

TRANSPORTATION CENTER

CONSUMER ORIENTED TRANSPORTATION
SERVICE PLANNING
CONSUMER ANALYSIS AND STRATEGIES

FINAL REPORT

RESEARCH
REPORT

NORTHWESTERN UNIVERSITY

EVANSTON • ILLINOIS

CONSUMER ORIENTED TRANSPORTATION
SERVICE PLANNING
CONSUMER ANALYSIS AND STRATEGIES

FINAL REPORT

REPORT 1 OF A SERIES

BY

THE CONSUMER ORIENTED TRANSPORTATION
SERVICE PLANNING GROUP

THE TRANSPORTATION CENTER
NORTHWESTERN UNIVERSITY

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CONSUMER-ORIENTED TRANSPORTATION SERVICE GROUP

The COTS group is an interdisciplinary research team associated with the Transportation Center at Northwestern University. Its goals are the advancement and application of consumer behavior, market research, and transportation demand analysis to provide transportation managers, regulators, and planners with techniques to understand and predict consumer response to transportation strategies.

The COTS group consists of faculty associates and graduate assistants involved in a series of funded and unfunded research investigating consumer response to transportation and communications strategies. Although the administrative structure varies by project, research responsibility is shared jointly by the faculty associates. The administrative structure for this project is Frank S. Koppelman and Alice M. Tybout, joint principal investigators, and John R. Hauser, faculty associate.

ACKNOWLEDGEMENTS

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Supplemental support and cooperation was provided by the City of Evanston under the direction of Edward A. Martin, City Manager, and Dennis Dawson, Assistant to the City Manager.

REPORT SERIES

This is Report 1 in the series Consumer Oriented Transportation Service Planning which describes the development of models of consumer response to local transportation services. The reports in the series are:

1. Consumer Oriented Transportation Service Planning: Consumer Analysis and Strategies - Final Report
2. Consumer Views of Transportation Service in Evanston: A Report Based on Focus Group Interviews
3. The Development and Implementation of A Questionnaire to Determine Consumer Wants and Needs
4. Preliminary Analysis of Perceptions, Preferences, Beliefs, and Usage of Transportation Services for Travel to Downtown Evanston
5. Models of Consumer Travel Behavior: Technical Report

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EXECUTIVE SUMMARY

Drawing on state-of-the-art methods in consumer behavior, market research, and transportation demand analysis, this report develops and implements a practical methodology to help managers design transportation service strategies that respond to consumer needs and desires.

The approach identifies how consumers process information to form perceptions of transportation service; provides explicit measures of consumer perceptions of existing and potential transportation alternatives; identifies and measures consumer feelings such as biases toward specific modes, personal expectations, and perceptions of societal norms; measures the relative importances of the perceptions and feelings on mode preference; and provides an understanding and measurement of situational constraints, such as availability, which combine with preference to influence choice of transportation mode. This diagnostic information helps analysts and planners understand consumer response and identify the most effective strategies to influence consumer behavior by directly affecting consumer perceptions, feelings, preferences, and situational constraints. A sequence of analytic models forecast how the strategies can be refined and evaluated relative to cost, institutional feasibility, and consistency with managerial goals.

Context

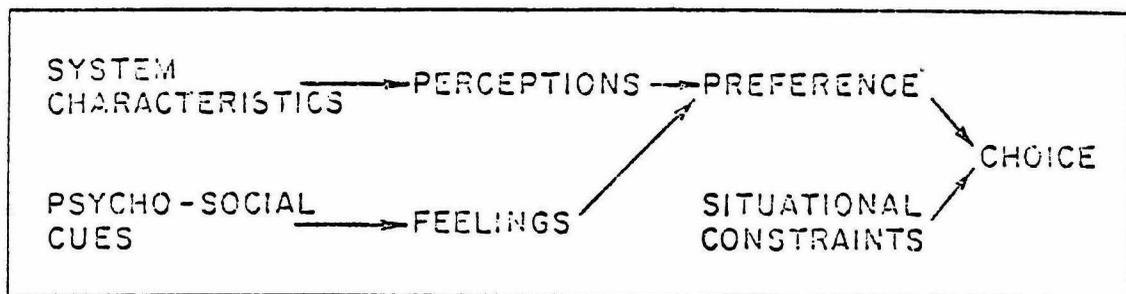
The methodology is implemented in Evanston, Illinois, a community of 80,000 people on Lake Michigan directly north of Chicago. The public transportation system includes: a rapid transit system, access to a commuter railroad, extensive local bus service, and bus service to neighboring suburbs.

Data

The analysis is based on responses to three 16-24 page questionnaires mailed to a total of 4,700 randomly selected households within Evanston (a 41% response rate was obtained). Demographic checks indicated that respondents are generally representative of the Evanston population. The questionnaires are specifically designed to provide the attitudinal, behavioral, and factual information necessary to analyze consumer response to transportation system modifications. The questionnaires were developed based on qualitative research (group interviews) and three rounds of pretest and pre-analysis. The three questionnaires dealt with nonwork/nonschool trips to downtown Evanston, work/school trips, and other trips within Evanston. The majority of the analysis is based on the questionnaires dealing with trips to downtown Evanston. Companion reports in this series describe the qualitative research, questionnaire design, and analysis.

Model

The consumer model is based on current theories of information processing that suggest that behavior (e.g., choice of transportation mode) is based on



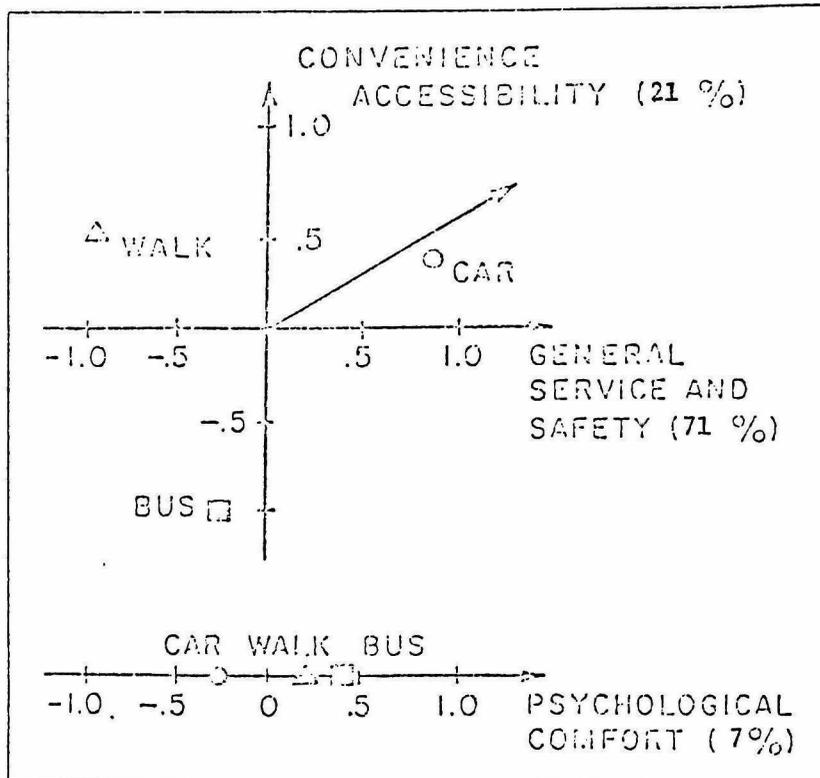
both what consumers prefer and on situational constraints which cause them to modify their preferred behavior. Furthermore, preference is based on how consumers perceive the world (which may vary by consumer and may not be totally

objective) and their feelings. These in turn are influenced by both system changes (e.g., increased bus frequency) and psycho-social changes (e.g., cultural, peer, and media influences). Thus, to better understand the consumer and to be responsive to a full range of strategies, the methodology directly measures perceptions, feelings, preference, and situational constraints and models their linkages to choice.

Diagnostics

Perceptions were measured on 25 psychological scales. Analysis revealed that consumers evaluated trips to downtown Evanston with respect to three basic perceptual dimensions: general service and safety (on time, quick, little effort, not tiring, safe at night, etc.), convenience and accessibility (come and go as I wish, available when needed, no long waits, etc.), and psychological comfort (not annoyed or made uncomfortable by others, no worry of injury). Average consumer perceptions of the three basic modes are shown below as well as an indication of the "ideal" direction of change (arrow). Relative importances of these perceptions in mode preference are shown in parenthesis beside the dimensions. The importance of these perceptions combined is approximately equal to the importance of mode feelings. Auto availability acts as a situational constraint influencing choice. No segmentation of consumers is significantly different with respect to their relative preferences, but the effect of auto availability varies by consumer group.

Based on this analysis, it is clear that if bus ridership is to be improved, strategies must be designed to improve consumer perceptions of general service/safety and convenience/accessibility -- perhaps in the direction of the arrow -- or increase the importance of mental comfort (since bus is well perceived along that dimension). Alternatively, and subject to practical and political considerations, the city can impose barriers to decrease auto availability.



Strategy Identification

Detailed analysis examines the specific attributes which make up the perceptual scales to determine how well the modes are perceived along each attribute and whether these perceptions accurately represent objective reality. For example, one specific analysis determined that the bus does run "on time" but is not perceived as such. Thus consumer perceptions of general service/safety may be improved with a relatively low cost information campaign to inform them of the good "on time" performance and educate them about the bus schedule. Other analyses determined that consumers' perceptions of "quick" were accurate and that improvements would require increasing the frequency of bus service -- a higher cost strategy. A total of 11 strategies for increasing transit ridership are identified.

Forecasts

To select a strategy, the City of Evanston must have forecasts of the expected changes in ridership which will result from implementation of a given strategy. Using a method called decision calculus, the analysis models are tempered with managerial judgment to quantify the impacts of the strategies. For example, the low cost information campaign is forecast to increase ridership anywhere from 0.3 to 7.6% while the higher cost frequency change would increase ridership 2.8 to 19.3%. All 11 strategies are evaluated. Additional strategies can be readily evaluated using models developed during this research.

Strategy Selection

The city government, with advice from the COTS Group, evaluated a series of short-term and long-term strategies by weighing the consumer travel response against cost, city goals, and feasibility of implementation. An information strategy combined with informative bus stop signs was selected tentatively for implementation and evaluation in the second year of funding. This particular strategy can be feasibly evaluated within the time period. Future research may evaluate longer term strategies as they are implemented by the city.

Strategy Evaluation

The first year research developed and implemented the consumer analysis, but before this type of analysis can be widely used, its accuracy must be evaluated. Thus the second year of funding will monitor the implementation of the identified strategy to determine if consumers respond as forecast. To accomplish this task, we are undertaking a series of behavioral analyses including interrupted time series analysis, before/after ridership counts, and consumer panels. These techniques and their use for evaluation are briefly reviewed in this report.

Summary

This report describes the development and implementation of an integrated consumer analysis methodology. This approach helps managers, planners, and regulators identify and select transportation strategies by providing them with a detailed understanding of how consumers respond to transportation service. Furthermore, the approach helps select the appropriate strategy by forecasting increases or decreases in ridership resulting from each strategy. Because the approach is based on state-of-the-art methods in consumer behavior, marketing research, and transportation demand analysis, it is sensitive to a wide range of strategies including marketing strategies such as information campaigns, persuasive advertising, or coupon strategies as well as service change strategies such as increased frequency, extended hours, or bus shelters. Future research will monitor consumer response to one or more of these strategies and compare it to forecasts.

INTRODUCTION

Public officials and private citizens alike acknowledge the need for local public transportation. Public transportation provides mobility to individuals who do not have any private means of transportation and offers an alternative to private transportation for all individuals. In addition, public transportation is desirable because it offers advantages over private transportation in terms of energy efficiency, environmental pollution, and congestion.

However, several observations indicate that individual and community needs often are not well met by existing public transportation systems. First, most local transportation services require substantial operating and capital subsidies, while at the same time, have considerable excess capacity, particularly during off-peak hours. Second, the low utilization of public transportation and the attendant prevalence of private auto trips results in traffic congestion, parking problems, and environmental pollution in many communities, and has contributed to national gasoline shortages. Finally, present users of public transportation express dissatisfaction with the quality of service provided.

The goal of this research is to develop practical methods to enable transportation planners to understand consumer needs and desires and respond to them by providing improved public transportation. Use of these methods will result in transportation services more likely to satisfy consumer needs and thus more likely to gain acceptance.

The methods of consumer-oriented transportation planning draw upon state-of-the-art^{*} knowledge in consumer behavior theory, marketing research, and transportation demand theory. Each of these is a necessary component of the method. Knowledge of consumer behavior helps identify the basic

process by which consumers evaluate and select transportation alternatives. Correct identification of the consumer response process enhances the accuracy and policy sensitivity of the model. Marketing research provides methods to measure the aspects of consumer behavior identified as relevant to transportation and insures accurate input to the models of transportation consumer. Explicit measures of consumer feelings, perceptions, and preferences provide diagnostic information to help planners and managers understand the consumer and formulate improved transportation strategies. Finally, transportation demand theory provides methods to forecast the impact of strategies designed to increase consumer satisfaction and acceptance.

The product of the consumer-oriented approach is important diagnostic information that provides transportation planners and managers with improved understanding of consumer behavior. Specifically, the approach results in:

- an identification of how consumers process information to form perceptions of transportation alternatives;
- explicit measures of consumer perceptions of each transportation alternative;
- identification and measures of consumer feelings such as biases toward specific modes, personal expectations, and perception of societal norms;
- measures of the relative importances of perceptions and feelings as they influence consumer preferences toward transportation alternatives; and
- an understanding and measurement of how situational constraints, such as availability, combine with preference to influence behavior, such as choice of transportation mode.

This diagnostic information is used to formulate strategies that influence consumers' behavior by affecting their perceptions, feelings, preferences, and situational constraints. Thus the planner or manager can formulate strategies based on consumer inputs. A sequence of analytic models forecasts the effect of these strategies so that the strategies can be refined and evaluated.

This dual focus of "understanding" for the development and refinement of strategies and "forecasting" for the evaluation of strategies is essential for successful strategy development. Forecasting is important, but does not stand alone. Successful transportation planning must be based on a thorough understanding of consumer behavior so that optimal strategies can be identified.

This report describes a consumer-oriented transportation planning process based on the synthesis of consumer behavior theory, marketing research, and transportation demand analysis. This approach is illustrated through an application to the development and evaluation of strategies in a suburban community north of Chicago, Illinois. First, a model of consumer transportation decision making is described and the context in which it was applied is detailed. Then, the data collection procedure and the empirical results are presented. Next, the results are interpreted and strategies for increasing consumer acceptance of public transportation are developed. Finally, demand estimations are made and a candidate set of high potential, strategically relevant strategies are specified.

THEORETICAL MODEL DEVELOPMENT

Efforts to understand consumer transportation behavior began in the late 1950s with aggregate studies correlating system characteristics (e.g.,

travel time, frequency, cost, etc.) and community characteristics (e.g., income, education, density, etc.) with demand for transportation alternatives (Martin, Memmott, and Bone, 1961; McLynn and Woronka, 1969; Quandt and Baumol, 1966; SARC, 1963). Although these models performed well in specific circumstances, they did not adequately represent consumer behavior and they provided little guidance for the development of strategies to directly influence such behavior. As a result, disaggregate demand models were developed in the early 1970s to examine the relationships between these variables and travel choice on the level of the individual consumer and to improve prediction of travel behavior (Ben-Akiva, 1973; Charles River Associates, 1972; Koppelman, 1975; McFadden, 1970). These disaggregate models, which are widely used today, provide a clearer specification of the relationship between system characteristics, consumer demographics, and travel choice than did aggregate models. However, like the aggregate models, they concentrate on observed system and community characteristics. Thus, they fail to provide a complete understanding of the consumer's transportation decision-making processes and are not sensitive to the wide range of strategies that can be developed to influence consumer behavior without expensive changes in system characteristics. Additional research is required to gain a better understanding of the consumer and make available the full range of strategic opportunities to community transportation planners and managers.

The critical factor present in consumers' decision making, but absent in traditional demand models, is consumers' perceptions which mediate the relationship between system characteristics and travel choice behavior. In recent years several transportation researchers have acknowledged the importance of perceptual variables (e.g., convenience, comfort) and have

focused on quantifying these variables so that they can be included, along with system characteristics such as time and cost, in disaggregate mode choice models (Nicolaidis, 1975; Spear, 1976). While this effort to quantify perceptions is important, it is not sufficient. An adequate understanding of the relationship between perceptions, system characteristics, preference, and choice is also needed. In order to model these effects correctly, we must draw on theory and methodology from psychology, consumer behavior, and marketing.

One way of viewing the interrelationship between system characteristics, perceptions, preference, and choice is given by the model of consumer transportation decision making in figure 1. This model is an extension of what

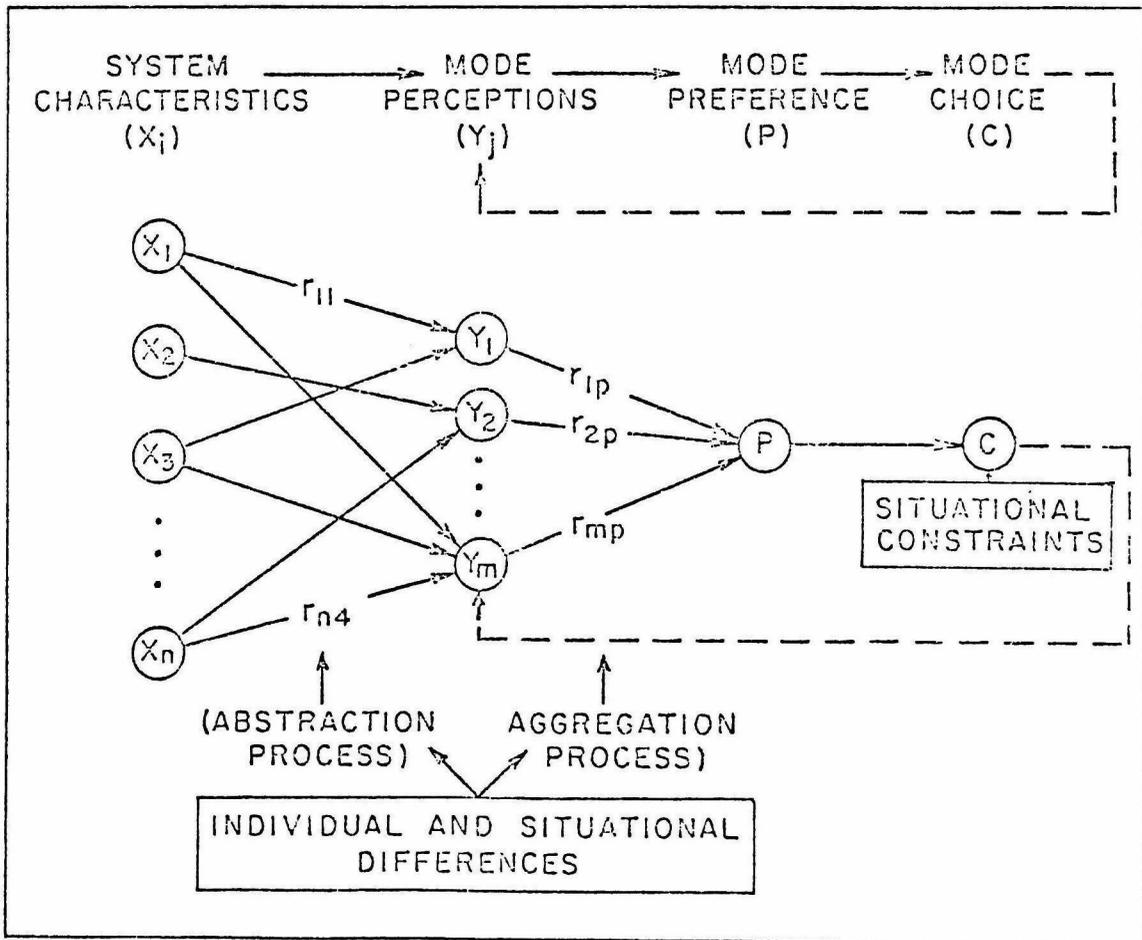


FIGURE 1: A MODEL OF CONSUMER TRANSPORTATION BEHAVIOR

is known as Brunswick's lens model (see Brunswick, 1952; Hammond, 1966). It is similar to models which have been used to describe consumer response to new products/services (Green and Wind, 1975; Hauser and Urban, 1977; Pessemier, 1977). In the model, the system characteristics (X_k) such as travel time, wait time, cost, and seat availability, serve as cues used by the consumer in forming his perceptions (Y_l) of the various modes (i.e., evaluation of performance, convenience, safety, comfort, etc.). Each system characteristic is a partial indicator of any particular perception, and the degree of the association between these factors is represented by the correlations (r_{kl}). For example, travel time may serve as a partial indicator of performance for a particular mode. Furthermore, a system characteristic such as travel time may influence several different perceptions in different ways (i.e., high travel time may be negatively correlated with performance but positively correlated with safety). This process of using system characteristics as cues in forming perceptions is called abstraction. Once perceptions are formed, they are aggregated to determine preference. A degree of association between the perceptions and preference is represented by the second set of correlations (r_{lp}). Preference, tempered by situational constraints such as mode availability, in turn, directs choice. Finally, choice and the experience gained may feed back to modify mode perceptions. Situational and individual differences not represented in this basic model influence decision making by influencing the manner in which the individual forms perceptions or aggregates perceptions to direct preference and choice.

There are several practical implications of this model.. First, if the model accurately represents consumers' transportation decision making, researchers should concentrate their efforts on understanding the abstraction and aggregation processes (i.e., are linear or non-linear models used?, etc.)

and should not confound these two processes by using both system characteristics and perceptions in one model predicting preference or choice, since these variables are likely to be highly correlated. Nor should they directly develop mode choice models from system characteristics. Second, because the model represents the stages in the consumer decision-making process, it can help the planner or manager diagnose problems in the transportation system. Problems may be the result of actual system performance, consumer misperceptions of that performance, or the importance consumers place on various perceptions. Third, the model provides an understanding of transportation consumers which can serve as the basis for developing a broad range of strategies to influence consumer travel choice decisions. This model can identify strategies which focus on directly altering consumer perceptions, preference, or choice. These strategies are considered in addition to traditional service modification strategies. For these reasons, the model in figure 1 is used as a basis for the study reported here.

The major objective of our research is to examine the relationships between consumers' mode perceptions, preference, and choice (i.e., the aggregation process) as a basis for developing strategies to modify consumers' choice. We also examine the adequacy of the model in determining the relative strengths of the relationships between reported system characteristics, perceptions, preference, and choice. Future research will deal with the direct measurement of the relationship between physical characteristics and perceptions.

Technical details of the research are contained in the following reports in this series. Report 2, "Consumer Views of Transportation Service in Evanston: A Report Based on Focus Group Interviews," describes the early qualitative research. Report 3, "The Development and Implementation of a

Questionnaire to Determine Consumer Wants and Needs," gives the motivation behind each question in the survey, describes the process by which communities can develop their own surveys, and gives the sampling frame and logistics of the Evanston Survey. An appendix to that report contains the final surveys and all developmental surveys. Report 4, "Preliminary Analysis of the Survey," gives the complete, unanalyzed results of the survey plus initial analyses to check the representativeness of the sample. Finally, Report 5, "Models of Consumer Travel Choice Behavior," gives the detailed technical analyses involved in the development of the consumer response models. Report 1, this report, focuses on the key ideas and results of the analysis.

CONTEXT OF THE RESEARCH

The research was conducted in the City of Evanston, Illinois, in cooperation with the City Manager's Office. Evanston is a northern suburb of Chicago, with a population of approximately 80,000. The Evanston public transit system includes: a rapid transit system which serves Evanston and connects with the Chicago rapid transit system, access to the Chicago Northwestern Railroad which runs between the northern suburbs and downtown Chicago, extensive local bus service, and bus service to neighboring suburbs.

The transit problems of the City of Evanston are typical of many suburban cities. Specifically, there is significant excess capacity on the public transit system, especially during off-peak hours. Thus Evanston provides a good context for research designed to understand consumers' travel behavior and evaluate strategies for increasing public transportation ridership during off-peak periods. Furthermore, because of the range of services available and its similarity to numerous other suburban cities in the United States, the insights gained from this research can be generalized to other areas.

DATA COLLECTION

Our approach to gaining an understanding of consumer travel behavior entailed developing a survey instrument for collecting individual data on the variables in the model in figure 1, using this data to measure and test the relationships between these variables, and generating and evaluating strategies designed to alter consumers' behavior. The outputs of this research are: (1) an improved model of the transportation consumer, (2) a methodology that can be used by planners to understand and respond to consumer needs and desires, (3) a carefully developed and tested set of consumer surveys that can be adapted to other communities, and (4) preliminary identification of a range of potentially effective strategies to improve public transportation service and increase ridership.

The primary research instrument used was a set of mail questionnaires. Questionnaires were used for data collection because they provide the most efficient means of collecting quantitative data on the major variables in the model for a large cross section of the population.¹ The questionnaires were administered by mail because this method allowed us to reach a broader cross section of the population than alternative methods (i.e., telephone or personal interview) and it allowed consumers to respond to the questionnaire, which was quite long, at their leisure.

The development of the questionnaires was a complex, lengthy process. Initial input was obtained from three major sources. A usage audit served to identify the most frequently used modes of transportation for various trip purposes within the community. These frequently used modes were included in

¹However, the use of a questionnaire, especially a mail questionnaire, made it impossible to assess actual system characteristics for the respondents at the same time as other variables were measured. Instead, only perceptions of system characteristics were obtained.

the questionnaires for consumer evaluation (space and time constraints prohibited requesting individuals to evaluate all modes). In addition, a series of focus group interviews² and a literature review served to:

- (1) generate a list of transportation service attributes important to consumers to be used in evaluating modes in the final questionnaire and
- (2) provide "semantics" so that the questionnaire could be phrased in a language used and best understood by the consumers. Because these inputs indicated that there were differences in the transportation attributes for different types of trips, three separate questionnaires were developed for three types of trips: trips to work or school, nonwork/nonschool trips to the CBD (Central Business District), and nonwork/nonschool trips to areas in the city other than the CBD.

On the basis of the focus groups and literature review, scales measuring attributes of transportation services important to consumers were developed and evaluated. This entailed generating an exhaustive list of attributes and then reducing this list to a manageable set of critical attributes (21-25 scales per mode) on the basis of the results of two pretests in which individuals in the community used the attributes to evaluate several modes and also indicated their mode preference and choice. (For more details on the scale development process, see Report 3 in this series.)

Once the scales were developed, the remaining sections of the questionnaires were drafted and a pretest of the entire questionnaire was conducted. Results of this pretest were used to uncover and correct problems and omissions in the questionnaire. In addition, the completed pretest questionnaires were used in a pre-analysis. This process entailed performing

²Focus group interviews are open discussions by 6-10 consumers led by a trained moderator focused on a particular topic -- in this case transportation in Evanston.

a full-scale statistical analysis on these responses to ensure that the questionnaire provided all the data necessary for the analysis planned on the final questionnaire. A few missing items were discovered and subsequently added, but the most important result of the pre-analysis was the recognition that mode-specific attributes, popular in the transportation literature, are not compatible with perceptual models except under special conditions. These conditions are that either there be parallel attributes for all modes or, if an attribute has no parallel for a mode (i.e., walk access for the walk mode), there be a clear extreme direction for that mode (walk access to walk is always very good). Based on the pretest and pre-analysis the final questionnaires were developed, printed, and mailed to a random sample of the target population (1,900 work/school trip, 1,900 nonwork/nonschool trip to the CBD, and 950 nonwork/nonschool trip to non-CBD destinations). A follow-up postcard was sent to every respondent seven days after the questionnaire mailing, urging them to return the questionnaire.

The various sections of the questionnaire obtained the following types of information:

1. System characteristics. Respondents estimated: travel time, broken down by access, wait, and on-vehicle time; bus frequency during rush and non-rush hours; distance to the nearest bus stop; and bus seat availability. They also provided data which was used to compute auto availability (i.e., they reported the number of drivers and autos in their household).
2. Perceptions. Respondents evaluated each of the frequently used modes (car, bus, and walk) by responding to 21-25 statements about mode attributes on a 5-point, strongly agree to strongly disagree

Likert scale. Respondents also expressed their feelings about transportation in terms of their affect, personal normative beliefs, social normative beliefs, and level of commitment by responding to 6-9 statements per mode regarding these factors on similar 5-point Likert scales.³

3. Preference. Respondents rank-ordered the three modes -- bus, auto, and walk -- in terms of their preference.
4. Choice. Respondents indicated the mode which they used for their most recent nonwork trip to the CBD and also estimated the frequency with which they used each of the available modes for similar trips in the preceding two months.
5. Consumer and situational differences. Participants answered demographic questions (i.e., age, income, education, etc.) and described characteristics of their most recent trip to downtown Evanston (i.e., purpose, time of day, etc.).

SOME KEY RESULTS

All three questionnaires were mailed out simultaneously and all have since been coded. The analyses described in the remainder of this report are based on the survey for trips to downtown Evanston. Preliminary analysis of the other surveys indicate that the structure of the results are similar.

³Historically, transportation researchers have focused on one psychological dimension, beliefs about attributes of the object (e.g., perception of mode convenience, comfort). Other psychological variables, including affect (an individual's liking-disliking of an object, see Ostrom, 1969), personal normative beliefs (an individual's perceptions of what he ought to do, see Fishbein, 1972), social normative beliefs (an individual's perception of what others want him to do, see Fishbein, 1972), and level of commitment (how easily is the individual's intended behavior influenced by unanticipated events, see Wicker, 1971), have been demonstrated to influence behavior. These elements have been included in our questionnaire so that their contribution to the explanation of transportation behavior can be examined.

Respondents

Forty-one percent of the individuals who received the questionnaires (782 out of 1,900) related to the nonwork trip to downtown Evanston returned it. Five hundred of these responses were selected for analysis on the basis of completeness of response to the attribute ratings and preference rankings questions. Comparison of the demographic characteristics of this sample with 1970 census data indicates that it is reasonably representative of the Evanston population, although some minor distinctions do exist (see Report 4 in this series for details on data screening and sample representativeness).

Description of System Characteristics

Consumers' perceptions of a variety of system characteristics (i.e., travel time, frequency, bus seat availability, bus accessibility, and auto availability) were measured.

Walk travel time for trips to downtown Evanston was perceived to range between 1-5 minutes and 86-90 minutes, while vehicular travel time for similar trips ranges from 1-5 minutes to 26-30 minutes for car and 1-5 minutes to 56-70 minutes for bus. Car availability ranged between 0.0 autos/driver to 3.0 autos/driver, however, 97% had one or less autos/driver.

Description of Perceptions of Mode Attributes

The questionnaire measured consumers' perceptions of three modes -- bus, walk, and car (passenger or driver) -- on 25 attributes chosen to be as complete as possible in representing consumer perceptions. Respondents' evaluations of the modes of these attributes are summarized in table 1.

Examination of the ratings in table 1 indicates that, in general, car is perceived favorably and outscores bus and walk. However, on cost

TABLE 1
AVERAGE STANDARDIZED ATTRIBUTE RATINGS*

	<u>BUS</u>	<u>WALK</u>	<u>CAR</u>
ON TIME	-.12	.08	1.13
NO TRIP SCHEDULING NECESSARY	-.78	-.48	-.07
RELAXING	.07	-.03	.26
CORRECT TEMPERATURE	.31	-.15	.80
NO WORRY OF ASSAULT	.76	.38	1.06
CAN COME AND GO AS I WISH	-.47	.67	.83
INEXPENSIVE	.56	1.10	-.59
ERRANDS TAKE LITTLE TIME	-.28	-.36	.81
NO WORRY ABOUT INJURY	.98	.68	.71
KNOW HOW TO GET AROUND	.73	1.04	.99
LITTLE EFFORT INVOLVED	.26	-.21	.64
AVAILABLE WHEN NEEDED	-.20	.91	.56
NOT MADE UNCOMFORTABLE BY OTHERS	.91	1.01	.90
NO PROBLEMS IN BAD WEATHER	.01	-.73	.30
PLEASANT DRIVERS OR OTHER PERSONNEL	.43	.43	.41
GET TO DESTINATION QUICKLY	-.09	-.50	.84
PROTECTED FROM SMOKING	.09	.65	.75
SAFE AT NIGHT	-.02	-.51	.68
NOT ANNOYED BY OTHERS	.74	.81	.57
NO LONG WAITS	-.30	.77	.75
EASILY CARRY PACKAGES	-.19	-.57	1.03
EASY TO TRAVEL WITH SMALL CHILDREN	-.01	-.37	.75
NOT TIRING	.44	-.30	.82
EASY GETTING IN AND OUT	.56	1.27	.82
EASY WALK ACCESS	.79	1.27	.96

* THE RATINGS WHICH APPEAR IN THIS TABLE WERE STANDARDIZED BY INDIVIDUALS ACROSS STIMULI AND SCALES TO REMOVE ANY TENDENCY OF AN INDIVIDUAL TO USE ONLY PART OF THE RANGE IN THE SCALE. IN ADDITION, ALL NEGATIVELY WORDED SCALES WERE MATHEMATICALLY REVERSED SO THAT HIGHER NUMERICAL VALUES IMPLY BETTER RATINGS.

("inexpensive") and stress attributes ("fear of injury," "annoyed by others") car fares less well. In contrast, bus is relatively poorly perceived. It receives favorable ratings only on cost and stress-related attributes and is viewed negatively in terms of service attributes. Walk is rated highly in terms of attributes measuring cost, service availability and environment, but is seen as time consuming and requiring considerable effort to use.

Factor analysis was used to reduce these 25 transportation service attributes to a smaller set of underlying dimensions. This was done for three reasons: First, consumers do not actually process information about each of the 25 attributes when making an evaluation or choice (see Bruner, Goodnow, and Austin, 1956). Instead, they reduce the information to a smaller, more manageable set of factors that capture the essence of the larger set. Thus, a simpler perceptual structure more closely approximates consumers' utilization of conceptual information in decision making. Second, this simpler structure helps managers and analysts better understand consumer processes so that they can formulate strategies to affect the most crucial components of consumer response. Third, factor analysis enables the analyst to make dimensions orthogonal, thus reducing multicollinearity and leading to stable coefficients when the dimensions are used in preference and choice models.

Factor analysis is a standard marketing research technique that has been used successfully in a myriad of product and service categories (Urban, 1975; Hauser and Urban, 1977). Recently, in destination choice models, Koppelman and Hauser (1978) have shown that factor analysis is superior to alternative perceptual models based on similarity scaling. Furthermore, they show that the reduced dimensions, factor scores, can forecast as well as the detailed service attributes, but the factor scores

provide a structure that helps the analysts and planners better understand and influence the consumers' response process.

Factor analysis of the attribute ratings was undertaken for two through six dimensions using common factor analysis with iterations and varimax rotation. The solutions for the various dimensions were compared on the basis of interpretability, explanatory power, and accuracy in predicting preference. On the basis of this analysis, three dimensions were chosen as the best representation of the perception space.

The factor loadings for the three-dimension solution appear in table 2 and mode perceptions on the three dimensions are graphed in figure 2. The

TABLE 2
THREE FACTOR ANALYSIS OF 24 ATTRIBUTE RATINGS
FOR BUS, WALK AND CAR

ATTRIBUTES RATED	FACTOR 1	FACTOR 2	FACTOR 3
ON TIME	<u>.57</u>	.40	-.08
NO TRIP SCHEDULING NECESSARY	.25	.27	-.27
RELAXING	<u>.48</u>	.14	.25
CORRECT TEMPERATURE	<u>.58</u>	.01	.11
NO WORRY OF ASSAULT	<u>.48</u>	.00	.30
CAN COME AND GO AS I WISH	.25	<u>.58</u>	-.04
ERRANDS TAKE LITTLE TIME	<u>.69</u>	.29	-.03
NO WORRY ABOUT INJURY	.18	-.07	<u>.47</u>
KNOW HOW TO GET AROUND	.09	.33	.20
LITTLE EFFORT INVOLVED	<u>.69</u>	.09	.21
AVAILABLE WHEN NEEDED	.02	<u>.67</u>	.09
NOT MADE UNCOMFORTABLE BY OTHERS	.05	.22	<u>.54</u>
NO PROBLEMS IN BAD WEATHER	<u>.62</u>	-.03	.14
PLEASANT DRIVERS OR OTHER PERSONNEL	.06	.09	.33
GET TO DESTINATION QUICKLY	<u>.77</u>	.16	-.03
PROTECTED FROM SMOKING	.12	.38	.04
SAFE AT NIGHT	<u>.62</u>	.00	.10
NOT ANNOYED BY OTHERS	.04	.12	<u>.51</u>
NO LONG WAITS	.16	<u>.64</u>	-.03
EASILY CARRY PACKAGES	<u>.71</u>	.13	-.08
EASY TO TRAVEL WITH SMALL CHILDREN	<u>.59</u>	.06	-.08
NOT TIRING	<u>.77</u>	-.00	.19
EASY GETTING IN AND OUT	-.15	<u>.51</u>	.29
EASY WALK ACCESS	-.12	<u>.48</u>	.28

Factor Interpretation:

- Factor 1 - General Service and Safety
- Factor 2 - Convenience and Accessibility
- Factor 3 - Psychological Comfort

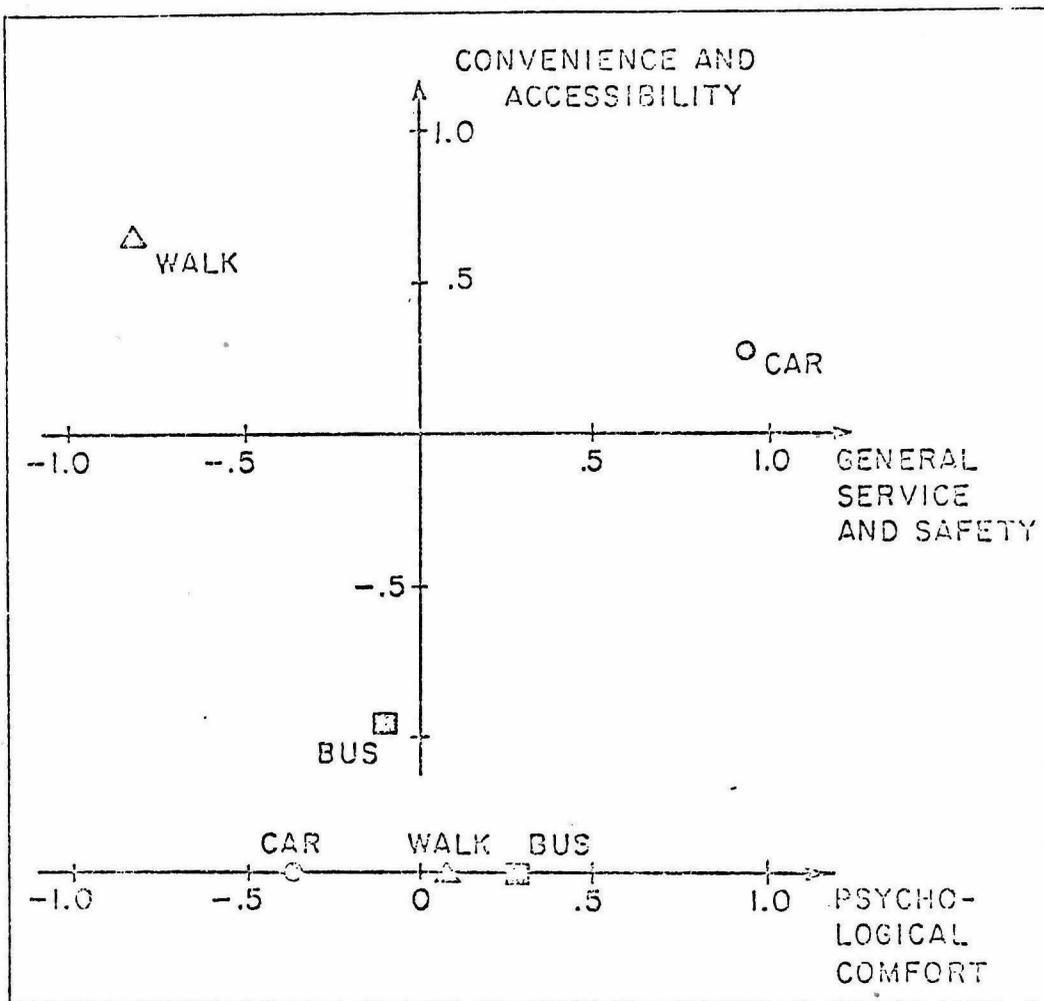


FIGURE 2: CONSUMER PERCEPTION OF ALTERNATE MODES

three factors -- which have been labeled general service and safety, convenience and accessibility, and psychological comfort -- account for 45% of the variance in the original attribute ratings. This is consistent with previous studies of this nature (see Hauser and Urban, 1977; Hauser and Koppelman, 1977).

Since the first two factors account for the major portion of that variance, they are graphed in a two-dimensional map, while the third dimension (psychological comfort) is graphed as a single scale under that map.

As figure 2 demonstrates, car is perceived favorably on both general service and convenience/accessibility. Walk does well on convenience and accessibility, while bus is best for psychological comfort (i.e., freedom from hassle).

Description of Feelings About Modes

(Perceptions of Factors other than Mode Attributes)

In an effort to determine whether psychological or perceptual factors other than evaluations of mode attributes influence transportation preference and choice, a variety of non-attribute travel perceptions were measured (i.e., affect, personal normative beliefs, social normative beliefs, extraneous events). These measures were factor analyzed to develop an aggregate measure of feeling toward each mode. This approach was taken because each of the original variables (affect, personal normative beliefs, etc.) was measured by a small number of questions per mode and, therefore, these measures were likely to be unstable if used separately. However, when the variables are combined, they provide a fairly reliable index of more general feeling toward the mode. The factor loadings for the three resulting factors -- car feelings, bus feelings, and walk feelings -- are presented in table 3. These factors account for 39% of the variance in the original set of questions.

Preference and Choice

First preference was clearly dominated by car (71% stated car as their first preference), while bus did well in terms of second preference (58% stated bus was their second preference). Consistent with the preference ratings, 72% used car for their most recent trip (16% walked and 12% used the bus). Cross-tabulation of first preference and choice data indicate that the vast majority of respondents (76%) used their most preferred mode.

	WALK FEELINGS	BUS FEELINGS	CAR FEELINGS
DIFFERENT FROM BUS RIDERS	.05	-.28	.01
ENJOY TRAVEL BY CAR	-.23	-.01	-.55
ENJOY TRAVEL BY BUS	-.12	<u>.71</u>	-.13
ENJOY TRAVEL BY FOOT	<u>.83</u>	.07	-.04
DEPRESSING TO TRAVEL BY CAR	.11	-.06	<u>.76</u>
DEPRESSING TO TRAVEL BY BUS	.04	<u>-.53</u>	.41
DEPRESSING TO TRAVEL BY FOOT	<u>-.67</u>	-.11	.31
PEERS SURPRISED IF RIDE BUS REGULARLY	-.08	<u>-.52</u>	-.06
OUGHT TO TRAVEL BY CAR	<u>-.45</u>	-.19	-.38
OUGHT TO TRAVEL BY BUS	.01	.52	.16
OUGHT TO TRAVEL BY FOOT	<u>.75</u>	-.01	.10
PEERS SURPRISED IF DROVE CAR REGULARLY	.18	.16	.32
IF WEATHER BAD, FEWER CAR TRIPS	-.07	.10	.31
IF WEATHER BAD, FEWER BUS TRIPS	-.14	-.34	.07
IF WEATHER BAD, FEWER WALK TRIPS	-.25	-.03	-.05
IF GASOLINE PRICE DOUBLED, MORE CAR TRIPS	-.30	-.21	-.14
IF GASOLINE PRICE DOUBLED, MORE WALK TRIPS	<u>.69</u>	.06	.16
IF GASOLINE PRICE DOUBLED, MORE CAR POOL TRIPS	.12	.18	.03
IF GASOLINE PRICE DOUBLED, FEWER CAR ALONE TRIPS	.15	.26	.09
PEERS SURPRISED IF WALKED ALOT	<u>-.66</u>	-.11	-.11
IF BUS FARES LOWER, MORE TRIPS BY BUS	.09	<u>.61</u>	.35
IF BUS FARES LOWER, FEWER TRIPS BY CAR	.06	.59	.34
IF BUS RAN MORE OFTEN, MORE BUS TRIPS	.21	<u>.40</u>	.27
WOULD TRAVEL BY CAR REGARDLESS OF COST	-.40	-.39	-.40
WOULD TRAVEL BY BUS EVEN IF LONG WALK	.12	<u>.50</u>	.11
IF PARKING COST DOUBLED WOULD WALK	<u>.44</u>	.04	.21
WILLING TO CAR POOL SOME TRIPS	.06	.09	.00

TABLE 3

FACTOR LOADINGS FOR MODE FEELINGS

However, it is interesting to note that a significant number of individuals (24%) did not choose their most preferred mode, perhaps due to situational constraints such as availability. This highlights the importance of consumers' second preferences and suggests an area of opportunity for public transportation, if it can overcome the poor perceptions most consumers have of bus with respect to convenience and accessibility.

Together, these descriptive results give the planner a picture of the current state of consumer reaction to the existing transportation system. The system characteristics indicate how the system performs with respect to measurable engineering characteristics. The factor analyses indicate the psychological structure of consumer perceptions and feelings and direct strategy toward influencing those perceptions and feelings which are the primary determinants of preference. The perceptual map (figure 2) gives the planner a simple representation of the competitive position of the alternative modes. The attribute ratings table (table 1) and the perceptual structure tables (tables 2 and 3) give the planner an indication of how to affect consumers' perceptions of the alternative modes.

For example, suppose the planner wants to improve consumer acceptance of the bus. Then he or she might concentrate either on "general service and safety" or "convenience and accessibility," since bus is perceived poorly along these dimensions. Alternatively, the planner can devise strategies to increase the importance of psychological comfort (bus does well on that dimension) or try to influence the feelings or predispositions toward bus or away from car. To select actions for any combination of these strategies, the planner would then look at the perceptual structure tables to select the attributes or feelings that most affect the perceptions he or she is trying to influence. For example, if the strategy were to increase consumer per-

ceptions of the "convenience and accessibility" of bus, the planner might direct actions at the attribute of "come and go as I wish," "available when needed," "no long waits," "easy getting in and out," and "easy walk access." Finally, to affect these attribute scales, the planner would select the system characteristics and/or marketing strategies most likely to influence their attributes.

Examination of tables 1, 2, and 3, and figure 2, suggests many potential strategies to improve consumer response to public transportation. But which strategy or set of strategies is most effective? To find the strategies that are most effective, one must understand the interrelationships between the perceptions and feelings, and one must understand their affect on preference and choice. These relationships are addressed next.

MODEL DEVELOPMENT

Before a set of analytic models are developed and before the effect of perceptions and feelings on preference and choice are estimated, we examine the data to determine if it is consistent with the conceptual model in figure 1.

Support for Conceptual Model

Our model of consumer travel behavior states that the impact of system characteristics on preference and choice is mediated by consumer perceptions. Therefore, system characteristics should be more highly correlated with perceptions of mode attributes than with preference or choice. Examination of table 4 indicates that this is the case for travel time, which is more highly correlated ($r = -.51$) with consumers' perceptions of "general service" than it is with preference ($r = -.31$) and choice ($r = -.31$). Similar results were obtained for blocks to bus stop, bus seat availability, and cost. On the

TABLE 4
Correlation Matrix

	System Characteristics				Perceptions			Feelings			Constraints	P
	TT	BLOCK	SEAT	COST	GS	C/A	PC	BF	WF	CF	APD	
Travel Time (TT)												
Blocks to Bus Stop	.05*											
Bus Seat Availability	-.09	.01*										
Cost	-.25	.04*	-.11									
General Service	-.51	-.07*	.22	.41								
Convenience/Accessibility	-.07	-.19	.14	-.06	.04							
Psychological Comfort	-.01*	-.14	.28	-.30	.03*	.04*						
Pro-Bus Feelings	-.18	-.03*	.09	.13	.48	.32	.25	-				
Pro-Walk Feelings	-.41	-	-	-.24	.60	.26	.19	-	-			
Pro-Car Feelings	-.11	-	-	-.13	.32	.13	.25	-	-	-		
Autos per Driver (APD)	.05	-	-	.00*	-.01*	.26	.03*	-	-	+.09		
Preference	-.31	-.03*	-.02*	.30	.56	.31	-.05	.31	.48	.21	.20	
Choice	-.31	-.08	.06*	.32	.52	.31	-.09	.22	.40	.15	.30	.66

*All correlations except those starred are significant at the .05 level.

other hand, autos per driver (APD), which acts more as a situational constraint than a system characteristic, is more highly correlated with choice ($r = .30$) than preference ($r = .20$). Furthermore, as expected, autos per driver is also associated with perceptions of "convenience and accessibility" ($r = .26$).

The cognitive dimensions are viewed as the determinants of preference and choice. Therefore, these variables should be relatively independent and highly correlated with preference and choice. In general, these con-

ditions are met. The intercorrelations between these variables are low and they are highly related to preference and choice (especially general service and convenience/accessibility).

Finally, the feelings variables provide measures of perceptions and personal biases not completely captured by attribute ratings. Because these are alternative perceptual measures, they should be intercorrelated with the perception factor scores. If, as expected, they are capturing personal and social beliefs, they should be more highly correlated with the perception factor scores than with the system characteristics. Finally, we expect them to be correlated with preference and choice. In general these conditions are met. The feelings variables are intercorrelated with perceptions of mode performance. These correlations are larger than those between feelings and system characteristics. The feelings variables are also highly correlated with preference and choice.

Because both the perceptions and feelings satisfy the conditions of the model and both are correlated with preference and choice, they will remain in the model subject to further testing.

Finally, preference and situational constraints are viewed as the determinants of choice. Thus, these variables should be highly correlated with choice. Consistent with this expectation, table 4 indicates that choice is most highly correlated with preference ($r = .66$) and highly correlated with a situational constraint -- auto availability ($r = .30$).

The above correlational analysis is consistent with the conceptual model in figure 1. Thus, we conclude that the data supports our model of consumer travel behavior and, therefore, we next estimate the relationships necessary to provide a predictive model based on the conceptual model of figure 1.

Model Components

In order to operationalize the conceptual model of figure 1, we must develop models of perceptions, feelings, preference, and choice. These relationships are shown in figure 3. The perception and feelings measures

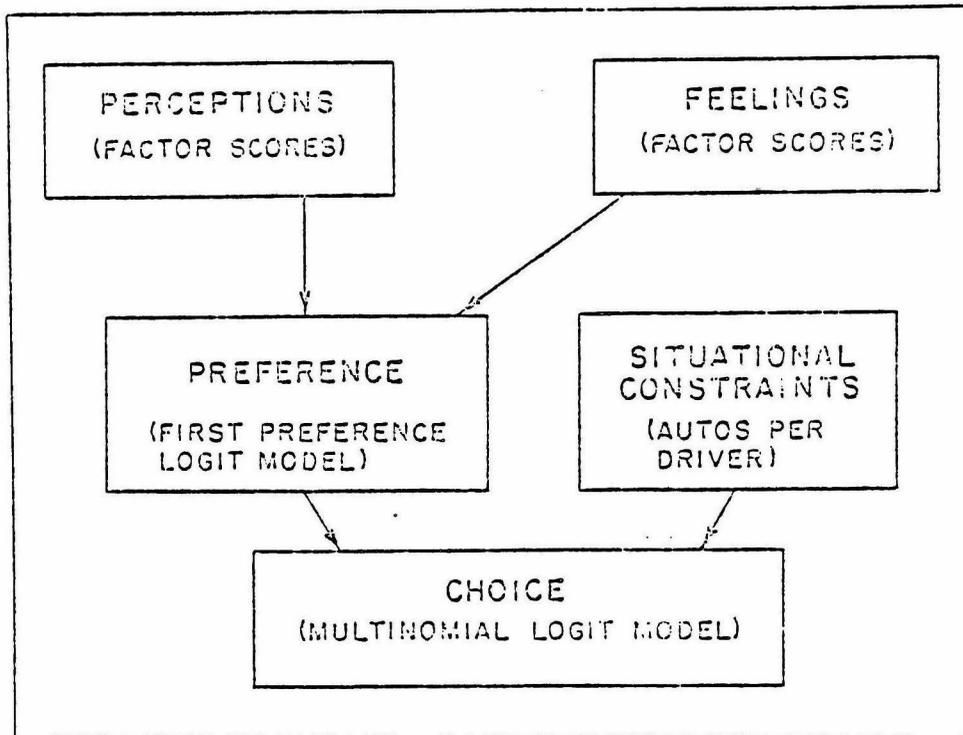


FIGURE 3: MODEL COMPONENTS

are operationalized with factor scores determined from the factor analyses described in tables 2 and 3.⁴ These factor scores are then explanatory variables in a preference model which probabilistically relates a weighted sum of the perceptions and feelings to each consumer's preference for each mode. This preference model is a multinomial logit model which uses first

⁴Factor scores are estimated as linear combinations of the attributes. The weights used in the linear function are called factor score coefficients and are determined from a regressionlike procedure. See Rummel, 1970. Similar results are obtained from principal components analysis.

preference as the dependent variable (McFadden, 1973; Hauser and Koppelman, 1977). Finally, the preference index that is developed and the situational constraint (autos per driver) are used as explanatory variables in a multinomial logit model which uses choice as the dependent variable. The equations are summarized in table 5 on the next page.

Preference Models

First preference logit was used to statistically estimate the importance weights (w_k 's and v_m 's) which relate the perceptions and feelings to preference. These models which are presented in table 6 are summarized below. The numbers reported are relative weights normalized so that their absolute values sum to 100%.

TABLE 6
PREFERENCE MODELS

<u>Variable Name</u>	<u>Relative Importance Weights*</u>	
	Model 1	Model 2
General Service and Safety	.66	.35 [.71]
Convenience and Accessibility	.23	.11 [.21]
Psychological Comfort	.11	.04* [.07]
Pro-Car Feelings		.07
Pro-Bus Feelings		.20
Pro-Walk Feelings		.23
<hr/>		
Percent Correctly Predicted	79.5	80.1
Information	54.2%	58.1%
χ^2 - statistic	527.6	565.7

*All coefficients, except those starred are significant at the .05 level. Alternative specific constants are included in each model to obtain consistent estimates for importance weights.

**Weights in brackets are normalized importance weights for the three performance perception variables.

TABLE 5
SUMMARY OF MODEL EQUATIONS.

Perceptions

$$x_{imk} = \sum_{\ell=1}^{25} f_{k\ell} y_{im\ell}$$

Feelings

$$F_{im} = \sum_{n=1}^{27} g_{mn} z_{in}$$

Preference

$$PI_{im} = \sum_{k=1}^3 w_k x_{imk} + \sum_{n=1}^3 v_n F_{im} \delta_m$$

$$p_{im} = \exp(\beta PI_{im}) / \sum_{j=1}^3 \exp(\beta PI_{ij})$$

Choice

$$L_{im} = \exp(\gamma PI_{im} + \alpha APD_{im}) / \sum_{j=1}^3 \exp(\gamma PI_{ij} + \alpha APD_{ij})$$

where

- $y_{im\ell}$ = individual i's rating of mode m on attribute ℓ
- z_{in} = individual i's rating of feeling measure n
- $f_{k\ell}$ = factor score coefficient relating attributes to perceptions
- g_{mn} = factor score coefficient relating feeling measures to feeling factors
- x_{imk} = factor score for individual i's perception of mode m along the k^{th} dimension
- F_{im} = individual i's feeling toward the m^{th} mode
- w_k = the relative importance of the k^{th} perceptual dimension
- v_m = the relative importance of the feelings toward the m^{th} mode
- δ_m = indicator variable ($\delta_m=1$ for mode m, $\delta_m=0$ otherwise)
- PI_{im} = individual i's preference index for the m^{th} mode
- p_{im} = probability that individual i prefers the m^{th} mode over other modes
- APD_{im} = autos per driver for individual i's household, note that APD is equal to zero for all modes but auto
- L_{im} = the probability individual i chooses mode m
- β, γ, α = constants

In Model 1, the cognitive dimensions (factor scores) and two mode bias variables are used to predict first preference. The importance weights for these dimensions in this model follow the same pattern as their identification in factor space. General service is the most important variable. Convenience and accessibility is next most important. And psychological comfort is least important.

In Model 2, the factor scores for respondents' feelings about each mode are added to Model 1. All three feelings variables are statistically significant, and they significantly improve the prediction and explanation of mode preference ($p < .001$). Furthermore, the addition of the three feelings variables has little impact on the relative weights of the cognitive dimensions. This finding supports our hypothesis that perceptual variables other than measures of mode attributes influence preference and suggests that efforts to alter preference should consider these variables.

In general, the models presented in table 6 do a good job of predicting first preference. The percent of first preferences correctly predicted by these models are all significantly higher than the percent which would be correctly predicted using a market share model (54.7%) or an equally likely model (33.3%). The information measure reported gives the percent of uncertainty (entropy) explained. This measure is an information theoretic interpretation (Hauser, 1978) of the pseudo R^2 measure (McFadden, 1973). Similar models were developed to predict rank preference using a rank logit model (Luce and Suppes, 1965). The rank ordering of variables and interpretation were the same.

Since Model 2 is significantly better than Model 1 in explaining mode preference, its structure is chosen for incorporation in the choice model. The importance weights in Model 2 indicate that the perceptions which most influence preference are "general service and safety" and "convenience and

accessibility." Thus, strategies which are to have major impact should either be directed at these variables or should focus on increasing the importance of psychological comfort (where bus performs well). Finally, since the mode-specific feelings variables are significant, evidence is provided that consumers' feelings about modes are important in the formation of mode preference. Thus these variables should be considered in developing strategies to influence mode preference.

Choice Models

Since situational variables as well as preference affect choice, a related set of models were developed to predict choice. These models are based on the multinomial logit model (McFadden, 1970) that is commonly used in the transportation demand literature. But there is one important difference. In standard models, the weights of all relevant variables are simultaneously estimated as if they were revealed by choice. In our formulation, an intermediate preference index representing individual i 's rating of mode m , PI_{im} , is developed based on estimated preference weights. This index is used along with situational constraints in predicting choice. The relative importance of perceptions and attitudes are obtained through analysis of reported rather than revealed preference. This formulation is based on the behavioral model in figure 1.

In order to test this formulation, we estimated two choice models. The standard "revealed preference" model relates choice directly to perceptions, feelings, and auto-availability. The "preference index" model is based on the consumer-oriented behavioral model in figure 1. Since the revealed preference model has more "degrees of freedom," the goodness-of-fit measures will be higher; but if the conceptual model in figure 1 is correct, this improvement in goodness-of-fit should not be statistically significant. Both models,

reported in table 7, do extremely well compared to a random model (33% correctly predicted, 0% information) and a model that assigns consumers mode choice probability in proportion to market shares (56% correctly predicted, 29% information).

TABLE 7
CHOICE MODELS

	Relative Importance Weights*	
	"Revealed Preference Model"***	"Preference Index Model"
General Service and Safety	.28	.35
Convenience and Accessibility	.26	.11
Psychological Comfort	-.02*	.04*
Pro-Car Feelings	.07*	.07
Pro-Bus Feelings	.08*	.20
Pro-Walk Feelings	.28	.23
	Parameter Estimates	
Autos per Driver (α)	.95	.90
Preference (γ)	3.35	3.07
<hr/>		
Percent Correctly Predicted	79.5	78.0
Information (%)	52.3	50.4
χ^2 - Statistic	481.6	464.1

*All coefficients except those starred are significant at the .05 level

**These normalized importance weights are obtained from a logit model including two alternative-specific dummy variables.

The revealed preference model fits the data significantly better than the preference index model at the 2.5% level. However, it does obtain a counter-intuitive (negative) but not significant weight for psychological comfort and non-significant parameters for both car and bus feelings. The relative importance weights are similar for both models except for convenience and accessibility (more important in the revealed preference model) and bus feelings (less important in the revealed preference model). The autos per driver variable (representing auto availability) is statistically significant and

similar in both models. Considering the mixed results obtained in comparing the two models (revealed preference is significantly better overall but does not obtain significant estimates of the influences of variables believed to be important) and the strong theoretical arguments in support of the conceptual model, we retain the preference index model to represent travel choice behavior.* The preference index model also provides better managerial insight than the revealed preference model since it considers both preference and choice directly.

In summary, the choice models in table 7 do an excellent job of predicting mode choice for respondents' most recent trip to downtown Evanston. All predictions are substantially better than market share or equally likely models would provide. Models predicting respondents' reported frequency of choice over the last two months were also developed. These models are generally similar to those shown in table 7.

Segmentation

Many researchers have hypothesized that different segments of the population respond differently when choosing among transportation alternatives. If this is true and such differences can be isolated in the models of consumers, then there is potential for identifying differential strategies directed at special segments of the population.

In the conceptual model in figure 1, segmentation can occur in the abstraction process, in the aggregation process, or in the choice process. If different segments of consumers form perceptions differently, changes in system characteristics or information strategies will affect segments differently. Such differential effects would be considered in any system modification strategy. If different segments form preferences differently, the relative importance of various perceptual dimensions varies by consumer segment, and planners might want to consider different services as well as marketing strategies for different segments.. Finally, if the choice process

differs by segment, the effect of situational constraints is more or less important depending upon the consumer segment. In this case, the planners might utilize strategies that remove or impose situational constraints differently for certain consumer segments.

Because the emphasis of this study is on the consumer's response process as a whole and since we do not explicitly model the abstraction process, we have concentrated on segmentation with respect to preference and choice. First, a number of candidate segmentation variables were selected. Next, different categorizations of those candidate variables were tested with a modified Friedman test (Koppelman, 1978) for significant differences in preference ranking. Table 8 summarizes the results of this directed search.

TABLE 8
POTENTIAL SEGMENTATION VARIABLES

<u>Variable</u>	<u>Categories</u>			<u>Significance*</u>
	(1)	(2)	(3)	
Age	≤29	30-59	≥60	.005
Education	High School	Some College	College Grad.	.010
Trip Purpose	Shop	Doctor, Eat, Bank	Other	.010
Length of Residence	<3 years	≥3 years	-	.005
Occupation	Student	Other	-	.005
Income	<\$10,000	≥\$10,000	-	.050
Driver's License	Yes	No	-	.005
No. of Cars	None	One or more	-	.005

Non-significant Variables*

Sex
Blocks to Nearest Bus Stop
Intermediate Stop on Trip

*Significance is based on a modified Friedman test. Cutoff is at the .05 level.

Age, education, trip purpose, length of residence, occupation, income, possession of driver's license, and number of cars in family were all identified as potential segmentation variables when categorized as shown in table 8. Table 8 also lists those segmentation variables for which no significant differences were identified.

Only the first four of these candidate segments were retained for testing for differences in preference weights, since for each of the last four variables one of the two segments contained an overwhelmingly large proportion of the observations. First preference logit models were estimated for each segment and compared to a model estimated for the group as a whole. The criteria for segmentation used are (1) that the importance weights be significantly different among segments and (2) that the segmented models predict significantly better than the unsegmented models. No segmentation passes these tests. For example, table 9 reports a segmentation test for age. There is some variation

TABLE 9
TEST OF PREFERENCE SEGMENTATION
EXAMPLE: AGE

Variable Name	Relative Importance Weights*			
	Overall	≤29	30-59	≥60
General Service and Safety	.35	.31	.32	.31
Convenience and Accessibility	.11	.03*	.12	.09*
Psychological Comfort	.04*	.06*	.03*	.00*
Pro-Car Feelings	.07	.03*	.14	-.05*
Pro-Bus Feelings	.20	.42	.15	.15*
Pro-Walk Feelings	.23	.15*	.25	.41
Sample Size	443	132	231	80
Percent Correctly Predicted	80.1	75.8	82.7	86.3
Percent Correctly Predicted-3 Segments			81.3	
Information (%)	58.1	56.6	62.0	62.7
Information-3 Segments			60.5	
χ^2 Statistic	565.7	164.2	314.7	110.2

$$\chi^2_{16} \text{ for segmentation} = (164.2 + 314.7 + 110.2) - 565.7 = 23.4$$

Non-significant at the .05 level

*All coefficients except those starred are significant at the .05 level. These importance weights are obtained from first preference logit models which include alternative-specific dummy variables.

in the relative weights among segments (especially for bus and walk feelings, but this variation is not statistically significant. These results are consistent with previous tests of preference segmentation reported in the modeling literature. (For example, Hauser and Urban [1977] could find no significant difference in preference for health care delivery services.)

The potential segments were next tested for differences in choice process. Multinomial logit choice models based on the preference index, autos per driver, and two alternative-specific dummy variables were estimated for each segment and subjected to similar tests of significance. In this case, significant improvements were identified for each of the four classifications tested. While the preference index proved to be statistically significant in each segment, the autos per driver situational constraint had a significant effect only in certain segments. Table 10, which summarizes the results for the three demographic-based segments,* shows that the autos per driver constraint is insignificant for those younger than 29 or older than 60, and for those having no college education.

Managerially, this suggests that strategies, such as restricted parking or high auto registration fees that constrain auto availability, will have a major impact on only certain segments of the population. However, in each case the impact is on the majority of the population.

Summary

The segmentation analysis completes the development of an analytic model of consumer response to transportation service. This model is based

*Only the three demographic-based segments are discussed here as these describe identifiable groups of the population.

TABLE 10
SIGNIFICANCE OF AUTOS PER DRIVER (APD)
FOR DIFFERENT SEGMENTS

<u>Variable</u>	<u>Information</u>	<u>Category</u>	<u>Percent of Sample</u>	<u>APD Significant</u>
Age	55.4	≤29	27	no
		30-59	50	yes
		≥60	24	no
Education	54.6	High School	13	no
		Some College	24	yes
		College Grad	63	yes
Length of Residence	53.4	< 3 years	29	yes
		> 3 years	71	yes

on the conceptual framework developed in consumer behavior theory (review figure 1) and is developed from state-of-the-art market research and demand analysis measurement and estimation techniques. More importantly, this analytic model represents the consumer process at a level that provides useful diagnostic information to suggest improved transportation strategies. Furthermore, because roughly 80% of the preference and choice can be correctly predicted, the model is sufficiently accurate to forecast the range of consumer response to recommended strategies.

STRATEGY IDENTIFICATION

The consumer model was developed as a decision support system. It fulfills this function by allowing us to identify and evaluate alternative strategies.

The first step in strategy identification is to examine the diagnostic information provided about perceptions, feelings, preference, choice, and segmentation to determine those aspects of the consumer response process most susceptible to change. Next, the correlation table and factor tables are used to identify those system characteristics or basic attribute and feelings scales that can best influence the perceptions, feelings, or situational constraints. Finally, strategies are identified which directly influence these system characteristics and basic attribute and feelings scales. Because these strategies are based on leverage points of the consumer response process, they are likely to have the greatest impact on consumer behavior.

After strategies are identified, they must be evaluated. That is, it is necessary to predict their expected impact on travel behavior. Ultimately, models will be developed which link system characteristics through perceptions to mode preference and choice. At present, we must rely on managerial judgment to estimate the effect of system or promotional strategies on perceptions and feelings and use the models of preference and choice to predict traveler response. This procedure focuses managerial judgments on micro-relationships such as the probable increase in perceived bus frequency resulting from published and posted bus schedules. Such judgments are easier to make and usually more accurate than judgments about the total process such as the probable increase in overall ridership which would result from distribution of bus schedule information. Specific procedures to enhance the accuracy of the required managerial judgments will be discussed in the next section. At this point, it is sufficient to note that reasonably accurate ranges of probable impacts can be forecast for the various strategies identified below (Hauser and Urban, 1977).

Before we identify the specific strategies for Evanston, we will give an overview of the types of strategies that can be identified and evaluated with consumer models.

Potential Strategies

In accord with our model, five basic types of strategies for influencing mode choice may be generated. These strategies, each focusing on a different model variable, are summarized below:

1. Modification of system characteristics. Strategies designed to modify system characteristics (i.e., product strategies) are appropriate when the system does not meet consumers' needs on some dimension and this dimension strongly impacts perceptions which influence preference and choice. System strategies may range from reducing bus fares or increasing bus frequency to introducing a new public transit or paratransit service.
2. Modification of consumer perceptions. Strategies designed to modify consumer perceptions directly (i.e., not by modifying system characteristics) are appropriate when consumers are either uninformed or misinformed about the system. Here, the task is to provide consumers with accurate information. In addition, modification of consumer perceptions may also be appropriate when consumers have accurate information about the system but interpret that information negatively (e.g., they know that the bus runs every 20 minutes and interpret that as poor service). When this occurs, persuasion may be employed in an effort to alter the individual's interpretation of the information.

3. Modification of consumer preference. Strategies designed to modify consumer preference may be employed when consumers' perceptions are accurate, but low importance is placed on characteristics of public transportation which are highly rated and high importance is placed on those which are poorly rated. In this situation the task is one of changing the importance weights so that dimensions on which public transportation performs well receive greater emphasis. Persuasive appeals may be used to do this.
4. Modification of situational constraints. Strategies designed to modify situational constraints are appropriate when these factors have a significant impact on mode choice (i.e., auto availability, parking availability, etc., may influence mode choice). This approach entails manipulation of situational factors so that incentives or disincentives for particular mode choices result (e.g., restricting parking in downtown areas may discourage car trips). These strategies tend to be perceived as more coercive than other types of strategies and they are often difficult to implement since legislation and regulation changes may be required. Furthermore, they may have undesirable effects such as shifting shopping trips to competitive shopping areas. Thus, constraint modification strategies are typically only used when other strategies have failed and when they can be broadly applied.
5. Modification of behavior. Strategies designed to modify individuals' choice behavior directly are appropriate when consumers are reluctant to try a particular service; but there is reason to believe that if they tried it, they would like it. Promotional strategies such as free rides, discount coupons, shop and ride, etc., may be used to encourage trial.

These five strategies represent the type of changes that can be identified and evaluated with consumer models. We must now look at the diagnostic information given by the models in order to identify specific strategies for Evanston.

Model Diagnostics

We look first at the perceptual map in figure 2. Relative to the other modes, bus does very poorly on convenience/accessibility, and relative to car, bus does poorly on general service. These poor perceptions of bus could be due to accurate perceptions of what is poor service or misperceptions of good service. In either case, effective strategies could be directed at improving bus along general service because of its high relative importance ($w_1=.71$) or at improving bus on the less significant but still important dimensions of convenience and accessibility ($w_2=.21$). For example, we may wish to change the perceptions of bus as indicated by the dotted arrow in figure 4. (The solid arrow indicates the "ideal" direction as given by the relative importance weights in table 6.)

Currently, the model suggests that strategies to affect psychological comfort ($w_3=.07$) would not have as large an impact as those that affect general service and convenience/accessibility. But if the importance of psychological comfort were increased through persuasive appeals such as testimonial advertising, then not only would improvements in psychological comfort have more of an effect, but bus would automatically be more preferred and chosen because it is already highly rated on that dimension.

Finally, the model suggests that the availability of autos has a significant effect on choice. Furthermore, the magnitude of this effect may be different for different segments of the population. In particular,

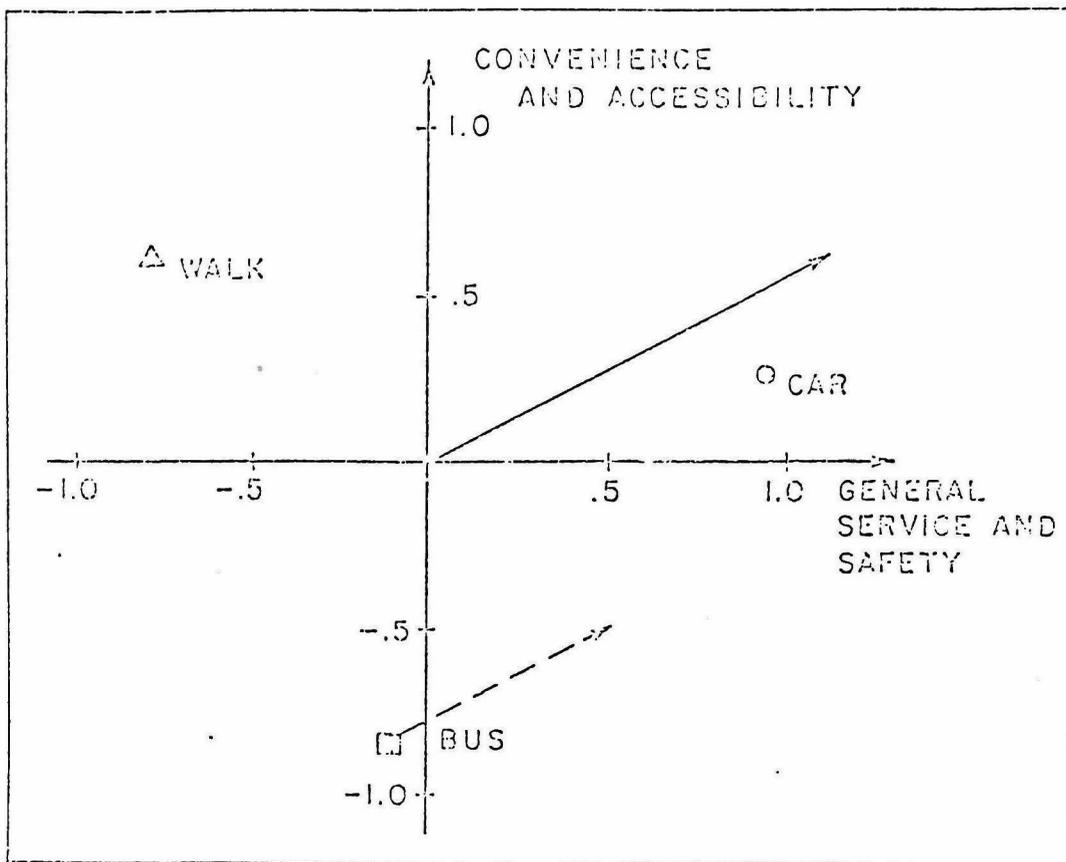


FIGURE 4: STRATEGY TO IMPROVE PERCEPTIONS OF BUS

its effect will be on majority groups in the population, generally characterized by high education, and central age range (30-59 years). The city may wish to increase bus ridership through strategies that constrain the availability of autos but must consider the possibility of diverting trips to destinations outside of Evanston.

The perception, preference, and choice models direct inquiry at certain general aspects of the consumer response process. To translate these general ideas into specific strategies, we examine table 4 to identify which system characteristics are correlated with each perceptual variable and we examine table 2 to identify which attributes compose each perceptual variable.

Specific Strategies

One approach to increasing public transportation ridership is to improve the perceptions of the general service and convenience/accessibility provided by bus. To do this, we first examine the specific attributes which make up the general service and convenience/accessibility dimensions (table 2). Attributes loading heavily on the general service factor are "on time," "correct temperature," "errands take little time," "little effort involved," "get to destination quickly," "no problems in bad weather," "easy to carry packages," "safe at night," "easy to travel with small children," and "not tiring." Of these attributes, bus scores very poorly on the six that are underlined. Similarly, the attributes which load heavily on convenience/accessibility are "come and go as I wish," "available when needed," "no long waits," "easy getting in and out," and "easy walk access." Next, we attempt to determine whether the low evaluation of bus on these attributes is the result of poor system performance or negative misperception of actual system performance.

Questionnaire responses indicate that a large proportion of Evanston residents have serious misperceptions about bus frequencies and routes. A separate study of bus system reliability (Turnquist et al., 1978) indicates varying degrees of reliability depending on locations along the route. Thus, it appears that the low "on time" and "no long waits" ratings for bus (table 1) are partly due to misperceptions or lack of information and partly due to variable system performance. One set of strategies which might improve bus general service and convenience/accessibility includes better maintenance of schedules, providing better information about bus schedules and routes, or both.

Evidence from another study of system performance (Bernstein et al., 1977) suggests that consumers accurately perceive the bus travel time from their homes to downtown Evanston. Thus, the negative evaluation of bus quickness-related attributes is primarily due to a negative interpretation of an accurate perception. Two alternative strategies for improving the "quickness" evaluation of bus and thereby improving the general service rating are; (1) modify the service (e.g., implement express buses) and (2) use persuasive communications to convince consumers that they should reinterpret the actual quickness more favorably (e.g., by stressing that no search for parking is required).

Similarly, negative perceptions of "ease of carrying packages," "ease of traveling with children," "night safety," "come and go as I wish," etc., can be examined to determine the cause of the negative rating and to suggest strategies for improving these perceptions.

The above approach to increasing public transit ridership is based on improving consumers' evaluation of bus on the general service and convenience/ accessibility dimensions. An alternative approach is to use persuasive communications to increase the relative importance of the psychological comfort dimensions where bus already outperforms car and walk. This might entail stressing the importance of getting to one's destination without being hassled (e.g., Greyhound's "leave the driving to us"). Once changes in the bus system have been made and it appears that the service is one that meets the needs of the consumer, strategies to alter behavior (i.e., encourage trial), such as coupons, free rides, etc., may be appropriate to help alter consumer perceptions.

The city can also try to improve bus ridership by decreasing the availability of car and decreasing consumers' perceptions of car with respect

to general service and convenience/accessibility. Such strategies might include raising the parking fee in the downtown parking garages (which is now 10¢ per hour) or increasing vehicle taxes, which are now \$25-\$55 per year. However, it is important to recognize that small changes in parking or registration costs can be expected to have only a small effect on travel choice, and large changes are difficult to implement.

The strategies identified above, and others, are summarized in table 11. Any single strategy or any combination of strategies would improve bus

TABLE 11

STRATEGIES

<u>Desired Effect</u>	<u>Potential Strategies</u>
Increase perceptions of bus on "general service and safety"	<ul style="list-style-type: none">● Inform consumers of good "on time" performance through direct mailing or better schedules.● Induce consumers to try the system and experience actual system performance through coupons or tokens.● Improve "quickness" with express buses.● Improve "easy to carry packages" with special package racks.● Improve "safe at night" through on vehicle radios or lighting
Increase perceptions of bus on "convenience and accessibility"	<ul style="list-style-type: none">● Inform consumers of good "on time" performance through direct mailing.● Inform consumers of potential service through improved information packages.● Induce trial to increase awareness and overcome misperceptions. Use coupons or tokens.● Improve perceptions by increasing the frequency of service.
Increase salience of "psychological comfort"	<ul style="list-style-type: none">● Advertising or direct mail to persuade consumers of the importance of getting to one's destination without being hassled.
Decrease auto availability	<ul style="list-style-type: none">● Increase parking fees.● Increase vehicle tax.● Decrease on street parking.

ridership. All non-information strategies have to be used in combination with an information campaign to insure maximum effectiveness. That is, if express buses are introduced, this strategy has to be communicated to the public to be effective.

FORECASTS OF CONSUMER RESPONSE TO STRATEGIES

The consumer analysis is used to identify the high potential strategies in table 11; but before we select a strategy for implementation, we must first quantify its impact. The first step in this selection is to use the consumer models to forecast the ridership impacts of the potential strategies. The next section will then compare this forecast, percent increase (decrease) in ridership, to other considerations such as cost, consistency with city goals, feasibility of implementation within the next year, and compatibility with external constraints such as bus driver union contracts. We begin with some background on our forecasting approach that synthesizes analytic models and managerial judgment.

Decision Calculus

Our procedure for forecasting the impact of changes combines the analytic models (table 5) and managerial judgment. This combination of the best features of both analysis and judgment is called "decision calculus" based on a definitive study by Little (1970). In that study of how mathematical models were used for decision support, Little found that judgmental inputs supplemented by quantitative models are often more useful and accurate than models that rely on quantifiable inputs alone. The primary reason for this effect is that the judgmental/quantitative models tend to be robust, i.e., hard to get absurd answers from, adaptive to a wide range of stra-

tegies since they are not limited to quantifiable inputs, and as complete as possible since important phenomena are included, even if they require judgmental inputs. In fact, it is often more realistic to judgmentally forecast a narrowly defined impact, such as the change in an attribute perception, than it is to build a complex yet incomplete quantitative model to forecast both the technological and psychological impacts of a system change.

This does not mean that judgment is always superior to quantitative methods. Rather, it means that the transportation analyst should not be limited by what can be quantified. The analyst should model as best as possible all important effects, then augment this model with judgment. In this way, the model is made to represent the "real world" as closely as is feasible. The analyst is not limited by prior bias toward quantifiable variables. Indeed, Lodish (1974) shows that analysts who limit themselves to quantifiable numbers may be more "exact" but "exactly wrong." Judgment acts as a moderating force toward "vaguely right."

Decision calculus identifies needed input, then seeks improved methods of judgment and, ultimately, analytic methods to quantify the inputs based on theoretical development and measurement. Decision calculus is an evolutionary problem-solving approach as opposed to a method-oriented approach.

Since Little first developed his concept, decision calculus models have expanded, and numerous methods have been developed to bound and direct judgment and to couple judgment with behavioral theory. Little and Lodish (1969) use the method for media scheduling. Lodish (1974) reports dramatic improvements in sales-force allocation. In more related models, Hauser and Urban (1977) use perception, preference, and choice models similar to those described in this paper to accurately forecast the effect of testimonials and changes in

hospital affiliation on MIT's health maintenance organizations. (Strategies increased enrollment 50% and are tracking on schedule.) Silk and Urban (1976) have been consistently within one percentage point on their predictions of the market share of new frequently purchased products, and Little (1975) reports extremely accurate forecasts using a complex model of multiple interacting strategies. For other uses of models similar to our conceptual model in figure 1, see Urban and Neslin (1977) and Hauser and Shugan (1977).

Based on this success, we have adopted a decision calculus approach to predicting the impact of strategy changes. Our analytic models (table 5) are used to forecast ridership based on judgmental predictions of the impact of strategy changes on perception. Decision calculus techniques are used to enhance the accuracy of these judgments.

Conceptual Process for Forecasts

If we had an explicit model of the abstraction process (review figure 1) and some method to forecast the impact of that change on system characteristics, then the conceptual forecast would proceed as in figure 5. The

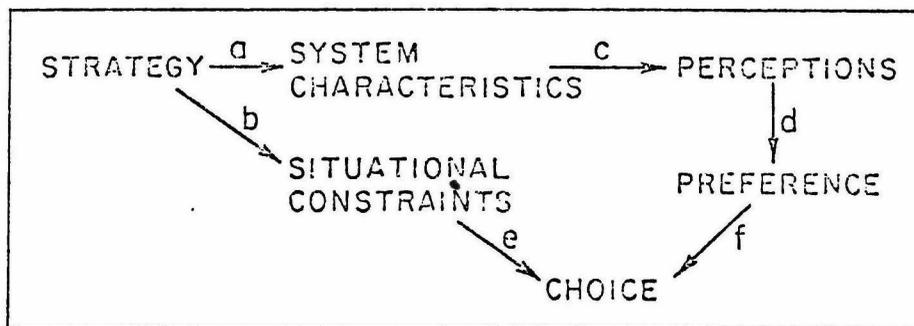


FIGURE 5: COMPONENTS OF PREDICTION

arrows a and b. require judgment or a detailed engineering model. Arrow c would be the abstraction model, while arrows d, e, and f are the analytic model (table 5) developed earlier in this report. We use decision calculus to make the judgments indicated by the dotted arrows in figure 6, while the solid arrows represent analytic models.

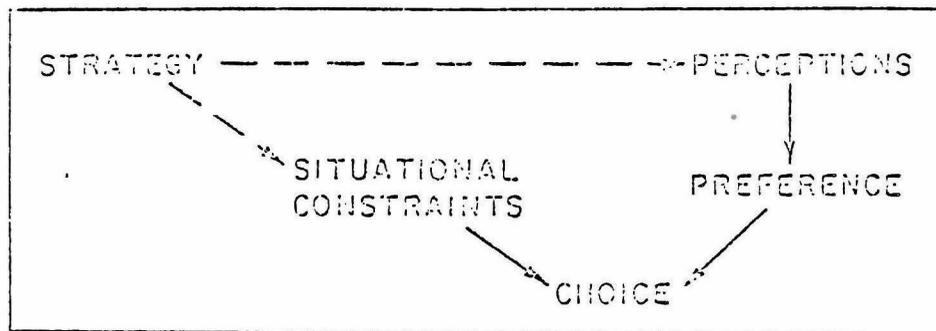


FIGURE 6: DECISION CALCULUS PREDICTION

Future research will quantify the abstraction process but, at present, based on the good predictability of the models (table 5), the accuracy of previous studies, and techniques to enhance judgment, we feel the decision calculus approach is sufficiently accurate to forecast the impact of the strategies in table 11.

Following figure 6, the conceptual forecasting process proceeds as follows:

1. Select a strategy or combination of strategies and judgmentally estimate its average impact on the attributes, the feelings scales, and autos per driver. The accuracy and ease of judgmental estimation is enhanced with procedures described later.
2. For each individual consumer in the sample, modify his/her perceptions of the attributes, feelings scales, and autos per driver by the estimated amount.

3. Use the mathematical models in table 5 to compute for each individual consumer, the new probabilities that he/she will choose bus, auto, and walk.
4. Compute aggregate ridership by summing the individual probabilities for all individuals.
5. Compare this predicted ridership to the ridership obtained under the status quo to obtain a percent change in ridership.

For example, suppose that an informational campaign is to be evaluated and, via judgment, we believe that the minimum impact will be to change consumers' ratings of bus only on the attribute scale "know how to get around." We believe that the ratings will increase by about 50% of the difference between bus and auto. To forecast the impact of this change, we increase each of the 500 consumers' ratings for bus by this amount and use the models in table 5 to predict each consumer's perceptions (factor scores), preference (preference index), and choice (probability of choice). Overall predictions are obtained by combining the individual predictions.

Procedures to Enhance Judgments

Clearly, judgment is a key component of the prediction method described in figure 6. To enhance the accuracy of these judgments, we use the procedures of anchor-point judgments, "stretchers," and convergence to estimate the range of impacts (dotted arrows in figure 6). Furthermore, we bound this range of impacts by predicting both pessimistic and optimistic levels of impact. Based on these procedures, the predicted impact should be reasonably accurate in (1) bounding the impacts and (2) ordering the strategies from high to low effectiveness.

The anchor-point procedure simply "anchors" and bounds the change on any given attribute by using judgments not on absolute change, but on the

percentage difference between one mode and another. For example, the implementation of express buses would improve consumers' perceptions of bus on "quick," but it is unlikely that bus would ever be perceived to be as "quick" as car. We might judge that express buses would increase that perception at least $1/10$ of the difference in perception between bus and car, but no more than $1/2$ the difference. The most likely impact might be to increase bus perceptions $1/5$ the difference from bus to car. For example, if a consumer's standardized perception of the "quickness" of bus were .1 and his/her perception of the quickness of car were .2, then the most likely impact of the change ($1/5$ the difference) would increase his/her perception of bus to 0.12.

Since the numerical procedure for steps 2, 3, and 4 requires over 100,000 binary operations for each strategy, we have developed an interactive computer package to automate these steps. The analyst simply estimates the impact on the attributes, feelings scales, and autos per driver; inputs this estimate with the on-line package; and interprets the results. See table 12 for the computer output corresponding to the express bus strategy described above.

The "stretcher" procedure uses consumer perceptions of concept descriptions of new, improved transit systems to suggest the range of impacts. In the Evanston questionnaire, two stretcher concepts were used: a public-operated paratransit system called Personalized Premium Service (PPS) and a private-operated shared taxi system called the Budget Taxi Plan (BTP). Average perceptions of these concepts are shown in table 13. We have found it is often easier to make anchor-point judgments with respect to these stretchers than with respect to car or walk because the stretchers are more representative of potential improvements in public transportation service than car or walk.

TABLE 12

SAMPLE COMPUTER OUTPUT
FOR STRATEGY CHANGE*

```

COTIP INTERACTIVE PREDICTION PROGRAM VERSION 2.2
DO YOU WISH TO MODIFY DATA. (YES OR NO)
? YES
WHAT TYPES OF VARIABLES ARE TO BE CHANGED
ATTRIBUTES/FACTOR SCORES/ENGINEERING/OPINIONS
TYPE 1 IF CHANGES ARE DESIRED, 0 OTHERWISE
  XXX/XXX
? 1 0 0 0
TYPE ATTRIBUTES DATA CHANGES
TYPE STOP TO END CHANGES,
  OP  VALUE  VAR ALT ALT  CLS  SEG
      NO.   1   2
  1 X  SXXX.XX  XX  XX  XX  XX  XX
? 3   20.    16   1   3
  2 X  SXXX.XX  XX  XX  XX  XX  XX
? STOP
LISTING OF 1 CURRENT CHANGES
  1  3. 20.000 16.  1.  3.  0.  0.  1.

IF YOU WISH TO MODIFY CHANGES TYPE YES OTHERWISE TYPE NO
? NO
WILL THIS RUN USE STRATIFIED DATA
IF STRATIFIED,TYPE STR. OTHERWISE, TYPE ALL.
? ALL
CURRENTLY THERE ARE 4 MODELS AVAILABLE
TYPE IN MODEL NUMBER
  XX
? 03
MODEL FOUND
  PREDICTIONS FOR MODEL THREE - 25 ATTRIBUTES, OPS, APD.
  ALT  CHOSEN  FREQNS  PERCENT  CHANGE  PERCENT
  1    49.98   437    .1144    1.02    .0209
  2    66.16   437    .1514    -.21    -.0031
  3   320.85   437    .7342    -.81    -.0025
      56 RECORDS WERE REJECTED
IF YOU WISH TO FINISH THE RUN TYPE STOP
IF YOU WISH TO CONTINUE TYPE NEXT
? STOP
TERMINATION REQUESTED. CONTROL IS RETURNED TO ONLINE SYSTEM.
ALL FILES REMAIN ATTACHED.

```

*All user input is preceded by "?"

TABLE 13
AVERAGE STANDARDIZED ATTRIBUTE RATINGS

	<u>Bus</u>	<u>Walk</u>	<u>Car</u>	<u>PPS</u>	<u>BTP</u>
1. On time	-.12	.08	1.13	.19	.08
2. No trip scheduling necessary	-.78	-.48	-.07	-.74	-.58
3. Relaxing	.07	-.03	.26	.55	.24
4. Correct temperature	.31	-.15	.80	.56	.48
5. No worry of assault	.76	.38	1.06	.83	.68
6. Can come and go as I wish	-.47	.67	.83	.02	.13
7. Inexpensive	.56	1.10	-.59	-.21	-.27
8. Errands take little time	-.28	-.36	.81	.14	.14
9. No worry about injury	.98	.68	.71	.88	.79
10. Know how to get around	.73	1.04	.99	.82	.79
11. Little effort involved	.26	-.21	.64	.66	.62
12. Available when needed	-.20	.91	.56	.27	.35
13. Not made uncomfortable by others	.91	1.01	.90	.81	.58
14. No problems in bad weather	.01	-.73	.30	.59	.45
15. Pleasant drivers or other personnel	.43	.43	.41	.39	.27
16. Get to destination quickly	-.09	-.50	.84	.13	.20
17. Protected from smoking	.09	.65	.75	.10	-.19
18. Safe at night	-.02	-.51	.68	.40	.44
19. Not annoyed by others	.74	.81	.57	.75	.54
20. No long waits	-.30	.77	.75	.02	.11
21. Easily carry packages	-.19	-.57	1.03	.62	.36
22. Easy to travel with small children	-.01	-.37	.75	.44	.33
23. Not tiring	.44	-.30	.82	.74	.69
24. Easy getting in and out	.56	1.27	.82	.66	.56
25. Easy walk access	.79	1.27	.96	.80	.75

With these procedures and with practice, we have found the micro-judgments easy to make both by the project team and by public officials familiar with transportation service in the community. From previous studies, we feel these judgments are sufficiently accurate for strategy evaluation.

Results

Table 14 lists the results of the forecasts of the impacts of 11 strategies. In each case, decision calculus judgments were made fore-

TABLE 14
FORECASTS OF STRATEGY IMPACTS

<u>Modification</u>	<u>Forecast Increase (%)</u>	<u>Modification</u>	<u>Forecast Increase (%)</u>
1. Information Campaign to increase knowledge of bus system.	0.3 to 7.6	7. Constrain auto availability	3.8 to 20.8
2. Add bus stop signs with information	0.2 to 5.8	8. Reduce perceived auto availability	1.4 to 3.6
3. Increase bus frequency by 1 bus per hour	2.8 to 19.3	9. Increase perceived bus availability (extended hours)	0.9 to 6.1
4. Add bus shelters	2.1 to 4.1	10. Increase perceived bus reliability	2.5 to 5.7
5. Improve bus safety	1.1 to 2.2	11. Make bus environment more pleasant	0 to 1.5
6. Make the bus more relaxing	0.7 to 2.2		

casting the impact of the strategy on one or more attributes, feelings, or situational measures. The range indicates both pessimistic and optimistic estimates. The appendix gives the detailed judgments that produced these estimates.

STRATEGY SELECTION

The primary thrust of our funded research has been to develop improved models of consumer response to transportation service so that managers could identify and evaluate strategies to modify consumer response. The output of this research is the consumer model (tables 1-10, figures 1-3) and an identification and impact forecast of short-term strategies for Evanston, Illinois (figure 4, tables 11 and 14), as well as questionnaires, theory, and detailed analyses described in subsequent reports in this series. But the second year of funding requires the selection and evaluation of one strategy.

To select the appropriate strategy, local public officials must consider the predicted ridership impacts together with cost, city goals, feasibility, and situational constraints. The final selection of a strategy is the responsibility of the Evanston city government. Although techniques exist to quantify managerial tradeoffs (Keeney and Raiffa, 1976; Farquhar, 1977), most decisions by local governments are based on the directed judgments of elected or appointed officials. In the case of Evanston, the appropriate officials are the City Manager (and staff), the Mayor, and the City Council. The research team provides the consumer analysis input to that decision. Since the final decision is based on a combination of factors, we now summarize some of the considerations salient to Evanston and describe the selection of a target set of strategies.

Costs

The effectiveness of various strategies in increasing ridership and meeting city goals must be balanced against the costs of these strategies. For example, adding an additional bus per hour to the Evanston system may not be the most cost-effective strategy, even though it has the largest impact on ridership. Approximate costs of candidate strategies are judgmentally estimated on the basis of data provided by the City of Evanston and Chicago Transit Authority (CTA), which operates the local bus service. In addition to actual dollar costs (i.e., costs of an additional bus and driver), an attempt is made to consider other impacts of the strategy (i.e., residents along the bus route may complain about increased congestion resulting from an additional bus/hour on their streets).

Consistency with City Goals

Although the impact of various strategies on bus ridership is a primary factor in strategy selection, other factors also must be considered. The

city has a wide variety of other goals which would influence the selection of a strategy to improve the transportation system. For example, the city is particularly concerned with serving the needs of special segments in the population (i.e., the poor, the elderly), even if strategies directed at these segments do not bring about the largest overall increase in public transportation ridership. Alternatively, the city may want to implement strategies which not only impact on bus ridership, but also encourage Evanston residents to shop in downtown Evanston rather than other nearby suburban cities or downtown Chicago. The consistency of various strategies with city goals was assessed in discussion with city officials.

Situational Constraints

Situational constraints influence the ability of the city to implement various strategies. Some strategies necessitate public approval (i.e., restricting driving in the downtown area). Others require joint agreement of different public agencies (i.e., the CTA, as operator, and the RTA (Regional Transit Authority) and City of Evanston, as funding agencies, must agree on increased service frequency and/or operating hours). These strategies require a long lead time (1-2 years) to implement and, therefore, are not feasible in the short run. However, if these strategies appear promising, they should be considered for implementation and evaluation in the long run. Similarly, bus driver union contracts may restrict on the city's ability to rapidly implement fare or coupon campaigns, etc.

Feasibility of Evaluation

A final consideration is whether the City of Evanston (and the technical analysts) can identify the differential impacts of multiple service strategies. To serve its long-run goals, city government must be able to evaluate the

effectiveness of its decisions so that it can modify them, if necessary. This does not mean that a strategy should not be implemented if it cannot be evaluated, but rather that strategy implementations should be timed so that differential and/or joint effects can be identified. For example, if the consumer analysis determines that three strategies -- fare change, information campaign, and special shop and ride coupons -- are synergistic and should be implemented together, then all three strategies should be implemented simultaneously rather than spaced over a one-month period. Evaluation of differential effects will be difficult, but the joint effects of the combined strategy can be readily identified. Alternatively, if the city wants to identify the differential impacts of each component, the introduction of the various components must be staged over time such that consumers' response to each component stabilizes and is measured before the next component is implemented. In the case of the three-component strategy described here, the city probably would need to allow a minimum of three months between the introduction of each component of the strategy in order to separate the effects of the components.

Besides timing of strategies, the issue of time needed to implement and evaluate various strategies must be considered. Some strategies, such as information campaigns, can be implemented quite rapidly -- in a matter of a few months -- and therefore can be evaluated within the time frame of DOT contract #DOT-OS-70062, which funds the implementation and evaluation stages of this research. Other strategies, such as the introduction of a new paratransit system, may take 3-5 years due to institutional delays and high costs (\$1-\$2 million). Thus, in selecting a strategy for evaluation, we will restrict our choice set to short-term strategies (ones requiring less than six months to implement). Testing the accuracy of our models in

forecasting response to short-run strategies will allow us to obtain rapid feedback and will enable us to make any modifications necessary. Thus, when an opportunity to assess a long-term strategy presents itself, we will have confidence in the ability of our models to accurately predict response.

Actual Strategy Selection

The preceding sections outline the general criteria which were used to screen strategies. In this section we briefly summarize how potential strategies are evaluated on these criteria. Then, on the basis of these evaluations, one strategy which is likely to be implemented and evaluated in the next year is identified.

Each of the 11 strategies developed on the basis of our research was evaluated on five criteria: (1) forecasted impact on bus ridership, (2) cost, (3) consistency with city goals, (4) situational constraints, and (5) feasibility of evaluation. All evaluations, with the exception of forecasts of strategy impact on bus ridership, reflect the combined judgment of the city and the research team. Forecasts of strategy impact on bus ridership were based on judgments and models developed by the research team. Strategy evaluations on the criteria are summarized in table 15.

The evaluations of strategies on the five criteria served as the basis for strategy screening. It was agreed that the strategy selected for implementation and evaluation should be the one which would be expected to result in the greatest increase in bus ridership, subject to the following constraints:

1. The strategy must have relatively low cost since city funds for transportation are limited and obtaining a grant from a local, state, or federal agency to cover costs requires more time than the one-year implementation and evaluation period allows.

TABLE 15
STRATEGY SELECTION MATRIX

Strategy	Forecasted Increase in Bus Ridership	Cost	City Goals	Situational Constraints	Feasibility of Evaluation
1. Information campaign to increase knowledge of bus system.	0.3 to 7.6%	low	consistent	none	feasible using time series analysis and panel data.
2. Bus stop signs with information on them.	0.2% to 5.8%	low	consistent	can't erect during winter months	feasible as in (1).
3. Increase bus frequency; add one bus per hour on each route.	2.8% to 19.3%	high	consistent	requires additional drivers and equipment (1-2 years lead time).	feasible as in (1), but not in time frame of DOT contract.
4. Bus shelters.	2.1% to 4.1%	moderate-high	consistent	can't erect during winter months.	feasible as in (1).
5. Improve bus safety.	1.1% to 2.2%	moderate	consistent	difficult to operationalize. Improved lighting or vehicle radios could be implemented, but it might take more than 6 months to do so.	feasible as in (1), but difficult to implement within time frame of DOT contract.

TABLE 15 (cont.)

Strategy	Forecasted Increase in Bus Ridership	Cost	City Goals	Situational Constraints	Feasibility of Evaluation
6. Make bus more relaxing.	0.7% to 2.2%	moderate-high	consistent, but low priority.	might require equipment changes that would take more than 6 months.	feasible as in (1).
7. Constrain auto availability by driving restrictions.	3.8% to 20.8%	low \$ cost, high cost in terms of public reaction.	inconsistent	restricting driving would require Council approval with low probability of being passed; may impose undesirable impacts.	feasible as in (1), but not in time frame of DOT contract.
8. Reduce perceived auto availability by parking constraints.	1.4% to 3.6%	low \$ cost, moderate cost in terms of public reaction.	somewhat inconsistent	likely to have resistance from the Chamber of Commerce and residents; could delay implementation.	feasible, although may be difficult to capture any change since predicted impact is small.
9. Increase perceived bus availability through extended hours.	0.9% to 6.1%	moderate-high	somewhat consistent	requires additional drivers; would need more than 6 months to implement.	feasible as in (1), but difficult to implement within time frame of DOT contract.

TABLE 15 (cont.)

Strategy	Forecasted Increase in Bus Ridership	Cost	City Goals	Situational Constraints	Feasibility of Evaluation
10. Increase perceived bus reliability.	2.5% to 5.7%	low	consistent	none	feasible as in (1).
11. Make bus environment more pleasant.	0% to 1.5%	moderate-high	consistent, but low priority.	would require cooperation of drivers; thus, would necessitate union approval, which could be difficult to obtain.	feasible as in (8).

2. The strategy must not be inconsistent with city goals. Thus, strategies which might be opposed by segments in the population important to the city (i.e., merchants), would not be acceptable.
3. The strategy must not be highly susceptible to situational factors which could impede its implementation within a six-month period.
4. The strategy must be feasible to conduct an adequate evaluation of the impact of it within the next year.

The following three strategies were evaluated as being adequate on all of the above criteria: (1) an information campaign to increase knowledge of the bus system, (2) erecting bus stop signs with route information on them, and (3) improving consumers' perceptions of bus reliability. Each of these strategies is relatively low in cost, consistent with city goals, has minimal situational constraints which would impede its implementation, and can be evaluated within the next year. However, each of the three strategies is expected to result in only a small increase in bus ridership (range from 0.2 - 7.6%). This is problematic since it may be difficult to detect such small changes in the evaluation phase. As a result, it was decided that a broad, high impact information strategy which combines aspects of all of the above strategies should be developed and implemented. This broader strategy combines distribution of route and schedule information with erection of bus stop signs. Further, informing consumers about the bus schedule might improve their perceptions of bus reliability since they will be able to plan their trips around the schedule and avoid long waits. While this broad strategy is expected to have a greater impact than any of the three original strategies alone and thus its impact is likely to be more measurable, it requires sacrificing the ability to separate the effects of route maps and

schedules, bus stop signs, and improved perceptions of reliability. In the next section, the program for evaluating this strategy is outlined.⁵

STRATEGY EVALUATION

The planned information strategy is three-pronged. First, all Evanston residents will be sent a letter from the city encouraging them to use the local bus system. Enclosed with the letter will be a detailed route/schedule brochure and a number to call for further information about the system. Second, bus stop signs with route information on them will be erected along all routes. Third, information on the bus system and the new bus signs will appear in local newspapers, such as the Evanston Review and the north suburban supplements of the Chicago newspapers, and will be promoted via posters displayed in banks and other businesses in the downtown area.

A three-pronged evaluation effort will be undertaken to determine the impact of the strategy. Each aspect of this evaluation is summarized below:

1. Analysis of time series data. Time series data will be analyzed to determine if any significant change in ridership occurred as a result of the strategy. This will entail analyzing ridership data over time (i.e., from September 1974 to several months after the strategy is implemented) with the strategy treated as an "interruption" in the data. Time series data on factors other than the strategy, which are known or likely to have an impact on bus ridership (i.e., weather, school attendance, the size and age distribution of the population, legal holidays, and employment in downtown Evanston),

⁵Some modification in the strategy may occur prior to implementation. In addition, we may have the opportunity to evaluate more than one strategy; therefore, the major purpose of the strategy selection and evaluation sections is to illustrate the general methodology which will be employed. This is done within the context of a specific example for the purposes of clarity.

will be collected so the effects of these factors can be identified in the analysis. In addition, bus ridership data for one or more non-equivalent control cities similar to Evanston (i.e., cities with a bus system and population similar to Evanston which share certain historical factors which may affect ridership -- weather, economic conditions, etc.) will be obtained for the same time period as the Evanston ridership data. The data will also be used to identify external effects in the analysis. This analysis of time series data should enable us to rule out most plausible rival hypotheses (i.e., non-strategy hypotheses) for any effect observed. Analysis will be done using the PACK computer program for analysis of time series data, which is available at Northwestern University.

2. Before-after ridership counts. Counts of actual riders (ridership data is generally calculated by applying a formula to fare box revenue) on two of the four Evanston bus routes will be conducted by the CTA for one week before and one week after the campaign takes place. These counts will supplement the time series data, in that they may be more sensitive to changes in ridership than the aggregate ridership data. However, because these counts may be influenced by trends or factors in the environment other than the strategy, they should not be interpreted in isolation, but rather should be examined in conjunction with the time series data.
3. Analysis of panel data. The Northwestern research team is currently working with the city to establish a "Transportation Advisory Panel" of 100-200 Evanston residents. This panel will be composed of individuals who agree to complete the following set of measures over a six-month period:

- (a) An initial mail questionnaire measuring their perceptions, preferences, and choices for travel alternatives (bus, car, walk). This questionnaire will be a modified form of the original Evanston surveys described earlier in this report.
- (b) A short bi-weekly mail questionnaire measuring their travel behavior for the previous week. Approximately 10 of these questionnaires will be completed during the six months the panel is in operation. Two of the bi-weekly questionnaires, after the information strategy is implemented, will be expanded to include questions measuring awareness of the strategy and trial and repeat usage of the bus system as a result of the strategy.

The impact of the strategy will be determined by analyzing panel members' awareness of the strategy and any change in their transportation attitudes and behavior following implementation of the strategy.

SUMMARY

This report summarizes the results of our consumer-oriented transportation service planning project. In this research, a model of the consumer transportation decision-making process was developed and tested. This model, which describes the decision-making process, involves two stages: (1) abstraction, in which consumers abstract system characteristics to form their perceptions of transportation alternatives; and (2) aggregation, in which consumers aggregate their perceptions to form their preferences for transportation alternatives. These preferences, plus any situational constraints such as mode availability, determine choice. This model of the consumer decision-making process was tested by measuring the variables in the model using a carefully developed mail questionnaire and then examining the actual relationships between these variables. In general, strong support for the model was obtained. Models of preference and choice, which correctly predicted these factors for 77-81% of respondents, were developed. These models were then used to identify strategies for increasing usage of public transportation.

Once potential strategies were developed, they were subjected to an extensive evaluation which included use of an interactive computer program to forecast their impact on ridership, assessment of their compatibility with city goals, determination of their costs, and identification of any constraints on their implementation.

Future research which will provide a more stringent test of our model and methodology will be conducted during 1978. This research will entail implementation and evaluation of strategies predicted by our model to influence ridership on public transportation. This research is necessary not only from a theoretical perspective (i.e., to test the causality of hypothesized relationships between variables), but also from a practical perspective. This model is only of value to transportation managers and planners if it can be demonstrated to help them generate and select effective strategies for influencing consumer mode choice.

APPENDIX

The text describes the identification of strategies to increase bus ridership. The text also describes the decision calculus approach used to estimate the impact of these strategies on perceived attributes and to predict bus ridership changes. These changes are summarized in table 14. This appendix identifies the judgmental estimates of strategy impacts on transportation perceptions. For each strategy, we list estimates of both the minimum and maximum impacts. Changes can occur in three ways: (1) by adding a constant, e.g., +.10; (2) by adding a percentage of the base value, e.g., +25%; or (3) by increasing the perception of one mode, say bus, by some percentage of the difference in perception between that mode and some other mode, e.g., bus +50% to car.

MODIFICATION

MINIMUM IMPACTS

MAXIMUM IMPACTS

Attributes Changed For Mode Change Specification Forecast Change In Bus Ridership (%)

Attributes Changed For Mode Change Specification Forecast Change In Bus Ridership (%)

Attributes Changed For Mode Change Specification Forecast Change In Bus Ridership (%)

Attributes Changed For Mode Change Specification Forecast Change In Bus Ridership (%)

1. Information Campaign to Increase Knowledge of Bus

Know How to Get Around

Bus +50% to Car

0.3

On Time Bus +50% to PPS

Know How to Get Around Bus +50% to Car

No Long Waits Bus +50% to Car

7.6

Not Tiring Bus +50% to BTP

2. Add Bus Stop Signs With Information

Know How to Get Around

Bus +33% to Car

0.2

On Time Bus +50% to PPS

Know How to Get Around Bus +33% to Car

No Long Waits Bus +25% to Car

5.8

Not Tiring Bus +33% to BTP

3. Increase Bus Frequency by One Bus Per Hour

Come and Go as I Wish

Bus +25% to Car

2.8

On Time Bus +50% to PPS

No Need to Schedule Bus +33% to Car

Come and Go as I Wish Bus +25% to Car

19.3

Errands Take Little Time Bus +33% to Car

Get to Destination Quickly Bus +100% to PPS

Not Tiring Bus +33% to BTP

MODIFICATION

MINIMUM IMPACTS

MAXIMUM IMPACTS

MODIFICATION	Attributes Changed	For Mode	Change Specification	Forecast Change In Bus Ridership (%)	Attributes Changed	For Mode	Change Specification	Forecast Change In Bus Ridership (%)
4. Add Bus Shelters	Know How to Get Around	Bus	+25% to Car		Know How to Get Around	Bus	+33% to Car	
	No Problems In Bad Weather	Bus	+50% to Car	2.1	No Problems In Bad Weather	Bus	+50% to Car	4.1
	Not Tiring	Bus	+25% to PPS		No Long Waits	Bus	+33% to BTP	
					Not Tiring	Bus	+50% to PPS	
5. Improve Bus Safety	Safe At Night	Bus	+25% to Car	1.1	No Worry About Injury	Bus	+50% to Car	2.2
					Safe at Night	Bus	+50% to Car	
6. Make Bus More Relaxing	Relaxing	Bus	+25% to Walk		Relaxing	Bus	+50% to Walk	
	Not Tiring	Bus	+10% to Car	0.7	Not Annoyed By Others	Bus	+100% to Walk	2.2
					Not Tiring	Bus	+50% to Car	
7. Constrain Auto Availability	Autos per Driver	Car	-10%	3.0	Autos per Driver	Car	-50%	20.8

MODIFICATION

MINIMUM IMPACTS

MAXIMUM IMPACTS

MODIFICATION	Attributes Changed	For Mode	Change Specification	Forecast Change In Bus Ridership (%)	Attributes Changed	For Mode	Change Specification	Forecast Change In Bus Ridership (%)
8. Reduce perception of Auto Availability	No Trip Scheduling Come and Go as I Wish	Car	-10%	1.4	No Trip Scheduling Come and Go as I Wish	Car	-25%	3.6
	Available When Needed	Car	-10%		Available When Needed	Car	-25%	
9. Increase Perceived Bus Availability (Extended Hours)	Available When Needed	Bus	+25% to Car	0.9	No Trip Scheduling Come and Go as I Wish	Bus	+25% to Car	6.1%
		Bus	+25% to Car		Available When Needed	Bus	+33% to Car	
10. Increase Perceived Bus Reliability	On Time No Long Waits	Bus	+10% to Car	2.5	On Time No Long Waits	Bus	+25% to Car	5.7
		Bus	+25% to Car			Bus	+50% to Car	
11. Make Bus Environment More Pleasant	Pleasant Drivers	Bus	+10% to PPS	0	Pleasant Drivers Protected From Smoking	Bus	+10% to PPS	1.5
		Bus	+10% to PPS			Bus	+60% to Car	

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