CONSUMER-ORIENTED TRANSPORTATION SERVICE PLANNING:

CONSUMER ANALYSIS AND STRATEGIES

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ABSTRACT

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

The methodology is based on a simplified information processing model that suggests 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

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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 psychosocial changes (e.g., cultural, peer, and media influences). In order to better understand the consumer and to identify a full range of managerial strategies, the methodology directly measures each intermediate component (i.e., perceptions, feelings, preference, and situational constraints) and models their linkage to choice.

The intermediate models are used to develop diagnostic information that identifies and directs potential managerial strategies. The combined models then forecast the impact on ridership of alternative strategies. These forecasts and situational factors, such as cost, city goals, and feasibility of implementation, are then weighed in order to select strategies. Ultimately, implemented strategies must be evaluated. The chapter concludes by outlining plans for doing so in future research.

The methodology is implemented in Evanston, Illinois, a community of 80,000 people on Lake Michigan directly north to 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. The analysis in this chapter is based on responses to a 16-page questionnaire mailed to 1900 randomly selected households within Evanston (a 41 percent response rate was obtained). This chapter describes the model, the analysis, the managerial diagnostics for Evanston, the forecasts, the strategy selection, and the plans for strategy evaluation.

1. 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 may offer 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 they 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 ensures accurate input to the models of the 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:

- A model 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 importance* of perceptions and feelings as they influence consumer preferences toward transportation alternatives
- 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 thorough understanding of consumer behavior so that optimal strategies can be identified.

This chapter 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. 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.

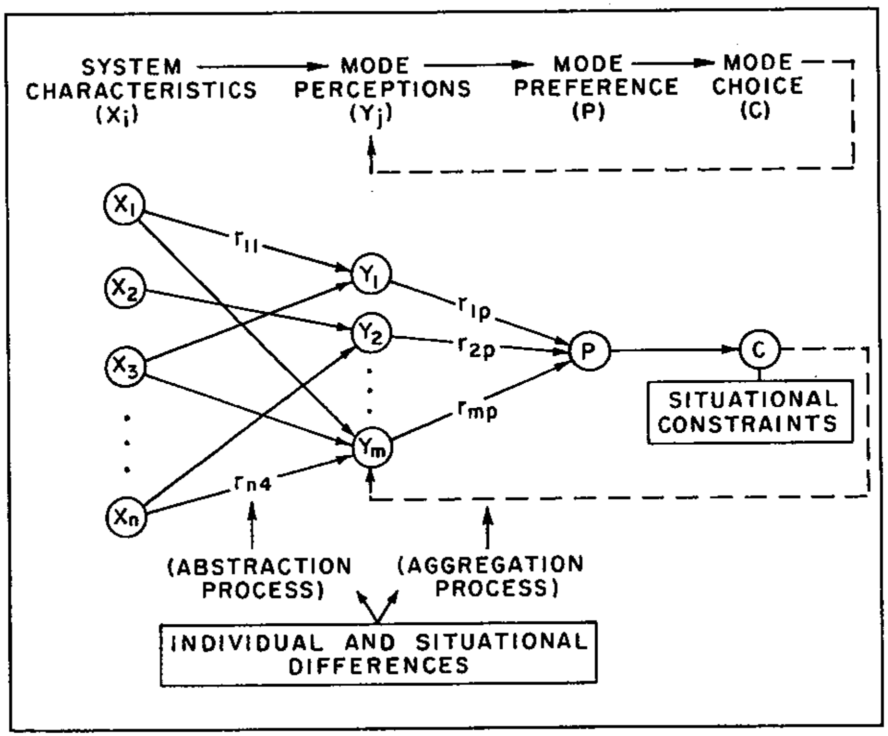
2. THEORETICAL MODEL DEVELOPMENT

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 [25, 27, 31, 33]. 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 [1, 5, 17, 26]. 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 [28, 35]. Although 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 is known as Brunswick's lens model (see Brunswick [4] and Hammond [9]). It is similar to models which have been used to describe consumer response to new products/services [8, 13, 30]. 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. Some insight on the degree of the association between these factors can be obtained by examining the simple correlations ($r_{k\ell}$). 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

Figure 1. A Model of Consumer Transportation Behavior.



and preference is represented by the second set of correlations ($r_{\ell p}$). 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 nonlinear models used? etc.) and should *not* confound these two processes by using both system characteristics and perceptions in one model predicting preference or choice, because 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 in the system 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. Some of these strategies focus on directly altering consumer perceptions, preference, or choice. Other strategies are the more 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.

3. 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 may be generalizable to other areas.

4. 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 these 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) a strategy-sensitive model of the transportation consumer's choice process; (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 the questionnaires for consumer evaluation (space and time constraints prohibited requesting individuals to evaluate all modes). In addition, a series of *focus group interviews*[2] and a literature review served to (1) generate a list of transportation service attributes important to consumers; and (2) provide "semantics" so that the questionnaire could be phrased in a language used and best understood by the consumers. Because these inputs suggested that there might be 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.

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 preanalysis. This process entailed performing 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. Based on the pretest and preanalysis the final questionnaires were developed, printed, and mailed to a random sample of the target population (1900 work/school trip, 1900 nonwork/nonschool trip to the CBD, and 950 nonwork/nonschool trip to non-CBD destinations). A follow-up postcard was sent to all consumers in the sample 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 the following: travel time, broken down by access, wait, and on-vehicle time; bus frequency during rush and nonrush 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.).

5. 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. Analysis of the other surveys indicate that the structure of the results are similar. That is, there is no significant difference in respondent demographics, and the structure, but not the parameters, of the perception, preference, and choice models is the same. Furthermore, there is no basic change in the strategies identified. Details are contained in Hauser and Wisniewski [15].

5.1. Respondents

Forty-one percent of the individuals (782 out of 1900) who received the questionnaires 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 suggests that it is reasonably representative of the Evanston population. Related surveys to a specially recruited consumer panel the following year gave similar results and suggest some stability in the consumer model.

5.2. 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 ranged from 1-5 minutes to 26-30 minutes for car and from 1-5 minutes to 56-70 minutes for bus. Car availability ranged between 0.0 autos/driver to 3.0 autos/driver; however, 97 percent had 1 or less auto/driver.

5.3. 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 ("inexpensive") and stress attributes ("fear of injury," "annoyed by others") car fares less well.

Table 1. Average Standardized Attribute Ratings[a]

Attribute rated	*Bus*	*Walk*	*Car*
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

[a] 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.

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 et al. [3]). 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. (Complicated tables such as Table 1 may provide too much information. The structure is much clearer after factor analysis.) Third, factor analysis enables the analyst to make dimensions orthogonal, thus leading to more stable coefficients when the dimensions, rather than the collinear attributes, 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 [13, 37]. Recently, in destination choice models, Koppelman and Hauser [19] gave evidence that suggests that factor analysis is superior to alternative perceptual models based on similarity scaling. Furthermore, they showed that the reduced dimensions, factor scores, can forecast as well as the detailed 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 interactions 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-dimensional solution appear in Table 2, and mode perceptions on the three dimensions are graphed in Figure 2. The three factors—which have been labeled general service and safety, convenience and accessibility, and psychological comfort—account for 45 percent of the variance in the original attribute ratings. This is consistent with previous studies of this nature [see Refs. 11, 13, 38].

Because 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).

5.4. Description of Feelings About Modes (Perceptions of Factors other than Mode Attributes)

In an effort to determine whether psychological or perceptual factors other than evaluation of mode attributes influence transportation preference and choice, a variety of nonattribute 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 belief, etc.) was measured by a small number of questions per mode, and therefore these measures were likely to be unstable if

Table 2. Three-factor Analysis of 24 Attribute Ratings for Bus, Walk, and Car[a,b]

Attributes rated	*Factor 1*	*Factor 2*	*Factor 3*
On time	*.57*	.40	−.08
No trip scheduling necessary	.26	.27	−.27
Relaxing	*.48*	.14	.26
Correct temperature	*.58*	.01	.11
No worry of assault	*.48*	.00	.30
Can come and go as I wish	.25	*.68*	−.04
Errands take little time	*.68*	.29	−.08
No worry about injury	.18	−.07	*.47*
Know how to get around	.09	.33	.20
Little effort involved	*.69*	.09	.21
Available when needed	.02	*.67*	.09
Not made uncomfortable by others	.06	.22	*.54*
No problems in bad weather	*.62*	−.03	.14
Pleasant drivers or other personnel	.06	.09	.33
Get to destination quickly	*.77*	.16	−.03
Protected from smoking	.12	.38	.04
Safe at night	*.62*	.00	.10
Not annoyed by others	.04	.12	*.51*
No long waits	.16	*.64*	−.03
Easily carry packages	*.71*	.13	−.08
Easy to travel with small children	*.59*	.06	−.08
Not tiring	*.77*	−.00	.19
Easy getting in and out	−.15	*.51*	.29
Easy walk access	−.12	*.48*	.28

[a] Factor interpretation: Factor 1, general service and safety; Factor 2, convenience and accessibility; Factor 3, psychological comfort.
[b] Italic numbers represent high loadings on each of the factors.

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 percent of the variance in the original set of questions.

(Because of the way in which attribute perceptions and feelings were measured—each attribute was measured for each mode, while each feeling scale was specific to one mode—we could not develop joint factor structures. Such joint structures represent an area of future research which could improve our understanding of the transportation consumer. Note that in joint structures, attribute factors and feelings factors would be orthogonal.)

5.5. Preference and Choice

First preference was clearly dominated by car (71 percent stated car as their first preference), while bus did well in terms of second preference (58 percent stated bus was their second preference). Consistent with the preference ratings, 72 percent used car for their most recent trip (16 percent walked and 12 percent used the bus). Cross-tabulation of first preference and choice data indicate that the vast majority of respondents (76 percent) used their most preferred mode. However, it is interesting to note that a significant number of individuals (24 percent) did not choose their most preferred mode, perhaps due to situational constraints such as availability for the most recent trip. 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 general service and convenience/accessibility. Alternatively, we can focus on modifying situational constraints.

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

Figure 2. Consumer Perception of Alternate Modes.

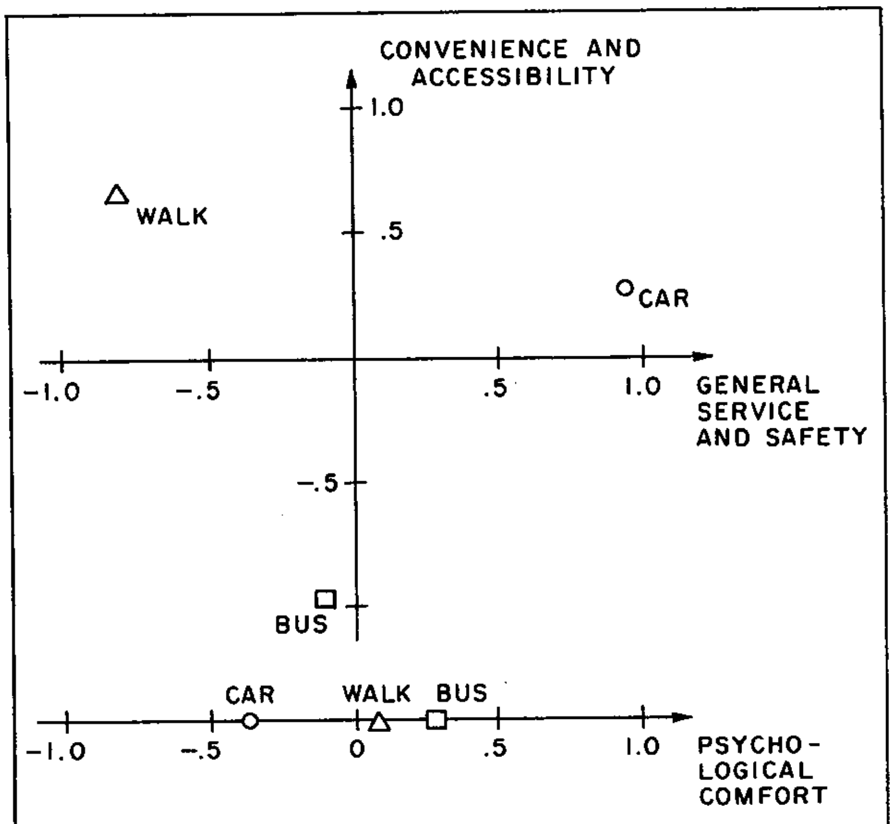


Table 3. Factor Loadings for Mode Feelings[a]

	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	*.71*	−.13
Enjoy travel by foot	*.82*	.07	−.04
Depressing to travel by car	.11	−.06	*.76*
Depressing to travel by bus	.04	*−.53*	.41
Depressing to travel by foot	*−.67*	−.11	.31
Peers surprised if ride bus regularly	−.08	*−.52*	−.06
Ought to travel by car	*−.45*	−.19	−.38
Ought to travel by bus	.01	*.52*	.16
Ought to travel by foot	*.75*	−.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	*.69*	.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 a lot	*−.66*	−.11	−.11
If bus fares lower, more trips by bus	.09	*.61*	.35
If bus fares lower, fewer trips by car	.06	*.59*	.34
If bus ran more often, more bus trips	.21	*.40*	.27
Would travel by car regardless of cost	−.40	−.39	−.40
Would travel by bus even if long walk	.12	*.50*	.11
If parking cost doubled would walk	*.44*	.04	.21
Willing to car pool some trips	.06	.09	.00

[a] Italic numbers represent high loadings on each of the factors.

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," because 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 perceptions 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 longer 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 these 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.

6. 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. We examine the correlation matrix as an initial indicator of linear relationships. If the data is consistent with the model, we have more mode faith in the model; if the data is inconsistent, then we must question the data, the model, or the linearity of the relationships.

6.1. 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 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 with preference ($r = .20$). Furthermore, as expected, autos per driver also is 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 conditions are met. The

Table 4. Correlation Matrix

	System characteristics				Perceptions			Feelings			Constraints	
Variable	*TT*	*Blocks*	*Seats*	*Cost*	*GS*	*C/A*	*PC*	*BF*	*WF*	*CF*	*APD*	*P*
Travel time (TT)												
Blocks to bus stop	.05*											
Bus seat availability	−.09	.01*										
Cost	−.25	.04*	−.11									
General service (GS)	−.51	−.07*	.22	.41								
Convenience/accessibility (C/A)	−.07	−.19	.14	−.06	.04							
Psychological comfort (PC)	−.01*	−.14	.28	−.30	.03*	.04*						
Pro-Bus feelings (BF)	−.18	−.03*	.09	.13	.48	.32	.26	—				
Pro-Walk feelings (WF)	−.41	—	—	−.24	.60	.26	.19	—	—			
Pro-Car feelings (CF)	−.11	—	—	−.13	.32	.13	.25	—	—	—		
Autos per driver (APD)	.05	—	—	.00*	−.01*	.26	.03*	—	—	+.09		
Preference (P)	−.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.

intercorrelations between these variables are low due to the factor analysis and they are highly related to preference and choice (especially general service and convenience/accessibility).

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. Further, 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.

Finally, preference and situational constraints are viewed as the determinants of 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.

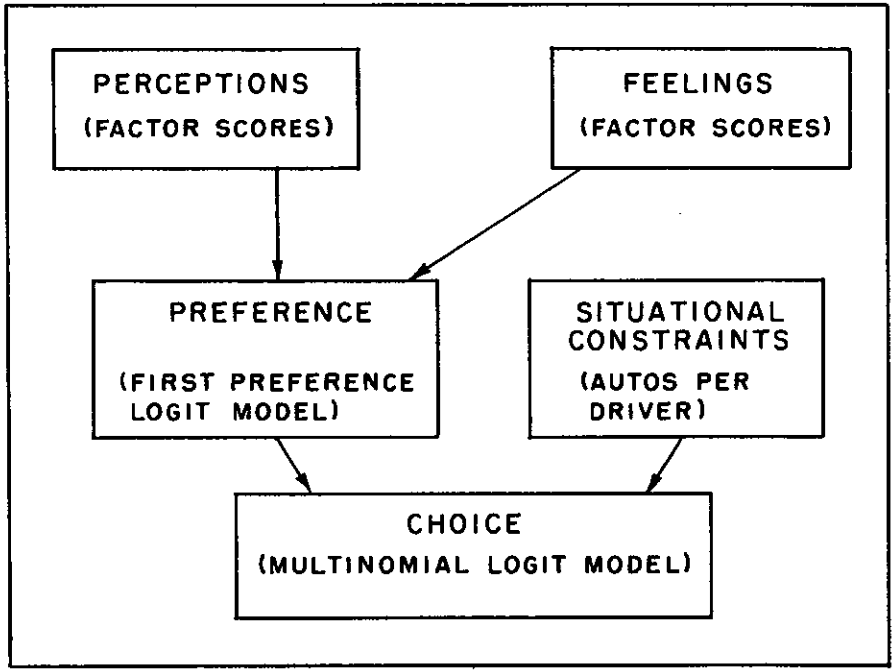
6.2. Model Components

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 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 that 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 that uses first preference as the dependent variable [26]. Finally, the preference index that is developed and the situational constraint (autos per driver) are used as explanatory variables in a multinomial logit model that uses choice as the dependent variable. The equations are summarized in Table 5.

6.3. Preference Models

First-preference logit was used to statistically estimate the importance weights (w_k's and v_m's) that relate the perceptions and feelings to preference. These models, which are presented in Table 6, are summarized below. The numbers

Figure 3. Model Components.



reported are relative weights normalized so that their absolute values sum to 100 percent.

In model 1, the cognitive dimensions (factor scores) 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 percent) or an equally likely model (33.3

Table 5. Summary of Model Equations

Perceptions

$$x_{imk} = \sum_{l=1}^{25} f_{kl} y_{iml}$$

Feelings

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

Preference

$$PI_{im} = \sum_{k=1}^{3} w_k x_{imk} + \sum_{n=1}^{3} v_m F_{im} \delta_m + \sum_{m=1}^{2} u_m \delta_m$$

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

Choice

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

where

y_{iml} = individual i's rating of mode m on attribute l
z_{in} = individual i's rating of feeling measure n
f_{kl} = 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 = relative importance of the k^{th} perceptual dimension
v_m = relative importance of the feelings toward the m^{th} mode
u_m = constant for the m^{th} mode—used to ensure consistent estimates of w_k and v_m
δ_m = indicator variable $\{\delta_m = 1$ for mode m, $\delta_m = 0$ otherwise$\}$
PI_{im} = individual i's preferenceindex 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

Table 6. Preference Models

Variable name	Relative importance weights[a] 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
Percent correctly predicted	79.5	80.1
Information (%)	54.2	58.1
χ^2 statistic	527.6	565.7

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

percent). The information measure reported gives the percent of uncertainty (entropy) explained. This measure is an information theoretic interpretation [10] of the pseudo-R^2 measure [26]. Similar models were developed to predict rank preference using a rank logit model [24]. The rank ordering of variables and interpretation were the same.

Because 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 that most influence preference are "general service and safety" and "convenience and accessibility." Thus, strategies that 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, because 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.

6.4 Choice Models

Because 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 [26] 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 preference rather than preference revealed by choice. Our 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. Because the revealed preference model has more "degrees of freedom" in the choice model, 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. (In both models the dependent measure is choice. In the revealed preference model the independent variables are three perceptions, three feelings, autos per driver, and two mode-specific constants. In the preference index model the independent variables are only the preference index and autos per driver. Thus the revealed preference model has 9 degrees of freedom versus 2 degrees of freedom for the preference index model.) Both models, reported in Table 7, do extremely well compared to a random model (33 percent correctly predicted, 0 percent information) and a model that assigns consumers' mode choice probability in proportion to market shares (56 percent correctly predicted, 29 percent information).

Table 7. Choice Models

	*Relative importance weights**	
	"Revealed preference model"[a]	*"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
Percent correctly predicted	79.5	78.0
Information (%)	52.3	50.4
χ^2 statistic	481.6	464.1

[a] These normalized importance weights are obtained from a logit model including two alternative-specific constants.
*All coefficients except those starred are significant at the .05 level.

The revealed preference model fits the data significantly better than the preference index model at the 2.5 percent level. However, it does obtain a counterintuitive (negative) but not significant weight for psychological comfort and nonsignificant 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.[5] The preference index model also provides better managerial insight than the revealed preference model because 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.

6.5. 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 then 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 then 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 then 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 because 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 [18] for significant differences in preference ranking. Table 8 summarizes the results of this directed search. 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 because each of the last four variables contained an overwhelmingly large proportion of the observations in one of the two segments, making estimation of choice models infeasible. 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 passed these tests. For example, Table 9 reports a segmentation test for age. There is some variation 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 [13] could find no significant difference in preference for health care delivery services.)

The potential segments next were 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

Table 8. Potential Segmentation Variables[a]

	Category			
Variable	*(1)*	*(2)*	*(3)*	*Significance**
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

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

[a] Nonsignificant variables were sex, number of blocks to nearest bus stop, and intermediate stop on trip.

Table 9. Test of Preference Segmentation Using Age as an Example

	Relative importance weights[a]			
Variable name	*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[b]	565.7	164.2	314.7	110.2

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

[a] These importance weights are obtained from first preference logit models which include alternative-specific constants.

[b] χ^2_{18} for segmentation = (164.2 + 314.7 + 110.2) − 565.7 = 23.4 (nonsignificant at the .05 level).

and subjected to similar tests of significance. In this case, significant improvements were identified for each of the four classifications tested. Although 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,[6] 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 that constrain auto availability, such as restricted parking or high auto registration fees, 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.

6.6. Summary

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

7. 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 that 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 microrelationships such as the probable increase in perceived bus frequency resulting from published and posted bus schedules. These judgments are easier to make and usually are more accurate than judgments about the total process (e.g. the probable increase in overall ridership that would result from distribution of bus schedule information). Specific procedures to enhance the accuracy of the required managerial judgments will be discussed in Section 8. At this point, it is sufficient to note that reasonably accurate ranges of probable impacts can be forecast for the various strategies

Table 10. Significance of Autos per Driver (APD) for Different Segments

Variable	*Information*	*Category*	*Percent of sample*	*APD significant*
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

identified below. (Hauser and Urban [13] report good experience in a variety of product and service categories.)

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.

7.1. 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 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 also may 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 because 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, and so on 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.

7.2. Model Diagnostics

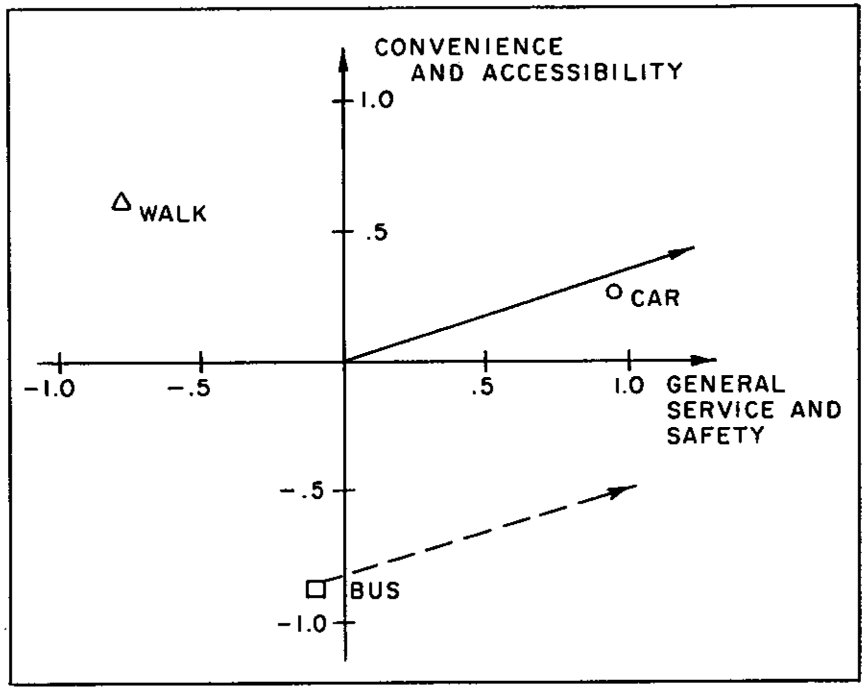
We look first at the perceptual map in Figure 2. Relative to the other modes, bus does very poorly on convenience/accessibility, and relative to car, bus does poorly on general service. These poor perceptions of bus could be due to accurate perceptions of what is poor service or misperceptions of good 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 dashed 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, 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 within Evanston, but must consider the possibility that such a strategy will divert trips to destinations outside 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

Figure 4. Strategy to Improve Perceptions of Bus.



are correlated with each perceptual variable and we examine Table 2 to identify which attributes compose each perceptual variable.

7.3. 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 that 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 italicized. Similarly, the attributes that 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 [36] 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 that 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 [2] 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 busses); 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 ridership. All noninformation strategies have to be used in combination with an information

Table 11. Strategies

Desired effect	*Potential strategies*
Increase perceptions of bus on "general service and safety"	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 "safety at night" through on vehicle radios or lighting
Increase perceptions of bus on "convenience and accessibility"	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"	Advertising or direct mail to persuade consumers of the importance of getting to one's destination without being hassled
Decrease auto availability	Increase parking fees Increase vehicle tax Decrease on street parking

campaign to insure maximum effectiveness. That is, if express buses are introduced, this strategy has to be communicated to the public to be effective.

8. 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. Section 9 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.

8.1. 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 [20]. In that study of how mathematical models were used for decision support, Little found that judgmental inputs supplemented by quantitative models often are 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 strategies because 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 [23] 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 [22] use the method for media scheduling. Lodish [23] reports dramatic improvements in sales force allocation. In more related models, Hauser and Urban [13] use perception, preference, and choice models similar to those described in this chapter to accurately forecast the effect of testimonials and changes in hospital affiliation on MIT's health maintenance organizations. (Strategies increased enrollment 50 percent and are tracking on schedule.) Silk and Urban [34] have been consistently within 1 percentage point on their predictions of the market share of new frequently purchased products, and Little [21] 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 [38] and Hauser and Shugan [12].

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.

8.2. 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 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 chapter. We use decision calculus to make the judgments indicated by the dotted arrows in Figure 6, while the solid arrows represent analytic models.

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 or 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'

Figure 5. Components of Prediction.

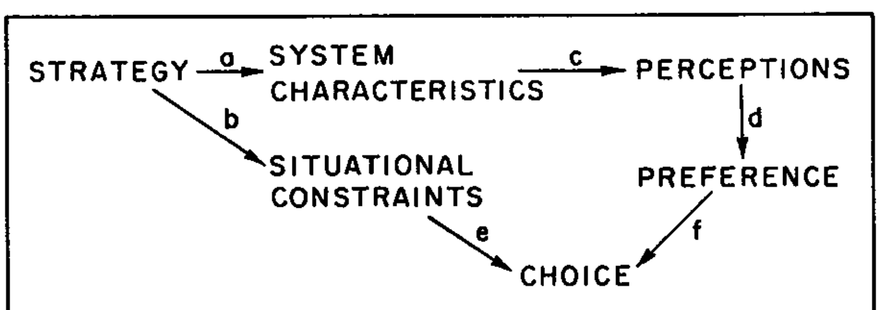
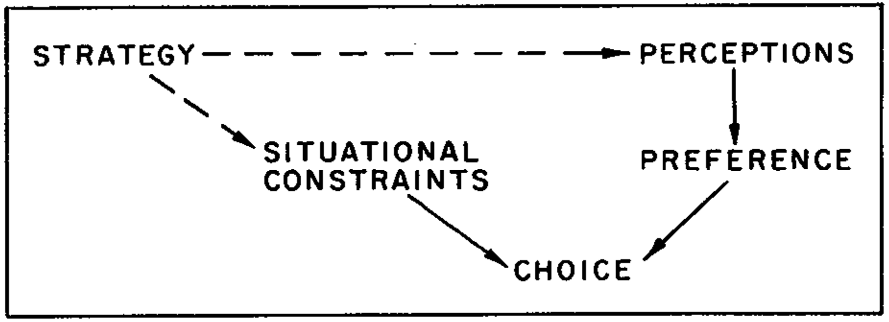


Figure 6. Decision Calculus Prediction.



ratings of bus only on the attribute scale "know how to get around." We believe that the ratings will increase by about 50 percent 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.

8.3. 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 (dashed 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 one-tenth the difference in perception between bus and car, but no more than one-half the difference. The most likely impact might be to increase bus perceptions one-fifth 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 (one-fifth the difference) would increase his or her perception of bus to .12.

Because 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.

Table 12. Sample Computer Output for Strategy Change[a]

```
COTSP 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
  X/X/X/X
? 1 0 0 0
TYPE ATTRIBUTES DATA CHANGES
TYPE STOP TO END CHANGES, NEXT TO ENTER CHANGES TO NEXT VARIABLE TYPE
  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, OP3, 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

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.
```

[a] All user input is preceded by "?"

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 privately 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.

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

8.4. Results

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

Table 13. Average Standardized Attribute Ratings

Attribute	*Bus*	*Walk*	*Car*	*PPS*	*BTP*
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

Table 14. Forecasts of Strategy Impacts

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

strategy on one or more attributes, feelings, or situational measures. The range indicates both pessimistic and optimistic estimates. This chapter's appendix gives the detailed judgments that produced these estimates.

9. STRATEGY SELECTION

The primary thrust of our 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. But the practicalities of implementation require 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 [6, 16], 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. Because 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.

9.1. 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 the 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).

9.2. Consistency with City Goals

Although the impact of various strategies on bus ridership is a primary factor in strategy selection, 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 that 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.

9.3. 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 (one to two 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.

9.4. 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 a reasonable time frame. Other strategies, such as the introduction of a new paratransit system, may take three to five 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.

9.5. 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 that 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 because 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.
2. The strategy must not be inconsistent with city goals. Thus, strategies that 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 that 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 that 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 to 7.6 percent). This is problematic because 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 because 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

Table 15. Strategy Selection Matrix

Strategy	*Forecasted increase in bus ridership*	*Cost*	*City goals*	*Situational contraints*	*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 stops signs with information on them	0.2% to 5.8%	Low	Consistent	Can't erect during winter months	Feasible as in entry 1
3. Increase bus frequency; add 1 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 entry 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 entry 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 entry 1, but difficult to implement within a reasonable time frame
6. Make bus more relaxing	0.7% to 2.2%	Moderate-high	Consistent, but low priority	Might require equipment changes that would take	Feasible as in entry 1

				more than 6 months	
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 entry 1, but not within a reasonable time frame
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 entry 1, but difficult to implement within a reasonable time frame
10. Increase perceived bus reliability	2.5% to 5.7%	Low	Consistent	None	Feasible as in entry 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 entry 8

strategies, it requires sacrificing the ability to separate the effects of route maps and schedules, bus stop signs, and improved perceptions of reliability. In Section 10, the program for evaluating this strategy is outlined.[7]

10. 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.

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) will be collected so the effects of these factors can be identified in the analysis. In addition, bus ridership data for one or more nonequivalent 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 should enable us to rule out most plausible rival hypotheses (i.e., nonstrategy hypotheses) for any effect observed.

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 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. *Before-after consumer surveys.* Surveys of separate random samples of Evanston residents will be conducted prior to and at several times following

implementation of the strategy. These surveys will provide self-reported data on consumers' knowledge, perceptions, preferences and ridership of the bus system.

The impact of the strategy will be determined by examining any change in these variables following implementations of the strategy. In addition, direct measures of strategy awareness and utility will be included in the post-strategy surveys.

11. SUMMARY

This chapter summarizes the results of our consumer-oriented transportation service planning model. 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 percent 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.

Research which will provide a more stringent test of our model and methodology is now being conducted. 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.

Postscript. Since the writing of this chapter, the bus information strategy has been implemented and evaluated as planned. Overall, this process provided strong support for the model. The predicted changes in consumer knowledge, perceptions, and ridership of the bus were observed. These changes only were

Table 16. Estimates of Strategy Impacts on Perceptions of Transportation

	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 (%)*
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	7.6
					Know how to get around	Bus	+50% to car	
					No long waits	Bus	+50% to car	
					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	5.8
					Know how to get around	Bus	+33% to car	
					No long waits	Bus	+25% to car	
					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	19.3
					No need to schedule	Bus	+33% to car	
					Come and go as I wish	Bus	+25% to car	
					Errands take little time	Bus	+33% to car	
					Get to destination quickly	Bus	+100% to PPS	
					Not tiring	Bus	+33% to BTP	
4. Add bus shelters	Know how to get around	Bus	+25% to car	2.1	Know how to get around	Bus	+33% to car	4.1
	No problems in bad weather	Bus	+50% to car		No problems in bad weather	Bus	+50% to car	
	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	0.7	Relaxing	Bus	+50% to walk	2.2
					Not annoyed by others	Bus	+100% to walk	
	Not tiring	Bus	+10% to car		Not tiring	Bus	+50% to car	
7. Constrain auto availability	Autos per driver	Car	−10%	3.8	Autos per driver	Car	−50%	20.8
8. Reduce perception of auto availability	No trip scheduling	Car	−10%	1.4	No trip scheduling	Car	−25%	3.6
	Come and go as I wish	Car	−10%		Come and go as I wish	Car	−25%	
	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	Bus	+25% to car	6.1%
					Come and go as I wish	Bus	+33% to car	
					Available when needed	Bus	+33% to car	
10. Increase perceived bus reliability	On time	Bus	+10% to car	2.5	On time	Bus	+25% to car	5.7
	No long waits	Bus	+25% to car		No long waits	Bus	+50% to car	
11. Make bus environment more pleasant	Pleasant drivers	Bus	+10% to PPS	0	Pleasant drivers	Bus	+10% to PPS	1.5
					Protected from smoking	Bus	+60% to car	

found in the short run, however. Details of the implementation and evaluation appear in, A. M. Tybout and F. S. Koppelman "Consumer Oriented Transportation Service: Modification and Evaluation," Final Report on U.S.D.O.T. Contract DOT-05-70062.

APPENDIX

The preceding 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. Table 16 identifies the estimates of strategy impacts on perceptions of transportation. 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 percent; 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 percent to car.

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NOTES

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

2. Focus group interviews are open discussions by six to ten consumers led by a trained moderator focused on a particular topic—in this case, transportation in Evanston.

3. Historically, 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 [29], personal normative beliefs (an individual's perception of what he or she ought to do—see Fishbein, 1972 [7]), social normative beliefs (an individual's perception of what others want him or her to do—see Fishbein, 1972 [7]), and level of commitment (how easily the individual's intended behavior is influenced by unanticipated events—see Wicker, 1971 [39]), have been demonstrated to influence

behavior. These elements have been included in our questionaire so that their contribution to the explanation of transportation behavior can be examined.

4. Factor 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 [32].) Similar results are obtained from principal components analysis.

5. Later analyses on the non-CBD data sets provided stronger support for the conceptual model.

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

7. Some 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.

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