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MODE CHOICE FOR THE URBAN WORK TRIP

By

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ABSTRACT

This research paper investigates the factors which influence mode choice (choice of car or bus) for the urban journey to work. A main objective of the study is to determine the validity of the attitudinal approach to explaining mode choice which explains mode choice by using the traveller's subjective impressions of the attributes of different modes. The second objective is to study the mode choice decision-making process and its relationship to actual mode choice, socioeconomic, demographic, and transportation characteristics.

Information was obtained from a sample of McMaster University employees using a questionnaire which was distributed in November of 1986. Respondents were asked to indicate their degree of preference for car or bus in response to hypothetical mode choice situations. The utility of this controlled simulation approach was also evaluated.

The results provide support for the attitudinal modelling of mode choice and for the general paradigm which seeks to explain human travel behaviour through the use of controlled simulation. The results provide information regarding the relative weighting of travel time and travel cost in the mode choice decision process. Also, hypothetical mode choice preference was shown to be related to actual mode choice but not to socioeconomic, demographic or transportation characteristics.

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L.P.P.
April, 1987

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CHAPTER 1 : INTRODUCTION

North American society places great emphasis on the private automobile. Large-scale adoption of the automobile has facilitated urban and suburban expansion. In general, increased use of the automobile has reduced the relative importance and attractiveness of mass transit and especially the bus. Unfortunately, increased use of the automobile has created several problems including increased air pollution and the ever increasing demand for expanded roads and highways. One of the most serious automobile induced problems is the congestion which occurs in some cities during the journey to work hours in early morning and late afternoon. If planners are to alleviate transportation problems they must have a better understanding of all aspects of travel behaviour.

This research paper addresses an important aspect of travel behaviour - mode choice for the urban work trip. Mode choice refers to the means of transportation used to make a trip, i.e., car, bus, bicycle, etc. The urban work trip refers to trips to and from work in an urban area. This research will focus on mode choice between car and bus only.

The general research question which has motivated this research is: What factors influence mode choice decisions for urban journey to work travel? There are

basically two approaches to answering such a question. The conventional approach explains mode choice using objective measures of independent variables such as travel cost, travel time, and income. The second and less conventional approach is known as the attitudinal approach. This approach, based on the information integration theory, explains mode choice by measuring the traveller's subjective impressions (perceptions) of the attributes of different modes (Meyer et al., 1977). This study will incorporate elements from both approaches but will concentrate primarily on the attitudinal approach.

Since it deals with individual's perceptions and decision-making processes, attitudinal modelling of mode choice is often characterized by the use of laboratory type experiments known as controlled simulation experiments. Individuals are asked to respond to hypothetical mode choice situations. The overall preference for car or bus exhibited by the individual in these situations is known as the individual's modal choice preference.

The main goal of this study is to evaluate the attitudinal modelling approach and the use of controlled simulation. This study will also seek to answer three specific research questions. They are: 1) Is modal choice preference related to the relative weighting of choice factors such as travel time and travel cost? 2) Is modal

choice preference related to differences in socioeconomic, demographic, and transportation characteristics? 3) Are responses to hypothetical mode choice situations related to actual mode choice? Basically, these three questions were addressed by Meyer et al. (1977). In fact, the research conducted here is largely based on this previous study and allows a comparison of the results of the two studies.

This report is divided into several sections. The literature review in the first section discusses recent mode choice literature including several important theoretical and methodological issues, providing the basis for the research questions. The next section discusses the research design including research hypotheses, questionnaire design, and sampling procedures. The analysis section follows and contains the statistical results from the testing of the research hypotheses. Finally, the conclusion summarizes the findings of the study while including a discussion of its limitations and suggestions for further research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Over the last ten years a large amount of literature has been devoted to the study of mode choice behaviour. It is widely recognized that the journey to and from work often presents a major transportation problem including traffic congestion and pollution (Turnbridge and Jackson, 1983, p. 1; Frisken and Keall, 1978, p. 1). Hence, a better understanding of the factors underlying mode choice decisions is essential to the success of transportation planning efforts.

A review of recent mode choice literature was conducted to determine an appropriate approach for investigating the research questions outlined earlier. The literature review uncovered several theoretical and methodological issues which are discussed below.

2.2 Aggregate versus Disaggregate Models

The first issue encountered in the literature was that of aggregate versus disaggregate models of transportation behaviour. Aggregate models predict the travel behaviour of aggregate populations while disaggregate models predict the travel behaviour of individuals. Most early travel models were aggregate models (Stephanedes et al., 1984, p. 14). Disaggregate models have recently become popular for several reasons.

First, aggregate models are often problematic. They

require large amounts of data and cannot include certain explanatory variables (Saunders and Ranniste, 1981, p. 7). Due to their assumptions, aggregate models are often descriptive rather than causal and often have large forecasting errors. Therefore, these models have limited policy applications (Stephanedes et al., 1984, p. 14).

Disaggregate models, on the other hand, can reveal causal relationships between explanatory variables and mode choice. Hence, disaggregate models can be better adapted to policy impact analysis (Stephanedes et al., 1984, p. 14). Disaggregate models have been directly compared to aggregate models. Watson found that in terms of model structure and predictive error the disaggregate approach is superior to the aggregate approach (Watson, 1974, p. 62, p. 65). Consequently, the use of disaggregate data and a disaggregate model seems appropriate for the research at hand.

2.3 Conventional versus Attitudinal Variables

Another issue which appeared in the literature was that of models employing conventional variables as opposed to models employing psychological or attitudinal variables. Conventional variables refer to objective measures of travel times, costs, and distances. Psychological or attitudinal variables refer to traveller perceptions of the attributes of different transport modes, e.g., perceived travel times,

costs, and safety.

Earlier studies used only conventional variables. Recently it has become standard practice to incorporate both conventional and psychological (attitudinal) variables into mode choice studies (Louviere et al., 1981b; Dumas and Dobson, 1979). Several studies which included attitudinal variables found they influenced mode choice. Ganek and Saulino found that convenience, comfort, and flexibility influence mode choice (Ganek and Saulino, 1976). Spear made comparisons between models of mode choice which included only time and cost variables and those that also included a convenience variable. He found that the goodness-of-fit was significantly better for the model including the convenience variable (Spear, 1976). Hence, researchers have shown that attitudinal variables can be included with conventional variables to improve mode choice models.

The variables of travel time and travel cost have consistently explained a large proportion of variance in mode choice behaviour (Louviere et al., 1981b, p. 9). Yet, there is an intuitive argument that the individual's own perceptions of travel time and cost are much more important than objective measures of time and cost (Louviere et al., 1981b, p. 9; Smith and Hall, 1981, p. 68). This argument makes sense "because people act on the basis of the situation they perceive rather than that which actually

exists" (Smith and Hall, 1981, p. 68). Therefore, the literature provides support for the use of perceived travel time and cost as independent variables.

2.4 Attitudinal Modelling of Travel Behaviour

The next question of interest is how to incorporate traveller perceptions of time, cost, and other attributes into a mode choice analysis, (i.e., how do researchers approach the attitudinal modelling of travel behaviour?) There exist several approaches to attitudinal modelling of travel behaviour. Current literature emphasizes two competing paradigms within attitudinal modelling. These paradigms are known as the revealed preference approach and the controlled simulation approach.

The revealed preference approach has received the greatest amount of attention (Louviere et al., 1981a, p. 3; Levin, 1979, p. 13). Revealed preference studies infer the relative importance of a variable from the strength of the relationship between that variable and actual reported travel behaviour (Johnson, 1975, p. 10). Conversely, controlled simulation does not deal with actual behaviour but with hypothetical behaviour. Levin notes,

> "Controlled simulation" studies deal with analysis of factors that affect choices when individuals are presented with hypothetical alternatives generated by experimental designs in which the factors of interest are systematically manipulated and other factors are controlled (Levin, 1979, p. 2).

Both approaches have advantages and disadvantages.

Revealed preference models are calibrated to real data and would therefore seem more valid than simulation models which are calibrated to hypothetical data (Louviere et al., 1981a, p. 1). But, the revealed preference approach has several disadvantages. Biases are introduced due to the lack of control of extraneous variance (Louviere et al., 1981a, p. 1). Extraneous variance is defined as the influence on the dependent variable of independent variables outside the purposes of the study. Most importantly, the significant relationships between explanatory variables and mode choice are correlational and thus causal inferences are not possible (Johnson, 1975, p. 11; Levin, 1979, p. 14; Meyer et al., 1980, p. 8). This situation exists because the range of variation of the independent variables is often severely restricted in the real world (Louviere et al., 1981b, p. 41). It is essential to maximize the variance of the independent variable because if the independent variable does not vary, "there is little chance of separating its effect from the total variance of the dependent variable" (Kerlinger, 1964, p. 308).

Cognitive dissonance occurs when individuals adjust their attitudes so as to justify their travel behaviour (Levin, 1979, p. 14-15; Dumas and Dobson, 1979). Cognitive dissonance would seem less of a problem in simulated choice environments where respondents may feel less compelled to

justify hypothetical choices than real choices.

The main advantage of the simulation approach is that the researcher can vary the independent variables over a wide range of values and therefore determine cause and effect relationships (Levin, 1979, p. 15; Meyer et al., 1980, p. 9). Also, revealed preference models require much larger samples than simulation models in order to attain the same inferential power (Louviere et al., 1981a, p. 21).

The main disadvantage of controlled simulation is the extent to whih responses in hypothetical situations represent actual intentions in the real world (Levin, 1979, p. 15-16). Fishbein and Azjen, after reviewing numerous studies conclude "that reported intentions are ordinarily a highly accurate method of predicting specific behaviour" (Johnson, 1978a, p. 29). As will be shown later, realistic simulation models have successfully predicted actual transportation behaviour.

A comparison of empirical studies using both the controlled simulation and revealed preference approaches follows. Louviere et al. directly compared revealed preference and controlled simulation models (Louviere et al., 1981a, p. 20). Their results showed that the two types of models had similar predictive abilities (Louviere et al., 1981a, p. 20). Also, the laboratory model was superior to the revealed preference model in terms of identifying important explanatory variables (Louviere et al., 1981a, p.

22).

Results from other mode choice studies also provide support for laboratory simulation. In a study of mode choice (flying versus driving) Louviere et al. found that "ratings of hypothetical trips in the controlled experimental design successfully discriminated between those who actually used different modes" (Louviere et al., 1981b, p. 36). Hall and Smith tested the hypothesis that "Individuals will make choices in response to hypothesized conditions in the same manner as they make choices under actual conditions" (Hall and Smith, 1981, p. 69). They could not reject this hypothesis for work trips (Hall and Smith, 1981, p. 70). Therefore, several simulation models have successfully predicted transportation behaviour.

The theoretical and empirical evidence suggests controlled simulation is superior to the revealed preference approach in several respects. Researchers suggest the two approaches are complementary and that the positive features of both approaches be combined (Louviere et al., 1981a, p. 1; Meyer et al., 1980, p. 23; Levin, 1979, p. 18).

2.5 Functional Measurement Technique

The final part of the literature review compares the two main approaches to attitude measurement in controlled simulation studies. Included in this discussion is a consideration of the research designs of several studies.

The first approach to attitude measurement requires respondents to rate the importance of several attributes (e.g., time, cost, and convenience) and then to rate their beliefs about each mode (e.g., car or bus) with respect to each attribute (variable) on an ordinal or interval scale (Levin, 1979, p. 5). Neveu used this approach to examine the influence of comfort, convenience, and reliability on mode choice for work travellers (Neveu et al., 1979). A similar design was used by Johnson to study the importance of various travel attributes on mode choice for work trips in the San Francisco Bay area (Johnson, 1978b). Unfortunately, in both the studies by Neveu and Johnson, the range of variation for each attribute is not specified. As mentioned earlier, the effect of an attribute on mode choice can depend on the range of variation of that attribute (Levin, 1979, p. 6). Also, since these studies do not manipulate the independent variables, the approach used by Neveu and Johnson cannot directly consider trade-offs which respondents make between competing factors, e.g., time and cost.

The second approach to attitude measurement is known as functional measurement. This technique is preferred over the first approach because the range of variation for attributes is specified and functional measurement uses factorial designs which require respondents to trade-off competing factors. Functional measurement asks respondents

to evaluate multiattribute mode choices (Levin, 1979, p. 6). This is done by simultaneously varying the levels of several variables in a factorial experimental design (Louviere et al., 1981b, p. 5). Respondents are then asked to rate their mode choice preference on a numerical scale for each of the hypothetical situations. These numerical scales can then be analyzed using analysis of variance to estimate the effect of each variable on mode choice (Levin, 1979, p. 7) and to examine the trade-offs between competing variables (Levin, 1979, p. 15).

Numerous studies have employed the functional measurement technique. For example, Odland and Jakubs (1977) studied preference functions for urban travel modes using a 3 x 3 complete factorial design. Levin and associates studied the factors affecting perceived safety of highway driving using an experimental factorial design (Levin et al., 1977).

One functional measurement study deserves particular attention. Meyer et al. (1977) tested the hypothesis that mode choice is influenced by the relative weighting of choice factors such as time, cost, and number of riders in the car. They varied levels of time difference favouring car over bus (0, 15, or 45 minutes), cost difference favouring bus over car (0, 25, or 75 cents per day), and number of riders in the car (0, 1, or 3). A complete 3 x 3

factorial design was formed for each pair of variables (i.e., cost difference versus time difference, cost difference versus number of riders, and time difference versus number of riders). Hence, three 3 x 3 factorial designs involving 27 hypothetical situations were formed overall. Respondents then rated each of the hypothetical situations on the relative likelihood of taking a car or bus on a numerical scale. These numerical ratings were then subjected to cluster analysis and subsequently analysis of variance to test the research hypothesis. Meyer et al. also included direct importance ratings of attributes, estimates of travel cost and time differences, actual measures of mode choice, and situational constraints. This use of conventional variables and elements from the revealed preference approach allows Meyer et al. to relate mode choice to socioeconomic characteristics and to predict actual mode choice using responses to hypothetical scenarios. Hence, the functional measurement technique of attitude measurement using factorial designs is seen as a powerful and flexible approach for testing mode choice research hypotheses.

2.6 Conclusions

Several conclusions may be drawn from this review. First, disaggregate models of transportation behaviour are generally superior to aggregate models. Secondly, transportation behaviour models should employ both

conventional and psychological (attitudinal) variables. Thirdly, within attitudinal modelling, controlled simulation is superior to the revealed preference approach, but elements from both approaches should be included in any study of mode choice. Finally, the use of the functional measurement technique and experimental factorial designs is supported by the literature.

CHAPTER 3 : RESEARCH DESIGN

3.1 Research Hypotheses

This study addresses three main research hypotheses. Formally, the hypotheses are as follows:

H_1: Modal choice preference as derived from hypothetical mode choice situations is related to the relative weighting of travel cost and travel time.

H_2: Modal choice preference as derived from hypothetical mode choice situations is related to differences in socioeconomic, demographic, and transportation characteristics.

H_3: Responses to hypothetical mode choice situations are related to actual mode choice.

3.2 Questionnaire Design

A mail questionnaire was used to collect data. The questionnaire contained three parts (See Appendix for copy of questionnaire). Part A elicited ratings of hypothetical trade-offs between travel time and travel cost. Specifically, each respondent was asked to rate the relative likelihood of taking a car or bus when faced with trade-off situations based on time difference (the car is 0, 15 or 30 minutes faster than the bus per one-way trip) and cost difference (the car costs \$0, \$1.50 or \$3.00 more than the bus per day). Responses to each situation were recorded on a 9-point scale where 0 represented "certain to take car" and 9 represented "certain to take bus". This car-bus preference scale provided information about each respondent's degree of preference for car or bus.

In the instructions, respondents were told to assume they had both a car and a bus available for their work trip. The purpose of this instruction was to elicit a car-bus preference separate from availability constraints.

Part B of the questionnaire contained questions about the following: the importance of various factors associated with the work trip, actual mode choice and satisfaction, estimates of transportation costs, times and distances, automobile ownership and availability constraints.

Part C of the questionnaire pertained to socioeconomic and demographic information. This section included questions about age, sex, marital status, occupation, education and income.

The questionnaire contained data measured at the nominal, ordinal, interval and ratio levels of measurement. Each question in the questionnaire was classified according to the type of data contained in the question (See Table A5). The statistical tests used depended on the levels of measusrement of the relevant data.

3.3 The Sample

A sample representative of the general population would have consisted of a large number of people employed in various occupations and various parts of the urban area. Such a sample was not feasible due to the time and expense

involved in such an undertaking. What was needed was a large group of people who worked in an urban area and could be surveyed at their place of employment. Hence, a sample of McMaster University employees was chosen.

The original sample of 204 people was randomly chosen from the McMaster University Faculty and Staff Directory 1985-86 which lists employees alphabetically. The random sample ensured that there was variation within the sample with respect to occupation and socioeconomic status.

The questionnaire was mailed to the 204 employees in early November of 1986. The questionnaires were distributed and returned through the intra-university mail system.

Returned questionnaires totalled 125 which represents a 61.3 percent response rate. Some questionnaires were not useable because they were incomplete or had been filled out by people who walked to work. Once the unusable questionnaires had been deleted, the number of respondents was reduced to 103 which equates to 50.5 percent of the original sample.

Table A1 shows a breakdown of the original sample by gender and employment type (faculty or staff). Table A2 shows a breakdown of the 103 completed returns by gender and employment type. The data show a higher response rate among females and staff and a lower response rate for males and faculty.

As expected, the university sample was generally

affluent with elevated income and education levels. The elevated socioeconomic status of the respondents affects the generalizability of results with respect to the second hypothesis. This problem will be discussed in greater detail in the analysis and conclusion chapters.

CHAPTER 4: ANALYSIS

4.1 Introduction

The analysis is described in several sections. Section 4.2 presents descriptive statistics for the socioeconomic, demographic and transportation characteristics of the 103 respondents. Section 4.3 defines three modal choice bias groups and compares the three groups in terms of modal choice preference. In Section 4.4, analysis of variance is used to see if the three bias groups differ in their relative weighting of travel cost and time. Section 4.5 explores the relationships between modal choice preference and socioeconomic, demographic and situational characteristics. Finally, Section 4.6 relates the responses in the hypothetical task to actual mode choice using a regression model.

4.2 Descriptive Statistics

Descriptive statistics were calculated for the socioeconomic, demographic, and transportation characteristics of the 103 respondents. The sample is split between 40 percent male and 60 percent female (Table A2). The average age of the sample is 43.1 years (Table A3). The sample is well educated with the average attained education level being an undergraduate university degree and the mode being a Ph.D. The mean household income falls in the $45,000 to $50,000 range and 24 percent of the sample has

household incomes greater than $70,000. Clearly, the sample is atypical. Elevated income and education levels are expected of a university sample. There is still a good deal of variation in income and education as is evidenced by the frequency distributions for these variables (Table A3). Therefore, the influence of these variables on mode choice should not be entirely masked by the generally affluent nature of the sample.

Turning to transportation characteristics, almost 84 percent of the respondents were members of one or two car households and the average number of automobiles per household was 1.8 (Table A4). Almost one quarter of the respondents said they had no bus available for their work trip while 90 percent of the respondents had an automobile available for their work trip, again consistent with the generally affluent nature of the sample. The average estimated distance to work was 12.2 km.(7.5 miles). Ratings of the importance of several variables with respect to the work trip showed that convenience and travel time were most important, while comfort, travel cost, and privacy were less important.

4.3 Definition and Comparison of Bias Groups

The raw responses of each respondent for the trade-off questions in Part A of the questionnaire were subjected to cluster analysis. This is a technique which

groups respondents with similar responses on particular variables into homogeneous clusters or groups. Cluster analysis was used so that inferences about individual decision-making processes could be made. The clustering method used was Ward's method because "empirical tests have shown Ward's method to yield the least error in reproducing known groupings" (Meyer et al., 1977, p. 11). The cluster analysis was designed to produce three clusters. It produced one cluster consisting of 39 members, one with 47 members, and one with 17 members. An examination of the grand mean across all cells for each cluster (group) allows identification of the clusters in terms of modal choice preference. Group 1 (with 39 members) had a grand mean of 0.25. Group 2 (with 47 members) had a grand mean of 3.21. Group 3 (with 17 members) had a grand mean of 6.65. Recall that the rating responses were recorded on a 0 to 9 point scale where 0 represented "certain to take car" and 9 represented "certain to take bus". Therefore, Group 1 may be labelled a car-biased group, Group 2 an unbiased group, and Group 3 a bus-biased group.

A comparison of the mean rating response for each group leads to the following hypothesis: the three groups differ significantly in terms of modal choice preference. Since the rating responses can be considered interval data, this research hypothesis can be tested using a one-tailed

t-test. This test involves three pairwise comparisons of group means. Therefore, three one-tailed t-tests were conducted. The results for the three t-tests are summarized in Table 4.1. The mean for the car-biased group is significantly less than both the means for the unbiased group and the bus-biased group. Also, the mean for the unbiased group is significantly less than the mean for the bus-biased group. Therefore, the three groups differ significantly in terms of modal choice preference. The car-biased group has the greatest preference for the car, the unbiased group is less car-biased, and the bus-biased group has the least preference for the car.

4.4 Relative Importance of Cost and Time

Having determined that the three groups differ in terms of mode preference, group differences in the relative weighting of travel cost and travel time can be examined. The null hypothesis (H_0) states that modal choice preference is not related to the relative weighting of travel cost and time. The alternate hypothesis (H_1) states that modal choice preference is related to the relative weighting of travel cost and travel time. The appropriate statistical test for this research hypothesis is a two-way within subjects analysis of variance with time difference (nominal-3 categories) and cost difference (nominal-3 categories) as the independent variables and the rating

Table 4.1 GROUP DIFFERENCES IN MODE CHOICE PREFERENCE

Bias Group	# of Cases	Mean	F	2-tail Prob.	Pooled Variance Estimate T Value	Pooled Variance Estimate 2-tail Prob.	Separate Variance Estimate T Value	Separate Variance Estimate 2-tail Prob.
Car	39	.251						
			9.49	.000	-14.70	.000	-15.86	.000
Unbiased	47	3.206						
Car	39	.251						
			12.19	.000	-27.13	.000	-19.01	.000
Bus	17	6.647						
Unbiased	47	3.206						
			1.28	.495	-9.76	.000	-9.19	.000
Bus	17	6.647						

response (interval) as the dependent variable. A two-way analysis of variance was performed for each bias group and the results were subsequently compared across bias groups. Table 4.2 shows the design of the analysis of variance for the three bias groups with mean values for each cell. Plots of the mean values in each cell for each bias group are shown in Figures 1 through 3. The corresponding analyses of variance are shown in Table 4.3 which gives the F ratios and significance of F for each group.

Several ideas should be kept in mind when examining Figures 1-3. First, the slopes and separation of the lines show the relative weights assigned to cost and time by each bias group. For example, a line which is nearly horizontal shows that time difference had little or no effect on mode choice for that cost difference level. Lines which are far apart indicate that cost difference had a large effect on car-bus preference. Parallel lines indicate that cost and time combine in an additive fashion to determine preference. Conversely, if the lines converge at a certain point, this suggests that cost and time combine in a nonadditive fashion to determine car-bus preference.

Comparing Figures 1-3, the lines for the bus-biased group are the highest, indicating preference for the bus, while the lines for the car-biased group are the lowest, indicating preference for the car. For all three bias groups, preference for the car increased as time savings for

Table 4.2 MEAN PREFERENCE RATINGS[1] OF BIAS GROUPS

			Cost Difference		
			$0	$1.50	$3.00
Time Difference (min.)	0	Car-biased	.10	.18	.67
		Unbiased	1.98	5.13	6.79
		Bus-biased	8.12	7.53	8.88
	15	Car-biased	.08	.10	.49
		Unbiased	.94	2.87	5.17
		Bus-biased	6.59	7.06	8.12
	30	Car-biased	.21	.08	.36
		Unbiased	.45	1.81	3.72
		Bus-biased	3.59	3.82	6.12

[1] Recall: 0 = certain to take car
9 = certain to take bus

Table 4.3 EFFECTS OF TIME AND COST ON MODE CHOICE PREFERENCE

	Car-biased Group (N = 39)		Unbiased Group (N = 47)		Bus-biased Group (N = 17)	
Factor	F	Signif F	F	Signif F	F	Signif F
Time (T)	.899	.408	52.435*	.000	36.655*	.000
Cost (C)	13.385*	.000	124.684*	.000	8.475*	.000
T X C	1.000	.408	2.520*	.041	.844	.499

* p <.05

Figure 1 MEAN RATING RESPONSES OF CAR-BIASED GROUP

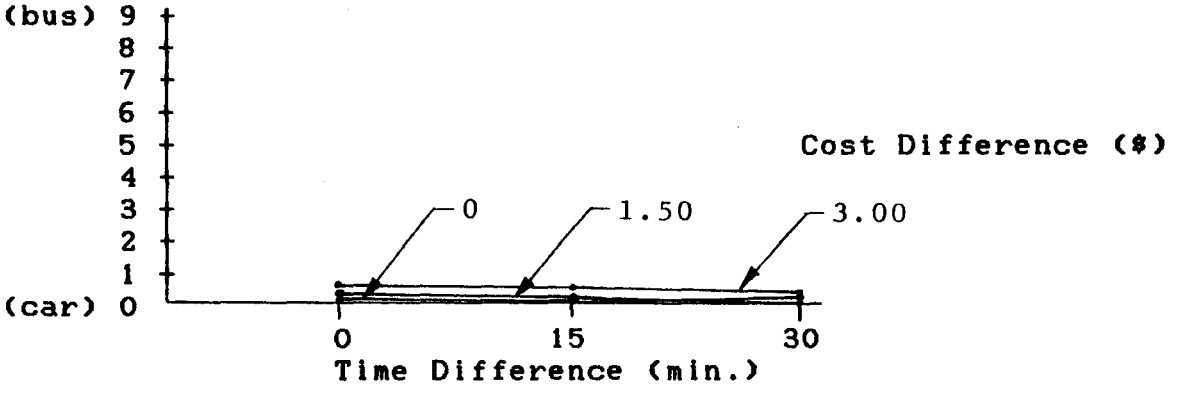


Figure 2 MEAN RATING RESPONSES OF UNBIASED GROUP

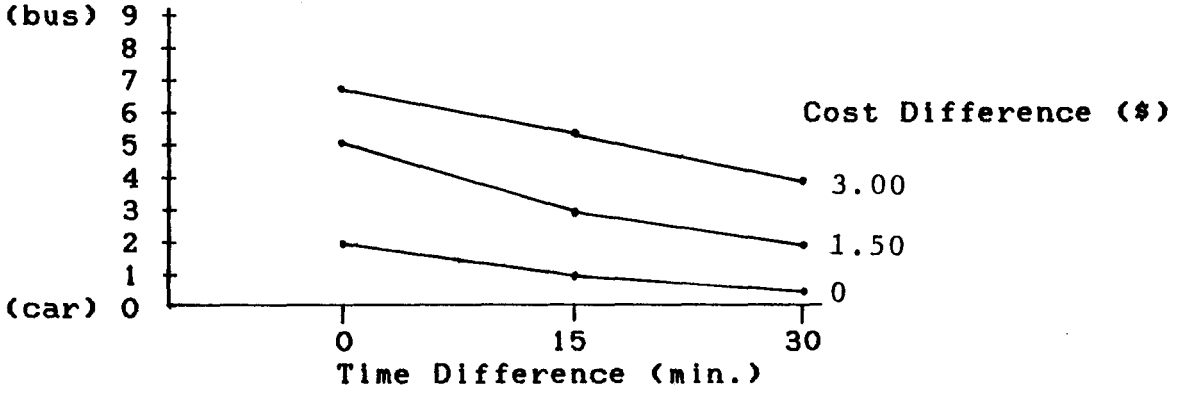
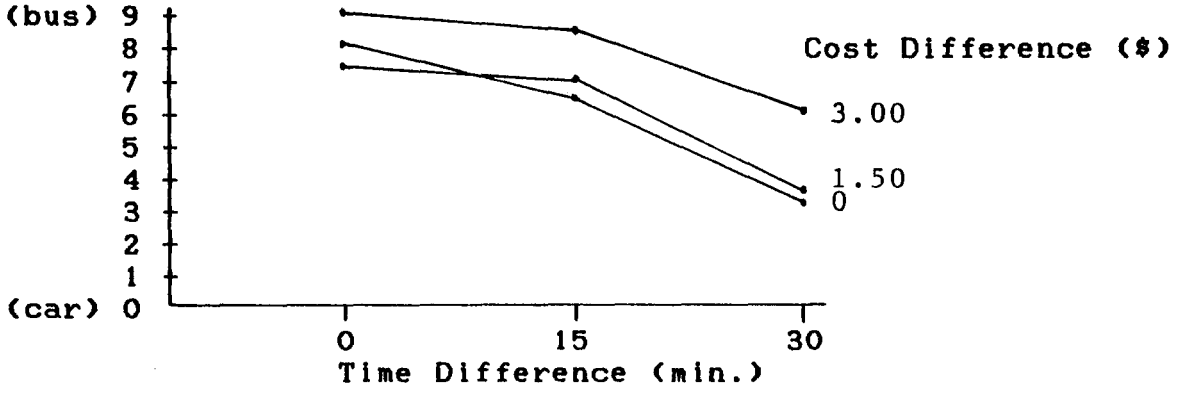


FIGURE 3 MEAN RATING RESPONSES OF BUS-BIASED GROUP



the car over the bus increased (i.e., the lines are negatively sloped) and preference for the car decreased as cost savings for the bus over the car increased (i.e., as cost difference increased, the lines became higher).

In Figure 1 (Car-Biased Group) the lines are clustered near the bottom of the preference scale, closely spaced, and nearly parallel. This result indicates that the car-biased group is so heavily biased toward the car that changes in cost and time have little effect on their choice of mode. The corresponding analysis of variance (See Table 4.3) does not exactly substantiate this result. Time had no effect on mode choice for the car-biased group but cost did have a significant effect.

In Figure 2 (Unbiased Group), the lines are considerably separated with a negative slope indicating that cost and time are important in the mode choice decision. The results of the analysis of variance for the unbiased group (See Table 4.3) substantiate this conclusion with both time and cost having a significant effect on mode choice.

In Figure 3, the lines are negatively sloped, particularly between 15 and 30 minutes, indicating the importance of time. The analysis of variance for the bus-biased group (See Table 4.3) shows that both cost and time had a significant effect on mode choice but that time is the relatively more important factor.

The car-biased and bus-biased groups showed no significant interaction effect indicating that for these two groups time and cost combined in an additive manner to determine mode choice. Additivity implies that the weight of a given factor (time or cost) is constant across levels of that factor. The unbiased group showed a significant interaction effect implying nonadditivity of time and cost. Nonadditivity means that the weight of a given factor varies across levels of that factor. The interaction effect for the unbiased group was only marginally significant at the .05 level and may be a result of the larger sample size for the unbiased group rather than the existence of a significant interaction effect.

Comparing the analysis of variance results for the three groups (See Table 4.3), it becomes apparent that the groups differ considerably in their relative weighting of travel cost and travel time. It might seem counterintuitive that the group which prefers the time-saving mode (car) would place greater importance on cost factors. However, this result indicates the car-biased group has a preference for the car but the degree of preference for the car is influenced by the amount of additional cost involved in driving the car. It would also seem counterintuitive to infer that the bus-biased group (cost-saving mode) places the greatest importance on time factors. Using the same

reasoning, the bus-biased group has a preference for the bus but the degree of preference for the bus is influenced by the additional time involved in taking the bus. The unbiased group is significantly influenced by both cost and time but is more heavily influenced by cost and is therefore more similar to the car-biased group than the bus-biased group.

4.5 Socioeconomic, Demographic, and Transportation Characteristics

The second research hypothesis states that modal choice preference as defined by the cluster groups is related to differences in socioeconomic, demographic, and situational transportation characteristics. This hypothesis is formally tested by comparing group differences on relevant questionnaire items using analysis of variance or chi-square tests depending on the level of measurement of the questionnaire item.

The demographic characteristics included were age and sex. Socioeconomic variables included were education and income. The constraint variables compared were estimated distance to work, car availability, and bus availability. Satisfaction with current mode and the importance ratings from Part B Question 1 of the questionnaire were also compared. Finally, actual mode choice was compared across the groups using usual mode of

travel to work (USUAL), frequency of car use (DRIVECAR), and frequency of bus use (BUS).

Table 4.4 contains the analysis of variance and chi-square results for the above variables. The only significant variable for the chi-square tests was USUAL. But, three of six cells have an expected frequency less than 5. This violates one of the major assumptions of the chi-square test and hence the significant result must be ignored. From Table 4.4, the only variables for which there were significant differences between the bias groups were DRIVECAR, BUS, and Travel Cost. DRIVECAR and BUS are measures of actual mode choice while Travel Cost is an importance rating. Hence, the null hypothesis that modal choice preference is not related to differences in socioeconomic, demographic, and transportation characteristics cannot be rejected.

Table 4.4 shows that bus-biased respondents rate the importance of travel cost much higher than car-biased respondents. This result seems opposite to the result from testing hypothesis one where the bus-biased respondents showed a more significant time effect. But, the importance ratings were made in the abstract while the rating responses involved trade-offs of specified levels of time and cost. The explanation of these seemingly conflicting results is that bus-biased respondents choose bus over car because of

Table 4.4 COMPARISON OF BIAS GROUPS ON SOCIO-DEMOGRAPHIC AND TRANSPORTATION VARIABLES

ITEM	Car-biased Group Mean	Unbiased Group Mean	Bus-Biased Group Mean	F	ANOVA Sig. F
Age	40.50	44.11	46.19	2.00	.141
Education	4.03	4.15	3.69	.50	.605
Income	10.55	9.86	8.88	1.48	.232
Estimated Home to Work Distance (km)	13.13	11.13	13.33	.35	.707
DRIVECAR (Trips as driver of car out of 40)	35.95	28.26	23.00	4.96*	.009
BUS (Trips by bus out of 40)	.10	5.62	10.65	6.86*	.002
Importance Ratings					
Travel Time	6.67	7.42	6.88	.84	.435
Travel Cost	4.00	5.54	6.35	6.26*	.003
Comfort	6.23	5.28	5.76	1.27	.285
Convenience	7.33	7.57	6.41	1.16	.319
Privacy	5.03	3.41	3.59	2.87	.062
Satisfaction with Current Mode	7.64	8.13	6.88	2.43	.093
	Percent	Percent	Percent		
Percent Male	35.9	45.7	35.3		
Car as Usual Mode*	100.0	89.4	75.0		
Bus Available for Work Trip	76.9	78.7	64.7		
Car Available for Work Trip	97.4	87.2	82.4		

*Significant at the .05 significance level.

cost savings but the degree of preference for the bus depends on changes in time factors. This same type of logic may be applied to car-biased respondents.

It may seem surprising that attitudes toward mode choice preference are weakly related to socioeconomic, demographic, and transportation constraint characteristics but several studies have arrived at this result (Meyer et al, 1977; Stopher, 1977; Tardiff, 1975). The sample is admittedly biased in terms of socioeconomic status. Therefore, conclusions with respect to socioeconomic status and its relationship to mode choice can extend only to the sample. Also, the fact that DRIVECAR and BUS differed significantly across the bias groups provides support for the notion that mode choice rating responses correspond to actual mode choice. This hypothesis is more formally tested in the next section.

4.6 Prediction of Actual Mode Choice

The third research hypothesis states that rating responses to hypothetical mode choice situations can be used to predict actual mode choice. This hypothesis is tested by developing a multiple linear regression model which predicts mode choice as a function of each respondent's mean response over all cells in the experimental trade-off task, perceived time and cost variables, and a bus availability constraint.

Four regression models were tested. In all cases

the dependent variable was mode choice which was measured as the proportion of work trips by bus during the month prior to receiving the questionnaire (See Part B Question 4 of the questionnaire).

The regression models tested are shown below:

Model 1

$$PropB=b_0+b_1MEAN + b_2TIME + b_3COST + b_4AVAIL$$

Model 2

$$PropB=b_0+b_1MEAN + b_2TIME + b_3COST + b_4 AVAIL + b_5 AGE + b_6 INCOME$$

Model 3

$$PropB=[b_0+b_1MEAN + b_2TIME + b_3 COST](AVAIL)$$

Model 4

$$PropB= [b_0+ b_1 MEAN + b_2 TIME + b_3 COST + b_4 AGE + b_5 INCOME](AVAIL)$$

where

PropB = proportion of trips by bus ($0 \leq PropB \leq 1$)

MEAN = mean response to trade-off task (0 to 9 scale)

TIME = estimate of actual bus-car time difference.

$$COST = \begin{cases} 1 \text{ if car rated cheaper than bus} \\ 0 \text{ otherwise} \end{cases} \quad \text{dummy variable}$$

$$AVAIL = \begin{cases} 0 \text{ if no bus available} \\ 1 \text{ otherwise} \end{cases}$$

AGE = age of respondent

INCOME = household income level of respondent (14 levels).

Notice that in models 1 and 2 bus availability is used as a dummy variable while in models 3 and 4 it is entered as a multiplier. Logically, it makes more sense to enter bus availability as a multiplier because if there is no bus available (AVAIL=0) then PropB must equal zero. Models 3 and 4 ensure that PropB equals zero when AVAIL equals zero while models 1 and 2 do not ensure this result. Therefore, models 3 and 4 are expected to have a higher predictive

ability than their counterparts, models 1 and 2. Also, models 2 and 4 include age and income as explanatory variables to determine the effect of these variables on mode choice. The results of the regression analysis appear in Table 4.5.

Notice that all four regression models are significant at the α = .001 level. Therefore, for all the models, at least one of the explanatory variables has a significant effect on proportion of trips by bus (mode choice).

Mean response to the trade-off task has the strongest significant effect on mode choice in all four models. Proportion of trips by bus (PropB) is positively related to mean response. Although bus availability is not a significant explanatory variable when used as a dummy variable (models 1 and 2), the inclusion of bus availability as a multiplier raises the R-square considerably in models 3 and 4. This result justifies the theoretical basis of models 3 and 4 outlined earlier. Bus availability is a significant explanatory variable when used as a multiplier. Time had a significant negative effect on PropB in models 3 and 4 where availability was used as a multiplier. Surprisingly, cost was not a significant factor in any of the regression models. If cost had been an estimate of car-bus cost difference rather than a dummy variable, then

Table 4.5 REGRESSION ANALYSIS RESULTS

Model 1

Variable	B	Sig T	F	Signif F	R Square
MEAN	.052	.000*	8.181	.000*	.2780
TIME	-.001	.359			
COST	-.021	.800			
AVAIL	.124	.100			
(Constant)	-.086	.393			

Model 2

Variable	B	Sig T	F	Signif F	R Square
MEAN	.059	.000*	8.481	.000*	.3948
TIME	-.001	.344			
COST	-.059	.497			
AVAIL	.083	.247			
AGE	-.009	.000*			
INCOME	.003	.663			
(Constant)	.294	.072			

Model 3

Variable	B	Sig T	F	Signif F	R Square
MEAN	.074	.000*	20.712	.000*	.4005
TIME	-.004	.008*			
COST	-.082	.346			
(Constant)	.036	.313			

Model 4

Variable	B	Sig T	F	Signif F	R Square
MEAN	.074	.000*	14.535	.000*	.4580
TIME	-.003	.018*			
COST	-.127	.165			
AGE	-.006	.006*			
INCOME	.001	.887			
(Constant)	.270	.021*			

* Significant at the .001 significance level.

the significance of cost may have been different.

The inclusion of age and income in models 2 and 4 revealed that age had a significant negative effect on PropB while income had no effect on PropB. The percentage of variation in the dependent variable (mode choice) explained by the independent variables ranged from 27.8% (Model 1) to 45.8% (Model 4). While this level of prediction may be considered low, the models identify the degree of importance of the explanatory variables.

The results of the regression analysis imply that rating responses to hypothetical mode choice situations can be used to predict actual mode choice. In fact, of the variables included in the regression, mean response to the trade-off task (MEAN) explained the greatest proportion of variation in mode choice. Surprisingly, income and cost did not have a significant effect on mode choice.

CHAPTER 5 : CONCLUSIONS

5.1 Summary

In summary, the analysis and results lead to the following conclusions. The first research hypothesis was confirmed. Modal choice preference is related to the relative weighting of travel cost and travel time. Specifically, for car-biased respondents, cost was relatively more important than time. Therefore, the degree of preference for the car was influenced by changes in the cost difference between car and bus. For the unbiased group, changes in both cost and time influenced mode choice but cost was relatively more important than time. Therefore, the unbiased group was more like the car-biased group. For bus-biased respondents, time was relatively more important than cost. Therefore, the degree of preference for the bus was influenced by changes in the time difference between car and bus.

The second research hypothesis was not confirmed. Modal choice preference was not related to differences in socioeconomic, demographic, and transportation characteristics. This result, although surprising, is consistent with several other studies. But, this result cannot be generalized to populations other than the sample used here due to the atypical socioeconomic composition of the sample.

Finally, the third research hypothesis was confirmed. Rating responses to hypothetical mode choice trade-off situations are related to actual mode choice.

The results of this study can be compared to the results reported by Meyer et al. (1977) because the research conducted here replicates their research design and methods of analysis. There are differences between the two studies with respect to overall car bias and the predictive ability of the mode choice models. But, Meyer et al. arrive at the same conclusions with respect to the research hypotheses and consequently this study reinforces the earlier results.

The research conducted here provides support for the attitudinal modelling of mode choice. The results show that the controlled simulation paradigm and the use of the functional measurement technique allow the researcher to estimate the relative importance of traveller perceptions of mode choice attributes and to examine the trade-off relationships between competing variables. The functional measurement technique can provide a great deal of information about the decision-making processes underlying mode choice. Hence, this study provides support for the general paradigm which attempts to understand human travel behaviour through the use of controlled laboratory simulation and real-world verification (Meyer et al., 1977, p. 31).

5.2 Limitations

This section discusses the limitations of this study. While these limitations do not adversely affect the results of the study, they should be noted to improve future research efforts.

First, some questions were omitted from the questionnaire for the sake of simplicity or brevity. For example, an open-ended question concerning actual constraints on mode choice was not included for two reasons: brevity and the inherent difficulty in analyzing responses. The inclusion of this type of question may have provided more information with respect to individual constraints on actual mode choice.

The variables included in the regression analysis did not offer as strong an explanation of mode choice as expected. Meyer et al. found their model explained 78% of the variation in mode choice while the model developed in this study, with the same independent variables, explained only 40% of the variation. Yet, the relative effect of the independent variables on mode choice is very similar in the two studies.

Finally, the socioeconomic bias of the sample limits the generalizability of the results for the second hypothesis to the sample population itself. The suspicion is that if the sample demonstrated a larger socioeconomic

variation then socioeconomic and transportation constraints may have had a significant effect on mode choice.

5.3 Further Research

This study has shown a link between individual differences in the weighting of cost and time factors and mode choice. The question remains whether these individual differences in decision-making processes are not a result of individual differences in socioeconomic and transportation characteristics, i.e., do socioeconomic and other characteristics exert their influence through individual decision-making processes? Therefore, the relationship between socioeconomic characteristics and the mode choice decision process requires further research and clarification. The fact that this study is based on a relatively homogeneous socioeconomic group suggests that variations in decision-making are to some degree independent of these other factors.

Many aspects of mode choice and travel behaviour are still not well understood. For example, there has been little research into mode choice and the transportation requirements of certain special populations, e.g., service dependent populations, central business district workers, and students. Also, suburbanization and a shorter work week are increasing the importance of non-work travel in our society. Hence, non-work travel such as recreation and

leisure trips should receive greater emphasis in future transportation research.

Future research should concentrate on the refinement of behaviourial models. It is suggested that these models may be applied to the planning of transportation systems and technologies. For example, behaviourial models may be used to predict the demand for different transportation modes or to predict responses to changes in transportation systems. By better understanding mode choice and all aspects of travel behaviour, we can develop better theories of travel behaviour and we can better plan future transportation systems and technologies.

A P P E N D I X

McMASTER UNIVERSITY
Department of Geography
1280 Main Street West, Hamilton, Ontario, L8S 4K1
Telephone: 525-9140 Ext. 4535

November 3, 1986.

Dear Sir/Madam:

Most people working in urban areas make important decisions with respect to transportation each and every day. For example, each of us must decide which means of transportation we will use to go to and from work. I am presently doing an honours research project which studies how different people make this decision.

My name is Luciano Piccioni and I am a fourth year student in the Department of Geography. I have prepared a questionnaire which I hope you will complete and send back to me as soon as possible. Please be sure to answer <u>every</u> question.

Once you have completed the questionnaire, please fold the questionnaire and seal it in the <u>white</u> self-addressed envelope provided. Then, simply drop the white envelope in the campus mail.

Thank you for your co-operation. I assure you that all answers will be held in strictest confidence.

Yours truly,

Luciano Piccioni

Luciano Piccioni.

LP/cm

Transportation Behaviour Survey

Part A

In this part of the survey you will be asked to indicate your preference for car or bus in response to various hypothetical situations.

INSTRUCTIONS: ASSUME both a car and a bus are available for your work trip.

READ each statement below and circle a response between 0 and 9 which reflects your preference where

0 represents "certain to take car" and
9 represents "certain to take bus"

An example appears below.

EXAMPLE

The car costs $1.50 more than bus (per day or round trip)
AND
the car is 30 min. faster than bus (per one-way trip)

certain to take car — certain to take bus

0 1 2 3 4 5 6 (7) 8 9

In this situation, this person prefers the bus over the car

Response

1. The car and bus cost the same
AND
the car and bus take same amount of time

car — bus

0 1 2 3 4 5 6 7 8 9

2. The car and bus cost the same
AND
the car is 15 min. faster than bus

car — bus

0 1 2 3 4 5 6 7 8 9

3. The car and bus cost the same
AND
the car is 30 min. faster than bus

car — bus

0 1 2 3 4 5 6 7 8 9

4. The car costs $1.50 more than bus AND the car and bus take same amount of time

car 0 1 2 3 4 5 6 7 8 9 bus

5. The car costs $1.50 more than bus AND the car is 15 min. faster than bus

car 0 1 2 3 4 5 6 7 8 9 bus

6. The car costs $1.50 more than bus AND the car is 30 min. faster than bus

car 0 1 2 3 4 5 6 7 8 9 bus

7. The car costs $3.00 more than bus AND the car and bus take same amount of time

car 0 1 2 3 4 5 6 7 8 9 bus

8. The car costs $3.00 more than bus AND the car is 15 min. faster than bus

car 0 1 2 3 4 5 6 7 8 9 bus

9. The car costs $3.00 more than bus AND the car is 30 min. faster than bus

car 0 1 2 3 4 5 6 7 8 9 bus

Part B

Please answer the following questions to help us learn more about your travel habits and your travel circumstances. Remember that all questions apply only to your work trip (that is trips to and from your place of employment.)

1. Please rate on a scale of 0 to 9 how important you consider the following factors to be for your work trip.

   0 = very unimportant
   9 = very important

Factor	Response (0 to 9)
Travel Time	___
Travel Cost	___
Comfort	___
Convenience	___
Privacy	___

2. Which mode of travel did you use to go to work today? (Check one)

   [ ] Driver of car
   [ ] Rider in a car
   [ ] Bus
   [ ] Other (Please Specify)_____

3. Indicate which mode of travel you usually use to go to work. (Check one)

   [ ] Driver of car
   [ ] Rider in a car
   [ ] Bus
   [ ] Other (Please Specify)_____

4. There are about 20 working days per month which translate into 40 work trips. Thinking back over the last month, how many times out of 40 did you use the means of travel listed below?

   ___ Driver of car
   ___ Rider in a car
   ___ Bus
   ___ Walking
   ___ Bicycle
   ___ Motorcycle

   Note: Total should equal 40

5. On a scale of 0 to 9, rate your satisfaction with your present mode of travel to work whether it be car or bus.

   0 = totally dissatisfied
   9 = totally satisfied

   Rating (0 to 9): ___

6a. Which city or town do you live in?_____

6b. What is the nearest street intersection to your home?
   _____

6c. What do you estimate to be the distance from your residence to your place of employment? ___ kilometers.

7. Answer questions 7a and 7b only if you normally use an automobile to go to work.

7a. How long does it take you to get to work by car? (include parking time and walking time.) ___ minutes; ___ don't know

7b. How long do you estimate it would take you to get to work by bus? (include waiting time for a bus, walking time, and transfer time.) ___ minutes; ___ don't know

8. Answer questions 8a and 8b only if you normally take a bus to work.

8a. How long does it take you to get to work by bus? (include waiting time for a bus, walking time, and transfer time.) ___ minutes; ___ don't know

8b. How long do you estimate it would take you to get to work by car? (include parking time and walking time.) ___ minutes; ___ don't know

9. Do you have a bus available to you for your work trip? (i.e. Is there a bus service from near your home to near your place of employment?) (Check one)

[ ] Yes [ ] No

10. How far from your residence is the nearest bus stop where you could board the bus to get to work? ___ blocks; or ___ kilometers; ___ don't know

11. Do you normally have an automobile available to you for your work trip? (Check one)
[ ] Yes [ ] No

12. How many autos, vans, pickups or other motor vehicles are there in your household? (Check one)

[ ]0 [ ]1 [ ]2 [ ]3 [ ]4 [ ]5

13. How many licensed drivers reside in your household? ___

14. Check the statement below which best reflects your opinion:

[ ] I think the car is more expensive than the bus per day.

[ ] I think the bus is more expensive than the car per day.

[ ] I think there is no difference in cost per day between a car and a bus.

Part C

Finally, in this section, we would like to know a little more about your background so that we can see how different types of people use different means of transportation.

15. Indicate whether you are male or female. (Check one)

[ ] Male [ ] Female

16. Please indicate your age as of your last birthday.____

17. Marital status. (Check one)

[ ] Single [ ] Married [ ] Separated [ ] Divorced [ ] Widowed

18. Please check one of the following categories which best describes your highest current education level.

___ completed elementary school (grades 1 - 8)
___ completed high school (grades 9 - 12)
___ completed a college diploma (2 or 3 years)
___ completed an undergraduate university degree (3 or 4 years)
___ completed a Master's degree or its equivalent (2 or 3 years post-graduate training)
___ completed a Ph.D. or its equivalent

19. In order to ensure that our sample is complete, we need an estimate of your annual gross household income. All information will be held in strictest confidence.

19a. Gross household income - the <u>total</u> income your <u>household</u> expects to earn from all sources this year. Please check the appropriate category below:

[ ] under $10,000	[ ] $30,000-$35,000	[ ] $55,000-$60,000
[ ] $10,000-$15,000	[ ] $35,000-$40,000	[ ] $60,000-$65,000
[ ] $15,000-$20,000	[ ] $40,000-$45,000	[ ] $65,000-$70,000
[ ] $20,000-$25,000	[ ] $45,000-$50,000	[ ] $70,000 +
[ ] $25,000-$30,000	[ ] $50,000-$55,000	

20. Please indicate your job title at McMaster._____

Table A1 BREAKDOWN OF ORIGINAL SAMPLE BY GENDER AND EMPLOYMENT TYPE

EMPLOYMENT TYPE	GENDER					
	Male		Female		Total	
	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
Faculty	77	37.7	12	5.9	89	43.6
Staff	34	16.7	81	39.7	115	56.4
Total	111	54.4	93	45.6	204	100.0

Table A2 BREAKDOWN OF RESPONDENTS BY GENDER AND EMPLOYMENT TYPE

EMPLOYMENT TYPE	GENDER					
	Male		Female		Total	
	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
Faculty	28	27.1	5	4.9	33	32.0
Staff	12	12.6	56	54.4	69	67.0
Total	41	39.7	61	59.3	102	100.0

VALID CASES 102 MISSING CASES 1

Table A3 SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

ITEM

Age Mean Age = 43.1 years

Education (Categories 1 to 6)
Mode = 6.00 (Ph.D)
Median = 4.00
Mean = 4.00 (Undergraduate University Degree)

FREQUENCY DISTRIBUTION OF EDUCATION

VALUE	CATEGORY	FREQ	PERCENT	VALID PERCENT	CUM PERCENT
Elementary School	1	1	1.0	1.0	1.0
High School	2	24	23.3	23.8	24.8
College Diploma	3	18	17.5	17.8	42.6
Undergrad Degree	4	14	13.6	13.9	56.5
Master's Degree	5	16	15.5	15.8	72.3
Ph.D.	6	28	27.2	27.7	100.0
MISSING VALUES	9	2	1.9	MISSING	
TOTAL		103	100.0	100.0	

Income (Categories 1 to 14)

Mode = 14.00 ($70,000+)
Median = 10.00 ($50,000-$55,000)
Mean = 9.97 ($45,000-$50,000)

FREQUENCY DISTRIBUTION OF INCOME

VALUE	CATEGORY	FREQ	PERCENT	VALID PERCENT	CUM PERCENT
$15,000-$20,000	3	1	1.0	1.0	1.0
$20,000-$25,000	4	6	5.8	6.2	7.2
$25,000-$30,000	5	6	5.8	6.2	13.4
$30,000-$35,000	6	4	3.9	4.1	17.5
$35,000-$40,000	7	7	6.8	7.2	24.7
$40,000-$45,000	8	11	10.7	11.3	36.1
$45,000-$50,000	9	9	8.7	9.3	45.4
$50,000-$55,000	10	5	4.9	5.2	50.5
$55,000-$60,000	11	9	8.7	9.3	59.8
$60,000-$65,000	12	13	12.6	13.4	73.2
$65,000-$70,000	13	1	1.0	1.0	74.2
$70,000+	14	25	24.3	25.8	100.0
MISSING	99	6	5.8	MISSING	
TOTAL		103	100.0	100.0	

Table A4 TRANSPORTATION CHARACTERISTICS OF RESPONDENTS

ITEM

Automobiles per household

Mean = 1.80
Mode = 2.00

Bus Availability (0 = No Bus Available; 1 = Bus Available)

	FREQUENCY	RELATIVE FREQ(PCT)
No Bus Available	25	24.3
Bus Available	78	75.7
TOTAL	103	100.0

Automobile Availability (0 = No Car Available; 1 = Car Available)

	FREQUENCY	RELATIVE FREQ(PCT)
No Car Available	10	9.7
Car Available	93	90.3
TOTAL	103	100.0

Estimated Distance to Work

Minimum = 1 km.
Maximum = 70 km.
Mean = 12.2 km.

Importance Ratings 0 = very unimportant
9 = very important

Respondents were asked to rate the importance of the following factors with respect to their work trip on a 0 to 9 scale.

	MEAN	STANDARD DEVIATION
Travel Time	7.0	2.8
Travel Cost	5.1	2.7
Comfort	5.7	2.7
Convenience	7.3	2.7
Privacy	4.1	3.3

Table A5 CLASSIFICATION OF QUESTIONNAIRE DATA

Nature of Questions	Question Number	ABBREV.	Type of Data
Part A			
Rating Responses to trade-offs	Q1 to Q9	SIT1 to SIT9	Interval
Part B			
Importance Ratings for 5 Factors: Travel Time Travel Cost Comfort Convenience Privacy	Q1	IMP1 to IMP5	Interval
Mode Used Today	Q2	TODAY	Nominal
Usual Mode	Q3	USUAL	Nominal
Trips per Mode	Q4	DRIVECAR	Ratio
		RIDECAR	Ratio
		BUS	Ratio
Satisfaction with Current Mode	Q5	SATISRAT	Interval
City of Residence	Q6a	CITY	Nominal
Nearest Street Intersection	Q6b	INTER	Nominal
Estimated Distance to Work	Q6c	ESTDIST	Ratio
Estimated Car Time	Q7a	CARTIME	Ratio
Estimated Bus Time	Q7b	BUSTIME	Ratio
Estimated Car Time	Q8a	CARTIME	Ratio
Estimated Bus Time	Q8b	BUSTIME	Ratio
Bus Availability	Q9	BUSAVAIL	Nominal
Bus Stop distance	Q10	BUSDIST	Ratio
Auto Availability	Q11	CARAVAIL	Nominal
Vehicles Per Household	Q12	CARS	Ratio

Table A5 (Continued)

	Nature of Questions	Question Number	ABBREV.	Type of Data
	Licensed Drivers	Q13	DRIVERS	Ratio
	Cost Estimate	Q14	COSTEST	Ordinal
Part C				
	Gender	Q15	SEX	Nominal
	Age	Q16	AGE	Ratio
	Marital Status	Q17	MARITAL	Nominal
	Education (6 levels)	Q18	EDUCAT	Interval
	Income (14 levels)	Q19a	INCOME	Interval
	Job Title	Q20	JOBTITLE	Nominal

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