REPORT NO. DOT-TSC-RSPA-78-14, III

ON THE DEVELOPMENT OF A THEORY OF TRAVELER ATTITUDE-BEHAVIOR INTERRELATIONSHIPS
Volume III: Executive Summary; Overview of Methods, Results, and Conclusions

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FINAL REPORT

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Washington DC 20590

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16. Abstract

The executive summary of this Final Report offers an overview of methods, results, and conclusions which support the development of a theory of traveler attitude-behavior interrelationships. Such a theory will be useful in the design of transport systems and operating policies which satisfy passenger requirements. A summary of project methods and achievements as evidenced by project reports serves as an introduction of theoretical considerations which guided the study. Various attitudinal components are identified and defined. Brief discussions of multiattribute models, hierarchical models, market segmentation, and structural equations are offered as a basis for appreciating theoretical and emperical findings. Selected findings are presented to clarify the nature of traveler attitude-behavior interrelationships. The relevance of study findings to traveler behavior theory and transport policy analysis is noted at the close of the executive summary.

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PREFACE

This research was funded through the Transportation Systems Center under contract DOT-TSC-1326. We are grateful to Drs. Joseph Dumas and Donald Sussman, both of the Transportation Systems Center, whose contributions to the project were based on their expertise in psychology and transportation. Moreover, their managerial approach was sensitive to the demands of this complex research efforts.

Our research has also been significantly aided by the contribution of three attitudinal transportation datasets. The Federal Highway Administration graciously made the Los Angeles, Santa Monica Freeway, 1976 dataset available for our modeling purposes. Dr. Abraham Horowitz from the Transportation and Urban Analysis Department of General Motors Research Laboratories made possible the contribution of the Chicago Ridesharing dataset for application in our research. Dr. Christopher Lovelock of the Harvard Business School kindly offered his San Francisco Transportation survey results for our use in the performance of this research.

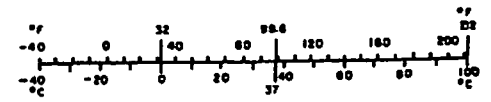
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Introduction

Despite an abundance of research on attitudes toward transportation systems,[1] there is no widely accepted theory of traveler behavior which incorporates traveler attitudes and allows specific predictions about the effects of changes in transportation systems. This has hindered attempts by transportation system designers to make cost-effective tradeoffs between system attributes. This project analyzed theories of traveler attitude-behavior interrelationships in an effort to understand the relationship between perceptions of system attributes and traveler satisfaction and behavior. The research derived techniques for quantifying attitudes and their interrelationships, and tested alternative theories. The theoretical development was oriented toward providing useful tools for transportation policy evaluation.

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[1]M. Wachs, "Consumer Attitudes Toward Transit Service: An Interpretive Review," *AIP Journal* 42 (1976): 96-103.

Project Overview

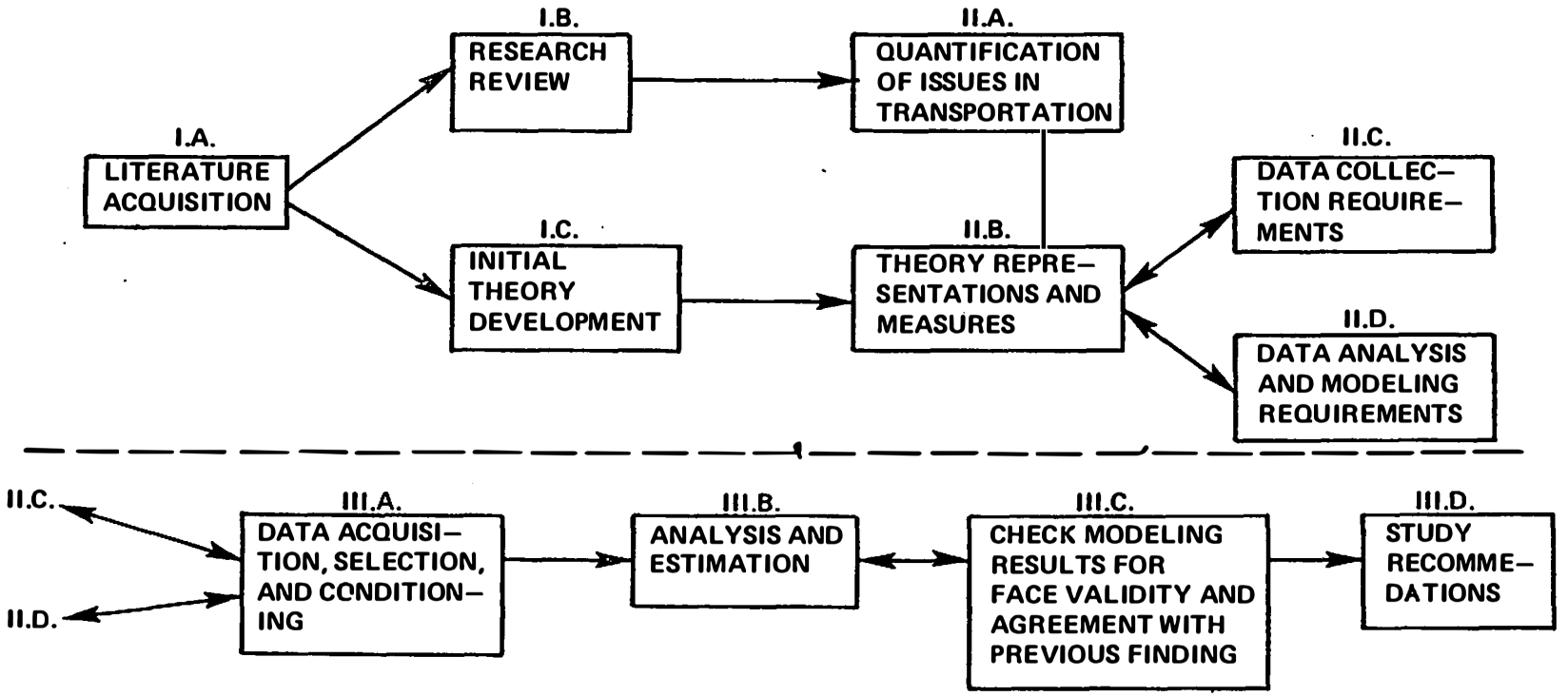
The three principal components of the study include a literature review, the initial theory development, and an empirical validation. The literature review and acquisition component surveyed modeling concepts, principles of consumer and traveler behavior, and statistical methodology. This background research supported initial model specifications and identified quantitative methods suitable for their estimation. While our modeling orientation was cognizant of the state of the art, it went beyond it in several important respects. The literature review also determined which datasets were available for testing alternative model specifications. These empirical tests were conducted to develop a basic knowledge of traveler behavior which would facilitate transport analysis and policy-making. Figure 1 shows an overview of the activities undertaken during the project.

Task 1 included literature acquisition, review and preliminary steps toward theory development. The literature review addressed such diverse areas as marketing research, social psychology, economics, statistics, sociology, transportation engineering, sampling theory and urban planning. We reviewed an item if it was relevant to the project and if it pertained to one of three topics: attitudinal studies, behavioral travel research and policy analysis, and model estimation and data collection procedures. Concepts from the attitudinal literature provided the substance for a theory, and the travel research and policy analysis literature indicated potential contexts for the theory's implementation and testing. The model estimation and data collection literature provided techniques for quantifying and validating theoretical formulations.

The second task involved refining theoretical formulations and identifying data issues. The theoretical concepts reviewed in Task 1 were organized to improve the understanding of traveler behavior. These, in turn, raised data issues with respect to dataset availability and model estimation procedures.

Figure 1

FLOWCHART OF STUDY DESIGN



Task 3 was primarily concerned with empirical analysis, undertaken to evaluate alternative theoretical propositions. A major effort in this task was an inventory of travel attitude-behavior datasets. To test model specifications, validation was performed by comparing estimated models among themselves and to prior theoretical and empirical findings. The result was an acceptable theory of traveler attitude-behavior interrelationships.

Project Reports

This research has been documented in a series of interim reports. The final report, including this Executive Summary, is a recompilation and extension of the earlier documents. A brief summary of each of the five interim reports and of the other two volumes of the final report follows.

Literature Taxonomy

This preliminary report organized a total of 316 books, articles and reports into critical areas of interest.[1] Pertinent literature was collected from the areas of consumer research, market research, and transportation analysis.

Interim Report #1

The first interim report documented initial theory formulations arising from the preliminary literature review.[2] This manuscript indicated the theoretical perspectives on attitude-behavior interrelationships which were used in the rest of the research effort.

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[1]Charles River Associates, *A Taxonomy of Attitude-Behavior Literature for Transportation Analysis* (Cambridge, Mass.: CRA, 1977).

[2]Charles River Associates, *Theoretical Perspectives on Attitude-Behavior Interrelationships in Transport Analysis* (Cambridge, Mass.: CRA, 1977).

Interim Report #2

This report provided an inventory of extant attitudinal transportation datasets.[1] The inventory indicated the potential resource materials which could be used to evaluate alternative model specifications.

Interim Report #3

Following a summary of the modeling orientation, the third interim report presented the empirical results of alternative model specifications.[2] Findings were reported for bus and carpool usage on three attitudinal datasets. In addition, we estimated models for alternative traveler segments. This report included the dataset questionnaires and coding practice.

Interim Report #4

The final interim report presented detailed theoretical findings of the research effort.[3] Theoretical and research extensions arising from the empirical and theoretical stages were indicated.

Final Report, Volume I

The first volume of the final report discusses the project's literature review.[4] The central focus is to develop the modeling orientation. This volume includes an expanded transportation dataset inventory.

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[1]Charles River Associates, *A Data Inventory Report for the Development of a Theory of Users' Attitudes Toward Transportation Systems* (Cambridge, Mass.: CRA, 1977).

[2]Charles River Associates, *Traveler Attitude-Behavior Interrelationships: Some Empirical Analyses* (Cambridge, Mass.: CRA, 1978).

[3]Charles River Associates, *Towards a Theory of Traveler Attitude-Behavior Interrelationships* (Cambridge, Mass., CRA, 1978).

[4]Charles River Associates, *On the Development of a Theory of Traveler Attitude-Behavior Interrelationships*, Volume I (Cambridge, Mass.: CRA 1978).

Final Report, Volume II

This volume begins with the empirical methodology and a description of the datasets.[1] The empirical and theoretical research results are presented with respect to attitude-behavior interrelations and market segmentation. A new hypothesis testing approach to market segmentation is implemented in this report. The potential implications of findings as well as the theoretical and research extensions are indicated.

Modeling Traveler Behavior With Attitudes

Attitudes are known to be correlated with traveler behavior and sociodemographic characteristics.[2] There is an emerging interest in whether attitudes are determinants of traveler patterns or whether traveler behavior causes attitudes.[3] The

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[1]Charles River Associates, *On the Development of a Theory of Traveler Attitude-Behavior Interrelationships*, Volume II (Cambridge, Mass.: CRA, 1978).

[2]W. W. Recker and T. Golob, "An Attitudinal Modal Choice Model," *Transportation Research* 10 (1976): 299-310; D. T. Hartgen and H. Tanner, "Individual Attitudes and Family Activities," *High Speed Ground Transportation Journal* 4 (1970): 329-467; A. D. Horowitz and J. N. Sheth, "Ridesharing to Work: A Psychosocial Analysis," in *Predicting Carpool Demand*, Transportation Research Board Special Report, in press; R. Dobson and M. L. Tischer, "Beliefs about Buses, Carpools and Single Occupant Autos: A Market Segmentation Approach," *Transportation Research Forum Proceedings* 17 (1976): 200-209; and C. H. Lovelock, *Consumer-Oriented Approaches to Marketing Urban Transit*, Ph.D. dissertation, Stanford University (Springfield, Virginia: National Technical Information Service, PB 220 781, 1973).

[3]R. Dobson, F. Dunbar, C. J. Smith, D. Reibstein and C. Lovelock, "Structural Models for the Analysis of Traveler Attitude-Behavior Relationships," presented at the 1978 Transportation Research Board meeting; T. F. Golob, A. S. Horowitz and M. Wachs, "Attitude Behavior Relationships in Travel Demand Modeling," in D. A. Hensher and P. R. Stopher (eds.), *Behavioral Travel Modelling* (London: Croom Helm, 1978); and C. H. Lovelock, "A Market Segmentation Approach to Transit Planning, Modeling, and Management," *Transportation Research Forum Proceedings* 16: 247-258.

latter issue is important because if attitudes cause behavior, then mode choice can be influenced by changing traveler viewpoints toward public transit, carpools, and single-occupant autos. By studying consumer preferences for transit attributes, for example, it is possible to specify one or more mixes of comfort, convenience, and safety which optimize consumer satisfaction within given cost constraints. A modeling framework can be developed which links subjective reactions to objective system features.

Even if attitudes do not determine behavior, they can still be used in a number of transportation policy and planning contexts, such as the identification of perceived user benefits. In order to determine the proper role for attitude research in transport analysis, it is essential to determine the nature of the interrelationships between traveler attitudes and traveler behavior. We use structural equations and flowgraphs to model these interrelationships.

Definition of Attitudinal Components

It is important to clarify what is meant by attitudes, since the term has been rather loosely used by transportation researchers.[1] Structuring attitudes into the following three components has widespread acceptance among social psychologists: cognitions, feelings, and behavioral intentions.[2] However, there is much controversy about the relationships among these components.

The "cognitive" or "perceptual" components represent a person's information about a tangible or intangible object.

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[1]M. D. Stearns, *Proceedings: TSC Workshop on Attitudinal Surveys for Transportation Planning and Evaluations*, UMTA Report No. 06-0049 -- 75 -- 1 (Washington, D.C.: U.S. Department of Transportation, November 1975).

[2]G. S. Day, "Theories of Structure and Change," in S. Ward and T. S. Robertson (eds.), *Consumer Behavior: Theoretical Sources* (Englewood Cliffs, N.J.: Prentice Hall, 1973).

Each piece of information can be broadly classified as either a belief in the existence of an object (awareness) or an evaluative belief about an object (perceptions or comparative judgments of specific attributes). The "affective" or "feeling" component deals with the person's overall feelings of like or dislike for an object, such as a bus. Affective (preference) judgments may be said to combine information about product evaluation and the individual's "ideal" product. Lastly, the "conative" or "intentions" component refers to the person's own behavioral intentions concerning the product. Such intentions are usually limited to a finite time period that depends on the prospective user's habits or planning horizon.

Three Modeling Perspectives

Three modeling perspectives from social psychology and marketing research have been merged and extended to form the basis of our approach to modeling traveler behavior with attitudes. Multiattribute models help us to appreciate the multiple determinants of traveler behavior. While multiattribute models highlight interrelationships among different kinds of perceptions, hierarchical models focus on interrelationships among different kinds of attitudinal components and behavior. The market segmentation approach recognizes that there may be differences among travelers in their perceptions or the interrelationships among attitudinal concepts and behavior.

Multiattribute Models

Rosenberg and Fishbein have asserted that liking an object, such as a bus, is a function of perceptions about the attributes of the object and the importance of those attributes to individuals.[1] The functional relationship between preference for an

[1]M. J. Rosenberg, "Cognitive Structure and Attitudinal Affect," *Journal of Abnormal Social Psychology* 53 (1956): 367-372; M. Fishbein, "An Investigation of the Relationships Between Beliefs About an Object and the Attitudes Towards that Object," *Human Relations* 16 (1963): 233-240.

object and attribute perceptions and importances is frequently assumed to be linear and additive.[1]

Beliefs pertain to object attributes. In the case of buses these attributes may include, but are not limited to, perceptions of bus comfort and convenience. The degree to which a bus is liked depends on whether it is perceived as possessing these and other relevant attributes, as well as how important the set of relevant attributes is to a consumer. Some attributes may be very important and yet not influence consumer preference because the traveler does not believe the bus to possess those attributes. Alternatively, buses may be very high on an attribute (e.g., low cost), but they may not be liked. In the latter case, multi-attribute models presume that consumers simply do not believe that the attribute is important.

While multiattribute models are known to correlate with consumer preference, their chief value to consumer research is in the area of diagnosis, not prediction. Aggregate measures such as satisfaction with the product and consumer purchase or usage intentions perform better than measurements of beliefs as predictors of buyer behavior.[2] However, these aggregate measures of consumer attitudes (i.e., satisfaction and usage intentions) fail to reveal the relative significance of product attributes as determinants of consumer preference. Furthermore, policy implications largely emerge from an understanding of those factors which can be adjusted to change consumer preference and behavior.

Hierarchical Models

Some behavioral theorists have suggested that several attitudinal constructs feed into one another before they ultimately influence behavior.[3] Typically, three attitudinal

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[1]W. L. Wilkie and E. A. Pessemier, "Issues in Marketing's Use of Multi-Attribute Models," *Journal of Marketing Research* 10 (1973): 428-441.

[2]J. N. Sheth, "A Field Study of Attitude Structure and the Attitude-Behavior Relationship," in J. N. Sheth (ed.), *Models of Buyer Behavior*, (New York: Harper and Row, 1974).

[3]R. J. Lavidge and G. A. Steiner, "A Model for Predictive Measurements of Advertising Effectiveness," *Journal of Marketing* 24 (October 1961): 59-62.

concepts are differentiated: cognition, affect and conation. Cognitions can be thought of as beliefs about product attributes, and affect is analogous to consumer preference or satisfaction with a product or service. It is often argued in hierarchical models that affect towards a service is a function of cognitions about that service. This is compatible with the multiattribute models mentioned above. Conation, specifically consumer purchase or usage intention, is viewed as being dependent on affect towards a product. Hierarchical models are structured as they are because it is presumed that cognitions and affect do not influence behavior directly; instead these models presume that cognitions and affect influence behavior through their position in the hierarchy, which has the structure: cognition-affect-conation-behavior.

Ramond discusses three variations of the basic hierarchical model which have been used in advertising research.[1] He names them "Learn-Feel-Do," "Learn-Do-Feel," and "Do-Feel-Learn." The "Learn" element, which denotes the cognitive element, refers to how and by what degree a consumer becomes aware of product attributes. The "Feel" component represents affect and describes whether consumers like or dislike the product. Behavior towards a product is expressed by the "Do" component of his hierarchical chains. The last two hierarchies are appropriately used in situations in which consumers adjust their attitudes so that they are consonant with behavior. Cognitive dissonance is one means of describing this behavior process.[2]

At the Second International Conference on Behavioral Travel Demand, the basic hierarchical model of cognition-affect-conation-behavior was suggested for explaining mode choice

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[1]C. Ramond, *Advertising Research: The State of the Art* (New York: Association of National Advertisers, 1976).

[2]L. Festinger, *A Theory of Cognitive Dissonance* (Stanford: Stanford University Press, 1957); Golob, Horowitz and Wachs, "Attitude Behavior Relationships."

by travelers.[1] Subsequent empirical research by Tischer and Dobson has shown that parts of the overall model are compatible with traveler judgments.[2]

Market Segmentation

Market segmentation analysis can make significant contributions to transport analysis. Fundamental similarities and differences among consumers are the basis for these contributions, and they can have critical implications for user and nonuser reactions to transportation services and facilities. Market segmentation is a way to process information about these similarities and differences in support of transportation policy-making.

Market segmentation is based on two key concepts. The theory first assumes that meaningful groups of actual or potential users of a product or service can be identified. The second concept revolves around the creative assessment of product and/or service requirements for different market segments. The objective of this activity is usually to maximize profits through rendering services and/or products which appeal strongly to lucrative market segments. Market segmentation, as traditionally used in business contexts, always refers to a market mechanism.

Market segmentation within a consumer research framework was introduced in transportation analysis in the early and

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[1]R. Dobson, "Uses and Limitations of Attitudinal Modeling," in P. R. Stopher and A. H. Meyburg (eds.), *Behavioral Travel-Demand Models* (Lexington, Mass.: Lexington Books, 1975).

[2]M. L. Tischer and R. Dobson, "An Empirical Analysis of Behavioral Intentions to Shift Ways of Traveling to Work," paper presented at the 1977 Transportation Research Board meeting.

middle part of the 1970s.[1] Transportation analysis has traditionally grouped households on the basis of geographic proximity (i.e., households are assigned to travel analysis zones). However, the introduction of market segmentation has shown that spatial arrangement is not the sole basis for aggregating households or individuals to a desirable level. Lovelock reviewed several alternative bases for segmentation in a transportation context and recommended a matrix approach consisting of traveler characteristics along one axis and trip purposes along the other.[2] Golob and Dobson have suggested that perceptions and preferences may serve as a useful transportation basis for grouping households or individuals.[3] Empirical evidence is available to support this assumption.[4]

In transportation, it is likely that the uses and objectives of a market segmentation procedure will be somewhat different from traditional business applications.[5] Hensher points to a key difference between the two applications when he remarks that the utility of a segmentation approach extends beyond behavioral

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[1]Ricardo Dobson, "Market Segmentation: A Tool for Transportation Decisionmaking," in D. A. Hensher and P. R. Stopher (eds.), *Behavioral Travel Modelling* (London: Croom Helm, 1978).

[2]Lovelock, "A Market Segmentation Approach."

[3]T. F. Golob and R. Dobson, "The Assessment of Preferences and Perceptions Toward Attributes of Transportation Alternatives," in P. R. Stopher and A. H. Meyburg (eds.), *Behavioral Demand Modelling and Value of Travel Time* (Washington, D.C.: Transportation Research Board meeting, (1974).

[4]R. Dobson and M. L. Tischer, "A Perceptual Market Segmentation Technique for Transportation Analysis," paper presented at the 1978 Transportation Research Board meeting, Washington, D.C.

[5]P. Kotler, *Marketing Management*, 3rd edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976); R. Frank, W. F. Massy, and Y. Wind, *Market Segmentation* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1975).

demand models. In other words, its scope of application is more inclusive than profit maximization. Some examples of more inclusive topics are better utilization of existing system resources, decreased needs for costly new system additions, and/or increased transit ridership among specific segments (such as the elderly or handicapped) even if such increased ridership may imply greater operating deficits. In transportation research, the term market segmentation is more generic than the traditional marketing definition of the term implies; the latter refers to a market mechanism.

Structural Equations and Flowgraphs

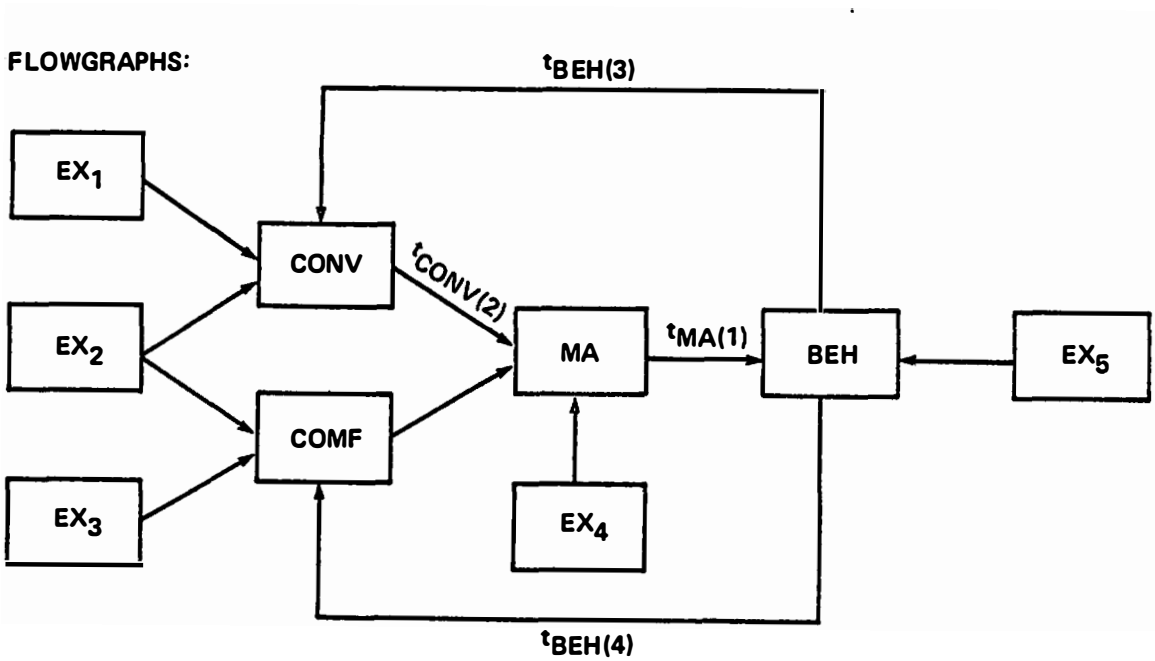
Structural equations and two-stage least squares are used to test hypotheses about the relationship between attitudes and behavior. A set of relationships is specified with structural equations, and then two-stage least squares is applied to compute coefficients and associated t-statistics.

Figure 2 shows a flowgraph and a set of structural equations representing this relationship. This flowgraph is typical of those used throughout the empirical analyses. The flowgraph depicts a multiattribute model in which cognitions, *CONV* and *COMF* for convenience and comfort perceptions respectively, act as determinants of modal affect, *MA*. It is also hierarchical because *CONV* and *COMF* indirectly influence behavior, *BEH*, through modal affect.

Since there is an isomorphism between flowgraphs and structural equations, the flowgraphs provide an overall view of an interconnected set of structural relationships. Figure 2 demonstrates this analogy for the system of Equations 1 through 4. The exogenous variables EX_1 through EX_5 designate demographic and/or transport system variables such as auto availability, income, and travel impedance. Each structural equation defines a part of the flowgraph. For example, Equation 1 denotes *BEH* and the two arrows that go into it from

Figure 2

EQUIVALENCE BETWEEN STRUCTURAL EQUATIONS AND FLOWGRAPHS



STRUCTURAL EQUATIONS:

(1) BEH = f(MA, EX_5)

(2) MA = f(CONV, COMF, EX_4)

(3) CONV = f(BEH, EX_1, EX_2)

(4) COMF = f(BEH, EX_2, EX_3)

MA and EX_5. The coefficients of the structural equations correspond to the arrows linking the variables in the flowgraph.

It is possible to indicate the statistical significance of the equation coefficients and the corresponding linkages by placing t-statistic values on the arrows. The computation of the coefficients and the relevant t-statistics can be achieved through two-stage least squares. Although the estimates of coefficients in the structural equations are based on data comprised of actual exogenous variables and estimated endogenous variables from the first stage, the only residuals of interest are those which result from the substitution of the coefficients into equations with actual, instead of estimated, endogenous variables on the right-hand side. Our t-statistics refer to the original variables. When a t-statistic is larger than necessary for statistical significance, the linkage is accepted as representing a structural relationship.[1] The $t_{BEH(3)}$ and $t_{BEH(4)}$, which are the t-statistics for the coefficients of *BEH* in Equations 3 and 4, test for the feedback of behavior on attitudes. The impact of perceived bus convenience on affect toward buses is assessed by $t_{CONV(2)}$. If $t_{CONV(2)}$ and $t_{MA(1)}$ are both statistically significant, then the influence of attitudes on behavior is supported.

Some Empirical Results with Theoretical Implications

At a very basic level, it is reasonable to assume that beliefs about the features or attributes of buses influence behavior toward buses. This assumption is relevant to other transport modes as well. If buses are perceived as convenient

[1]Three levels of statistical significance (i.e., $p < .10$; $p < .05$; $p < .01$) are reported. The .10 level is used as a minimum rather than the .05 level because of the preliminary nature of the research and the concern that all potentially important relationships be identified.

and comfortable, then travelers are more likely to use them than if buses are seen as inconvenient and uncomfortable. It is important to note that the assumption that cognitions influence behavior does not preclude other possible causes. Therefore, even if buses are viewed as having attractive attributes, bus usage still might be low because of other reasons. These other reasons could be based on a variety of factors, such as the extent to which a traveler likes or is satisfied with buses. Perceptions are not the sole attitudinal input to behavior. This is an important issue for system designers since it suggests that making changes in system features may not produce changes in ridership unless these other factors are also taken into account.

The notion that cognitions influence behavior is compatible with multiattribute formulations. When cognitions refer to several different attributes of bus service, then a model which links cognitions to behavior has a multiattribute character. It is also possible that cognitions are caused by behavior, and that any correlation between cognitions and behavior is a function of the effect of behavior on attitudes. This latter proposition has been discussed by Horowitz and his associates,[1] among others. A third and final possible interrelationship is that attitudes and behavior are mutually dependent.[2] This last assumption can be represented by flowgraphs with arrows going from cognitions to behavior and also from behavior to cognitions.

The Datasets

Several types of variables were employed in the structural equation analyses which have been presented in Volume II of the

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[1]Golob, Horowitz, and Wachs, "Attitude-Behavior Relationships;" and A. D. Horowitz, "A Cognitive Dissonance Approach to Attitudinal Modeling in Travel Demand Research," paper presented at the Transportation Research Board meeting, 1978.

[2]Dobson *et al.*, "Structural Models."

Final Report. Travelers' perceptions of mode attributes, general satisfaction with a transport mode, and intention to use a mode were the attitude measures. Behavior was represented by frequency of mode use. There was also a large set of predetermined or exogenous variables which are used in the structural equations. These include demographic characteristics of mode users and transportation system characteristics.

Three datasets were used for analyses reported in Volume II of the Final Report. The Federal Highway Administration dataset was assembled from an attitudinal transportation survey conducted in the Los Angeles area. This survey included information on several modes of transportation: buses, personal auto, and carpooling. The General Motors dataset included information on the same three transport modes although carpools were examined in extra detail. Chicago was the data acquisition site. Professor Lovelock's dissertation dataset served as our third resource for modeling traveler attitude-behavior interrelationships. His dataset, which was collected in San Francisco prior to the implementation of BART, also contains information on multiple transport modes. Analyses reported in this Executive Summary refer exclusively to the Federal Highway Administration.

Complete descriptions of the three datasets are provided in Volume II of the Final Report. The datasets are documented with a brief summary of their contents, relevant portions of its questionnaire, and transformations used to develop the socioeconomic and transport system exogenous variables. Tables of acronyms define and abbreviate the variables used from each data resource. Definitions for exogenous variable acronyms are provided at the bottom of figures in which they are initially introduced. The endogenous variables are described in the text. Comparative empirical analyses for all three datasets are described in the second volume of the Final Report; these analyses are based on a structural equation framework.

The Role of Behavioral Feedback

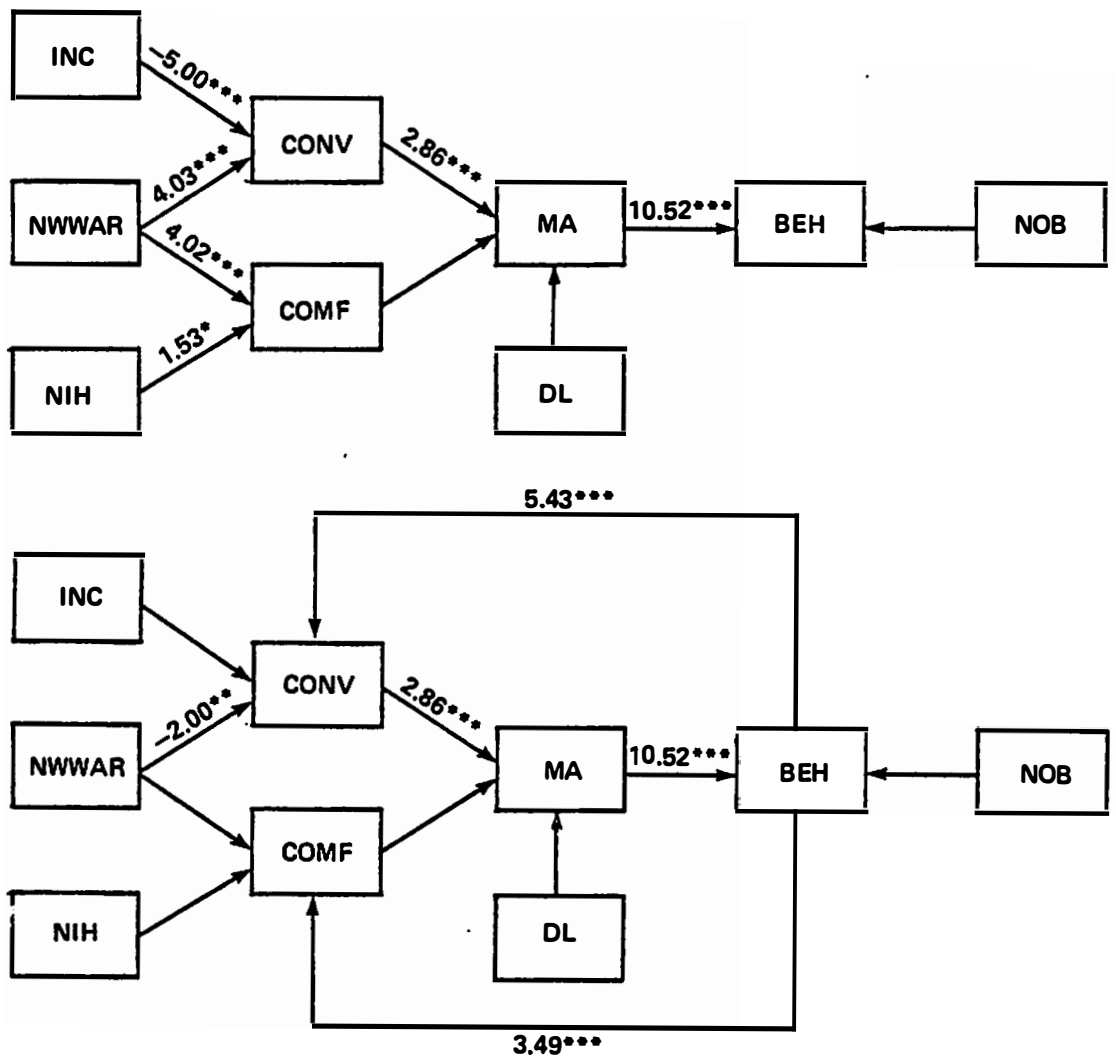
The role of behavioral feedback with respect to traveler attitude-behavior interrelationships is highlighted in the two flowgraphs of Figure 3. These flowgraphs are identical except for the inclusion of behavioral feedback to convenience and comfort perceptions in the bottom flowgraph. The inclusion of behavioral feedback allows for the possibility of mutual dependence between attitudes and behavior. That is, while attitudes influence behavior, behavior can, in turn, influence attitudes. While numerous theorists have asserted that attitudes cause behavior or vice versa, few empirical analyses have tested the hypothesis that causation occurs simultaneously in both directions. The estimation of this kind of formulation can be achieved with two-stage least squares.

The t-statistics in the bottom flowgraph provide empirical support for the proposition that attitudes and behavior simultaneously influence one another. The effect of behavior on cognitions is demonstrated by the t-values from behavior to convenience and comfort perceptions. In both cases, the t-values are statistically significant beyond the .01 level. Therefore, it is clear that usage of a mode, in this case buses, can influence travelers' perceptions of modal alternatives. It is also important to observe that attitudes, namely perceptions of system attributes through modal affect, can prompt behavior toward modal alternatives. By improving either people's perceptions of bus attributes or modifying their affect toward buses, bus patronage can be increased.

The introduction of behavioral feedback to cognitions suggests that, after the impact of behavioral feedback is considered, sociodemographic indicators may be of little or no importance as an incremental determinant of cognitions. In any event, the t-values for income and number in the household are not statistically significant in the bottom flowgraph, although

Figure 3

BEHAVIORAL FEEDBACK IN A SIMPLE ATTITUDE-BEHAVIOR MODEL



* p<.10 ** p<.05 *** p<.01

EXOGENOUS VARIABLES:

INC = Household Income

NWWAR = Number of Household Workers-Autos Divided by Number of Household Workers

NIH = Number of Residents in Household

DL= Number of Driver's Licenses in Household

NOB = Number of Blocks

they are significant in the top flowgraph without behavioral feedback. A comparison of the top and the bottom flowgraphs also indicates that the attitude-to-behavior links are not influenced by the introduction of feedback. While this finding is based on an identity in the structural equation model, the fact that the data interrelationships support the model shows that attitudes and behavior can simultaneously influence each other.

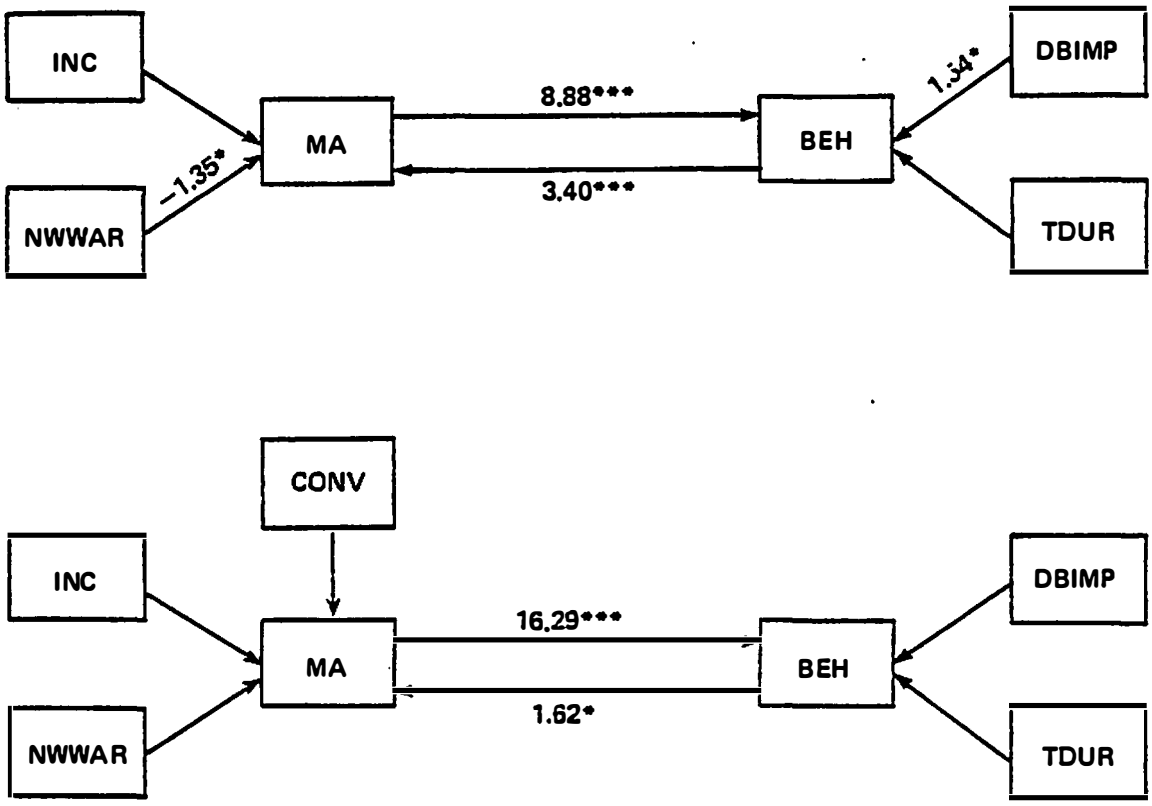
The Role of Intervening Variables

Figure 3 demonstrates that attitudes and behavior can be linked to one another. The status of intervening variables is, however, not resolved. Are intervening variables necessary for the mutual dependence property to hold? Do intervening variables, such as modal affect or intention, add incremental explanatory power to cognitions in explaining behavior? Empirical results bearing on these matters are presented below.

Figure 4 shows two flowgraphs in which there are no intervening links between attitudes and behavior. That is, behavior and attitudes interact with each other directly. Modal affect is the attitudinal variable which is assumed to influence, and be influenced by, behavior. The mutual dependence hypothesis is supported for both formulations. This finding demonstrates that intervening variables are not necessary as mediators of attitude-behavior interrelationships. While none of the antecedent variables to behavior and modal affect are statistically significant, the interrelationships between attitudes and behavior are sensitive to those formulations. The introduction of convenience perceptions as an antecedent variable for modal affect substantially increases the t-value characterizing the strength of the impact of modal affect on behavior. While this manipulation is not fully compatible with the definition of convenience perceptions as an endogenous variable, it highlights the strength of perceptions of system attributes generally, and

Figure 4

THE MUTUAL DEPENDENCE OF MODAL AFFECT AND BEHAVIOR



* p<.10 ** p<.05 *** p<.01

EXOGENOUS VARIABLES:
DBIMP = Auto Travel Impedance–Bus Travel Impedance
TDUR = Duration of Commute Trip from Home to Work

convenience perceptions in particular, as factors which should be considered in transport system design and operating policies.

The incremental explanatory capabilities of both modal affect and intention are assessed in Figure 5. Both the top and bottom flowgraphs show three arrows from attitudinal variables leading to behavior. The structural equation model corresponding to these arrows tests for the impact on behavior of convenience perceptions, comfort perceptions, and modal affect, respectively, while other variables are held constant. In both cases, the t-value for the intervening variable is statistically significant. This result confirms that modal affect and intention add explanatory power with respect to behavior for this dataset. Additional analyses across other datasets and for other modes are required to assess the generality of the finding.

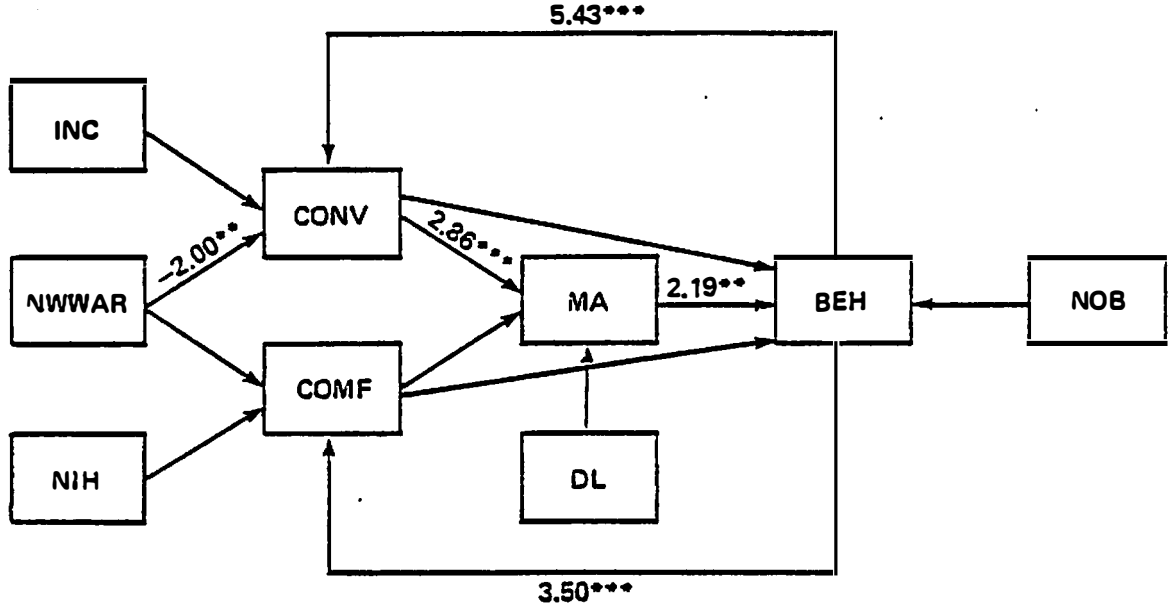
The Role of Market Segmentation

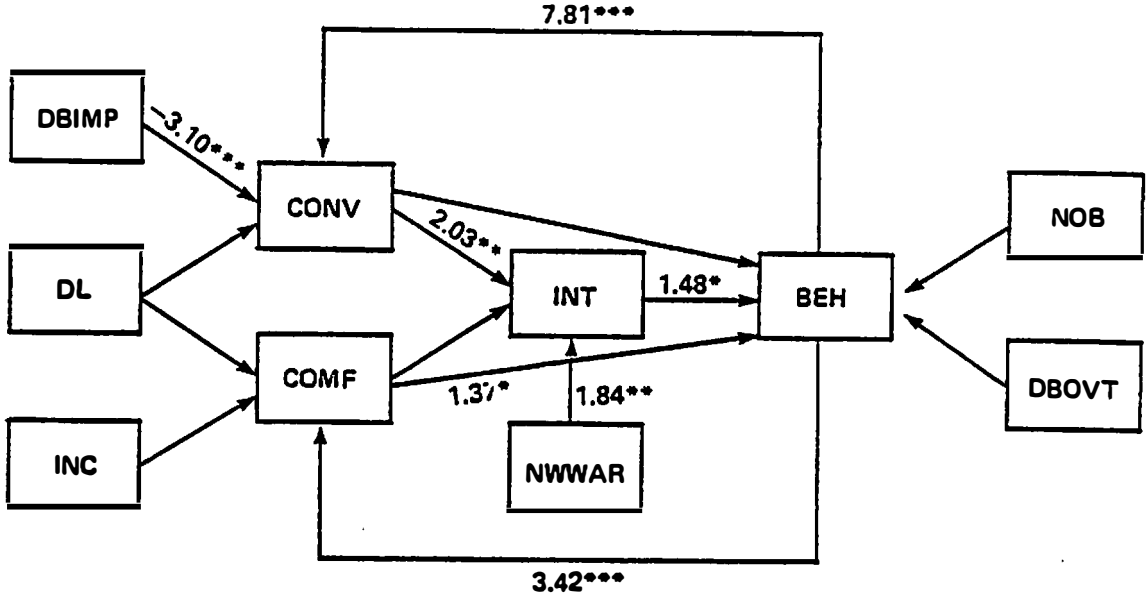
Market segmentation can be used with structural equation methods to increase explanatory power and to estimate the differences in traveler attitude-behavior interrelationships across segments. We developed and applied statistical tests for evaluating these two effects. This process involves an adaptation of the Chow test to assess the incremental explanatory ability of segmented models. The adapted statistical test compares the R^2 from a full sample model estimation with a function of R^2s across segments for model structures which are identical except for segmentation. Membership in a segment is represented by variables which assume a value of 1 for membership and 0 otherwise. These variables are designated segmentation variables.[1] In order to facilitate the explanation of the segmentation research, the

[1]Such variables are more often called dummy variables. We avoid this terminology to simplify the presentation.

Figure 5

THE ROLE OF AFFECT AND INTENTION FOR ATTITUDE-BEHAVIOR INTERRELATIONSHIPS





* p<.10 ** p<.05 *** p<.01

explanation of the segmentation research, the endogenous and exogenous variables are termed unprimed variables, and the products of these variables with the segmentation variable are termed primed variables.

Figure 6 shows a representative model of the interrelationships for behavior and attitudes toward buses. The segmentation basis in this model is traveler intention of switching to buses. The segmentation variable is assigned a value of zero for travelers with an intention score below the mean and one for travelers with an intention score greater than the mean. The first stage estimation process is performed using the original variables and the primed variables. The top flowgraph of Figure 6 presents t-statistics for the full sample. The second and third flowgraphs depict, respectively, the t-values for the unprimed and primed variables.

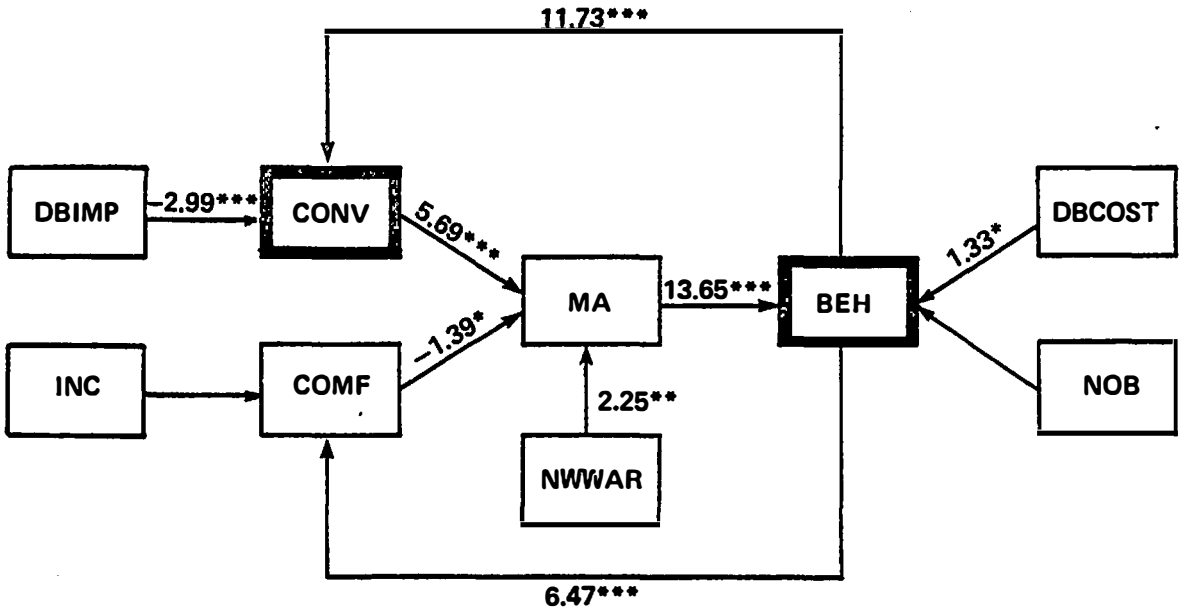
The full sample estimation of the model indicates attitude-behavior interrelationships similar to those in the models presented earlier. Characteristic patterns of statistically significant relationships are displayed. The linkages of convenience to modal affect and modal affect to behavior are present. The t-value for the linkage of comfort perceptions to modal affect has the wrong sign, but the level of statistical significance is marginal ($.10 > p > .05$). The influence of behavior on attitudes is also shown to be highly significant.

The adapted Chow test indicates that two sets of relationships are significantly different across the high and low intention segments. A segmented sample was more effective than the full sample in estimating the underlying structure with respect to convenience perceptions and bus usage. These segmentation effects are indicated on the flowgraphs by the thick, dark outline for the blocks denoting these variables.

Figure 6

AN APPLICATION OF TEST TO SEGMENTED INTENTION SAMPLES FOR BUSES

FULL SAMPLE –FHWA



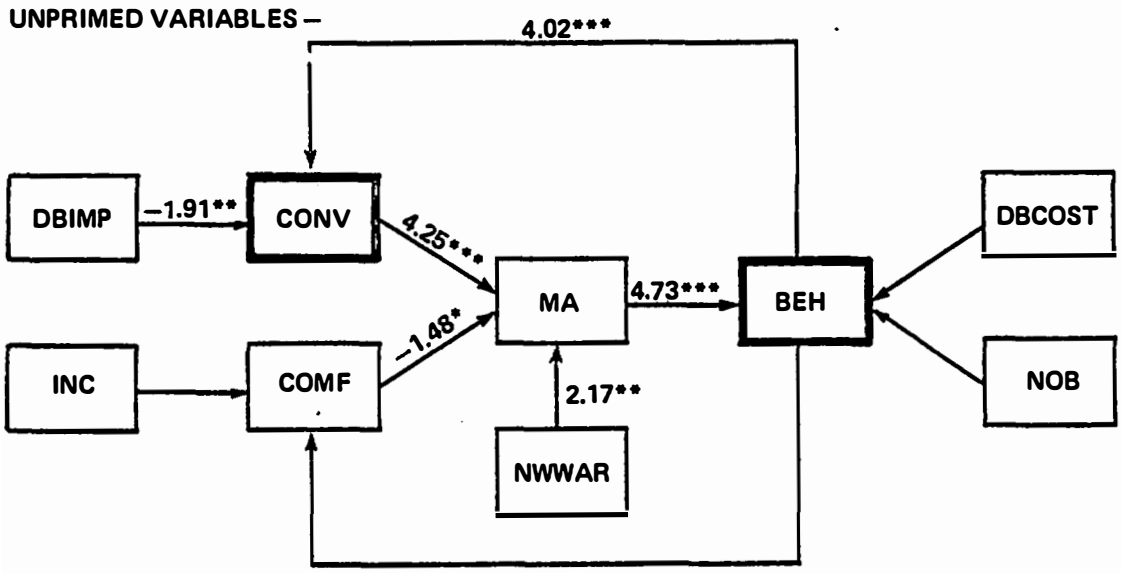
*p<.10 **p<.05 ***p<.01

Figure continued on following page.

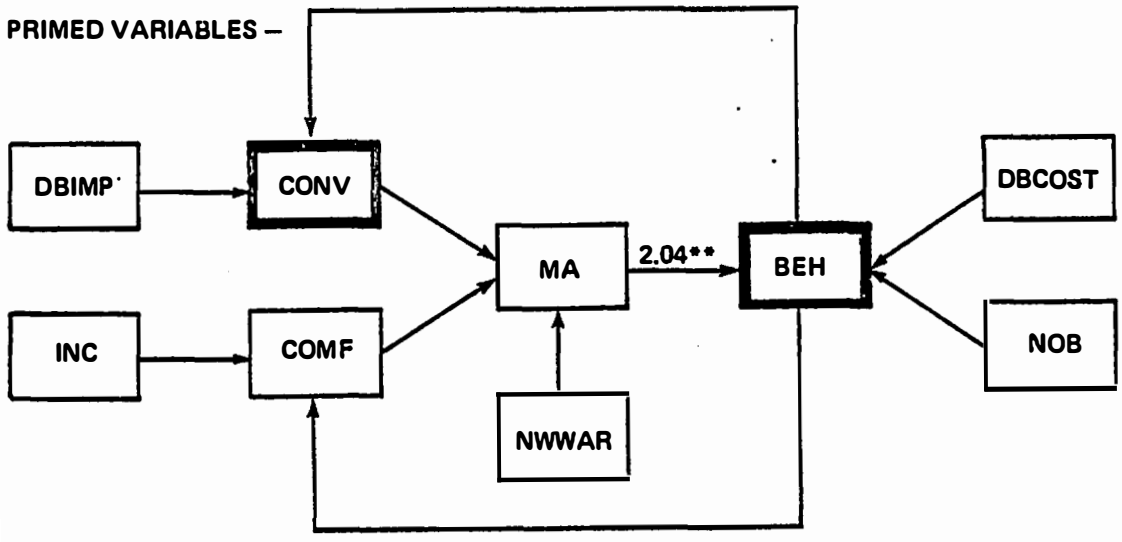
EXOGENOUS VARIABLES:
DBCOST = Bus-Auto Cost

Figure 6

AN APPLICATION OF TEST TO SEGMENTED INTENTION SAMPLES FOR BUSES
(continued)



$D3_{BEH}$: t = .31 $D3_{MA}$: t = .76 $D3_{CONV}$: t = 2.10 $D3_{COMF}$: t = .41



*p<.10 **p<.05 ***p<.01

The t-statistics reported in the second flowgraph indicate the significance of the interrelationships for the low intention group; these values are for the unprimed variables. Our analysis technique generates these statistics for one segment, but the same results can be obtained for all segments by any of several techniques (e.g., by running separate models for each segment). The pattern of interrelationships for variables is comparable to the full sample findings, but the t-values are lower in every case for the low intention segment.

The t-statistics for the primed and segmentation variables quantify the effect of segmentation on interrelationships among variables. The third flowgraph shows the t-values for the primed variables, and the t-values for the segmentation variables are shown in between the second and third flowgraphs. The only endogenous variable to reveal a level effect to segmentation was convenience perceptions ($D3_{CONV}$ t = 2.10). The high intention segment viewed buses as more convenient than the low intention segment. The high intention segment was also differentiated from the low intention segment in strength of relationship of modal affect as an input to bus usage.

The results of the adapted Chow test and the structural equation analysis with segmentation and primed variables demonstrate that traveler segmentation can influence interrelationships among attitudes and behavior. This presentation initially demonstrated that segmented models were statistically superior in explanatory power relative to unsegmented models. Secondly, it showed how attitude-behavior interrelationships vary across segments. In particular, it was revealed that traveler groups can be differentiated from one another in terms of their perception of system attributes, convenience in this case. It was also possible to quantify different levels of modal affect impact on frequency of bus usage across traveler segments.

Principal Behavioral and Policy Conclusions

The objective of this project was to develop a theory of attitudes towards transportation systems in order to clarify the relationship between system attributes and traveler behavior. Issues considered in the development of this theory include the salient attributes of transportation alternatives which are evaluated by travelers, the interaction of travelers' attitudes towards these attributes and towards transportation alternatives, the interaction of attitudes with contextual and demographic variables, various measures and definitions of attitudes, and the relationships among attitudes and behavior. The theory was oriented to finding attributes of transportation system design and operations which impact users' well-being and behavior.

Review of Attitude-Behavior Research Findings

The empirical research performed in this study involved using two-stage least squares and structural equations to test hypotheses about various linkages among attitudinal variables, behavioral and situational variables. From the standpoint of specifying attitudinal models, the major results can be summarized as follows.

- Perceptions of system attributes influence behavior. Convenience perceptions stand out as an extremely salient factor underlying traveler behavior. Feelings about the social costs of automobile driving and comfort perceptions have a weaker association with traveler behavior than convenience perceptions.
- Affect (or behavioral intentions) are determined by attitudes toward the attributes of an alternative, including the consumer's perception of these attributes and his evaluation of the attributes.

- Consumer choices are determined by affect towards an alternative, subject to objective constraints such as whether the alternative is realistically available to the consumer.
- Consumer attitudes (perceptions, affect and intention) and behavior mutually influence each other.
- Perception and evaluation of each attribute is a function of the choices among alternatives made by the consumer as well as exogenous factors such as lifestyle, life cycle and other demographic descriptors.
- Different sets of structural assumptions about attitude-behavior interrelationships are relevant to alternative traveler segments, which can be defined with respect to behavior intention and possibly other variables.

Policy Implications

The most important results of this report are theoretical in nature because of the thrust of the objectives. However, we can generalize some policy implications which have emerged from the empirical analyses. Briefly stated, we can point to the following.

- Transit operating policy and systems design must take account of the determinants of affect in order to attain ridership goals. This goes beyond simply making transit available and includes instilling a favorable view of transit *generally*. The ability for planners and operators to do this is somewhat limited, but they might take a lesson from modern marketing procedures practiced in the private sector.
- Expenditures on transportation system improvements and information campaigns associated with systems should stress traveler convenience over comfort. Traveler feelings about the social costs of automobile driving should be stressed less than convenience factors of alternative modes in information campaigns.

- Distinct differences among travelers in how attitudes relate to behavior require a market segmentation approach in transportation policy analysis and simulation.
- Favorable evaluation of transit attributes, and travelers' attitudes towards these attributes is necessary but not sufficient to attain transit ridership. Although affect towards transit is partially determined by favorable attitudes towards attributes, transit ridership is clearly correlated with more than these attitudes. Other factors which seem relevant include demographic variables (e.g., dwelling unit type and auto availability) and social variables (e.g., peer group influence).
- Transit capture of current auto riders is more difficult than the revealed tradeoffs among attributes indicate. That is, improved transit service will not immediately increase ridership because attitude change will first be necessary. Insofar as attitude change depends upon certain behavioral change, transit market penetration will certainly not be immediate.

Potential Extensions

The significance of this project's findings can be judged by the new knowledge which the project contributes as well as by the number of new analyses and applications which emerge from it. The analysis framework used in this study represents a synthesis and/or extension of earlier work.[1] The fundamental

[1]T. J. Tardiff, "Causal Inferences Involving Transportation Attitudes and Behavior," *Transportation Research* II (1976): 397-404; D. R. Heise, *Causal Analysis* (New York: John Wiley & Sons, Inc., 1975); Dobson *et al.*, "Structural Models;" R. Dobson, "Uses and Limitations of Attitudinal Modeling," in P. R. Stopher and A. H. Meyburg (eds.), *Behavioral Travel-Demand Models* (Lexington, Mass.: Lexington Books, 1976).

psychological principle around which this study centers is that traveler behavior can be best understood by examining attitude-behavior interrelationships, and that these interrelationships are not invariant across different groups of travelers. The techniques applied in the study have resulted in findings which provide a basis for a widely accepted theory of traveler attitude-behavior interrelationships with significant policy implications.

There are numerous possible extensions of the empirical and theoretical findings uncovered by this project. Some prominent ones are to:

- Assess the range of potential determinants of model affect and behavioral intention as mediators between cognitions and behavior;
- Develop and implement a policy simulation capability based on attitude-behavior interrelationships;
- Examine structural assumptions in a time-series environment to evaluate alternative mechanisms for accounting for behavior change over time;
- Extend the modeling framework to concurrently deal with two or more modes;
- Test a wide array of market segmentation bases to assess their usefulness and to understand how important segmentation analysis is for travel behavior analysis; and
- Establish a bridge between travel attitude-behavior models and more traditional travel analysis procedures.

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