39 (8,9).
missing values var40 var42 var43 var47 var48 var49 var50 var53 var54 var55 var56 var57 (9).
missing values var41 var59 (4,9).
missing values var44 var45 var46 var51 (3,9).
missing values var52 (8,9).
missing values var58 var61 var62 (9).
missing values var65 var66 var68 var73 var75 var76 var77 var78 (9).
missing values var61 (0,9).
missing values var79 var80 var81 var82 var83 var84 var85 var86 (9).
missing values var63 var64 var67 var69 var70 var71 var72 var74 (9).

recode var67 (1=5) (5=1).
recode var69 (1=5) (5=1).
recode var74 (1=5) (5=1).
recode var63 (1=5) (5=1).
recode var70 (1=5) (5=1).
recode var82 (1=5) (5=1).
recode var75 (1=5) (5=1).

frequencies variables = var39 var40 var41 var42 var43 var44 var45 var46 var47.
frequencies variables = var48 var49 var50 var51 var52 var53 var54 var55 var56.
frequencies variables = var63 var64 var67 var69 var70 var71 var72 var74 var82.
frequencies variables = var65 var66 var68 var73 var75 var76 var77 var78.
frequencies variables = var57 var58 var59 var61.
frequencies variables = var62 var79 var80 var81 var83 var84 var85 var86.

missing values var21 (5,9).

missing values var10 (0,9,3).
frequencies variables = var10.
comment dummy with users of OC bus and non-users.
do if (var10=1).
compute rideship=1.
else if (var10=2).
compute rideship=0.
end if.

```

```

comment recoding var02 areas into north,south,east,west and CBD.
missing values var02 (81,99).
compute area=-1.
if (var02=1) area=1.
if (var02=2) area=1.
if (var02=3) area=2.
if (var02=4) area=2.
if (var02=5) area=3.
if (var02=6) area=2.
if (var02=7) area=4.
if (var02=8) area=4.
if (var02=9) area=4.
if (var02=10) area=4.
if (var02=11) area=1.
if (var02=12) area=2.
if (var02=13) area=1.
if (var02=14) area=1.
if (var02=15) area=5.
if (var02=16) area=2.
if (var02=17) area=4.
if (var02=18) area=4.
if (var02=19) area=4.
if (var02=20) area=4.
if (var02=21) area=3.
if (var02=40) area=3.
missing values area (-1).
frequencies variables = area.

```

```

comment dummy with work/school goers and non-work/school persons.
missing values var03 (7).
do if (var03=1).
compute dwork=1.
else if (var03=2).
compute dwork=0.
end if.

```

comment recoding var04 Destination.

missing values var04 (0,99).

compute dest=0.

if (var04=1) dest=5.

if (var04=2) dest=5.

if (var04=3) dest=5.

if (var04=4) dest=6.

if (var04=5) dest=6.

if (var04=6) dest=2.

if (var04=7) dest=5.

if (var04=8) dest=5.

if (var04=9) dest=1.

if (var04=10) dest=2.

if (var04=11) dest=2.

if (var04=12) dest=2.

if (var04=13) dest=2.

if (var04=14) dest=5.

if (var04=15) dest=4.

if (var04=16) dest=2.

if (var04=17) dest=2.

if (var04=18) dest=5.

if (var04=19) dest=1.

if (var04=20) dest=1.

if (var04=21) dest=5.

if (var04=22) dest=5.

if (var04=23) dest=5.

if (var04=24) dest=5.

frequencies variables = dest.

comment recoding and creating a dummy variable for car users with non-users as reference.

missing values var05 (9,3,4).

do if (var05=1).

compute dcar=1.

else if (var05=2).

compute dcar=0.

end if.

value labels dcar 1'car user' 0'nonuser'.

frequencies variables = dcar.

comment start with independent variables.

do if (var98=1).

compute dsex=1.

else if (var98=2).

compute dsex=0.

end if.

value labels dsex 1'male' 0'female'.

frequencies variables = dsex.

t-test groups = dsex (0,1)/ variables= ridership.

regression variables = rideship dsex/

descriptives/dep = rideship / enter.

comment creating dummy variables, others as reference category.

do if (var90=1).

compute eng=1.

else.

compute eng=0.

end if.

do if (var90=2).

compute fr=1.

else.

compute fr=0.

end if.

do if (var90=3).

compute both=1.

else.

compute both=0.

end if.

frequencies variables= eng fr both.

comment recoding var92 into occupation.

missing values var92 (99).

compute occ=0.

if (var92=1) occ=1.

if (var92=2) occ=1.

if (var92=3) occ=2.

if (var92=4) occ=2.

if (var92=5) occ=3.

if (var92=6) occ=3.

```

comment creating dummy variable for occ.
do if (occ=1).
compute docc1=1.
else.
compute docc1=0.
end if.
do if (occ=2).
compute docc2=1.
else.
compute docc2=0.
end if.
frequencies variables = docc1 docc2.
compute inc=-1.
if (var96=1) inc=1.
if (var96=2) inc=2.
if (var96=3) inc=3.
if (var95=1) inc=4.
if (var95=2) inc=5.
if (var95=3) inc=6.
missing values inc (-1).
frequencies variables = inc.
comment upto the above the results are very good.

```

```

comment recoding age into young middle and old.
missing values var89 (8,9).
compute age=0.
if (var89=1) age=1.
if (var89=2) age=1.
if (var89=3) age=2.
if (var89=4) age=2.
if (var89=5) age=3.
if (var89=6) age=3.

```

comment making age into dummy variable with old as reference.

```

do if (age=1).
compute dage1=1.
else.
compute dage1=0.
end if.
do if (age=2).
compute dage2=1.

```

```
else.  
compute dage2=0.  
end if.  
frequencies variables = dage1 dage2.
```

```
comment recoding education into university ,secondary & lower school.  
missing values var91 (9).  
compute educ=0.  
if (var91=1) educ=1.  
if (var91=2) educ=1.  
if (var91=3) educ=2.  
if (var91=4) educ=2.  
if (var91=5) educ=3.  
if (var91=6) educ=3.
```

```
comment converting education into dummy variable with lower school as reference.
```

```
do if (educ=1).  
compute deduc1=1.  
else.  
compute deduc1=0.  
end if.  
do if (educ=2).  
compute deduc2=1.  
else.  
compute deduc2=0.  
end if.  
frequencies variables = dwork deduc1 deduc2.
```

-> FACTOR

-> /VARIABLES var39 var40 var41 var42 var43 var44 var45 var46 var47 var48
var49 var50 var51 var52 var53 var54 var55 var56 var57 var58 var59 var61
var62 var63 var64 var65 var66 var67 var68 var69 var70 var71 var72 var73
var74 var75 var76 var77 var78 var79 var80 var81 var82 var83 var84 var85
var86 /MISSING LISTWISE /ANALYSIS var39 var40 var41 var42 var43 var44
var45 var46 var47 var48 var49 var50 var51 var52 var53 var54 var55 var56
var57 var58 var59 var61 var62 var63 var64 var65 var66 var67 var68 var69
var70 var71 var72 var73 var74 var75 var76 var77 var78 var79 var80 var81
var82 var83 var84 var85 var86
-> /PRINT INITIAL KMO AIC EXTRACTION ROTATION FSCORE
-> /FORMAT SORT BLANK(.39)
-> /CRITERIA MINEIGEN(1) ITERATE(200)
-> /EXTRACTION PC
-> /CRITERIA ITERATE(200)
-> /ROTATION VARIMAX .

-> LOGISTIC REGRESSION rideship

-> /METHOD=ENTER fac1_5 fac2_5 fac3_5 fac4_5 fac5_5 fac6_5 fac7_5 fac10_5
-> /SAVE PRED LRESID ZRESID DEV
-> /CLASSPLOT /ORIGIN
-> /CRITERIA PIN(.05) POUT(.10) ITERATE(200) .

-> LOGISTIC REGRESSION rideship

-> /METHOD=ENTER fac1_5 fac2_5 fac3_5 fac4_5 fac5_5 fac6_5 fac7_5 fac10_5
-> dage1 dage2 deduc1 deduc2 docc1 docc2 dsex eng fr both
-> /SAVE PRED LRESID ZRESID DEV
-> /CLASSPLOT /ORIGIN
-> /CRITERIA PIN(.05) POUT(.10) ITERATE(200) .

APPENDIX B

Correlation Matrix

B.1 With Observed variables

Correlation Matrix:

	VAR39	VAR40	VAR41	VAR42	VAR43	VAR44	VAR45
VAR39	1.00000						
VAR40	.58406	1.00000					
VAR41	.58603	.71596	1.00000				
VAR42	.39760	.36329	.06244	1.00000			
VAR43	.55499	.72994	.75464	.40806	1.00000		
VAR44	.43928	.31290	.32560	.24195	-.03971	1.00000	
VAR45	.36623	.22336	.27682	.28586	-.03618	.60835	1.00000
VAR46	.36263	.20649	.27590	.27588	-.03493	.58746	.86259
VAR47	.60662	.72707	.77946	.38466	.72824	.37866	.34043
VAR48	.40065	.31787	.31580	.29539	.43728	.21899	.14341
VAR49	.65124	.68760	.76476	.38470	.72402	.37817	.38032
VAR50	.41598	.53674	.47313	.35475	.53977	.35222	.09800
VAR51	.61213	.80079	.75192	.43245	.74796	.41776	.34047
VAR52	.26040	.09727	.23993	.25282	.30212	.08708	.14745
VAR53	.69972	.79104	.80460	.51237	.83019	.36746	.34028
VAR54	.12810	.04125	.16490	.05759	.13049	.20138	.20826
VAR55	.65153	.73595	.73244	.45191	.72935	.42747	.36764
VAR56	.63182	.72142	.75520	.43187	.73693	.36058	.33302
VAR57	.39649	.45784	.48987	.32267	.53949	.27661	.24218
VAR58	.61928	.74279	.73742	.43283	.76214	.37018	.31009
VAR59	-.08034	-.07320	-.15980	.00561	-.15710	-.08801	-.04593
VAR61	.02812	-.05810	.04158	.06973	.06457	.01890	-.02270
VAR62	.07019	.01059	.00891	.07565	.01520	.03812	.02903
VAR63	-.19503	-.14934	-.16561	-.18251	-.16644	-.05686	-.24529
VAR64	.00838	.00334	-.09240	.03690	-.07826	.11319	-.07682
VAR65	.06057	.04434	.09964	.07029	.08183	.06006	.17350
VAR66	.00851	-.02638	.02309	-.00395	-.03637	.00328	.14091
VAR67	-.17832	-.07757	-.07585	-.06519	-.07317	-.05651	-.16324
VAR68	.02285	.07389	.08359	.11627	.14423	-.01149	.03207
VAR69	-.03861	-.07095	-.02439	.01169	-.00570	-.02062	-.00518
VAR70	.06477	.13169	.05474	.05472	.07416	.08587	-.06193
VAR71	.09540	.07047	-.02819	.07680	.06185	.01465	-.09998
VAR72	-.00576	.07708	.02746	.03176	.05530	-.01301	-.02689
VAR73	.00457	.03528	.08339	-.00957	.03349	-.00538	.05101
VAR74	-.07673	.03727	.00253	-.03997	.00204	.01284	-.03341
VAR75	.00358	-.06568	-.07865	.01416	-.06460	-.06157	.01485
VAR76	.05383	.01807	.13050	.03289	.10375	.02401	.11400
VAR77	.00206	.00664	-.10800	-.01740	-.14357	.11544	-.02962
VAR78	.02760	.03138	.06213	-.06012	.00596	.01328	.01237

VAR79	-.12672	-.04164	-.09703	.02715	.01523	-.17048	-.14264
VAR80	-.03352	-.15693	-.08810	-.03641	-.07150	-.08134	-.02302
VAR81	.13639	.03696	.02188	.07064	.04437	.03788	.08914
VAR82	-.11038	-.05317	-.16041	-.01593	-.11062	-.07627	-.18914
VAR83	-.16409	-.13364	-.19007	-.03687	-.13502	-.18254	-.18393
VAR84	-.01535	-.10517	-.02632	-.03157	-.03832	-.02804	.00015
VAR85	-.05835	-.02236	.01936	.03162	.03847	-.03070	-.05612
VAR86	.07043	.04593	.03030	.05410	.06699	.01840	-.11735

	VAR46	VAR47	VAR48	VAR49	VAR50	VAR51	VAR52
VAR46	1.00000						
VAR47	.31968	1.00000					
VAR48	.15227	.01212	1.00000				
VAR49	.37793	.79967	.32469	1.00000			
VAR50	.07346	.47429	.41775	.24771	1.00000		
VAR51	.34819	.77726	.39404	.78672	.56255	1.00000	
VAR52	.12818	.22407	.23948	.24353	.16722	-.07163	1.00000
VAR53	.34828	.82015	.42791	.83203	.55086	.85088	.28678
VAR54	.11881	.13180	.18486	.12814	.21273	.12056	.15441
VAR55	.35861	.75617	.43129	.76093	.55805	.84232	.19802
VAR56	.31728	.75144	.34949	.73522	.50104	.79788	.16746
VAR57	.24343	.52171	.35536	.53528	.39527	.51861	.32881
VAR58	.32814	.78855	.40293	.76166	.51141	.79363	.24178
VAR59	-.02232	-.12702	-.10801	-.16170	-.10975	-.17594	.01836
VAR61	-.04859	.03131	.01092	-.02553	.13312	-.00985	.07463
VAR62	.08604	.05107	-.00204	-.02482	.08472	.03596	-.01130
VAR63	-.22046	-.18554	-.06988	-.20469	-.02987	-.14117	-.21910
VAR64	-.05781	-.04522	.01705	-.05457	.06747	-.01006	-.09253
VAR65	.18613	.07861	.06148	.09074	.02046	.09122	.03251
VAR66	.11602	.04775	-.18163	-.03543	-.10206	-.02493	.06669
VAR67	-.12896	-.15286	-.00190	-.12101	-.00049	-.13093	-.01389
VAR68	.03184	.13844	-.00701	.14003	.05750	.16105	.03829
VAR69	.00615	-.05244	.07490	.00672	.00480	-.04560	.05433
VAR70	-.06107	.07258	.10331	.05819	.19550	.09862	-.07634
VAR71	-.05952	.00654	.12797	-.01341	.16192	.01202	.02873
VAR72	-.08194	.03017	.02637	.01109	.05998	.04154	-.06380
VAR73	.08451	.11704	-.16725	.04902	-.06837	.01089	.09337
VAR74	-.11908	-.04893	.09827	-.01784	.06668	-.03348	.03996
VAR75	-.03969	.01179	-.18500	-.03055	-.07485	-.06892	-.00691
VAR76	.13333	.13498	-.03274	.17000	-.06423	.11739	.07564
VAR77	-.08488	-.03878	-.07535	-.07176	-.00293	-.04799	-.14614

VAR78	.00493	.05804	-.12535	.03268	-.01963	-.02785	.07426
VAR79	-.18747	-.06553	-.08571	-.08493	-.06441	-.10738	.06584
VAR80	-.04158	-.11360	.00512	-.10746	-.08485	-.11372	.00916
VAR81	.08634	.09589	-.03643	.04392	.03613	.01539	.07924
VAR82	-.15832	-.13697	-.05905	-.16671	.02284	-.09110	-.21784
VAR83	-.14993	-.14642	-.12609	-.19396	-.10927	-.11073	-.22433
VAR84	.00643	-.03633	-.03654	-.05283	-.02543	-.06193	.01080
VAR85	-.06000	.04278	-.03489	.00851	.01834	.03747	.01089
VAR86	-.03698	-.00758	.07818	.00206	.07457	.02512	.00223

	VAR53	VAR54	VAR55	VAR56	VAR57	VAR58	VAR59
VAR53	1.00000						
VAR54	-.09773	1.00000					
VAR55	.85701	.09977	1.00000				
VAR56	.81057	.15148	.78176	1.00000			
VAR57	.58878	.14439	.51298	.18886	1.00000		
VAR58	.83233	.15210	.79078	.76416	.57396	1.00000	
VAR59	-.13791	-.09370	-.10271	-.09917	-.17071	-.11593	1.00000
VAR61	.02922	.13293	-.00317	.05126	-.00648	-.00742	-.04012
VAR62	.02464	.06690	.05766	.08560	-.08836	.02313	.18857
VAR63	-.23652	.02443	-.22857	-.17918	-.19678	-.18832	.27724
VAR64	-.08029	.08137	-.04478	-.02593	-.06934	-.02715	.27286
VAR65	.12282	.02636	.08190	.08512	.11411	.05044	-.42591
VAR66	.03067	-.08744	.05122	.00132	.02979	.00812	-.12004
VAR67	-.12500	.04049	-.13418	-.12149	-.07385	-.09846	.23427
VAR68	.14876	-.08334	.10328	.06394	.15854	.12800	-.14954
VAR69	-.05860	.19276	-.05907	.00176	-.00550	-.00704	.00227
VAR70	.04580	.15096	.05132	.09761	.00727	.11563	.15430
VAR71	.00939	.13106	.02443	.02460	.02631	.10615	.12321
VAR72	-.01188	.15275	.02028	.12149	-.08854	.03553	.24723
VAR73	.08040	-.13757	.03765	-.00172	.08738	.06397	-.10674
VAR74	-.04896	.16100	-.02489	-.02790	-.00143	.02288	.16733
VAR75	-.04375	-.07169	-.00566	-.04851	-.01041	-.02463	.06840
VAR76	.14672	-.07826	.14000	.05841	.15714	.04675	-.15173
VAR77	-.09834	-.00511	-.03854	-.04242	-.11060	-.01595	.23999
VAR78	.06213	-.19650	-.00681	-.02060	.04289	-.03527	-.29012
VAR79	-.04190	-.13597	-.09152	-.08988	-.00199	-.10208	-.05805
VAR80	-.11643	.04830	-.08921	-.09493	-.08552	-.11365	.02875
VAR81	.08059	-.01793	.07510	.06438	.00348	.05195	-.20126
VAR82	-.17315	.06790	-.14641	-.06447	-.22681	-.08204	.24745

VAR83	-.19212	-.07619	-.18868	-.10672	-.21645	-.14406	.19622
VAR84	-.02331	-.01497	-.00120	-.06326	-.00320	-.07726	-.05115
VAR85	.03069	-.08593	-.01135	.01633	.08714	.06565	-.04506
VAR86	.06794	-.06972	.04645	.05157	-.01246	.05942	.03098

	VAR61	VAR62	VAR63	VAR64	VAR65	VAR66	VAR67
VAR61	1.00000						
VAR62	.53375	1.00000					
VAR63	-.00177	.12225	1.00000				
VAR64	.01358	.14299	.40022	1.00000			
VAR65	.02750	-.00432	-.34495	-.27367	1.00000		
VAR66	-.00964	-.03360	-.35078	-.20159	.17657	1.00000	
VAR67	.08963	.14471	.33590	.23935	-.14727	-.17394	1.00000
VAR68	-.27655	-.34122	-.08253	-.17387	-.00888	.13596	-.20971
VAR69	.13208	.17054	.18888	.12311	-.00015	-.19184	.14951
VAR70	.07267	.12561	.33322	.37030	-.29415	-.28908	.23845
VAR71	.06590	.11752	.30742	.29127	-.18072	-.28178	.16353
VAR72	.06399	.06774	.22248	.20804	-.18688	-.20554	.24077
VAR73	-.04476	-.11882	-.22545	-.24799	.07314	.25841	-.07624
VAR74	.11293	.13247	.19961	.15920	-.05860	-.10045	.21851
VAR75	.01363	.02591	-.08921	-.03410	-.03097	.12747	-.08302
VAR76	-.00356	.00695	-.17580	-.28097	.25809	.28200	-.10729
VAR77	-.05212	.11124	.20312	.23621	-.13555	-.09519	.22958
VAR78	-.02750	-.20414	-.36231	-.23953	.20863	.23762	-.28231
VAR79	-.17535	-.27075	-.08186	-.16519	-.01451	.16105	-.08383
VAR80	.13220	.13326	.09884	-.01262	.00807	-.12120	.11029
VAR81	-.02085	.01228	-.22782	-.12799	.25096	.21101	-.20052
VAR82	.04266	.14652	.45820	.29598	-.20975	-.24476	.25777
VAR83	-.02647	.06303	.37392	.24250	-.30214	-.16597	.18107
VAR84	-.02499	-.04587	-.15822	-.11738	.21237	.12480	-.16336
VAR85	-.16384	-.22913	.02068	-.05378	-.04784	.12554	-.12394
VAR86	-.01653	.13940	.08652	.13791	.05315	-.02771	.21496

	VAR68	VAR69	VAR70	VAR71	VAR72	VAR73	VAR74
VAR68	1.00000						
VAR69	-.13648	1.00000					
VAR70	-.11661	.14492	1.00000				
VAR71	-.10211	.19217	.45191	1.00000			
VAR72	-.13807	.05493	.26146	.30135	1.00000		

VAR73	.21343	-.44487	-.22559	-.19733	-.19975	1.00000	
VAR74	-.21402	.37170	.14923	.11849	.04960	-.35049	1.00000
VAR75	.04116	-.03714	-.09224	-.14402	-.14582	.13986	-.05594
VAR76	.19399	.04029	-.30449	-.21486	-.19523	.04203	-.07006
VAR77	-.14866	.12124	.18484	.12358	.25319	-.27681	.16686
VAR78	.15385	-.26697	-.25459	-.31575	-.25252	.28725	-.30967
VAR79	.38416	-.15336	-.23903	-.16203	-.03197	.09803	-.07570

VAR68	VAR69	VAR70	VAR71	VAR72	VAR73	VAR74
-------	-------	-------	-------	-------	-------	-------

VAR80	-.09824	.16453	-.00366	.07196	.09024	-.08583	.08195
VAR81	.08487	-.01604	-.17338	.00023	-.07093	-.05589	-.10742
VAR82	-.17445	.19515	.35778	.34461	.30576	-.24349	.21987
VAR83	-.12349	.12142	.19509	.14926	.20945	-.08810	.09982
VAR84	.08474	-.14810	-.13951	-.10785	-.12090	.08284	-.05637
VAR85	.33543	-.14016	-.03343	-.09927	-.13135	.08107	-.03838
VAR86	-.04843	.09701	.10730	.15447	.04818	.00503	.10783

VAR75	VAR76	VAR77	VAR78	VAR79	VAR80	VAR81
-------	-------	-------	-------	-------	-------	-------

VAR75	1.00000						
VAR76	-.00925	1.00000					
VAR77	-.04212	-.13628	1.00000				
VAR78	.05133	.17840	-.19110	1.00000			
VAR79	-.00398	.07062	.01584	.03996	1.00000		
VAR80	.04176	.06712	.05709	-.11684	-.08587	1.00000	
VAR81	-.09631	.24310	-.00397	.14915	.09669	.02568	1.00000
VAR82	-.17001	-.21124	.27315	-.31122	-.09430	.10309	-.06250
VAR83	.07127	-.19275	.21441	-.28179	-.06225	.08520	-.33120
VAR84	.06176	.22368	-.07858	.12286	.08908	.02936	.25208
VAR85	.08202	-.00221	-.06077	.04861	.23866	-.14814	-.12416
VAR86	.00794	.07257	.17046	-.12423	-.15413	.14048	-.02751

VAR82	VAR83	VAR84	VAR85	VAR86
-------	-------	-------	-------	-------

VAR82	1.00000				
VAR83	.38948	1.00000			
VAR84	-.13677	-.26624	1.00000		
VAR85	.00163	-.00051	-.03009	1.00000	
VAR86	.15704	.15093	-.07836	-.04994	1.00000

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .79775

Bartlett Test of Sphericity = 12502.709, Significance = .00000

Anti-image Covariance Matrix:

	VAR39	VAR40	VAR41	VAR42	VAR43
VAR39	.36620				
VAR40	-.02163	.23128			
VAR41	.00833	-.01538	.07810		

----- FACTOR ANALYSIS -----

	VAR39	VAR40	VAR41	VAR42	VAR43
VAR42	.01010	-.01085	.10307	.20441	
VAR43	-.00119	-.01019	-.00045	-.00143	.01195
VAR44	-.01369	-.02073	-.00050	-.00293	.02655
VAR45	.00372	-.02254	.00635	.00188	.02178
VAR46	-.00944	.00518	-.01020	-.01362	.01448
VAR47	-.00961	.00819	-.00500	-.00151	-.00954
VAR48	-.02625	.02157	-.00024	.00517	-.01740
VAR49	-.01266	.00457	-.00053	.00521	-.00267
VAR50	.00650	-.00980	.00202	.00269	-.00436
VAR51	.01403	-.02282	.00109	-.00351	-.00540
VAR52	.01372	.00206	-.00608	-.02266	-.01371
VAR53	-.01123	.00581	-.01262	-.02024	-.00736
VAR54	-.02514	.02799	-.02973	-.04414	-.02219
VAR55	.00825	.00259	.00660	.01027	.00211
VAR56	.00433	.00569	-.01260	-.01484	-.00939
VAR57	.01858	.00794	-.00721	-.00766	-.01142
VAR58	.02030	-.01784	.01067	.01416	-.00055
VAR59	-.02571	-.02417	-.01438	-.03602	.00157

APPENDIX C

Miscellaneous SPSS Output


```

-> LOGISTIC REGRESSION rideship
-> /METHOD=ENTER fac1_5 fac2_5 fac3_5 fac4_5 fac5_5 fac6_5 fac7_5 fac10_5
-> dage1 dage2 deduc1 deduc2 docc1 docc2 dsex eng fr both
-> /SAVE PRED LRESID ZRESID DEV
-> /CLASSPLOT /ORIGIN
-> /CRITERIA PIN(.05) POUT(.10) ITERATE(200) .

```

Dependent Variable.. RIDESHIP

Initial Log Likelihood Function-2 Log Likelihood 379.71989

-2 Log Likelihood 8.484

Goodness of Fit 24379478.6

	Chi-Square	df	Significance
Model Chi-Square	371.236	18	.0000
Improvement	371.236	18	.0000

----- Variables in the Equation -----

Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
FAC1_5	38.0946	21.5543	3.1236	1	.0772	.0544	3.50E+16
FAC2_5	3.5654	11.4800	.0965	1	.7561	.0000	35.3523
FAC3_5	-1.2426	1.8958	.4296	1	.5122	.0000	.2886
FAC4_5	-.3958	2.3689	.0279	1	.8673	.0000	.6732
FAC5_5	-4.3251	3.2502	1.7708	1	.1833	.0000	.0132
FAC6_5	9.1665	6.1045	2.2548	1	.1332	.0259	9570.7890
FAC7_5	.8156	1.7567	.2155	1	.6425	.0000	2.2605
FAC10_5	10.0981	6.7324	2.2498	1	.1336	.0256	24297.34
DAGE1	8.0139	7.7527	1.0685	1	.3013	.0000	3022.685
DAGE2	16.0478	11.4507	1.9641	1	.1611	.0000	9320881
DEDUC1	-7.8988	6.9342	1.2975	1	.2547	.0000	.0004
DEDUC2	-26.7687	21.3152	1.5772	1	.2092	.0000	.0000
DOCC1	-14.9402	11.5604	1.6702	1	.1962	.0000	.0000
DOCC2	-1.5292	4.8248	.1005	1	.7513	.0000	.2167
DSEX	-2.0946	3.9122	.2867	1	.5924	.0000	.1231
ENG	40.7090	25.0399	2.6431	1	.1040	.0412	4.78E+17
FR	25.1324	192.0296	.0171	1	.8959	.0000	8.22E+10
BOTH	15.9668	77.7594	.0422	1	.8373	.0000	8595786

-> LOGISTIC REGRESSION rideship
-> /METHOD=ENTER fac1_5 fac2_5 fac3_5 fac4_5 fac5_5 fac6_5 fac7_5 fac10_5
-> /SAVE PRED COOK LRESID ZRESID
-> /ORIGIN
-> /CRITERIA PIN(.05) POUT(.10) ITERATE(20) .

Total number of cases: 1997 (Unweighted)
Number of selected cases: 1997
Number of unselected cases: 0

Number of selected cases: 1997
Number rejected because of missing data: 1720
Number of cases included in the analysis: 277

Dependent Variable Encoding:

Original Value	Internal Value
.00	0
1.00	1

Dependent Variable.. RIDESHIP

Beginning Block Number 0. Initial Log Likelihood Function

-2 Log Likelihood 379.71989

Beginning Block Number 1. Method: Enter

Variable(s) Entered on Step Number

1..	FAC1_5	REGR factor score	1 for analysis	1
	FAC2_5	REGR factor score	2 for analysis	1
	FAC3_5	REGR factor score	3 for analysis	1
	FAC4_5	REGR factor score	4 for analysis	1
	FAC5_5	REGR factor score	5 for analysis	1
	FAC6_5	REGR factor score	6 for analysis	1
	FAC7_5	REGR factor score	7 for analysis	1

FAC10_5 REGR factor score 10 for analysis 1

-2 Log Likelihood 74.690
Goodness of Fit 1946.635

Chi-Square df Significance

Model Chi-Square 305.030 8 .0000
Improvement 305.030 8 .0000

Classification Table for RIDESHIP

	Predicted		
	.00	1.00	Percent Correct
	0	1	
Observed	0000000000000000		
.00	0	111	0 100.00%
	0000000000000000		
1.00	1	6	157 96.29%
	0000000000000000		
	Overall 97.80%		

----- Variables in the Equation -----

Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
FAC1_5	4.5133	.6103	54.6840	1	.0000	.3725	91.2210
FAC2_5	.7753	.2933	6.9887	1	.0082	.1146	2.1712
FAC3_5	.5238	.3440	2.3188	1	.1278	.0290	1.6885
FAC4_5	.0741	.3087	.0576	1	.8104	.0000	1.0769
FAC5_5	-.3044	.3224	.8914	1	.3451	.0000	.7376
FAC6_5	.5514	.3162	3.0404	1	.0812	.0523	1.7356
FAC7_5	.0783	.3087	.0643	1	.7998	.0000	1.0814
FAC10_5	.3083	.2808	1.2049	1	.2723	.0000	1.3611

4 new variables have been created.

Name	Contents
PRE_1	Predicted Value
COO_1	Cook's Distance
LRE_1	Logit Residual
ZRE_1	Standardized Residual

APPENDIX D

1995 Attitude Survey Questionnaire

OC TRANSPO PUBLIC TRANSPORTATION SURVEY
WEIGHTED FREQUENCIES - FREQUENCY OF USE
(1995)

Q1) Do you sometimes use a car in the Ottawa-Carleton region, whether you or someone else drives it?

	FREQUENT	CASUAL	NEVER
Yes	55.4	85.4	97.7
No	43.6	14.3	2.2
Other	0.9	0.3	0.1

N = 1962 (all respondents)

Q2) If yes - Is it your own car, a business car or someone else's?

Your own car	61.8	88.0	90.2
A business car	1.3	1.6	3.6
Someone else's car	34.5	10.2	5.8
Other	2.4	0.2	0.4

N = 1546 (car user)

Q3) Would you say that you use a car.... (PROBE)

Everyday	20.6	63.0	74.6
Nearly every day (4-6 times/week)	15.6	15.9	13.7
2-3 times a week	32.6	14.9	10.3
Once a week	17.2	3.4	0.9
Less than once a week	6.5	2.1	0.4
Less than once a month	4.7	0.0	0.0
Never	1.3	0.0	0.0
Don't know	1.7	0.7	0.1

N = 1546 (car user)

	FREQUENT	CASUAL	NEVER
Q4) For what purpose do you use a car most often?			
Work	18.9	45.3	57.0
Other work related purposes	0.8	0.5	3.0
Shopping			
- in the downtown area	6.8	2.8	3.0
- in areas other than downtown	10.8	8.1	7.7
- both	9.5	8.2	5.6
Personal business such as banking and going to - the doctor	15.0	13.3	10.4
Pleasure, entertaining or visiting			
- in the downtown area	4.4	3.9	1.3
- in areas other than downtown	9.3	4.1	2.9
- both	11.2	4.1	3.1
Attending school/university	5.6	8.2	4.5
PROBE: Other types of trips			
SPECIFY: _____	7.4	1.2	1.3
Refused/Don't know	0.3	0.2	0.0

N = 1546(car user)

Q5) Do you participate in a car pool?

Yes	9.3	6.3	10.2
No	83.2	90.9	87.2
Other/Don't know	7.5	2.7	2.6

N = 717(work related trips)

Q6) Have you taken OC Transpo buses in the last six months to get around in the Ottawa-Carleton region?

Yes	100.0	100.0	0.0
No	0.0	0.0	100.0
Don't Know	0.0	0.0	0.0

N = 1962(all respondents)

	FREQUENT	CASUAL	NEVER
--	----------	--------	-------

Q21) How do you usually pay your bus fare?

Cash	23.6	69.6	---
Ticket	15.8	17.6	---
Monthly bus pass	60.1	8.0	---
Other	0.5	1.0	---
Don't know/Refused	0.0	3.8	---

N = 1071 (bus user)

Q21 (ii) Do you know that tickets and passes are cheaper than paying cash?

Yes	85.8	88.5	---
No	14.2	11.5	---

N = 370 (cash user)

Q21 (iii) If bus pass mentioned-/what type of bus pass do you use?

Senior pass	15.8	34.6	---
Student pass	29.6	15.9	---
Unipass	21.8	18.2	---
Transpass	32.0	28.8	---
Don't know	0.7	2.4	---

N = 505 (pass user)

Q22) (i) Do you use the bus after seven p.m.?

Yes	23.5	11.5	---
Sometimes	28.0	15.1	---
No	48.4	69.4	---
Don't know	0.2	3.9	---

N = 1071 (bus user)

(ii) Do you use the bus on weekends?

Yes	37.5	12.2	---
Sometimes	22.8	18.1	---
No	39.5	65.8	---
Don't know	0.3	4.0	---

N = 1068

	FREQUENT	CASUAL	NEVER
(iii) IF YES, SOMETIMES - On Saturdays?			
Yes	69.1	48.9	---
Sometimes	28.1	47.6	---
No	2.4	2.5	---
Don't know	0.4	1.0	---

N = 562

(iv) On Sundays?

Yes	47.5	18.2	---
Sometimes	29.6	37.4	---
No	20.3	42.1.	---
Don't know	2.6	2.3	---

N = 569

Q23) For what purpose do you use a bus most often?

Work	46.2	18.0	---
Other work related purposes	3.9	2.5	---
Work sub-total	50.1	20.5	
Shopping			
- in the downtown area	5.7	15.2	---
- in areas other than downtown	3.3	6.0	---
- both	4.8	2.5	---
Shopping sub-total	13.8	23.7	
Personal business such as banking and going to the doctor	6.7	10.7	---
Pleasure, entertaining or visiting			
- in the downtown area	2.5	8.6	---
- in areas other than downtown	1.7	2.5	---
- both	3.1	8.4	---
Pleasure sub-total	7.3	19.5	
Attending school/university	19.1	5.3	---
Car unavailable	1.3	13.8	---
PROBE: Other types of trips SPECIFY: _____	1.8	6.7	---

N = 1071 (bus user)

	FREQUENT	CASUAL	NEVER
--	----------	--------	-------

Q24) Of the following, what is the most important reason for taking the bus?

Bus cheaper than alternatives	16.4	7.0	---
Good bus service	8.2	3.4	---
Environmental reasons	5.6	9.5	---
No car available	40.2	42.1	---
Parking	12.1	17.3	---
All of the above	12.9	9.1	---
None/Other/Don't know	4.7	11.6	---

N = 1071 (bus user)

Q25) Where do you get information about current schedules and route changes?

Bus Stops	14.7	12.9	---
Transitway stations	7.5	2.6	---
Bus drivers	7.2	2.8	---
On bus info..	17.1	15.0	---
Newspaper	4.0	2.2	---
OC Transpo offices	24.4	32.9	---
Word of mouth	7.2	4.2	---
Other	8.2	10.1	---
Don't know	9.7	17.2	---

N = 1071 (bus user)

Q26) Do you pick up other information that is available on the buses...

Regularly	16.3	5.0	---
Sometimes	37.3	24.7	---
Never	45.4	62.0	---
Don't know	1.0	8.3	---

N = 1071 (bus user)

Q27) Do you ever use the 560 telephone timetable system?

Yes	54.6	39.6	---
No	42.8	52.0	---
Haven't heard of 560 system/ Don't know what it is	2.3	2.9	---
Other/don't know	0.4	5.5	---

N = 1071 (bus user)

(ii) If yes - How often do you use it?

Everyday	14.4	3.1	---
Nearly every day (4-6 times a week)	13.4	0.3	---
2-3 times a week	22.2	0.8	---
Once a week	20.5	12.1	---
Less than once a week	12.3	19.7	---
Less than once a month	16.2	62.7	---
Never	0.0	0.0	---
Other	0.0	0.0	---
Don't know	0.9	1.3	---

N = 535

Q28) Over the last six months have you ever called the OC Transpo information centre, that is the 741-4390 number?

Yes	50.2	38.2	---
No	49.1	55.5	---
Haven't heard of it/ don't know	0.8	6.3	---

N = 1071 (bus user)

If Yes - Did you find it easy to get through?

Yes	83.9	82.4	---
No	13.8	13.4	---
Other	1.8	1.9	---
Don't know	0.4	2.3	---

N = 498

	FREQUENT	CASUAL	NEVER
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Did you find that the information you were given was accurate?

Yes	92.7	91.5	---
No	5.1	7.3	---
Other	1.5	1.2	---
Don't know	0.7	0.0	---

N = 413

Do you find the staff courteous?

Yes	95.4	93.4	---
No	2.8	3.8	---
Other	1.5	0.0	---
Don't know	0.4	2.7	---

N = 381

Q29) (i) Do you use the TV screens in shopping centres and transit stations for information on bus times?

Yes	47.7	35.0	---
No	51.5	58.6	---
Don't know	0.8	6.4	---

N = 1071 (bus user)

(ii) If Yes - Are they accurate?

Yes	82.8	88.1	---
No	16.1	6.7	---
Don't know	1.1	5.2	---

N = 470

Q30) (i) If there is a printed schedule at a bus stop, have you ever referred to the information chart concerning bus times?

Yes	75.2	67.4	---
No	23.1	27.4	---
Don't know	1.8	5.3	---

N = 1071

FREQUENT CASUAL NEVER

(ii) If Yes - in your experience, is the information accurate?

Yes	78.7	80.2	---
No	14.4	11.4	---
Other	5.3	5.9	---
Don't know	1.9	2.5	---

N = 764

Q31) (i) Do you happen to use bus timetable leaflets?

Yes	42.0	24.2	---
No	56.5	70.0	---
Other	0.3	---	---
Don't know	1.1	5.8	---

N = 1071 (bus user)

(ii) If Yes - Where do you get them?

OC TRANSPO Offices	27.8	32.6	---
From the bus driver	29.6	26.8	---
Transitway	22.7	10.3	---
Shopping centres	11.3	7.8	---
Friends	0.4	11.2	---
Mailed after calling 741-4390	1.4	5.1	---
Other (specify)	5.1	6.2	---
Don't know	1.7	0.0	---

N = 400

Q32) (i) Have you within the last six months called the OC Transpo Customer Service number for any reason? (Used for complaints and commendations - 748-4408)

Yes	14.4	2.2	---
No	84.2	92.1	---
Don't know	1.3	5.7	---

N = 1071 (bus user)

	FREQUENT	CASUAL	NEVER
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(ii) Did you find the staff you dealt with helpful?

Yes	87.9	47.6	---
No	9.6	52.4	---
Don't know	2.5	0.0	---

N = 118

Q33) Do you have a system map of the bus routes?

Yes	36.4	18.6	---
No	56.1	65.1	---
Don't know	7.5	16.3	---

N = 1071 (bus user)

Q34) Have you ever heard of OC Transpo's easier access programs which, among other features, allows the bus to "kneel" or lower the front step.

Yes	76.2	48.9	---
No	23.4	46.2	---
Don't know	0.4	4.9	---

N = 1071 (bus user)

If Yes---When you ride the bus do you ever see the driver lower the front step?

Often	6.3	4.1	---
Sometimes	27.8	19.7	---
Rarely	19.1	19.0	---
Never	46.1	55.4	---
Don't know	0.7	1.8	---

N = 740

	FREQUENT	CASUAL	NEVER
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Q35) When you ride the bus do the drivers call out the names of the major stops?

Often	5.8	3.2	---
Sometimes	38.2	25.4	---
Rarely	25.9	24.1	---
Never	29.4	38.5	---
Don't know	0.7	8.8	---

N = 1071(bus user)

MOVING ON TO A FEW QUESTIONS ABOUT THE TRANSITWAY

Q36) (i) Do you think the new transitway bus roadways are a good investment or a poor investment for the region?

Good investment	82.1	73.3	66.4
Poor investment	6.8	9.9	14.4
Haven't heard of transitway/			
Don't know what it is	2.7	2.2	4.2
Other	1.0	1.0	0.7
Don't know	7.4	13.6	14.3

N = 1962(all respondents)

(ii) Have you ever been on the transitway yourself?

Yes	90.7	84.1	53.4
No	8.2	14.3	43.1
Don't know	1.0	1.6	3.5

N = 1889

(iii) Do you feel that Transitway stations are safe places to wait for a bus?

Yes	49.1	42.7	43.6
No	15.9	21.6	18.7
Depends	16.7	17.3	8.5
Sometimes	2.7	2.4	3.4
Not at night	11.0	10.1	12.1
Don't know	4.6	5.9	13.7

N = 1374

	FREQUENT	CASUAL	NEVER
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(iv) Why not?

Intimidated by kids/gangs	7.3	6.6	6.2
Not many people around	32.4	30.8	34.7
Not enough security	22.8	29.0	23.4
Not enough emergency phones	2.1	0.0	1.6
All of the above	14.3	15.2	13.8
Poor lighting	0.7	0.0	1.2
Other	12.1	11.6	11.2
Don't know	8.3	6.8	7.9

N = 633

Q37) Now, I'm going to read to you a list of general opinions expressed by people living the Ottawa-Carleton area. These opinions are related to bus service. For each statement, would you please tell me if you strongly agree, agree, disagree, or strongly disagree.

(i) The bus system is not easy to use.

Strongly disagree	12.4	6.2	2.6
Disagree	69.5	65.9	51.4
Does not agree or disagree	3.3	2.7	4.2
Agree	12.6	20.5	24.0
Strongly agree	2.0	1.3	4.3
Don't know	0.2	3.4	13.6

(ii) The bus routes are well-planned.

Strongly disagree	2.6	4.2	2.6
Disagree	13.7	14.1	17.8
Does not agree or disagree	6.7	11.2	6.1
Agree	70.0	59.2	45.2
Strongly agree	3.6	1.6	2.1
Don't know	3.5	9.6	26.3

(iii) The transitway has improved bus service for me.

Strongly disagree	2.5	1.8	3.6
Disagree	11.4	13.6	15.2
Does not agree or disagree	8.8	11.7	10.0
Agree	52.4	49.8	27.1
Strongly agree	15.3	7.3	4.2
Don't know	9.3	15.8	40.0

	FREQUENT	CASUAL	NEVER
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(iv) Customers get a good deal on fares during off-peak hours and weekends.

Strongly disagree	7.9	5.5	7.1
Disagree	24.1	25.1	20.6
Does not agree or disagree	8.9	4.8	6.8
Agree	46.5	52.2	32.2
Strongly agree	4.7	2.1	2.2
Don't know	7.9	10.3	31.2

(v) Route changes are too frequent.

Strongly disagree	2.1	0.5	0.6
Disagree	54.7	37.5	19.1
Does not agree or disagree	8.7	12.8	9.3
Agree	18.3	19.0	16.2
Strongly agree	3.7	2.4	1.8
Don't know	12.4	27.8	53.1

(vi) There is really no problem with personal security when taking the bus at night.

Strongly disagree	9.1	7.8	8.1
Disagree	36.0	43.9	44.5
Does not agree or disagree	9.3	11.1	6.1
Agree	30.8	25.5	20.1
Strongly agree	1.6	0.8	0.7
Don't know	13.3	10.8	20.5

(vii) Transitway stations are not kept clean.

Strongly disagree	3.0	3.6	1.2
Disagree	59.9	53.9	31.4
Does not agree or disagree	7.4	10.3	7.7
Agree	16.8	13.0	11.9
Strongly agree	2.0	2.1	1.6
Don't know	10.9	17.1	46.2

(viii) Bus service is unreliable.

Strongly disagree	6.3	2.6	2.2
Disagree	63.3	64.5	46.2
Does not agree or disagree	6.4	6.1	6.9
Agree	18.9	17.2	17.3
Strongly agree	4.2	5.6	2.8
Don't know	0.9	4.0	24.7

(ix) The frequency of buses is adequate.

Strongly disagree	5.3	5.4	2.0
Disagree	21.5	20.6	17.0
Does not agree or disagree	6.1	7.6	7.1
Agree	61.5	58.9	43.9
Strongly agree	3.7	2.7	1.7
Don't know	2.0	4.8	28.3

(x) Transfers are generally convenient.

Strongly disagree	2.4	4.9	1.7
Disagree	10.9	13.5	11.4
Does not agree or disagree	8.2	7.4	5.8
Agree	65.7	61.6	43.2
Strongly agree	3.8	3.7	1.0
Don't know	8.9	8.8	36.9

(xi) Bus shelters are kept clean.

Strongly disagree	1.8	1.7	0.8
Disagree	20.0	16.7	12.9
Does not agree or disagree	5.8	5.9	6.5
Agree	66.0	69.5	48.3
Strongly agree	3.0	0.6	0.8
Don't know	3.3	5.6	30.6

(xii) Buses are not kept clean.

Strongly disagree	5.6	1.9	0.8
Disagree	69.2	73.5	44.5
Does not agree or disagree	5.2	5.9	8.1
Agree	16.6	13.0	11.5
Strongly agree	2.0	0.9	1.2
Don't know	1.4	4.7	33.8

	FREQUENT	CASUAL	NEVER
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(xiii) Cash fare for a single peak-hour trip is too expensive.

Strongly disagree	1.1	1.0	0.4
Disagree	17.9	22.0	10.7
Does not agree or disagree	6.4	4.3	4.9
Agree	40.5	43.6	37.0
Strongly agree	23.8	23.2	18.6
Don't know	10.3	6.0	28.4

(xiv) The bus pass is a good buy.

Strongly disagree	2.3	3.2	1.6
Disagree	9.4	9.1	12.7
Does not agree or disagree	5.4	6.8	5.1
Agree	63.2	53.4	44.2
Strongly agree	13.8	6.0	2.6
Don't know	5.8	21.5	33.8

(xv) The map showing all the bus routes is difficult to understand.

Strongly disagree	4.3	0.4	1.5
Disagree	54.4	49.0	38.0
Does not agree or disagree	4.8	5.1	4.9
Agree	24.0	26.1	18.8
Strongly agree	3.5	3.8	3.1
Don't know	9.1	15.6	33.6

(xvi) Bus drivers are courteous.

Strongly disagree	4.0	7.4	3.2
Disagree	15.2	13.7	11.2
Does not agree or disagree	12.6	11.1	9.6
Agree	62.0	61.8	48.5
Strongly agree	5.1	2.7	2.3
Don't know	1.0	3.3	25.2

FREQUENT

CASUAL

NEVER

(xvii) There is really no problem with personal security when walking in my neighborhood at night.

Strongly disagree	4.7	6.0	4.9
Disagree	34.9	33.2	30.2
Does not agree or disagree	8.3	4.7	2.8
Agree	42.1	44.8	48.9
Strongly agree	3.3	4.8	4.1
Don't know	6.5	6.5	9.2

(xviii) One of the most unpleasant things about taking the bus is the behavior of other passengers.

Strongly disagree	3.0	4.1	0.6
Disagree	41.0	42.7	29.4
Does not agree or disagree	7.6	8.0	4.8
Agree	40.1	37.2	33.5
Strongly agree	6.7	4.2	5.4
Don't know	1.6	3.7	26.3

(xix) Taking buses benefits the environment.

Strongly disagree	0.5	1.4	1.4
Disagree	4.6	6.5	8.4
Does not agree or disagree	3.2	2.5	2.7
Agree	71.8	70.8	65.2
Strongly agree	17.7	16.7	15.0
Don't know	2.2	2.0	7.4

(xx) Taking the bus is frustrating

Strongly disagree	3.4	2.3	0.5
Disagree	54.8	42.4	23.2
Does not agree or disagree	6.9	6.6	5.9
Agree	29.3	39.6	42.0
Strongly agree	4.9	7.2	10.0
Don't know	0.6	2.0	18.4

FREQUENT CASUAL NEVER

(xxi) No matter where I live, I will always avoid taking the bus.

Strongly disagree	25.0	9.9	4.0
Disagree	57.1	65.1	51.0
Does not agree or disagree	4.1	3.0	2.9
Agree	6.5	16.6	21.6
Strongly agree	1.1	3.2	9.3
Don't know	6.2	2.3	11.3

(xxii) It is reasonable for people to stand sometimes on rush-hour buses.

Strongly disagree	2.0	2.2	1.7
Disagree	15.7	18.0	11.9
Does not agree or disagree	3.6	2.9	2.4
Agree	72.2	70.5	66.0
Strongly agree	3.3	3.7	3.5
Don't know	3.2	2.8	14.4

(xxiii) There is really no problem with security when using a multi-story car park at night

Strongly disagree	12.5	11.3	10.6
Disagree	39.0	48.9	54.8
Does not agree or disagree	9.9	6.2	6.4
Agree	12.8	17.6	10.4
Strongly agree	1.0	1.7	1.0
Don't know	24.7	14.2	16.7

(xxiv) OC Transpo should buy more air conditioned buses.

Strongly disagree	3.2	1.0	3.1
Disagree	27.7	37.3	25.2
Does not agree or disagree	10.0	10.9	6.2
Agree	40.4	34.5	34.4
Strongly agree	13.4	8.5	5.7
Don't know	5.3	7.8	25.4

N = 1962 (all respondents)

FREQUENT CASUAL NEVER

Q38) All things considered, would you say that over the last year your bus service has got better, worse or stayed the same?

Better	16.9	13.1	7.0
Worse	8.5	5.3	4.2
Same	70.0	61.8	24.7
Don't know	4.7	19.8	64.1

N = 1962 (all respondents)

Q39) If you could improve OC Transpo services in one way, what would it be?

More Buses	15.3	11.4	7.7
Better drivers	5.7	6.9	1.6
Buses on time	7.0	1.5	0.8
Better connections	2.1	2.6	1.8
More stops	0.2	0.3	0.0
Later services	3.7	4.5	1.3
More routes	5.1	5.6	4.0
Cheaper fares	14.9	18.7	12.4
No food on bus	0.3	0.0	0.1
Better security	0.4	0.3	0.9
Cleaner	0.3	0.0	0.0
Smaller buses off-peak	0.3	0.0	0.0
Nicer atmosphere	2.6	3.0	1.1
More direct routes	1.7	2.7	5.0
Expand transitway	0.1	1.1	0.7
Build rail system	2.1	2.5	1.3
Other	4.8	2.7	4.1
Don't know/Refused	33.1	36.2	57.0

N = 1962 (all respondents)

Q40) What age group are you in?

18-24	26.3	17.1	8.9
25-34	23.8	24.3	26.7
35-44	16.0	18.5	26.0
45-54	9.7	14.2	14.5
55-64	11.0	10.8	12.7
65+	12.7	14.3	10.0
Refused	0.6	0.8	1.2

	FREQUENT	CASUAL	NEVER
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Q41) What language do you normally use at home

English	81.7	86.5	83.5
French	7.4	7.5	7.3
Both	4.7	4.5	5.6
Other	5.9	1.1	3.1
Refused	0.3	0.4	0.5

Q42) How far did you go in school?

Completed grade school or less	2.4	3.4	2.4
Some high school or completed	28.3	24.6	23.0
Technical or business college	17.9	19.1	20.1
Some university	19.2	13.7	9.3
Completed university	20.8	27.7	29.8
Graduate study	10.1	11.2	13.6
Refused/Don't know	1.4	0.4	1.7

Q43) What is your usual occupation?

Professional	3.3	5.7	5.9
Semi-professional	7.9	11.6	14.7
Skilled white collar	27.6	22.1	26.9
Unskilled white collar	9.5	9.4	12.2
Skilled blue collar	1.4	2.1	5.4
Unskilled blue collar	5.7	7.3	5.2
Student	18.1	12.9	3.8
Housewife	2.3	3.9	3.2
Retired	10.4	16.7	12.2
Unemployed	0.1	0.7	1.5
Refused	5.9	2.1	3.9
Don't know	7.7	5.5	4.9

Q43 (i) Is that with the...

Federal public service	37.6	24.6	16.9
Municipal or regional	5.4	3.3	5.2
OC Transpo	0.9	0.0	0.2
None of the above	53.5	65.7	70.5
Don't know	2.6	6.3	7.1

	FREQUENT	CASUAL	NEVER
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Q44) Is your total household income before taxes above or below \$35,000?

Above	44.8	52.9	62.0
Below	31.4	28.5	17.0
Refused	0.1	0.0	0.1
Don't know	23.6	18.6	20.9

Q44 (i) If above...would that be?

\$35-\$45	29.2	21.5	22.8
\$45-\$55	20.4	30.0	16.1
Above \$55	37.2	37.7	46.4
Don't know/refused	13.2	10.8	14.7

(ii) If below...would that be?

Below \$15	36.0	28.7	14.4
\$15-\$25	31.0	32.2	22.7
\$25-\$35	19.7	24.7	46.0
Don't know/refused	13.4	14.5	17.2

Q45) Do you have a current driver's licence?

Yes	72.3	90.9	96.2
No	27.2	8.9	3.3
Don't know	0.5	0.1	0.5

(i) Sex

Male	40.0	43.5	52.3
Female	60.0	56.5	47.7

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