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16. Abstract

The second volume of this final report presents conceptual and empirical findings 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 brief consideration of theoretical concepts precedes the review of our empirical methodology. Structural equations, flowgraphs and two-stage least squares are simply explained because they provide a framework for understanding theoretical and empirical findings. General empirical results comprise a substantial portion of this report. The structure of traveler attitude-behavior interrelationships is examined for two transport modes, buses and car-pools, over three different datasets. Among the major findings are that traveler attitudes influence behavior toward transport alternatives and that traveler attitudes and behavior mutually affect each other. Various theoretical extensions of this work are described. A new quantitative procedure for assessing differences between travel market segments is developed and implemented. The relevance of the modeling orientation to transport system design and policy analysis is noted. Some implications of the modeling approach for data collection efforts are also noted.

Vol. I, Input to Theory Development, has 194 pages.
Vol. III, The Executive Summary, has 38 pages.

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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 effort.

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.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

Chapter 1
INTRODUCTION

The major thrust of this volume is the development of a heory of traveler attitudes and behavior toward transportation ystems. The theory development effort emerges from Volume I, oward the Selection of a Modeling Orientation. That volume is omprised of a literature review of consumer research, a dis- ussion of modeling orientation and an inventory of attitudinal ransportation datasets. The literature review and modeling rientation discussion provided a framework for selecting models f consumer attitude-behavior interrelationships for empirical nd theoretical analysis. The attitudinal datasets used in these nalyses were identified through the inventory of attitudinal ransportation datasets.

Brief Statement of Modeling Orientation

To minimize the need to refer to Volume I, a brief descrip- ion of the modeling orientation is provided here. Those who re familiar with the presentation on traveler attitude-behavior heory from the preceding volume may wish to proceed to the final ection of this chapter, Volume II Format.

Multiattribute Models

Theorizing by both Rosenberg and Fishbein has resulted in a wide variety of multiattribute models.[1] These researchers believe that the liking of 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. The functional relationship between preference for an object and attribute perceptions and importances is frequently assumed to be linear and additive.[2]

Beliefs pertain to object attributes, and 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 the bus is perceived as possessing these and other relevant attributes, as well as how important the set of relevant attributes is to consumers. Some attributes may be very important and yet not influence preference for a bus because the bus is not believed 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, multiattribute 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. Multiattribute models are relatively data intensive because they explain consumer behavior in terms of several variables, for example, those

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

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

presumed that they 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: "Learn-Feel-Do," "Learn-Do-Feel," and "Do-Feel-Learn."[1] 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. Ramond notes that Learn-Feel-Do is particularly appropriate for characterizing the manner in which printed advertising influences buyer behavior. "Do" precedes "Feel" in the other two sequences, implying that behavior influences preferences. These last two hierarchies are appropriately used in situations where consumers adjust their attitudes so that they are consonant with behavior. Cognitive dissonance is one means of describing this behavioral process.[2]

At the Second International Conference on Behavioral Travel Demand, the basic hierarchical model of cognition-affect-conation-behavior was suggested in a transportation context.[3] It was noted that such a modeling orientation may be suitable for explaining mode choice by travelers. Subsequent empirical research by Tischer and Dobson has shown that parts of the

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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); and T. F. Golob, A. D. Horowitz and M. Wachs, "Attitude Behavior Relationships in Travel Demand Modeling," *Proceedings, Third International Conference on Behavioral Travel Demand Modeling* (Elmsford, N.Y.: Pergamon Press, forthcoming).

[3]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).

Market segmentation within a consumer research framework was introduced in transportation analysis in the early and middle part of the 1970s.[1] While transportation analysis has traditionally grouped households on the basis of geographic proximity (i.e., households are assigned to travel analysis zones), 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]

Within a transportation sphere, it is likely that the uses and objectives of a market segmentation procedure will differ

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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]C. H. Lovelock, "A Market Segmentation Approach to Transit Planning, Modeling, and Management," *Transportation Research Forum Proceedings* 16th Annual Meeting (1975), pp. 247-258.

[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, 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.

nalysis technique. This methodology, which takes simultaneity mong relationships into account, is not commonly used in the ransportation research field. Therefore, Chapter 2 discusses he methodology and research findings format in depth. Chapter is an overview of the nature and scope of three attitudinal ransportation datasets which are used in our empirical studies. ncluded in this chapter are lists of variable acronyms employed hen reporting empirical findings. Chapter 4 presents empirical esults on traveler attitude-behavior structures across datasets nd modes, and with respect to market segments. Chapter 5 evelops theoretical implications for traveler attitude-behavior nterrelationships from the empirical findings. Theoretical nd research extensions which naturally arise from this esearch are reviewed in Chapter 6; such extensions include ituation-specific modeling, multimodal models, longitudinal daptation and a policy simulation procedure. Chapter 7 sets orth the conclusions and policy implications, including the ata collection and survey design implications of the empirical esults.

(see Johnston[1] and Theil[2]). A complete econometric discussion of the modeling problem and alternative approaches has been given by Fisher.[3]

One application of the methodology in a transportation context is Tardiff's estimation of various models of traveler attitudes and behavior which are jointly dependent on a set of antecedent variables such as personal and situational descriptors.[4] Tardiff suggests that his findings should be generalized cautiously because they have not been tested on more than one dataset and because of the methodological simplicity with which he treated attitude variables.

The structural equation method, estimated by two-stage least squares, allows the specification of mutual dependence between atttitudes and behavior. The flow-graph in Figure 2-1 depicts a simple situation in which attitudes (A) and behavior (B) are mutually dependent. Such a feedback model is referred to as a nonrecursive relationship. The variables EX_1 and EX_2 are exogenous variables because their values are determined by factors outside the system of equations depicted by the relationships shown in Figure 2-1. In this example, exogenous variables can be demographic variables (e.g., EX_1 equals income and EX_2 equals family size). The variables A and B are called endogenous variables because their values are determined by this system of equations. The structural equations for Figure 2-1 have the following representation:

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[1]J. Johnston, *Econometric Methods*, 2nd edition (New York: McGraw-Hill Book Company, 1972).

[2]H. Theil, *Principles of Econometrics* (New York: John Wiley & Sons, Inc., 1971).

[3]F. Fisher, *The Identification Problem in Econometrics* New York: McGraw-Hill Book Company, 1966).

[4]Timothy J. Tardiff, "Causal Inferences Involving Transportation Attitudes and Behavior," *Transportation Research 11* 1977): 397-404.

$$B = f_a(A, EX_2) \quad \text{and} \tag{2-1}$$

$$A = f_b(B, EX_1). \tag{2-2}$$

Attitudes and behavior are on both sides of the system of equations. While ordinary least squares requires that right-hand variables be independent of residuals, this assumption will be violated when any variable appears on both sides of a system of equations. However, unbiased estimates for this system of equations can be obtained by using two-stage least squares. The first stage of this procedure estimates the endogenous variables as a linear function of the exogenous variables. The least squares representation of this stage is:

$$B \simeq f_1(EX_1, EX_2) = \hat{B}; \text{ and} \tag{2-3}$$

$$A \simeq f_2(EX_1, EX_2) = \hat{A}. \tag{2-4}$$

The estimates of the endogenous variables, $\hat{B}$ and $\hat{A}$, are substituted into the structural equations to estimate their coefficients. This second stage can be denoted by:

$$B \simeq f_3(\hat{A}, EX_2); \text{ and} \tag{2-5}$$

$$A \simeq f_4(\hat{B}, EX_1). \tag{2-6}$$

The results of the second stage can be used to test hypotheses about the relationships among attitudes and behavior. For example, the interpretation of mutual dependence can be based on the statistical significance of the coefficients for $\hat{A}$ and $\hat{B}$ in Equations 2-5 and 2-6. If the coefficients for both estimated endogenous variables are statistically significant, then mutual dependence is supported. To the extent that only one endogenous variable has a statistically significant

ontributions to segmentation analysis are also presented
n Chapter 5.

The regression coefficients for each of the equations ithin the system can be reported to indicate the contribu- ion each right-hand variable makes to the left-hand variables. nless variables are standardized, the regression coefficients ill confound level of contribution with metric. As a conse- uence, the strength of relationships cannot be directly nferred from regression coefficients for unstandardized ariables. Even standardized variables yield regression oefficients which need to be adjusted by their stand error n order to assess statistical significance. This adjustment esults in the t-statistics, which lead to a simple and immed- ate interpretation of the strength of relationships between ariables.

The hypothesis that one variable has a statistically sig- ificant impact on another variable is assessed by a t-statistic. urthermore, the direction of an explanatory effect is indicat- d by the sign of the t-statistic, which is the same as the orresponding regression coefficient. A representation of the eneral structural equation format is depicted below. The ariables are standardized so there are no constants in the tructural equations.

$$A = f_a\ (B,\ EX_1); \qquad (2\text{-}7)$$

$$B = f_a\ (A,\ EX_2) \qquad (2\text{-}8)$$

hese general function relationships can be expressed as:

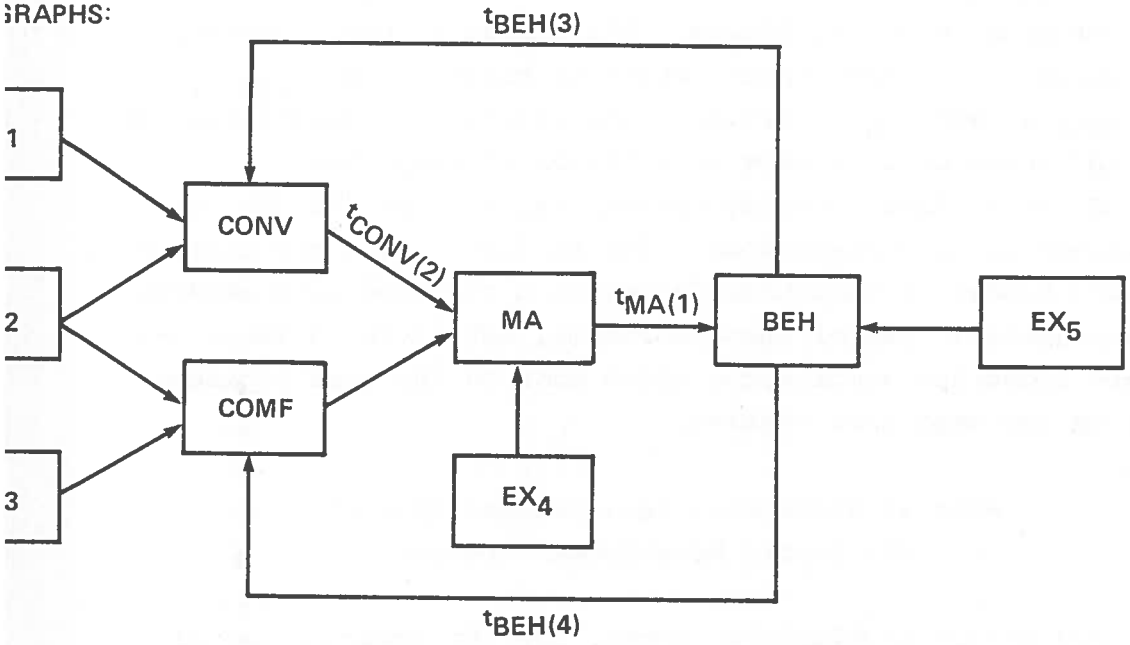
$$A = \underset{(t_1)}{c_1}B + \underset{(t_2)}{c_2}EX_1 \text{ and} \qquad (2\text{-}9)$$

$$B = \underset{(t_3)}{c_3}A - \underset{(-t_4)}{c_4}EX_2. \qquad (2\text{-}10)$$

Figure 2–2

EQUIVALENCE BETWEEN STRUCTURAL EQUATIONS AND FLOWGRAPHS

GRAPHS:



TURAL EQUATIONS:

f(MA, EX_5)

(CONV, COMF, EX_4)

= f(BEH, EX_1, EX_2)

= f(BEH, EX_2, EX_3)

Figure 2—3

THEORY CONSTRUCTION PROCESS

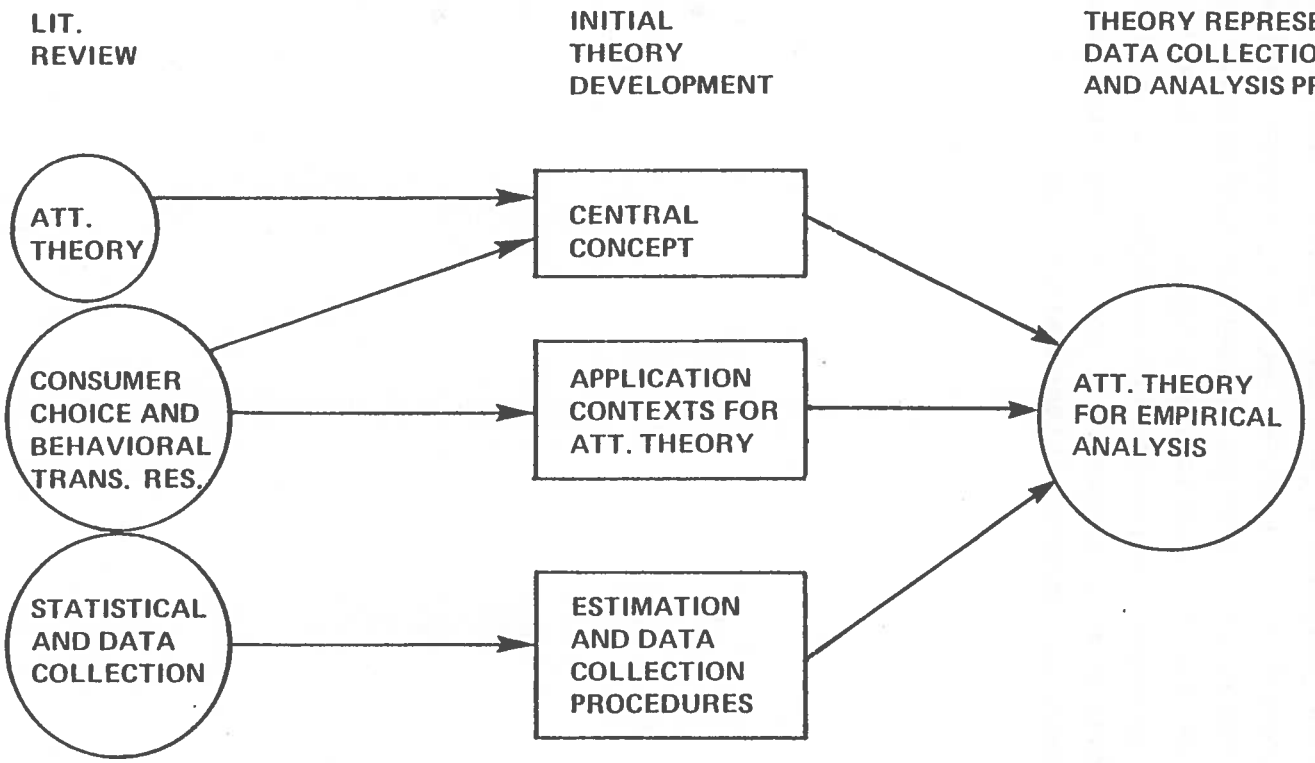
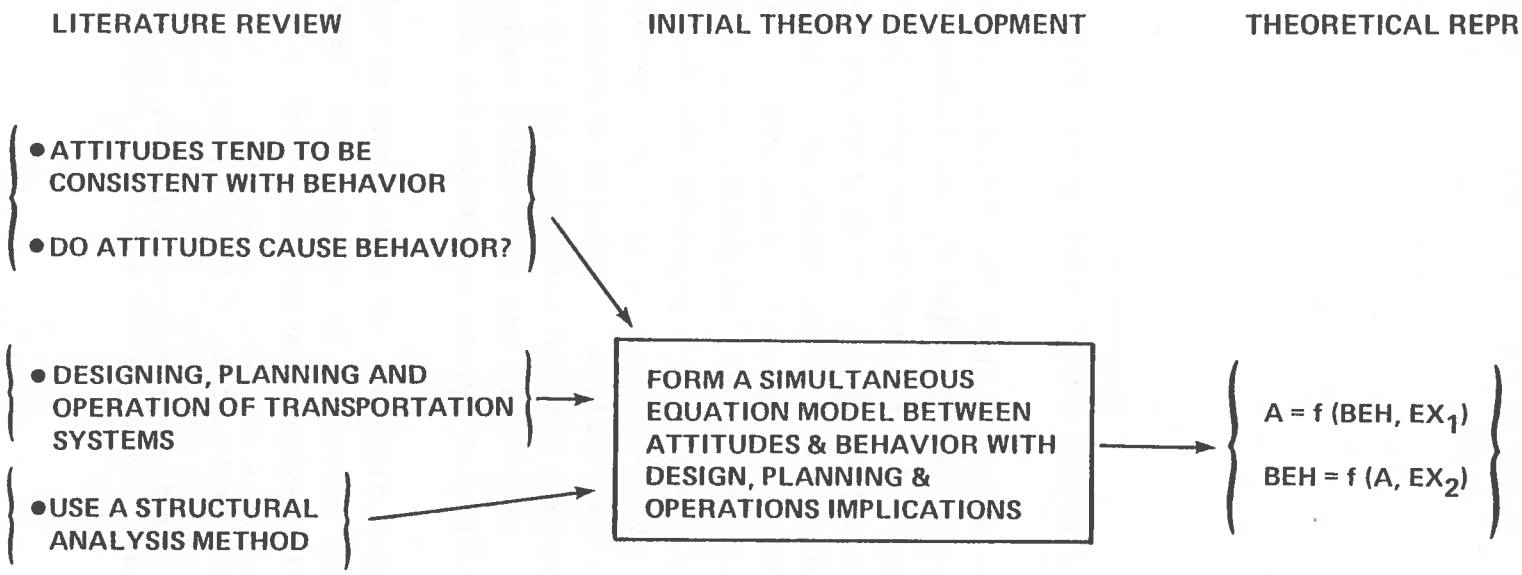


Figure 2–4

INSTANCE OF THEORY CONSTRUCTION



d intention to use a mode are examples of attitude measures. havior is represented by frequency of mode use. There is so a large set of predetermined, or exogenous, variables om each dataset which are used in the structural equations. ese include demographic characteristics of mode users and ansportation system characteristics in the case of the FHWA taset.

FHWA Attitudinal Transportation Dataset

The FHWA dataset was assembled from an attitudinal trans- rtation survey conducted in the Los Angeles area. This sur- y included information on several modes of transportation: blic transit, personal auto, and carpooling. The 1,160 spondents were sampled on the basis both of employment in near the central business district, and of location within o miles of the freeway.[1] When a household contained more an one worker, the person taking the lesser-used mode was osen to be interviewed. (The lesser-used modes were ranked the following order: riding in a carpool, taking a bus, iving a carpool, and driving alone.) Table 3-1 provides ditional information on aspects of the FHWA dataset.[2] For ir modeling purposes, the subset of 889 individuals who worked wntown is utilized. Additional respondents are eliminated ie to nonresponse; therefore, the full sample size varies om 715 to 810 according to the mix of variables specifying ie model. The FHWA dataset is used to analyze the interrela- tionship of attitudes and traveler behavior with respect to ublic transit and the carpooling mode. Five endogenous

---

[1]R. Dobson and M. L. Tischer, "A Comparative Analysis of eterminants for Central Business District Worker Mode Choices," *ransportation Research Record* (1978, in press).

[2]Table 3-1 is derived from Table 4-1, "An Inventory of ttitudinal Transportation Datasets," in Volume I of the present eport.

ariables were used for each mode: behavior, modal affect, ntention, perceived convenience, and perceived comfort (see ppendix B for coding practices). The FHWA dataset includes ystem data on travel times and distances which are of particu- ar interest as a set of exogenous variables. Table 3-2 con- ains a complete listing of the FHWA endogenous and exogenous ariables and their respective acronyms, which are employed n the flowgraph representation of the empirical results pre- ented in the following chapters. The derivation and develop- ent of the system data are discussed in Appendix C.

GM Attitudinal Transportation Dataset

Cross dataset analysis on the ridesharing mode is based n the FHWA and GM data. The GM dataset, the Carpooling uestionnaire, includes 1,010 respondents from the Chicago rea. Because of the original purpose of the dataset, respon- ents were instructed to complete the entire questionnaire; espondent selection was dependent on modal status and place f employment.[1] Enterprises which employed at least 100 people ere randomly chosen from a list of Chicago firms, and those irms which agreed to participate distributed the question- aire to their employees. The eventual sample for the struc- ural equation consists of approximately 400 respondents. able 3-3 presents further information on sample selection and ata collection for the GM dataset. The GM dataset contains nformation on four endogenous variables: behavior, modal ffect, perceived time and convenience, and perceived social osts of auto use. A complete list of the endogenous and xogenous variables and their acronyms is provided in Table 3-4,

[1]A. D. Horowitz and J. N. Sheth, "Ridesharing to Work: A sychosocial Analysis," GMR-2216, Revised (Warren, Mich.: eneral Motors Research Laboratories, 1977).

Table 3-3

AN ATTITUDINAL TRANSPORTATION DATASET - GM

cation, Date & Contact	Chicago, Illinois, 1975, General Motors Research Laboratories
spondents	1020
ta Collection Procedures	Distributed by personnel managers, self-administered and mailed back. Format: semantic differential and seven-point Likert scales.
mple Selection	Business firms that employed at least 100 people were randomly chosen from a list of Chicago firms. 80% of them were agreeable to participation.
rvey Purpose	Carpooling Questionnaire for identification of attitudes about carpools and transit modes to apply to transportation planning.
rvey Information	• Demographic data • Attitudinal data on ridesharing and solo driving • Travel characteristics • Summary trip on usual mode • Responses to probable motivation for a switch to carpooling.

nd the coding practice for the set of variables is presented
n Appendix B.

Lovelock Attitudinal Transportation Dataset

The Lovelock dataset, employed in cross dataset analysis
n public transit, is a compilation of multimode information
ollected in the San Francisco area (prior to BART's opera-
ion).[1] However, in our analysis we use only information per-
aining to bus usage. The Lovelock attitudinal transportation
ataset is comprised of 1,313 commuters and noncommuters.
able 3-5, the dataset inventory tabular entry, presents addi-
ional information on specific study design issues, such as
ne data collection procedure. The attitudinal measures of
ransit attributes refer to commute trips, when applicable,
nd other trips. The sample size for the empirical analysis
ncludes approximately 750 commuters who responded to the
ttitudinal questions. The endogenous variables are perceived
as convenience, intention of public transit use, perceived
vailability of automobiles, and frequency of commute and
oncommute trips by bus. Table 3-6 provides the entire list
f endogenous and exogenous variables in the Lovelock dataset
nd their respective acronyms, and Appendix B presents the
oding practice applied to this attitudinal data.

---

[1]C. H. Lovelock, "Consumer Oriented Approaches to Marketing
rban Transit," Ph.D. dissertation, Stanford University (Spring-
ield, Va.: NTIS, PB-220 781).

Table 3-6

ACRONYMS FOR THE LOVELOCK DATASET

ronym	Definition
dogenous	
BEH	Frequency of bus use for commute and noncommute trips
INT	Would you use bus if new and improved services were offered
CONV	Bus convenience
PAV	Public bus availability for commuting
ogenous	
IDL	Yes or no: Individual has driver's license
NIH	Number in household
AUTOS	Number of autos in household
NIHWAR	NIH minus autos divided by NIH
DL	Regular drivers
AAVAIL	Car availability
BTITB	Bus timetable possession
BADK	Bus advertising knowledge
TRES	Years at residence
TSUB	Years at place of employment

Figure 4-1 shows two flowgraphs which use a single intervening variable between cognitions and behavior. The cognitive variables, traveler perceptions of bus convenience and comfort, are based on perceptions of specific aspects of bus service. The top flowgraph represents modal affect as an intervening variable between cognitions and behavior. It plays this role because convenience is related directly to affect which is, in turn, related directly to behavior. Both of these associations are statistically significant beyond the .01 level by a one-sided test.[1] It is also interesting to note that the demographic antecedents of perceived convenience and comfort are, with one exception, statistically significant at well beyond the .01 level. Common expectations were confirmed when it was shown that income was inversely related to positive perceptions of bus convenience, and that number in the household (HH) was related directly to positive perceptions of bus comfort. The latter relationships are significant at the .01 and .10 levels, respectively. A variable indicating the lack of auto transportation for commute trips (NWWAR) was related directly to positive perceptions of both bus convenience and comfort ($p < .01$).

The bottom flowgraph of Figure 4-1 uses intention of switching to buses in response to bus system improvements as an intervening variable. Intention functions in this role since the convenience-to-intention and intention-to-behavior links are statistically significant at the .05 and .01 levels, respectively. The number of household workers without autos is another determinant of behavioral intention. The statistical insignificance of the comfort-to-intervening variables link in both the upper and lower flowgraphs in Figure 4-1 suggests that perceptions of bus comfort do not

[1]One-sided tests are reported in Chapters 4 and 5, because it is always assumed that the sign of a coefficient is known. Statistically significant t's are reported along arrows as per conventions described in Chapter 2.

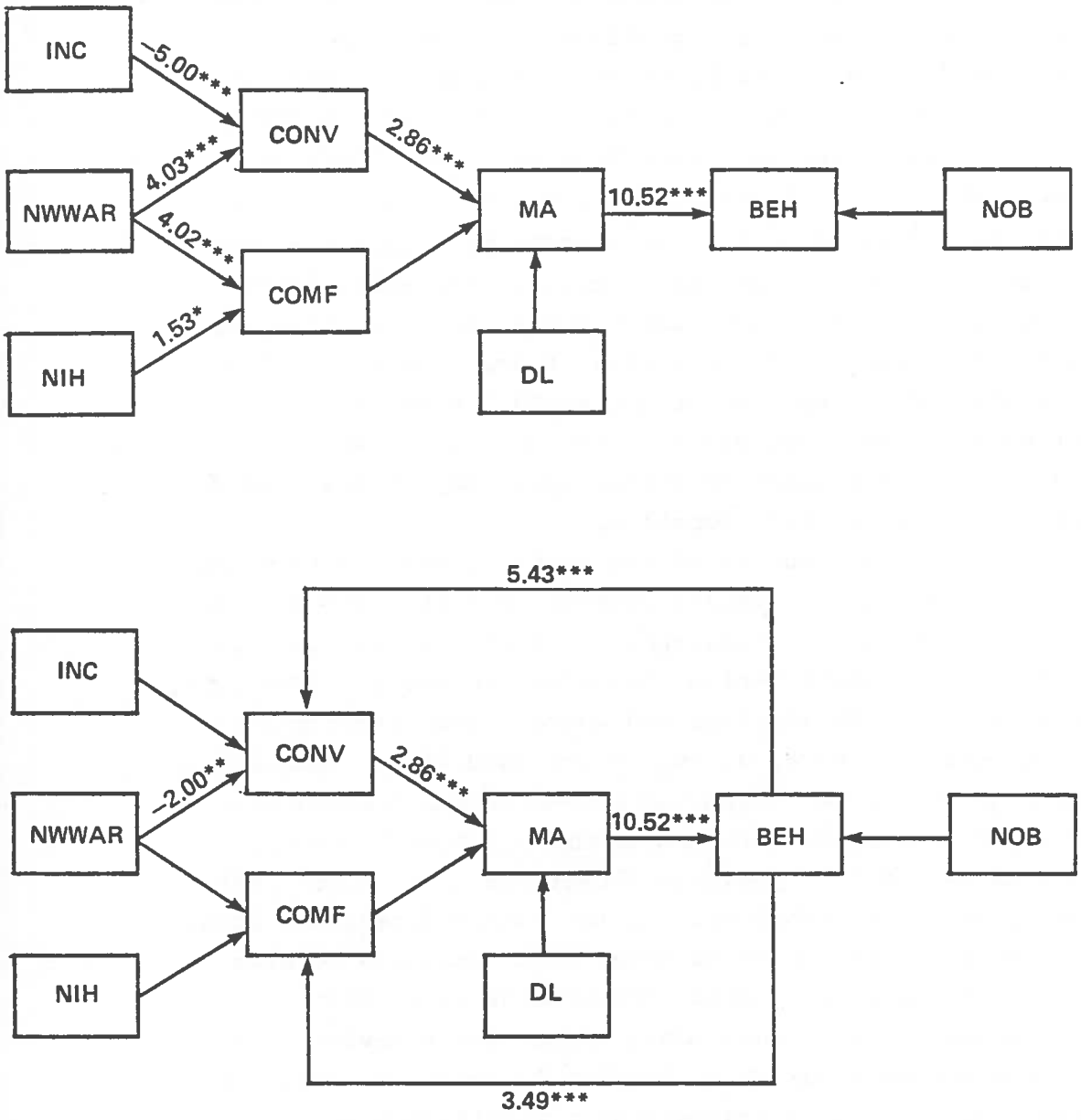
influence bus usage. The demographic variable antecedents of bus cognitions are all significant at various statistical levels. Perceptions of bus convenience are inversely related to the indicant of bus travel time, DBIMP. Positive perceptions of bus comfort appear to decline with rising household income. The number of driver's licenses in a household reveals the degree to which alternate travel options to the bus are feasible; as these options increase, positive perceptions of bus convenience and comfort decrease.

Figure 4-2 presents a traditional hierarchical model which expresses a set of nested relationships. Behavior is shown to be dependent on intention which is, in turn, functionally related to modal affect. The attitude-behavior hierarchy commences with cognitions that are correlated with modal affect. The string of t-values from perceived convenience through behavior are all significant at beyond the .01 level. While the comfort-to-affect link is not statistically significant, perceptions of bus comfort are inversely correlated with out-of-vehicle time and number of blocks to be walked after exit from a bus at the .05 and .10 levels, respectively. The number of driver's licenses is once again found to influence perceived convenience. Modal affect toward buses is determined, in part, by the number of workers in a household without autos. Similarly, intention of switching to buses is affected by residence in apartments as opposed to single-family homes.

The mutual dependence of behavior and attitudes is perhaps the most important hypothesis analyzed in this report. Figure 4-3 contains two flowgraphs, one of which represents mutual dependence. The top flowgraph (which is also presented in Figure 4-1) depicts a recursive relationship between attitudes

Figure 4–3

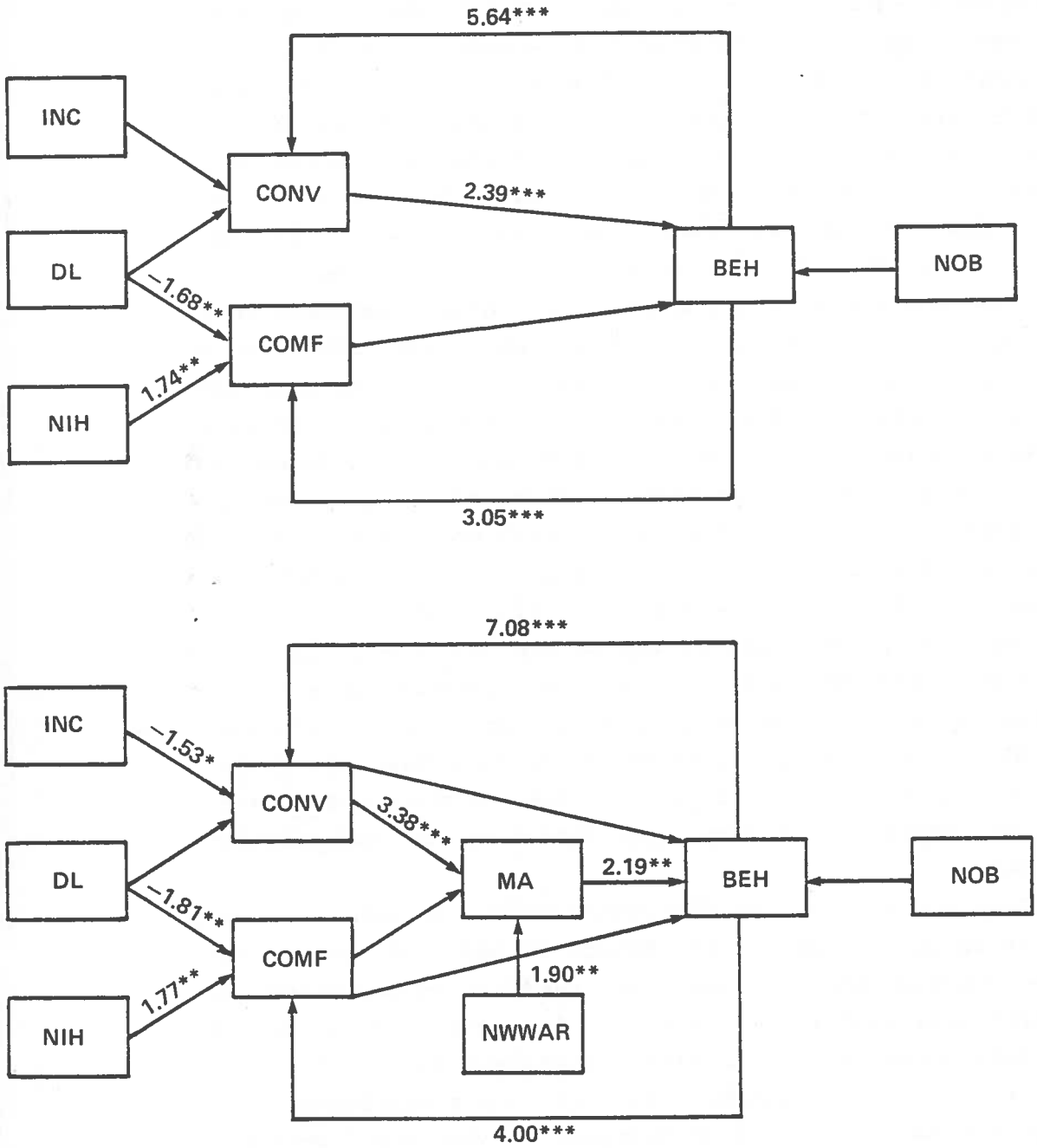
BEHAVIORAL FEEDBACK IN A SIMPLE ATTITUDE-BEHAVIOR MODEL



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

Figure 4—4

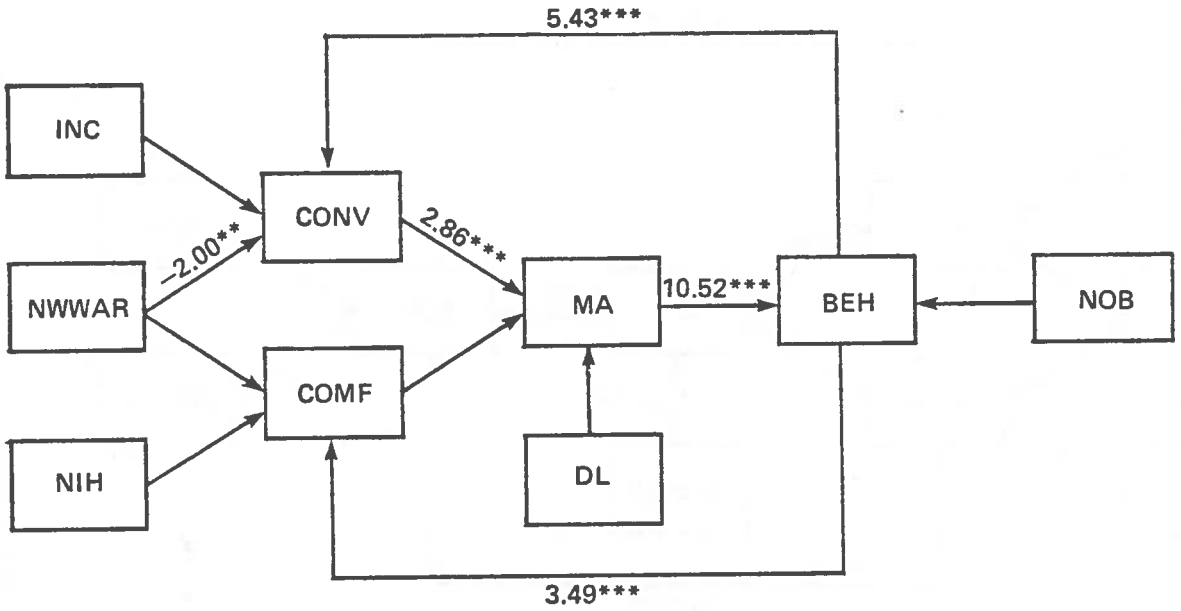
THE ROLE OF AFFECT FOR ATTITUDE-BEHAVIOR RELATIONSHIPS

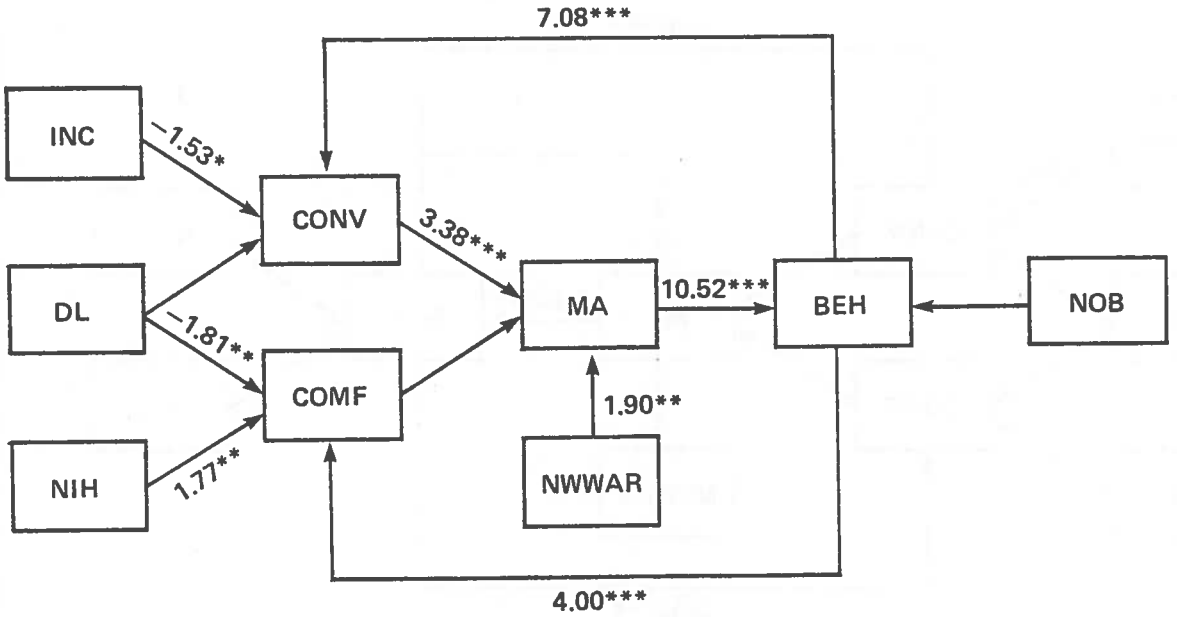


*p<.10 **p<.05 ***p<.01

Figure 4–5

EXOGENOUS VARIABLE EFFECTS





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

the relationship between cognitions and affect is the usual one. Bus convenience, but not comfort, perceptions are statistically associated with modal affect ($p < .01$). No link to modal affect in the bottom flowgraph is statistically significant. One condition which will explain this result is that the partial correlation of perceived convenience with affect, holding behavioral feedback constant, is not significant. It has been shown in previous flowgraphs that convenience perceptions are strongly associated with modal affect.[1]

The flowgraphs in Figure 4-7 are identical except for the definition of perceived bus availability. In the upper flowgraph, bus availability is defined as the inverse of perceived bus riding time plus 2.5 times perceived out-of-vehicle time. Perceived availability in the lower flowgraph is a dummy variable indicating perceptions of whether bus service is available or not. The behavior-to-cognitions linkages are all statistically significant ($p < .01$). Modal affect in each configuration is shown to influence behavior. However, the links from cognitions to modal affect does not manifest a strong influence even with respect to the convenience perceptions. This finding can result from correlated effects of perceived bus availability and convenience with respect to modal affect.

In Figure 4-8 the flowgraph representations isolate the cognition terms. Four cognition variables are shown to have strong influence on modal affect when each is presented as its single cognitive determinant. The first and second flowgraphs, part one of Figure 4-8, are identical except for the definition of perceived bus availability. The two flowgraphs on the next page of Figure 4-8 are identical attitude-behavior configurations,

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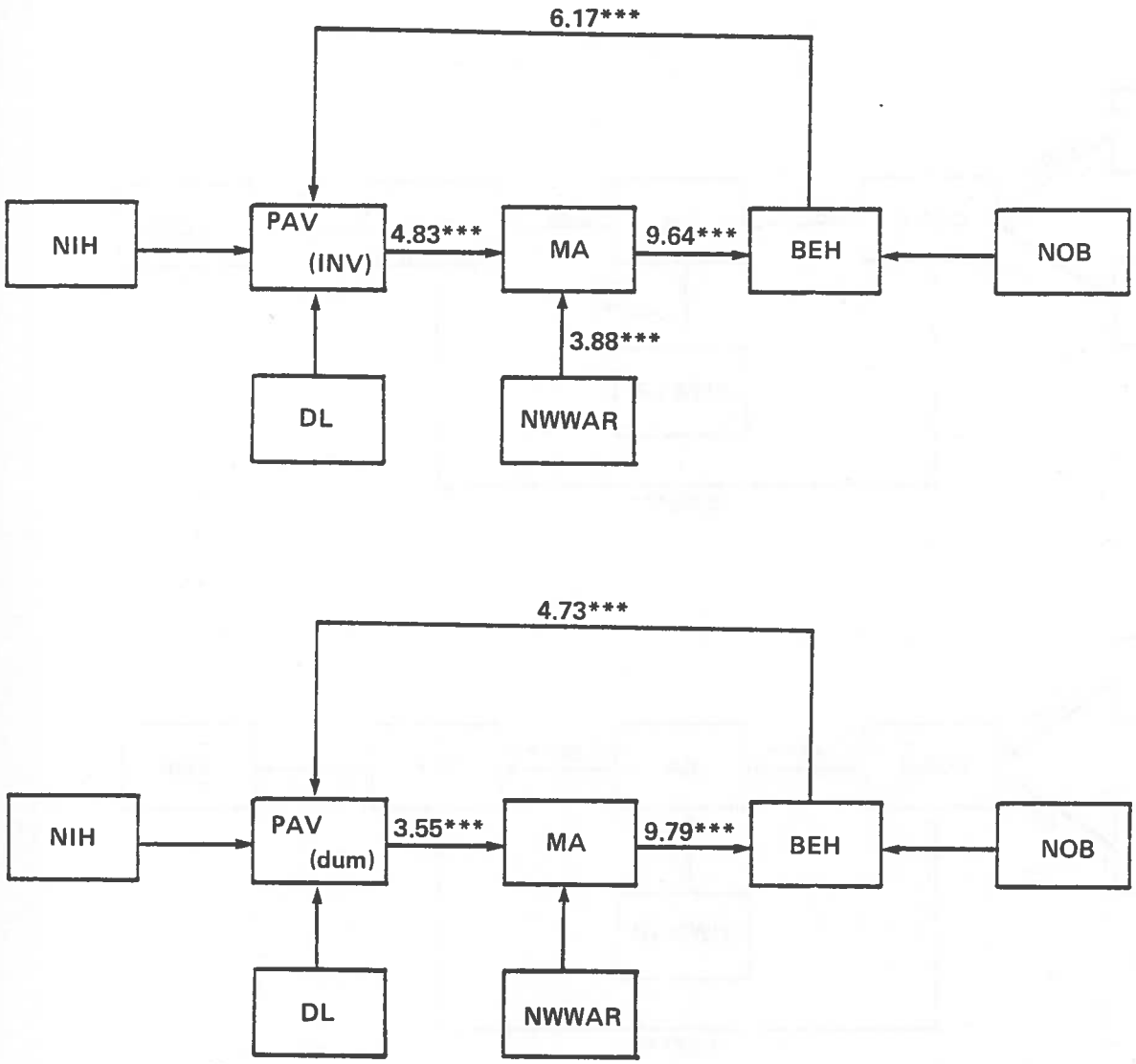
[1]A similar explanation is appropriate for the lack of statistical significance between behavioral feedback and modal affect. Information bearing on this point is available in Figure 4-16.

Figure 4–8

SINGLE COGNITION LINKS TO MODAL AFFECT



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

Figure continued on following page.

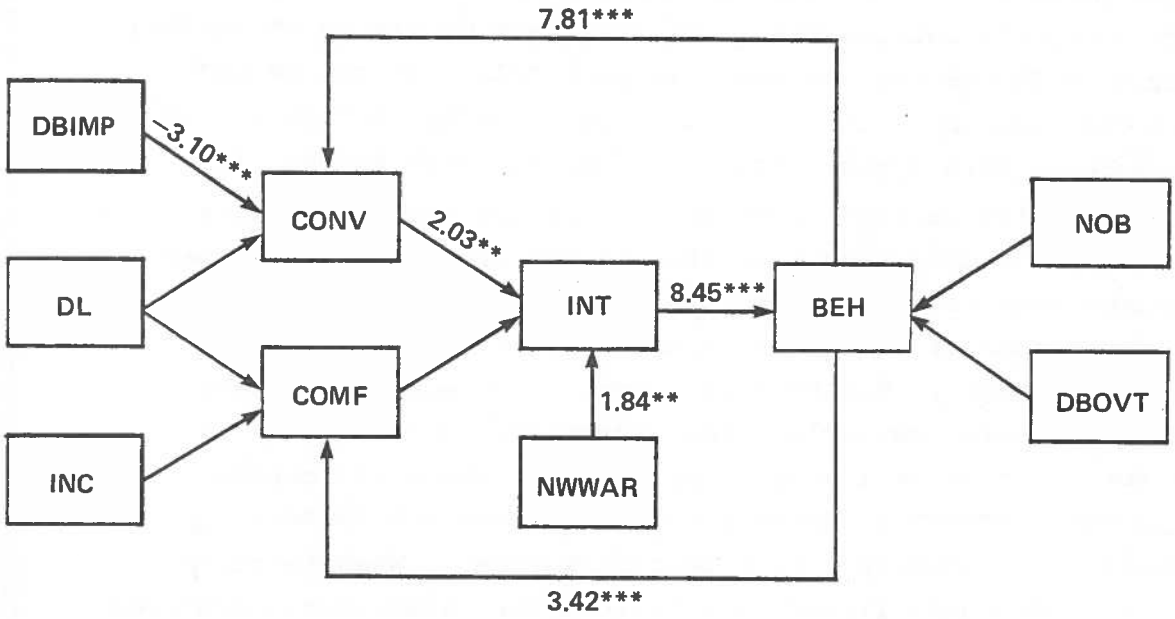
similar to those on the first page. The one difference lies in the type of cognition: the top flowgraph utilizes convenience perceptions while the lower one includes comfort perceptions. Modal affect in each of the structures depends on the cognitive factor. PAV_{inv} and PAV_{dum}, which manifest no impact upon modal affect in Figure 4-7 are shown to have statistically significant associations with modal affect in these structures. Similarly, perceptions of comfort are generally not found to determine modal affect (see Figure 4-6), yet as the only cognitive factor its impact is significant at the .01 level. The mutual dependence assumption is supported in all four flowgraphs because attitude-to-behavior and behavior-to-attitude links are all significant.

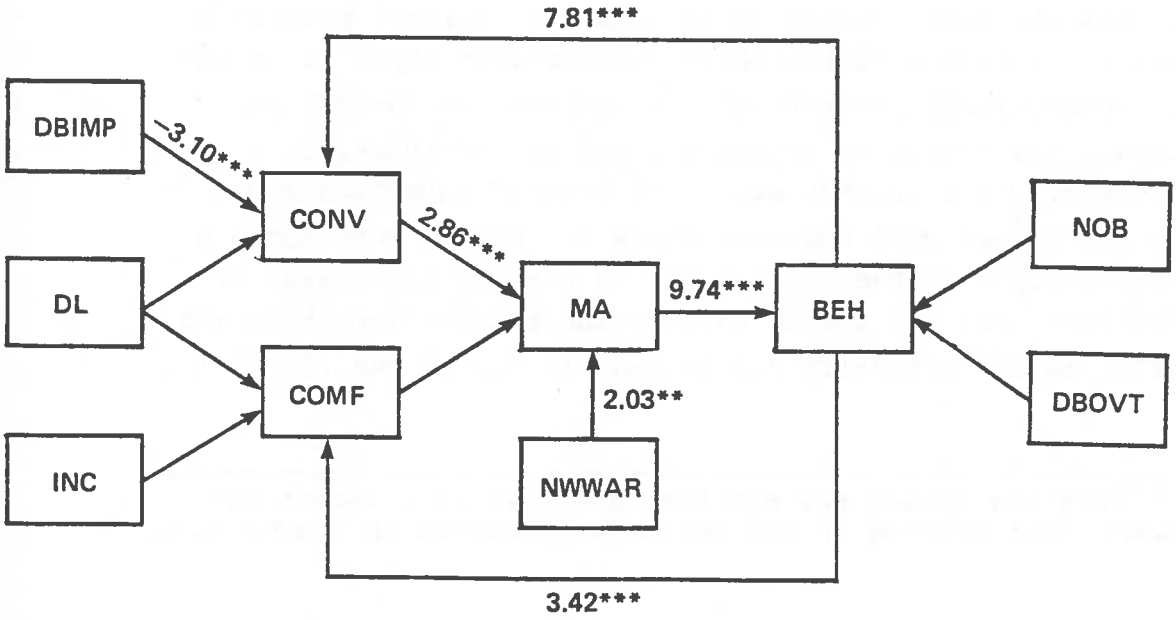
Modal affect and intention are compared as intervening variables in Figure 4-9. The flowgraphs are identical with respect to their endogenous variable structure except for the interchange of modal affect and intention. The top flowgraph, which is similar to most of the previous examples, has behavioral feedback to cognition as well as convenience perceptions-to-affect and affect-to-behavior links which are statistically significant ($p < .01$). The bottom flowgraph, which preserves the behavioral feedback effect, shows that intention is statistically associated with behavior. In addition, convenience perceptions feed into intention at a statistically significant level. These results are compatible with the conclusion that intention functions as an intervening variable in the same way that modal affect does.

Figure 4-10 presents another perspective on this issue. Two flowgraphs, which are identical except for a single change, are shown in this example as well. Modal affect and intention function in a parallel fashion across these two flowgraphs.

Figure 4—10

THE COMPARABILITY OF AFFECT AND INTENTION AS INTERVENING VARIABLES
(Part 2)

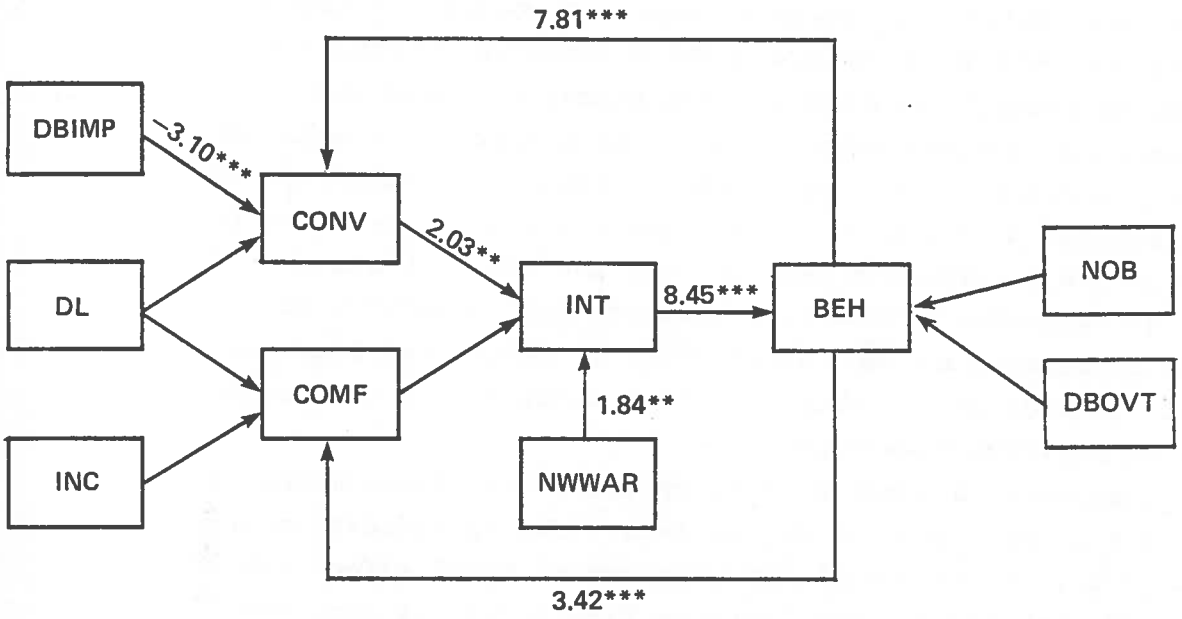


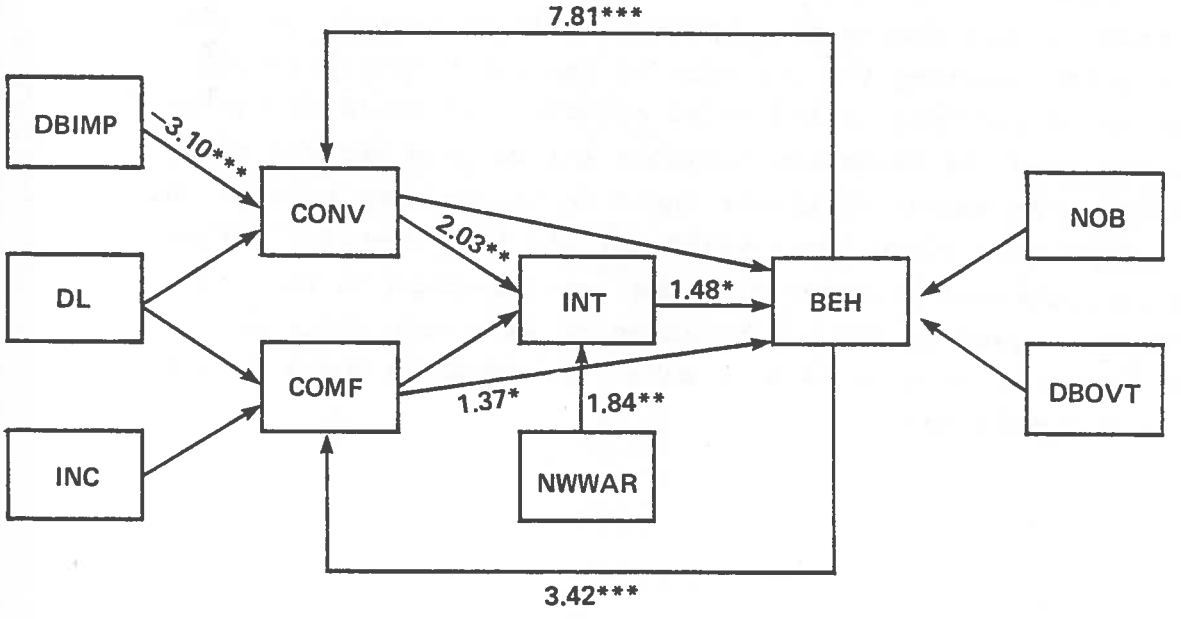


* p<.10 ** p<.05 *** p<.01

Figure 4—11

EXOGENOUS VARIABLE EFFECTS ON THE ROLE OF INTENTION AS AN INTERVENING VARIABLE

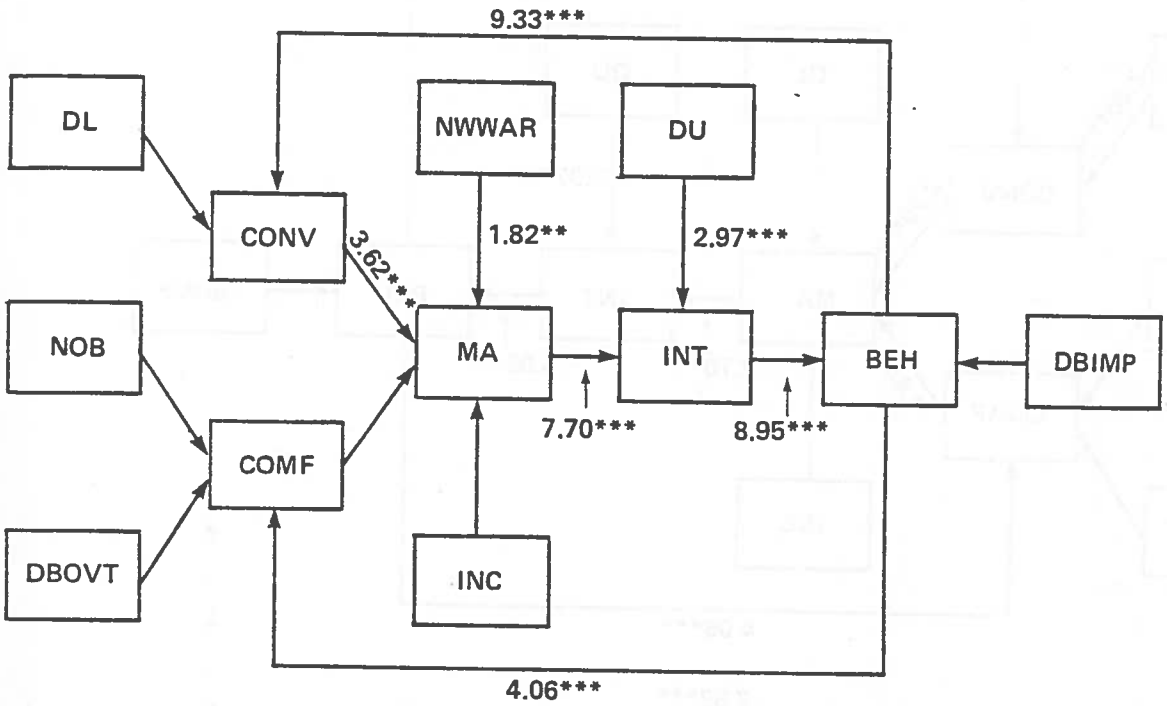




* p <.10 ** p<.05 *** p<.01

Figure 4–12

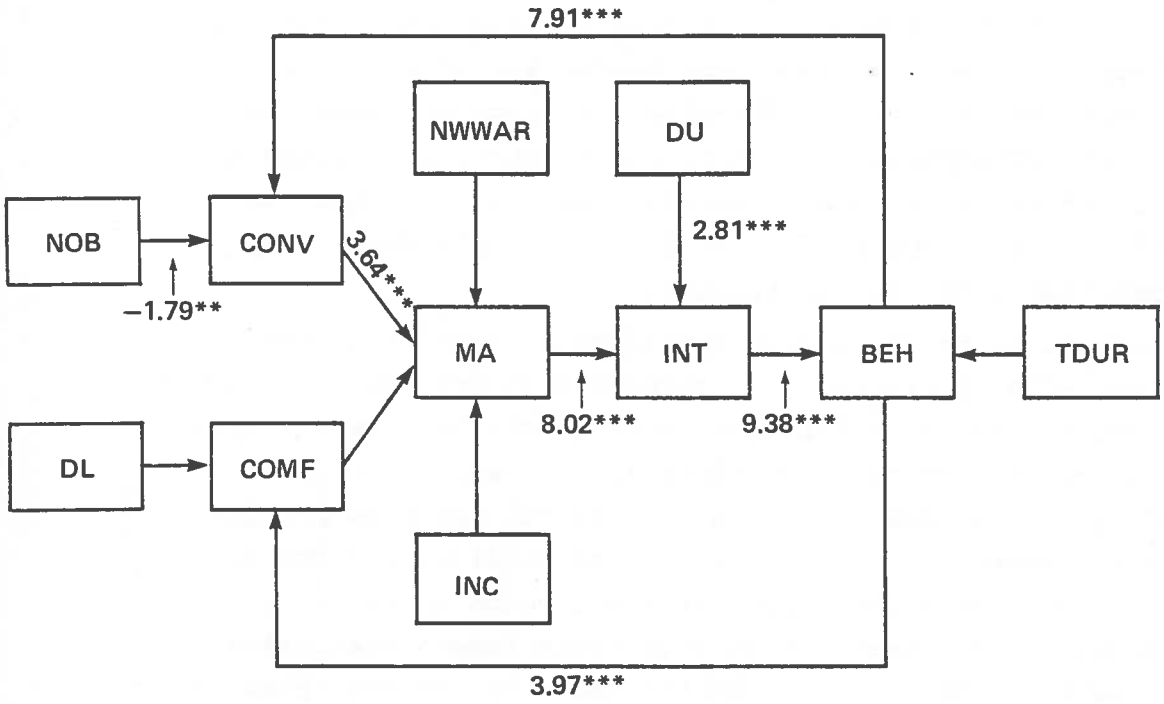
A SIMPLE HIERARCHICAL MODEL WITH FEEDBACK



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

Figure 4–13

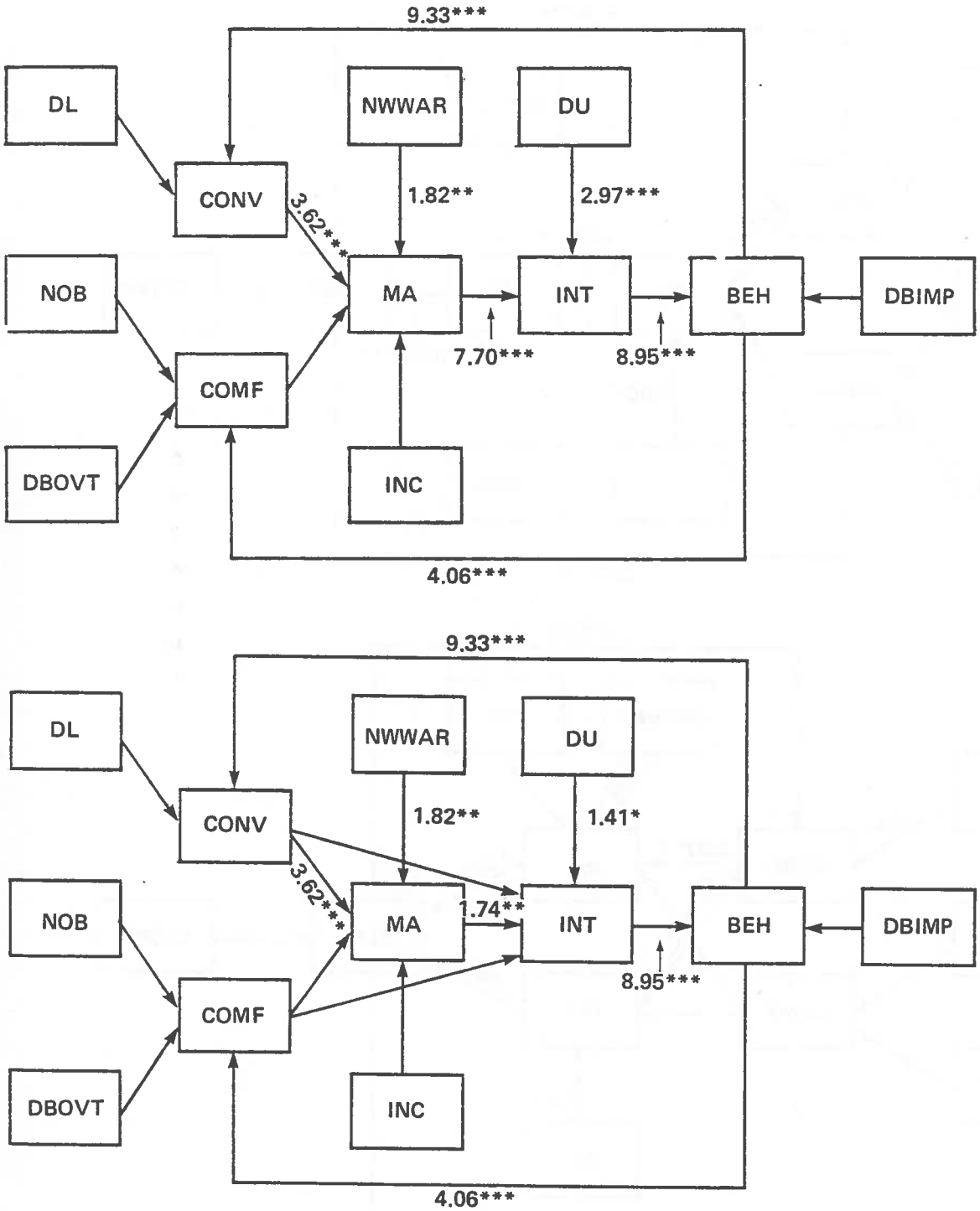
EXOGENOUS VARIABLE EFFECTS ON A SIMPLE HIERARCHICAL MODEL
(continued)



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

Figure 4—14

THE INTERVENING ROLE OF AFFECT BETWEEN COGNITIONS AND INTENTIONS



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

Figure 4-16 presents flowgraphs which are simpler in structure than those previously studied. The flowgraphs in Figure 4-16 evaluate the potential for mutual dependence between modal affect and behavior, and between intention and behavior. The three flowgraph results are consistent with the mutual dependence hypothesis, suggesting that mutual dependence between attitudes and behavior does not demand the use of an intervening variable. While the exogenous variable links to endogenous variables are generally not statistically significant, these links would be statistically significant in one case if they had the right sign.[1] The addition of convenience perceptions as an exogenous variable to modal affect increases the strength of the affect-to-behavior link while it concurrently diminishes the behavior-to-affect link. Since CONV is logically an endogenous variable, the manipulation is not strictly correct -- however, its result is reasonable and interesting. The last flowgraph shows that intention can serve as modal affect does when there is a direct link between attitudes and behavior.

Attitude-Behavior Structures for Carpool Usage

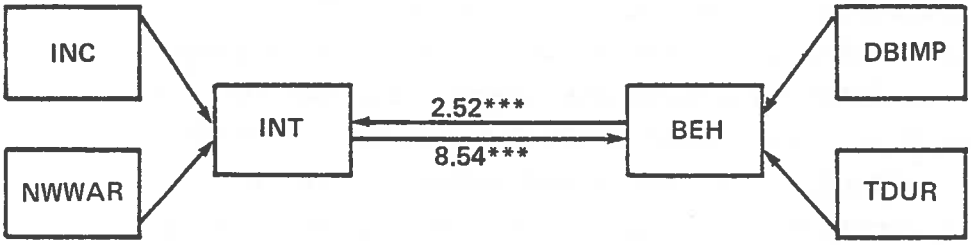
This portion of Chapter 4 describes empirical models of carpool usage based on attitudinal, demographic, and system variables. As with the discussion of factors underlying bus usage, various structural assumptions are represented by flowgraphs and tested by two-stage least squares analysis. The structures for carpool versus bus usage can be compared by reviewing t-values for similar flowgraphs across modes.

---

[1]These t-values are shown for information purposes only. It should be understood that they do not denote statistical significance because in a one-sided test, as used in these analyses, the sign must be correct for statistical significance to be demonstrated.

Figure 4—16

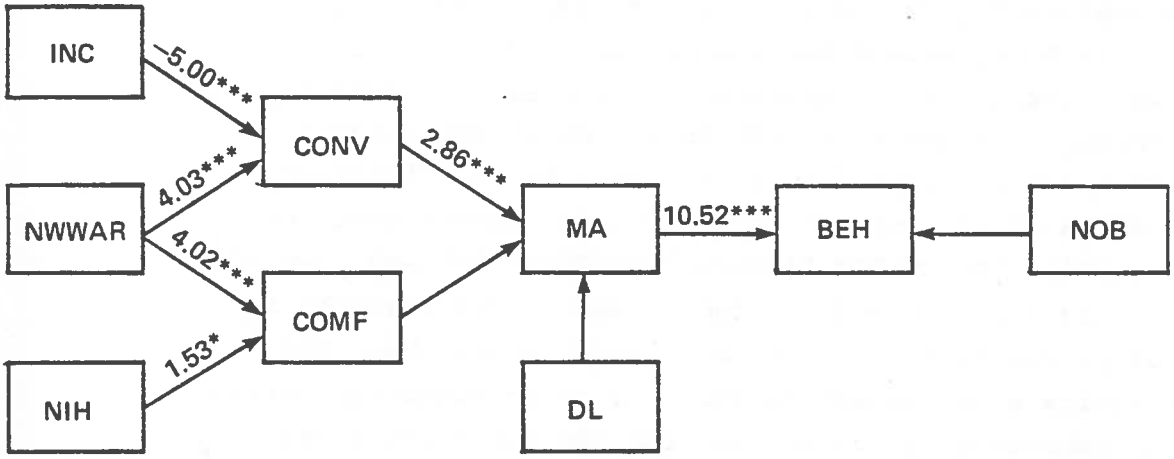
THE MUTUAL DEPENDENCE OF ATTITUDES AND BEHAVIOR
(continued)

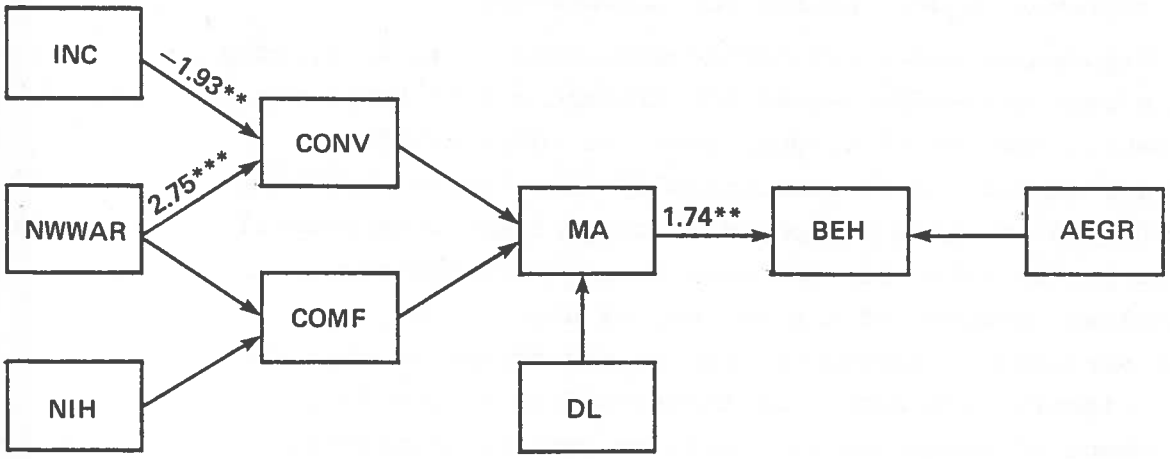


*p<.10 **p<.05 ***p<.01

Figure 4—17

COGNITION-AFFECT-BEHAVIOR FOR BUSES AND CARPOOLS

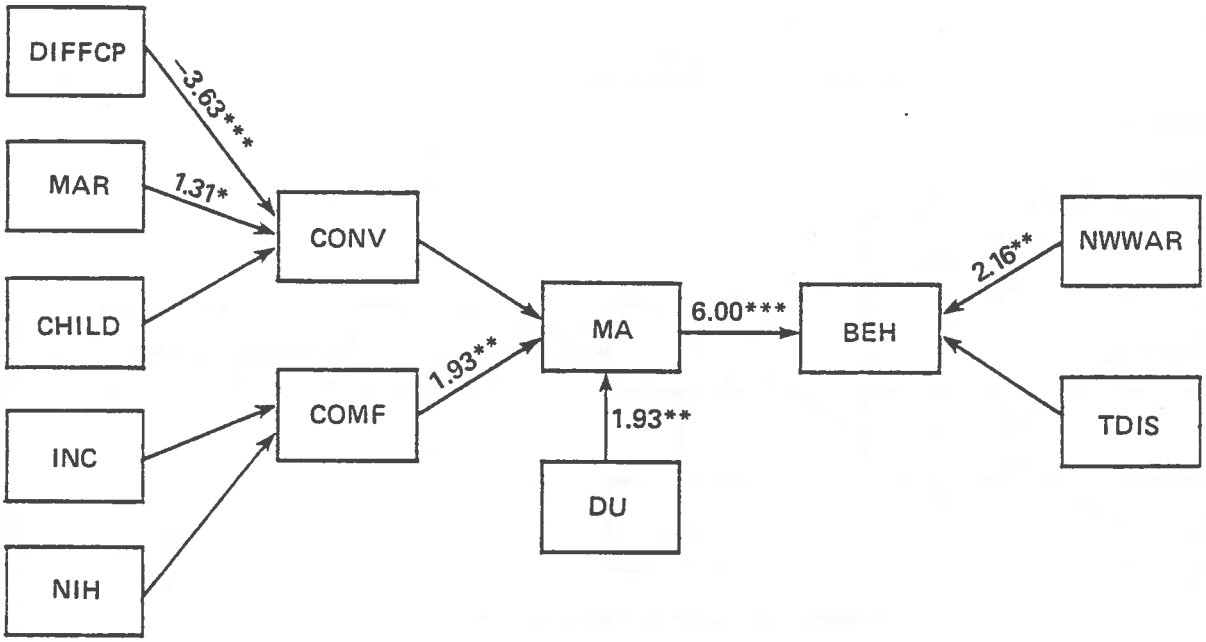




* p<.10 ** p<.05 *** p<.01

Figure 4—18

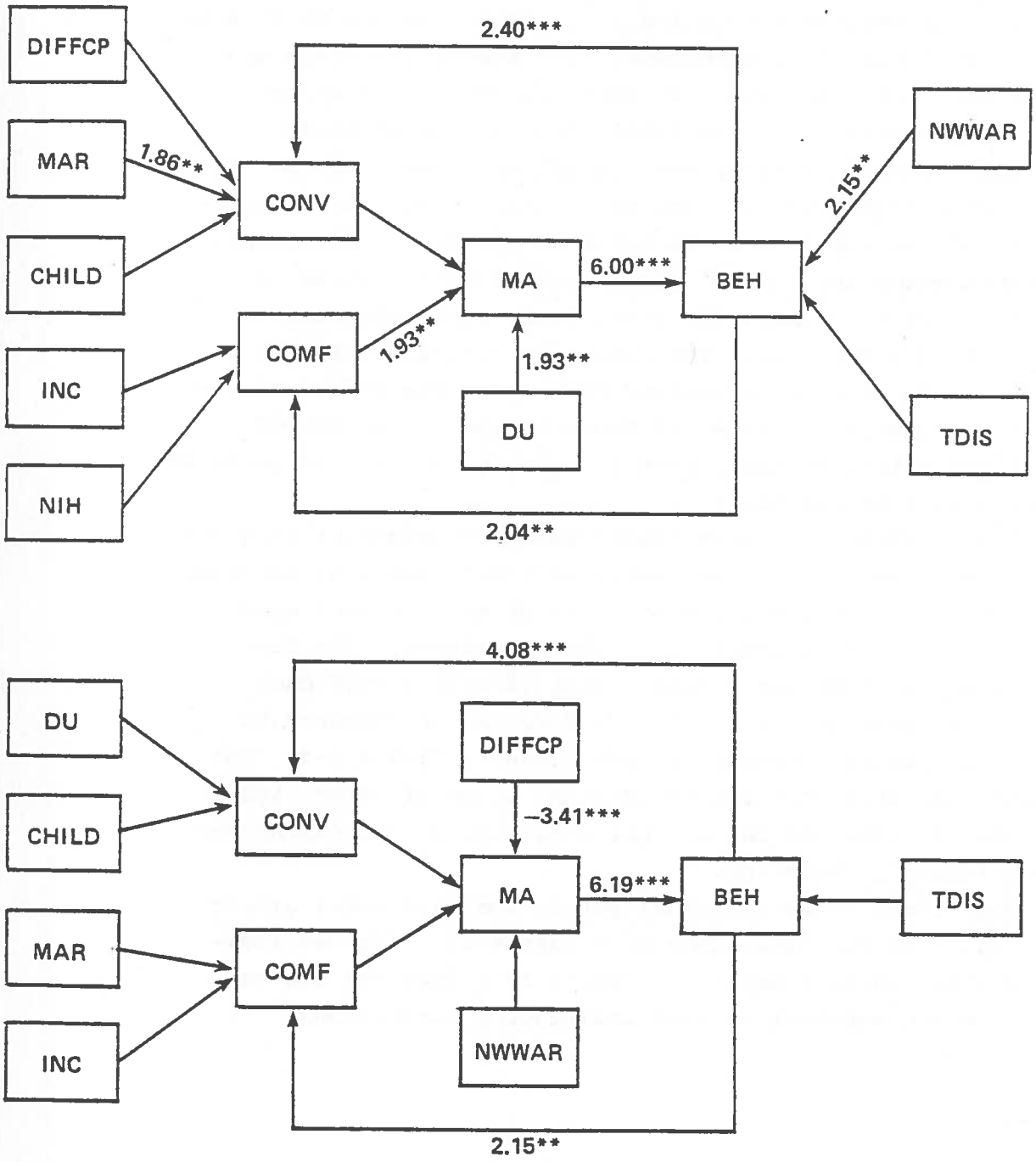
EXOGENOUS VARIABLE EFFECTS WITHOUT BEHAVIORAL FEEDBACK



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

Figure 4–20

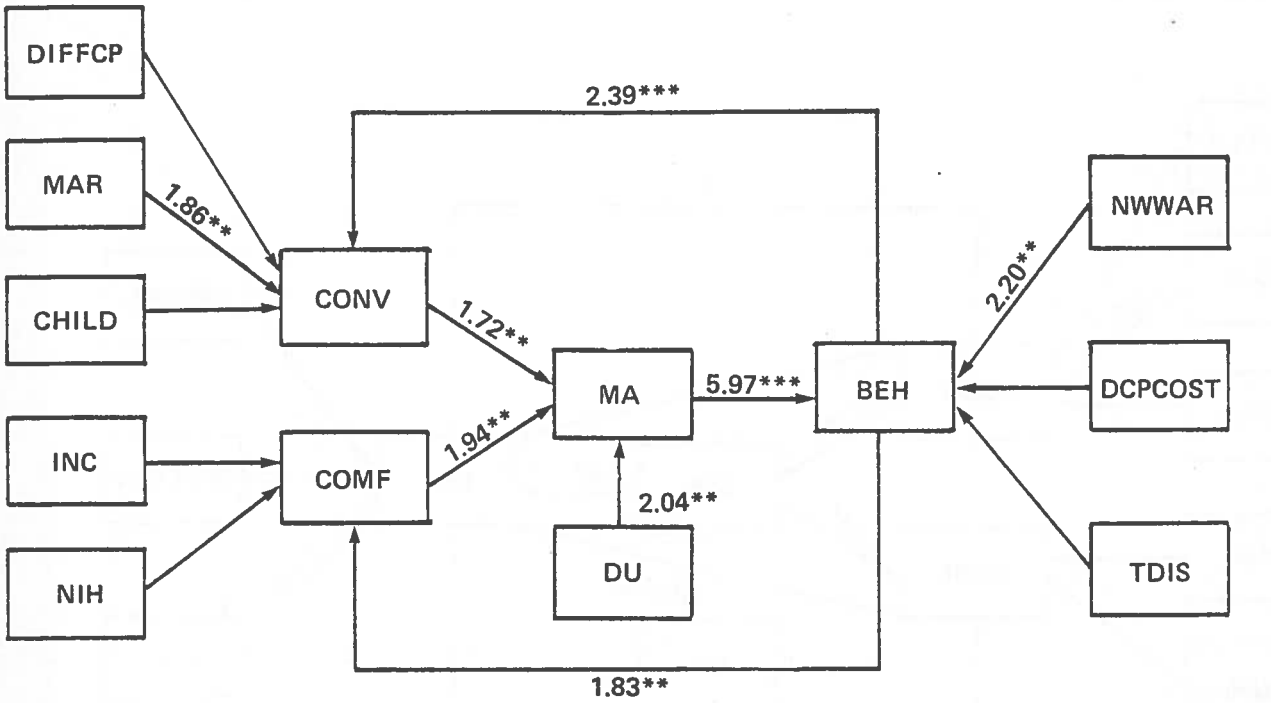
EXOGENOUS VARIABLE EFFECTS WITH BEHAVIORAL FEEDBACK
(Part 2)

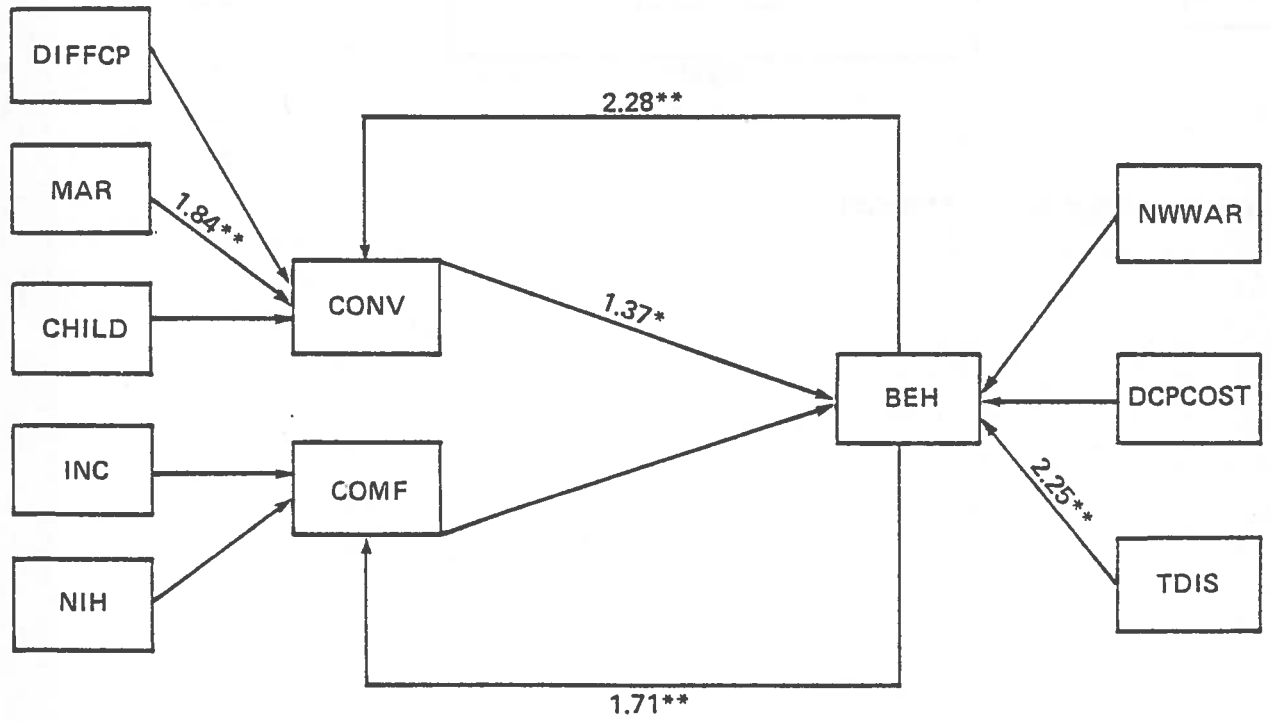


* p<.10 ** p<.05 *** p<.01

Figure 4–21

THE ROLE OF AFFECT FOR ATTITUDE-BEHAVIOR RELATIONSHIPS



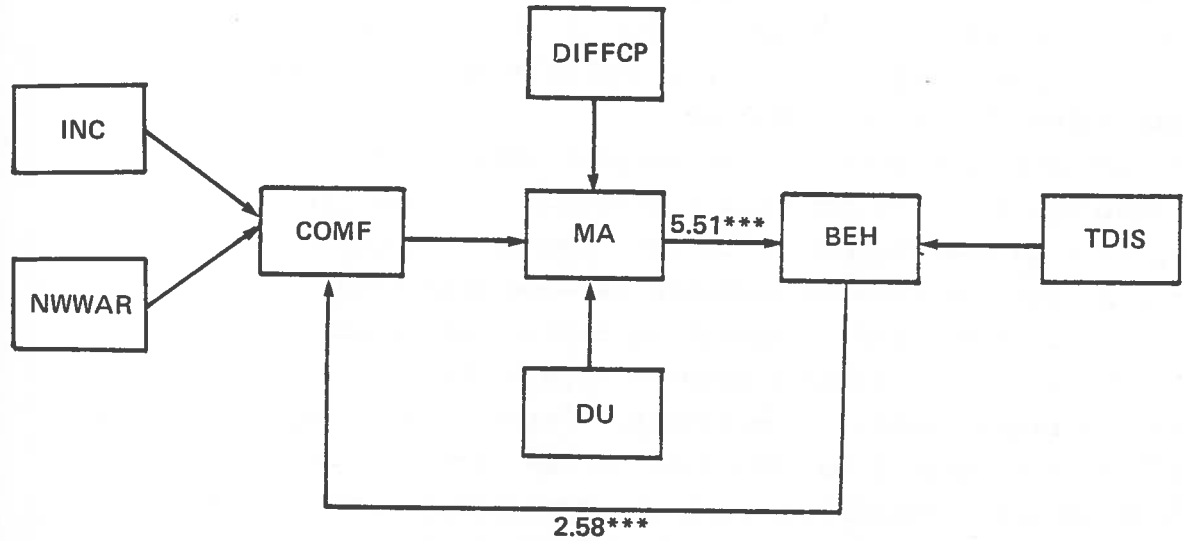


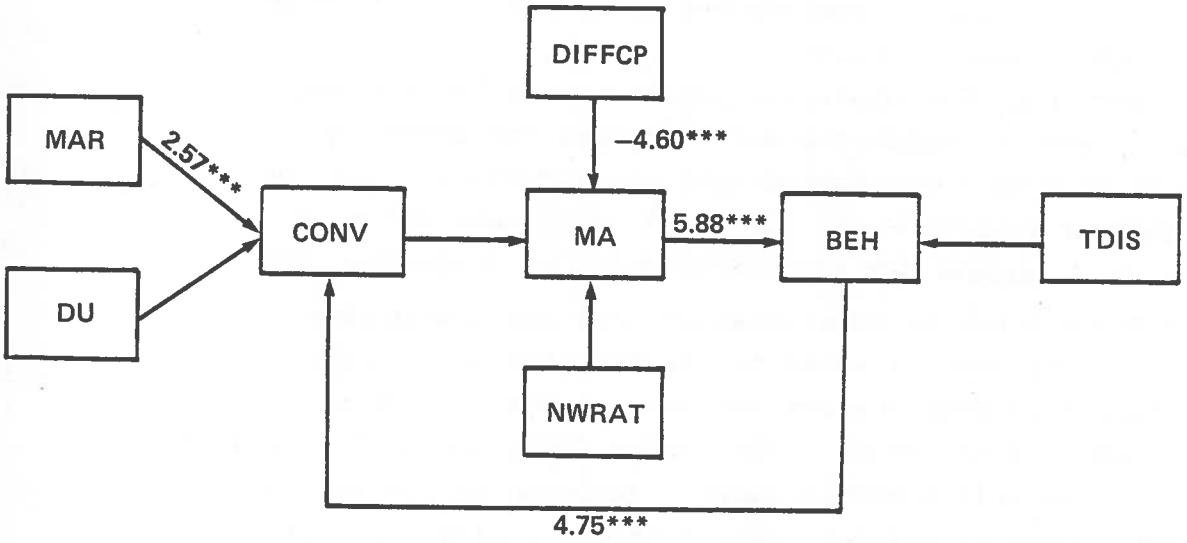
*p<.10 **p<.05 ***p<.01

Figure continued on following page.

Figure 4–22

LINKS BETWEEN CARPOOL PERCEPTIONS AND MODAL AFFECT

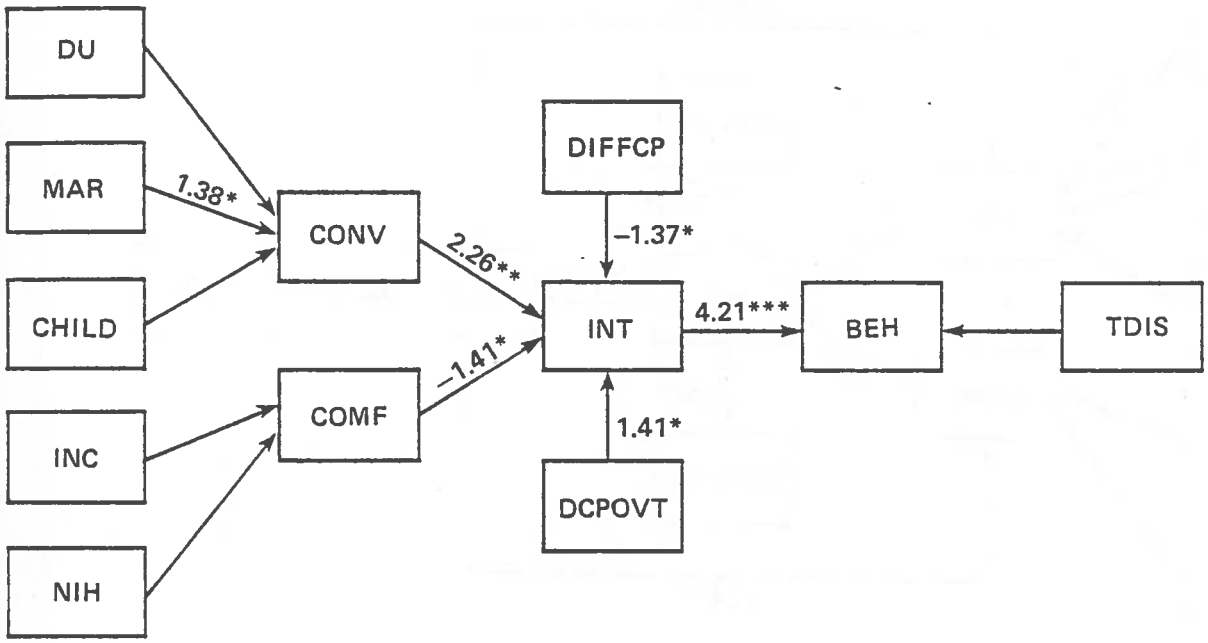




*p <.10 **p <.05 ***p <.01

Figure 4–23

INTENTION AS AN INTERVENING VARIABLE WITHOUT BEHAVIORAL FEEDBACK



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

respect to carpool convenience perceptions and intention to use. As demonstrated above, the linkages among endogenous variables display a sensitivity to exogenous variables. In this instance, the cognition-to-intention links both become statistically nonsignificant. The feedback of behavior to cognitions is invariant under the exogenous variable manipulation.

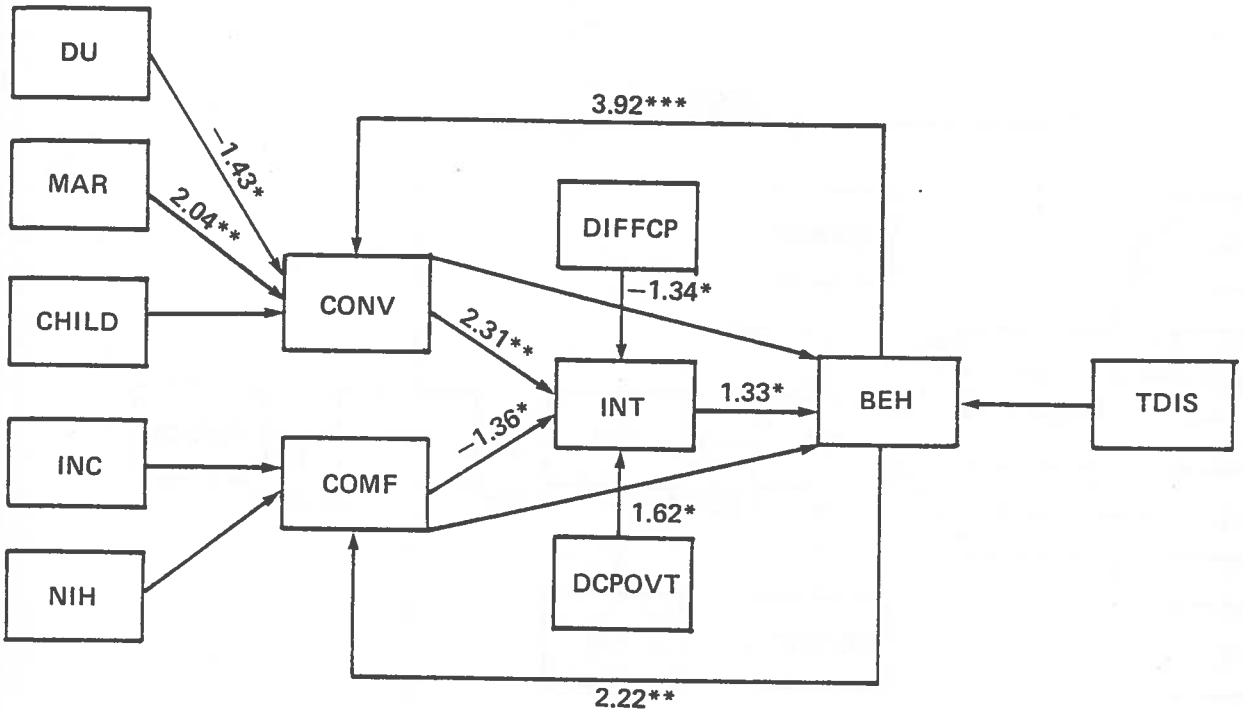
The role of intention for carpool usage is evaluated in the three flowgraphs of Figure 4-25. The top flowgraph again supports the mutual dependence hypothesis, with intention serving as an intervening variable. The link between comfort and intention has the wrong sign. The second flowgraph omits the mediating variable, but the mutual dependence hypothesis is still supported. This modification results in a marginally significant relationship between convenience perceptions and behavior. The last flowgraph of Figure 4-25 shows three attitudinal variables with arrows going to behavior. This arrangement demonstrates that intention has explanatory strength relative to behavior which goes beyond cognitions.

Figure 4-26 shows a hierarchical model with both modal affect and intention as intervening variables between cognitions and behavior. The relationship between the intervening variables is traditional, with affect feeding into intention. The configuration of exogenous and endogenous variables results in a set of statistically significant t-values from perceived convenience through to behavior. The feedback of behavior on cognitions is also statistically significant to both convenience and comfort perceptions. The reported difficulty of finding carpool mates (DIFFCP) is strongly associated with carpool usage ($p < .01$).

The same hierarchical set of relationships is investigated in Figure 4-27, but the selection and positioning of DIFFCP and other exogenous variables is adjusted.

Figure 4–25

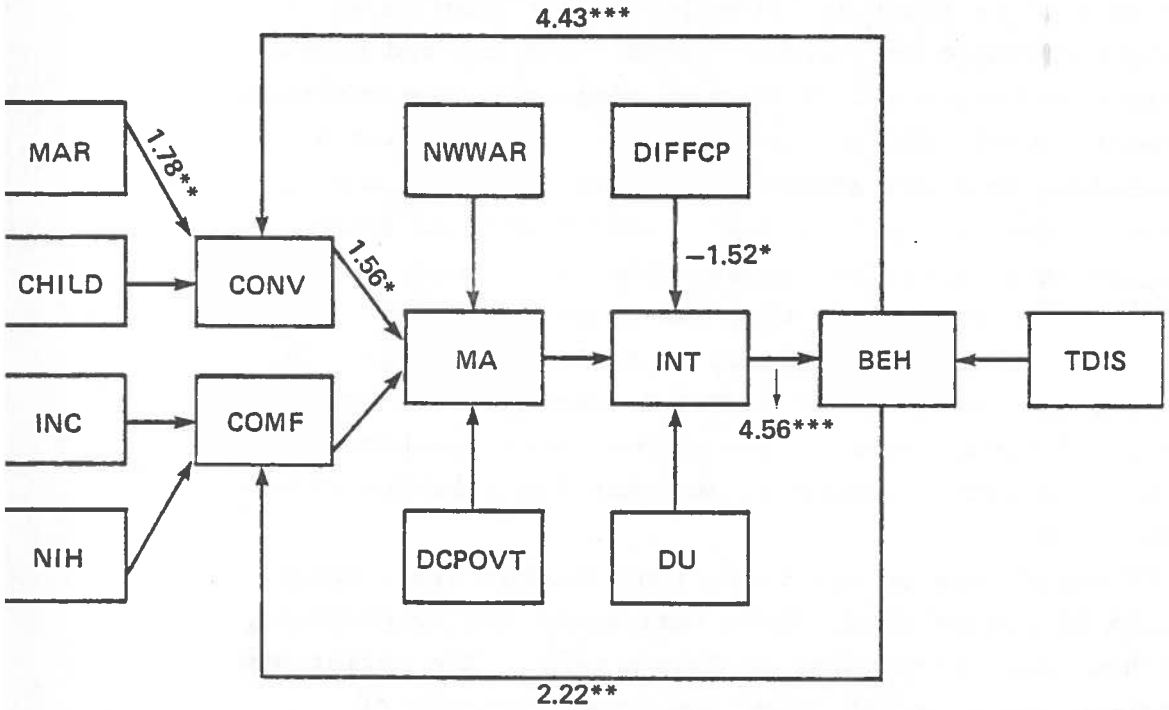
THE ROLE OF INTENTION AS AN INTERVENING VARIABLE
(continued)

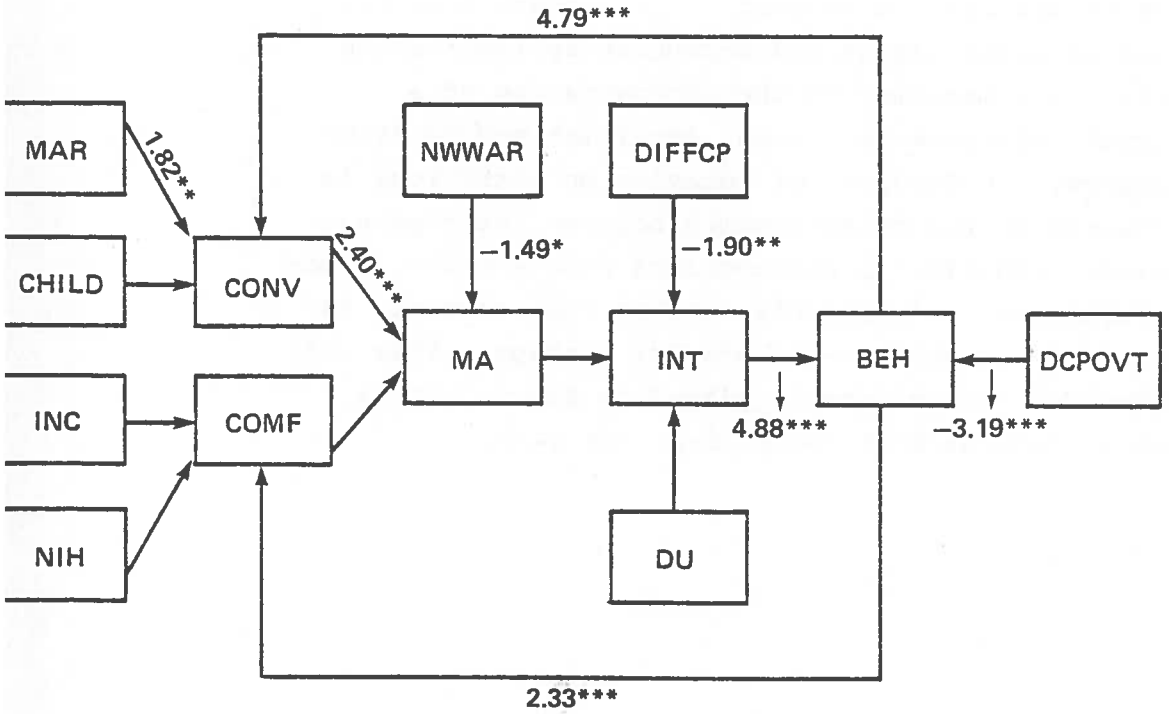


*p<.10 **p<.05 ***p<.01

Figure 4–27

THE ROLE OF DIFFCP ON THE AFFECT TO INTENTION LINK

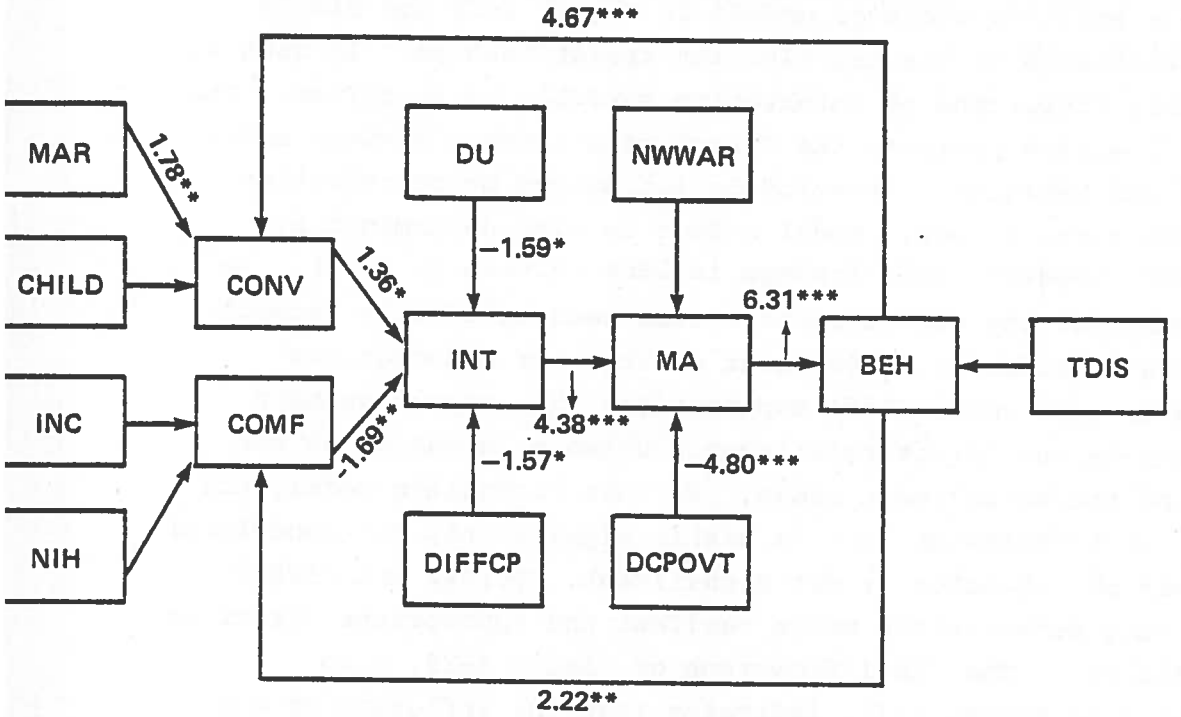


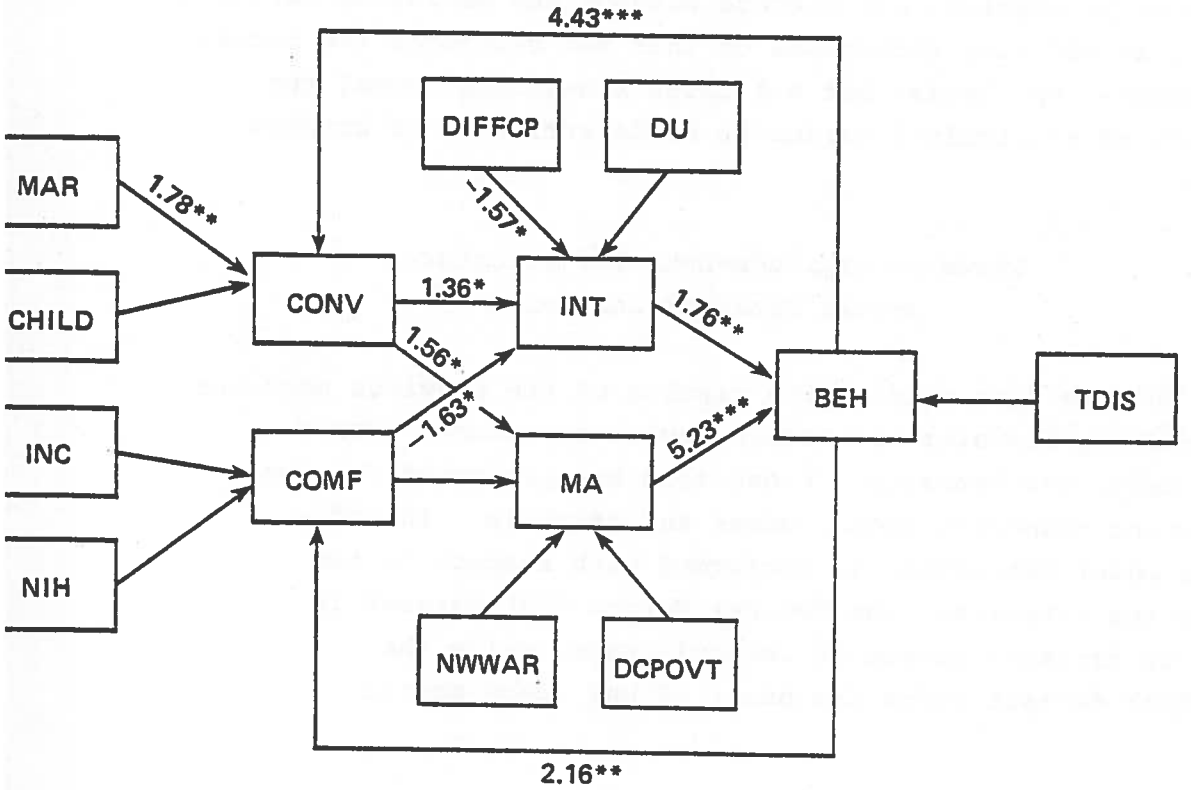


p<.10 ** p<.05 *** p<.01

Figure 4–28

VARIATIONS ON THE SIMPLE HIERARCHICAL MODEL

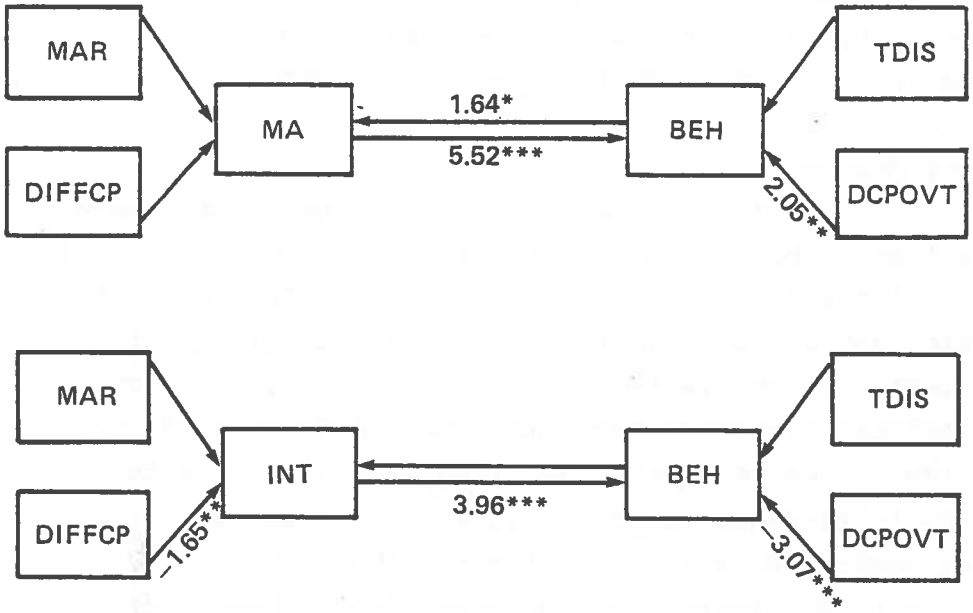


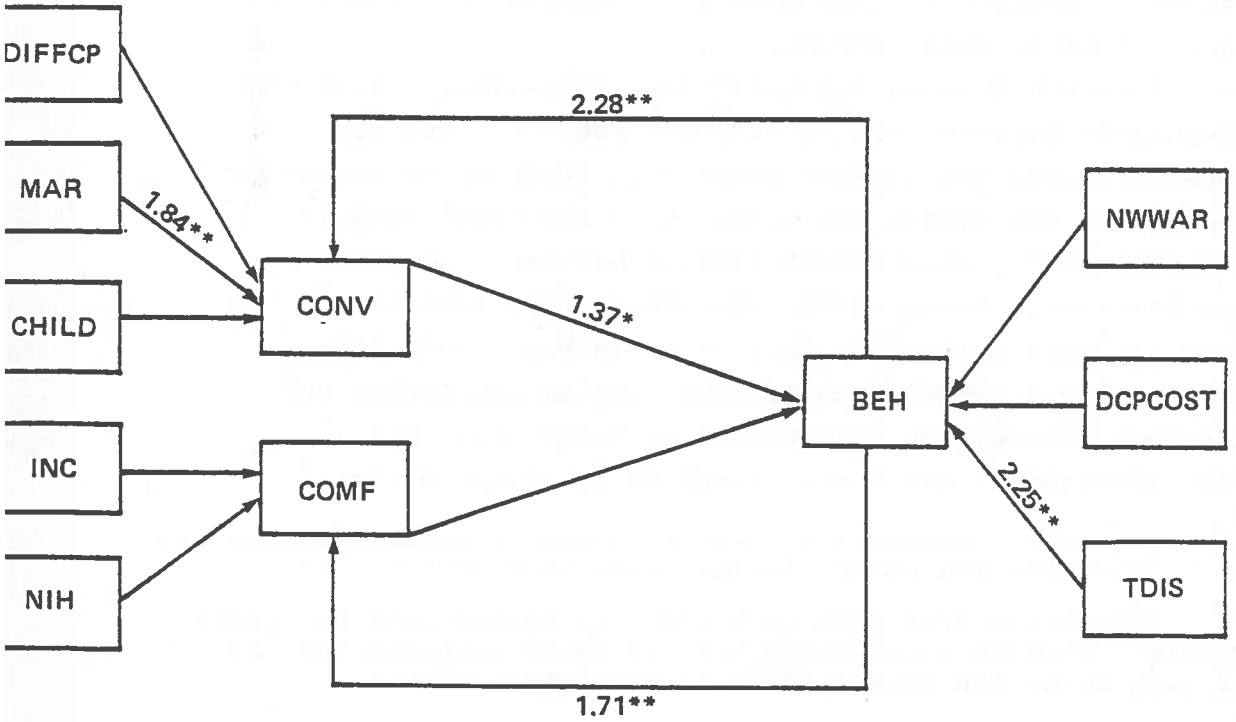


* p<.10 ** p<.05 *** p<.01

Figure 4—29

THE MUTUAL DEPENDENCE OF ATTITUDES AND BEHAVIOR

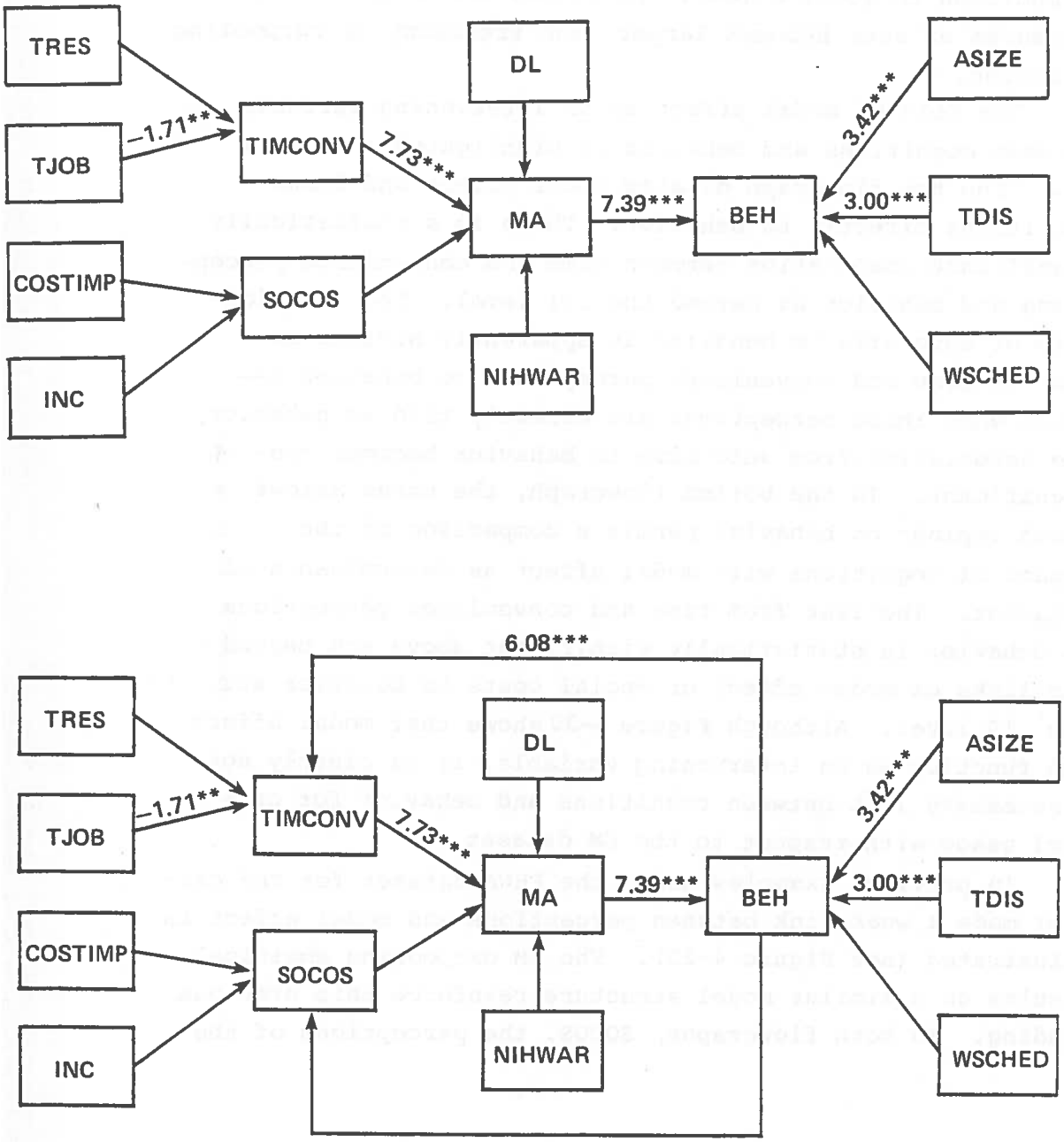




*p<.10 **p<.05 ***p<.01

Figure 4–30

AFFECT LINK BETWEEN COGNITION AND BEHAVIOR WITH AND WITHOUT BEHAVIORAL FEEDBACK



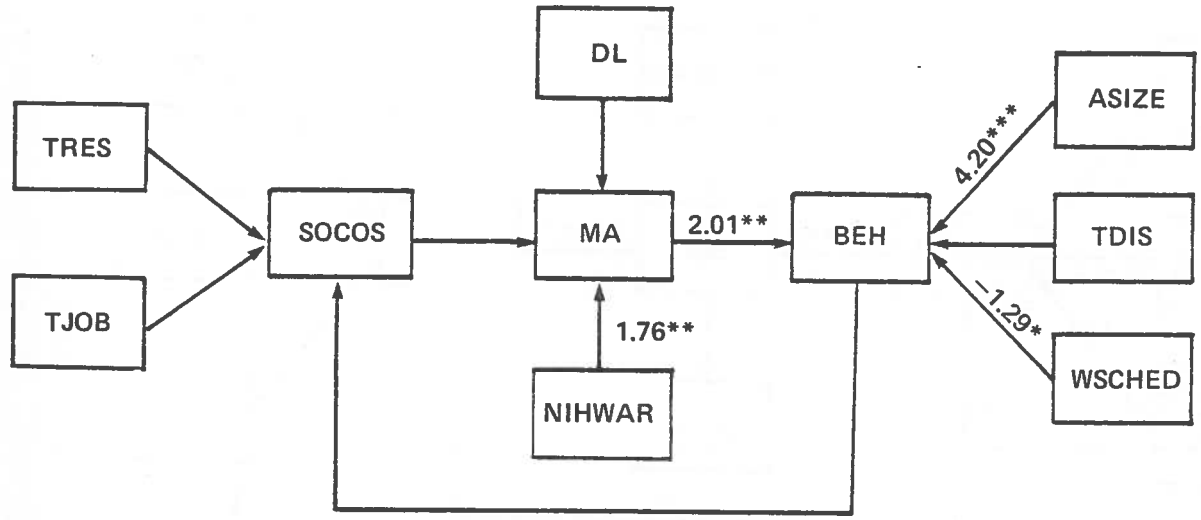
* p <.10 ** p <.05 *** p <.01

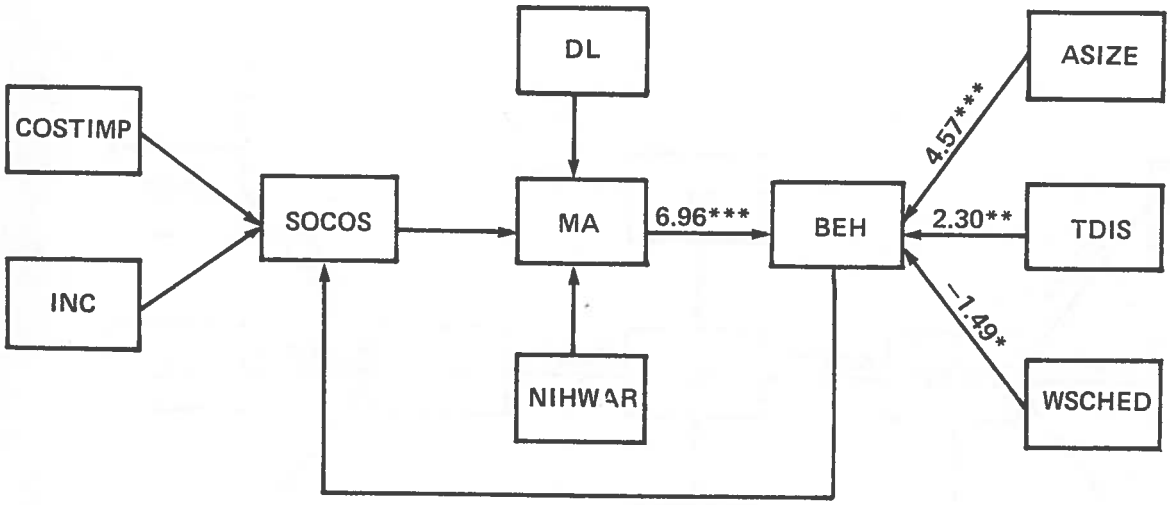
social costs of automobile driving, does not manifest an effect upon modal affect. The feedback relationship from BEH to SOCOS is also not found to be statistically significant. On the other hand, the link from modal affect to behavior is statistically significant in both flowgraphs. It appears that attitudes are related to carpooling behavior, but perceptions on the social costs of auto driving do not follow the typical pattern. Two of the exogenous behavioral determinants of the upper flowgraph ASIZE and USCHED, are significant. NIHWAR has a significant influence on affect toward carpooling. The behavioral determinants on the lower flowgraph are all significant. The manipulation of exogenous variables, however, causes NIHWAR, a determinant of affect, to surrender explanatory power.

Figures 4-30, 4-31, and 4-32 fail to uncover any relationship between carpool usage and the perceived social costs of auto use. Figure 4-33 builds on this finding by presenting flowgraphs which omit this cognition variable. The top and bottom flowgraphs are identical, except for the selection and positioning of exogenous variables with respect to modal affect and time and convenience perceptions. The cognition-to-behavior linkage is statistically significant ($p < .01$) in both structures. Behavioral feedback to time and convenience perceptions is statistically significant in the top flowgraph. While the bottom flowgraph does not demonstrate behavioral feedback, two of the three antecedent variables for time and convenience perceptions are statistically significant. Furthermore, since the two t-values which mediate the cognition-to-behavior linkage are larger than those in the top flowgraph, behavior is shown to be a statistically significant input to cognition.

Figure 4–32

THE LINK OF SOCOS TO MODAL AFFECT





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

Bus Usage Models

The bus usage models based on the Lovelock dataset also have somewhat different cognition variables than those employed in the analysis of the FHWA dataset. The perceived availability of buses is a new cognitive variable which is used exclusively in the Lovelock dataset. Perceived bus convenience is defined in terms of perceptual questions of bus service. Questions were selected for the definition of perceived bus convenience on the basis of research judgment because factor analysis results were not available. The specific questionnaire items and their use in variable construction are provided in Appendices A and B. The Lovelock dataset did not contain a direct assessment of modal affect, but there was information on intention to use in response to service improvements.

Figure 4-34 presents flowgraphs with either one or two cognition variables as input to intention. The top flowgraph does not show an uninterrupted series of significant t-values between cognition, in this case bus convenience perceptions, and bus usage. While the link from intention to behavior is statistically significant, the cognitive input to intention is nonsignificant. In the bottom flowgraph, the perception of bus availability is a determinant of bus usage through the intervening variable of intention. Perceptions of bus convenience are correlated with intention, but the sign is wrong and the corresponding t-value is consequently not significant.[1] Behavioral feedback to cognitions is statistically significant in both flowgraphs.

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[1]The t-value is shown to indicate the strength and direction of the relationship. The stars are placed to follow the convention of other flowgraphs.

The mutual dependence of attitudes and behavior through an intervening variable is affirmed in the bottom flowgraph of Figure 4-34. Figure 4-35 examines mutual dependence without an intervening variable. The mutual dependence assumption is tested in a fashion comparable to that employed for Figure 4-16, and the result is similar. While there is a statistically significant link between attitudes and behavior, the impact of attitudes on behavior is greater than that of behavior on attitudes.

Attitude-Behavior Structures for Alternative Traveler Segments

The preceding research in attitude-behavior structures for carpool and bus usage overlooks the potential for differences in structure across groups of travelers. The strength of the relationships between attitudes, behavior, and their antecedents may vary among groups of travelers. One positive aspect of our analysis method is its sensitivity to model specification which provides a means for assessing the validity of this assumption.

It is reasonable to suspect that the attitude-behavior structure differs between alternative travel market segments. The flowgraphs presented in this section are designed to explore this issue in a preliminary way. Market segmentations are reported here for the FHWA and GM datasets with respect to bus and carpool.

Simple attitude-behavior structures are studied in the segmentation analyses. Model configurations are similar to facilitate comparison between the FHWA bus and carpool modes

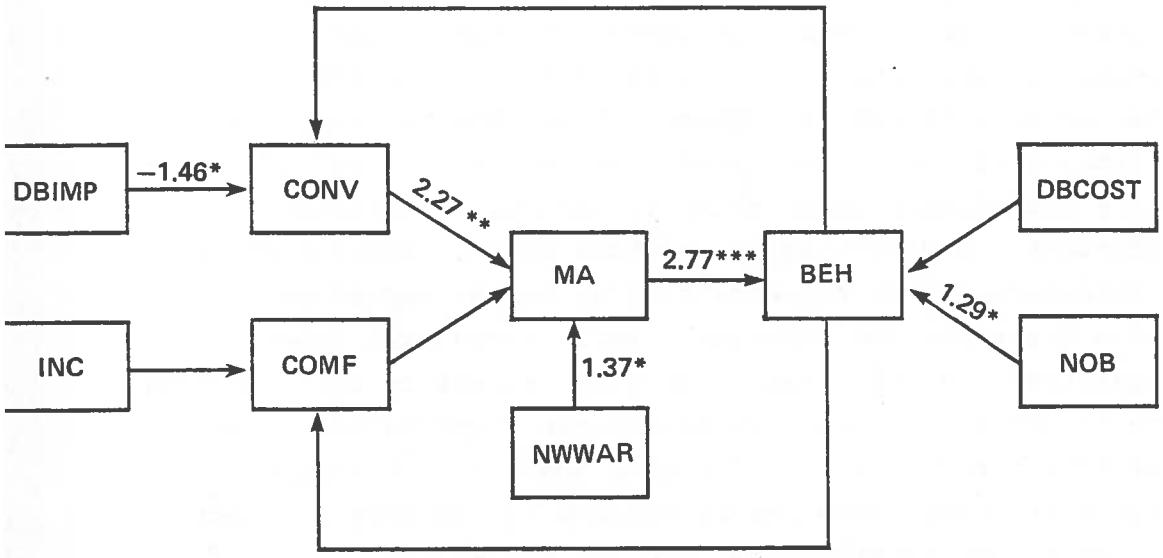
since the results are sensitive to different exogenous variable specifications. The abbreviations used in the flowgraphs can be referenced from Tables 3-2 and 3-4, the acronym lists for the FHWA and GM datasets, respectively.

Figure 4-36 presents three flowgraphs which reveal the effect of segmentations on intention to use buses with respect to the FHWA dataset. The first flowgraph shows a simple model of bus usage for the whole sample. The second and third flowgraphs represent, respectively, the fit of this model to the top and bottom third of travelers, scaled by their intention to use buses. The full-sample flowgraph reveals the cognition-to-behavior linkage through modal affect. While the behavioral feedback to cognitions is statistically significant for both perceived comfort and convenience, only convenience is related to modal affect with the correct sign. The t-values for this flowgraph are representative of those reported in prior sections for similar model specifications.

The second and third flowgraphs also show the cognition-to-behavior linkage. The upper third of travelers with respect to intention produce a flowgraph with generally lower t-values than the full-sample flowgraph. This finding holds for the lower third of travelers as well. The result is probably dependent, in part, on the smaller sample size for the two segments. Behavioral feedback to cognitions is a factor which differentiates those travelers with high-intention scores from those with low ones. While both market segments reveal an attitude-to-behavior relationship, only those travelers with relatively high intention scores have a statistically significant link from behavior to cognitions. In this case, the manifestation of a mutual dependence relationship between attitudes and behavior is itself associated with an attitudinal variable, intention to use.

Figure 4–36

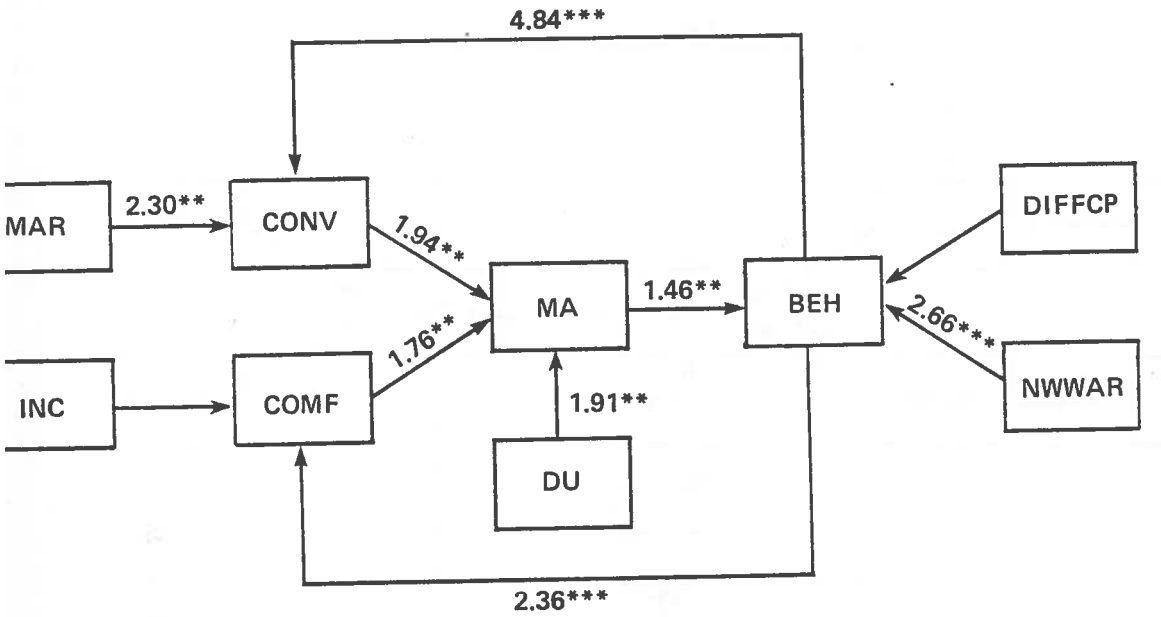
COMPARISONS OF SEGMENTED INTENTION SAMPLES FOR BUSES
(continued)

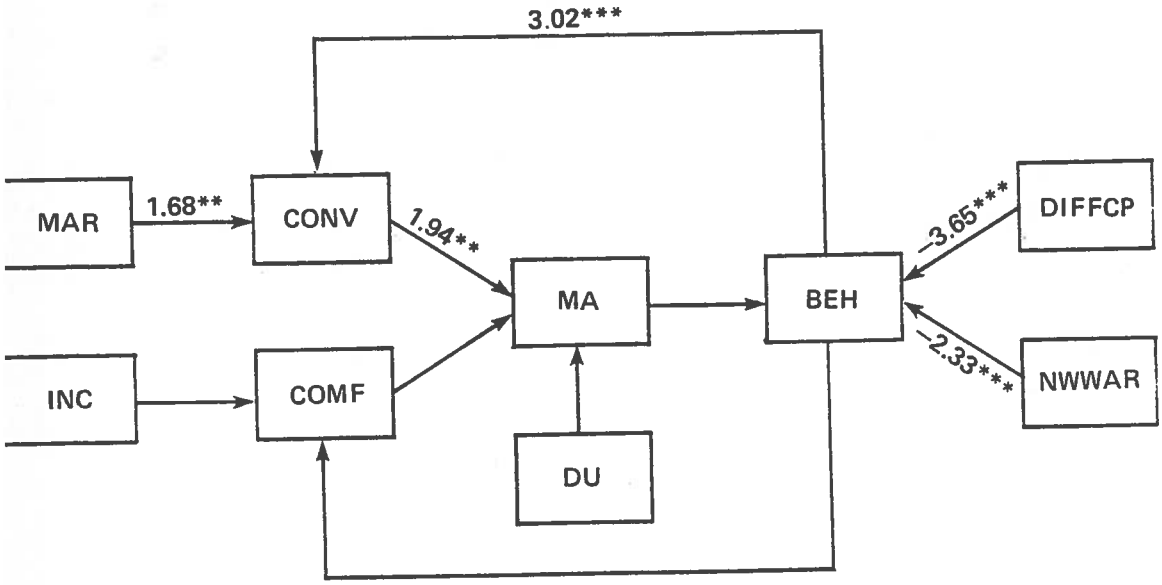


* p<.10 ** p<.05 *** p<.01

Figure 4–37

COMPARISON OF SEGMENTED INTENTION SAMPLES FOR CARPOOLS



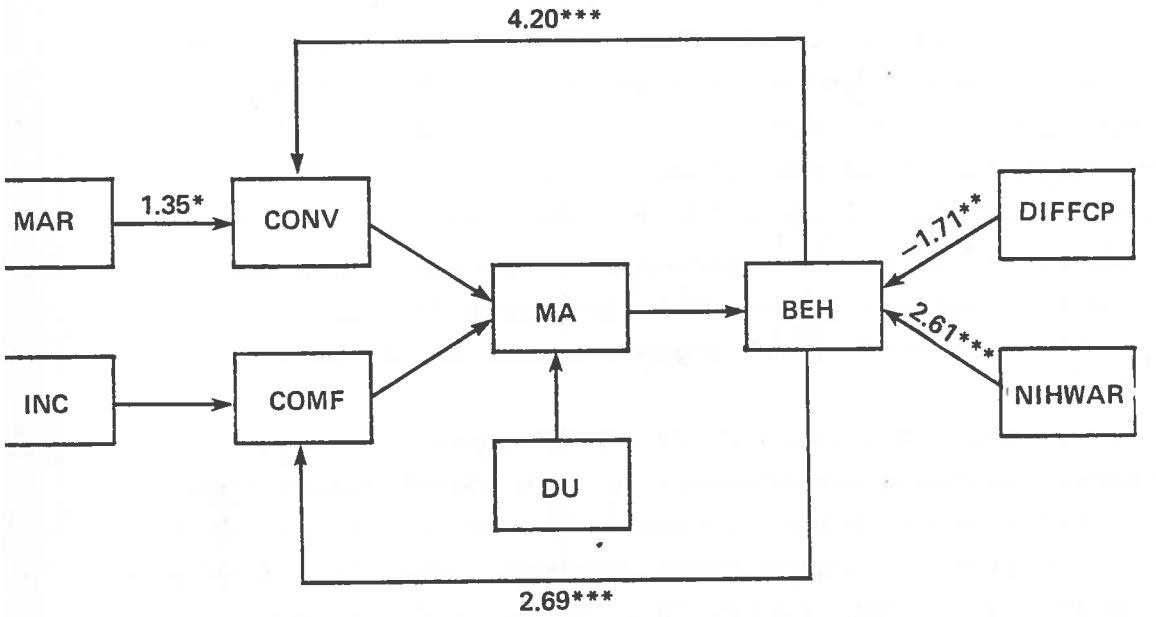


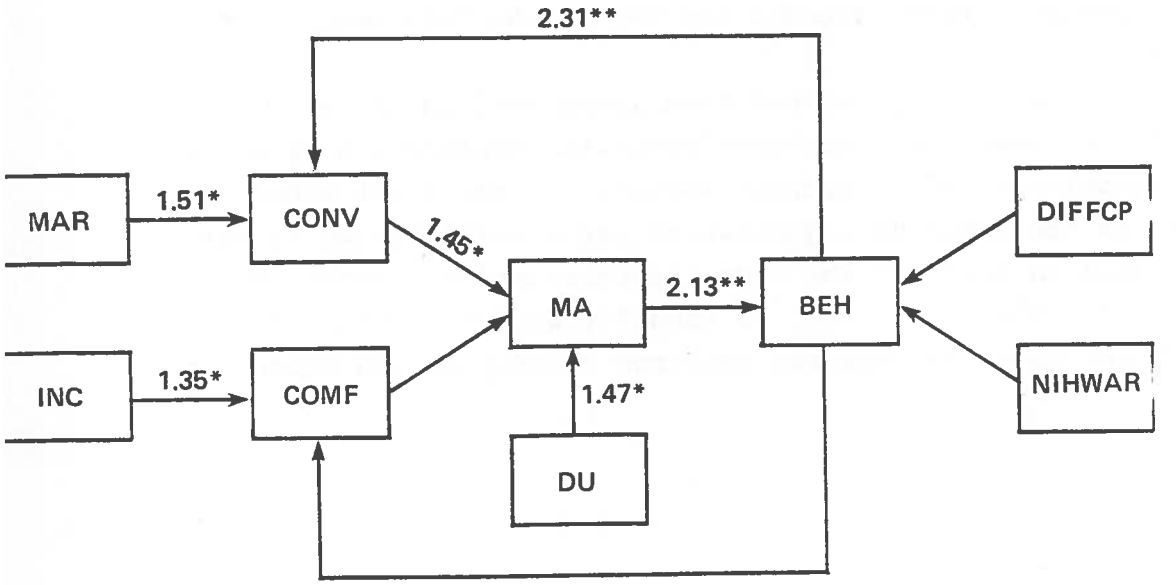
* p<.10 ** p<.05 *** p<.01

Figure continued on next page.

Figure 4–38

COMPARISON OF CARPOOL MODELS ON RACIALLY SEGMENTED SAMPLES

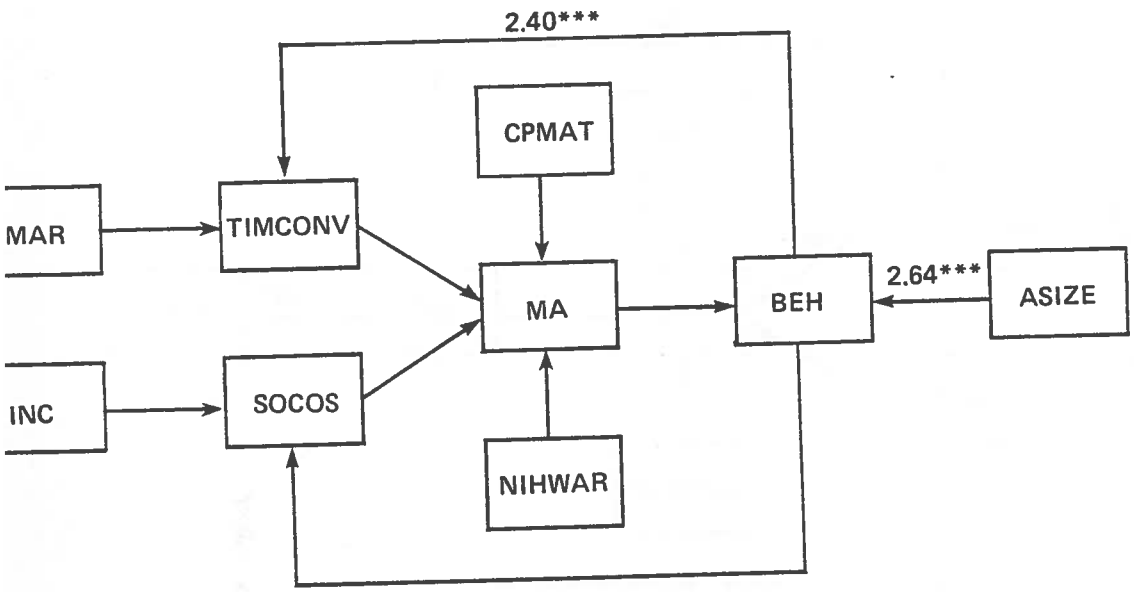


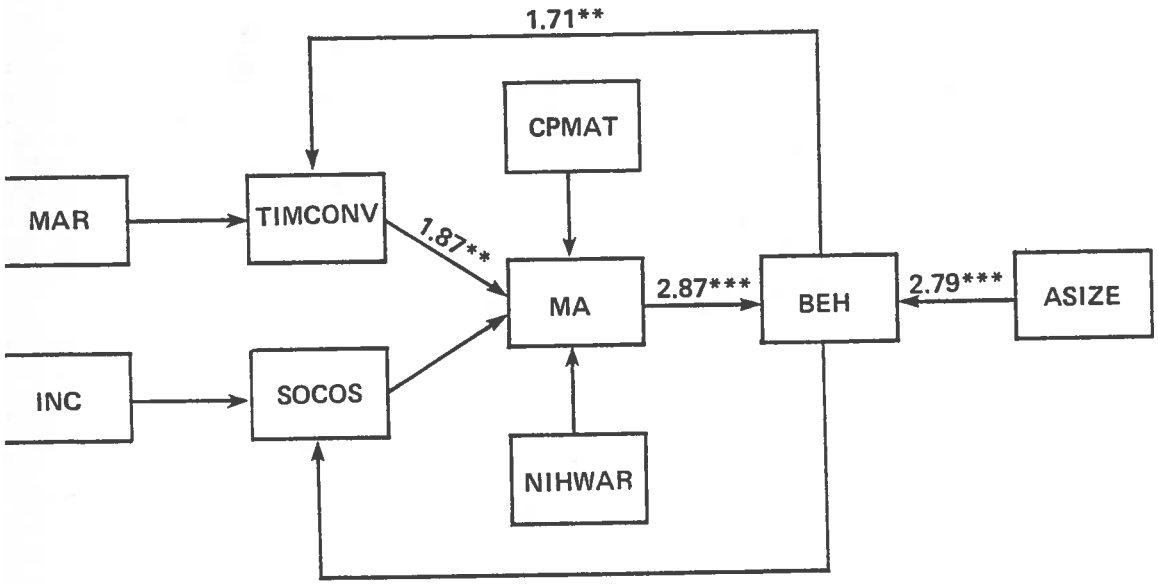


* p<.10 ** p<.05 *** p<.01

Figure 4--39

COMPARISON OF SEGMENTED SAMPLES ON SEX FOR CARPOOL USAGE





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

Figure continued on following page.

concurrently insightful with respect to transportation policy. A second serious consideration is the need for a standard test to measure the effectiveness of segmentation. The preliminary results indicate that traveler segment and full sample findings are different. A test to measure the significance of the difference in traveler segments among themselves and in relation to the full sample, must be developed. Such a segmentation technique issue will be presented in Chapter 5 of this report.

Traveler Attitude-Behavior Interrelationships

At a very basic level, it is reasonable to assume that beliefs about buses influence behavior towards them.[1] If buses are seen as convenient 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 for other reasons. These other reasons could be based on a variety of other factors, such as the extent to which a traveler likes or is satisfied with buses. Perceptions are not the sole attitudinal input to behavior.

Modeling Cognitions and Behavior

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. Multiattribute consumer research models frequently relate cognitions to affect or preference for an object. The linking of cognitions to affect, and the input of affect into behavior constitutes a multiattribute, hierarchical model when more than one type of cognition is considered. Two cognitions used below are perceptions of bus convenience and bus comfort.

As mentioned in Volume 1, cognitions may be caused by behavior, and any correlation between cognitions and behavior may be a function of the effect of behavior on attitudes. The latter proposition has been discussed by Horowitz and his associates, among others.[2] Finally, attitudes and behavior may be

---

[1] This assumption is relevant to other transport modes as well.

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

ally different linked to behavior represents a lack of support for multiattribute formulations in this context.

One reasonable extension of the simple hierarchical model discussed above involves the insertion of intention into the behavioral chain between modal affect and behavior; Figure 4-2 depicts such a model. This kind of formulation has been previously advocated for use in transportation planning and consumer research settings.[1] The more complex formulation in Figure 4-2 performs in a comparable fashion to the simpler model. While it may be conceptually appealing to have modal affect feed into behavioral intention, which in turn determines behavior, the comparison of empirical results in Figure 4-2 with those in Figure 4-1 does not compel such a formulation. It is acknowledged, however, that while intention refers to behavior at a future date, our intention and behavioral data were collected at the same time. If intention at time *t* and behavior at time *t+1* were used, then the superiority of the model in Figure 4-2 might be evident.

The Role of Behavioral Feedback

The role of behavioral feedback with respect to traveler attitude-behavior relationships is highlighted in Figure 5-1. The top and bottom flowgraphs are identical, except for the introduction of behavioral feedback. A comparable pair of flowgraphs was analyzed in the text describing Figure 4-3. 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 have postulated

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[1]Dobson, "Uses and Limitations," *op. cit.*; and Sheth, "A Field Study," *op. cit.*

that causation occurs simultaneously in both directions. The estimation of this kind of formulation can be achieved with a two-stage least squares technique.

The principal conclusions from Figures 4-3 and 5-1 is that attitudes and behavior are mutually dependent on each other. This result holds whether there are one or two intervening variables between cognitions and behavior. The impact of the sociodemographic antecedents on cognitions is adjusted in a comparable fashion for both examples; none of the sociodemographic variables have statistically significant correct signs as inputs to convenience and comfort perceptions. It is also worth noting 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 Cognitions to Modal Affect

In all of the attitude-behavior structures presented this far in Chapter 5, convenience perceptions have influenced modal affect. However, none of the model linkages of comfort perceptions to modal affect manifest significant explanatory power. One condition which could explain this result is that the two cognitions, perceptions of convenience and comfort, are related in their effect on modal affect. The degree of overlap could be so great that their individual effects on modal affect are obscured in a model with both cognitions.

The bus usage model can be respecified to indicate a single cognition as a determinant of modal affects. The last two flowgraphs in Figure 4-8 present two bus usage models, one with perceptions of convenience as the sole cognitive antece-

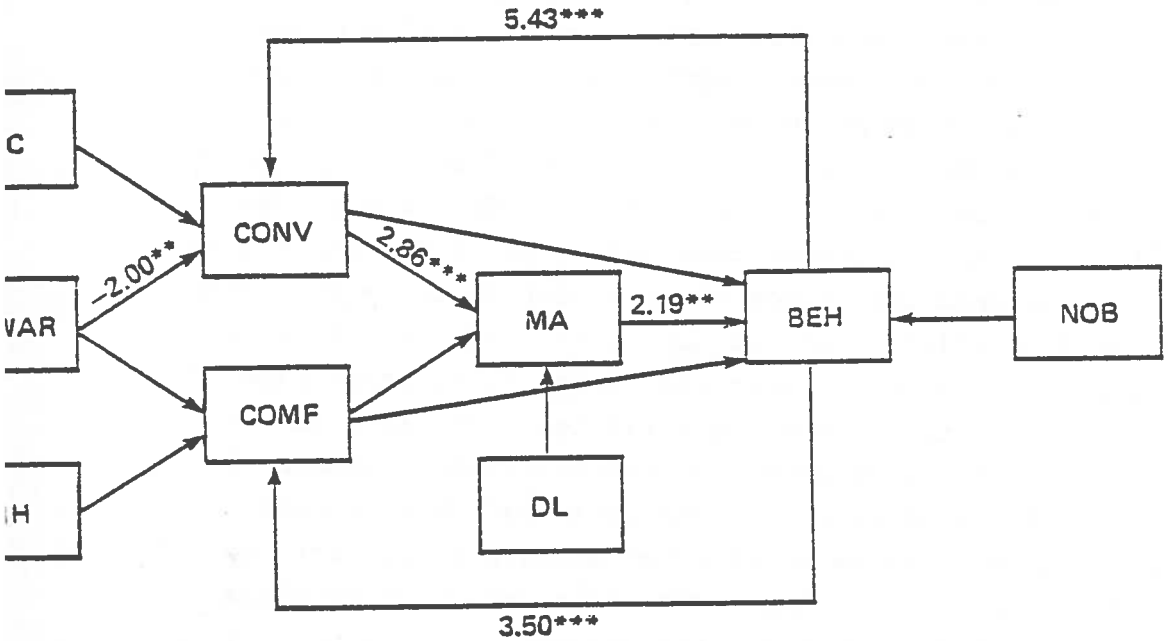
necessary as mediators of attitude-behavior interrelationships. The mutual dependence property can be demonstrated when there are no intervening variables.

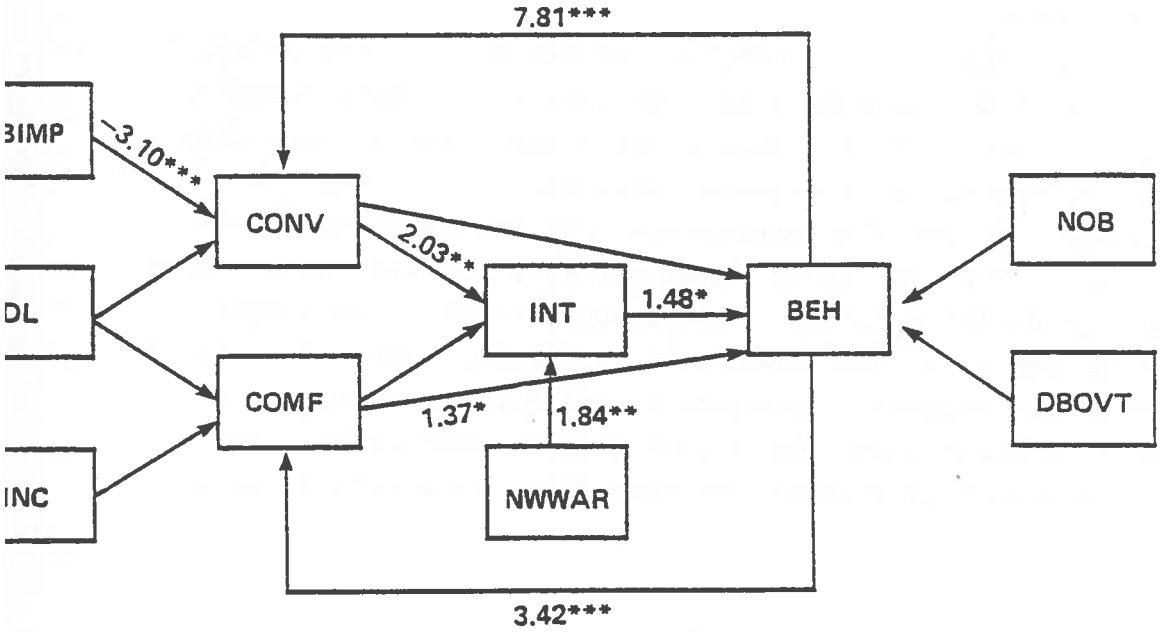
Figure 5-2 presents more empirical evidence to support the theoretical proposition that mediating variables are not necessary for the maintenance of a mutual dependence property between attitudes and behavior. Direct mutual dependence, in this instance between cognitions and behavior, is represented in the bottom flowgraph. This flowgraph shows that cognitions about a mode do not require an intervening variable to mediate their impact on behavior. The link between convenience perceptions and behavior is statistically significant beyond the .01 level. The top flowgraph in Figure 5-2 is identical to the bottom one except for the insertion of modal affect between cognitions and behavior. This insertion results in a larger t-value linking attitudes to behavior. The two flowgraphs together suggest that modal affect may not be necessary to mediate the effect of cognitions on behavior, but that modal affect adds incrementally to the explanatory power of attitude influence on behavior.

The incremental explanatory capabilities of both modal affect and intention are assessed in Figure 5-3. Both the top and bottom flowgraphs show three arrows from attitudinal variables leading to behavior. The structural equation corresponding to these arrows tests for the impact on behavior of convenience perceptions, comfort perceptions, or modal affect, respectively, while other variables are held constant. In both cases, the t-value for the intervening variable is statistically significant. This result does imply that modal affect and intention add incremental explanatory power with respect to behavior.

Figure 5-3

THE ROLE OF AFFECT AND INTENTION FOR ATTITUDE-BEHAVIOR INTERRELATIONSHIPS





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

paths removes arguments over whether attitudes influence behavior, and also provides a basis for understanding how attitudes can be used in the context of policy analysis. The latter point will be addressed in examples presented below as well as in Chapter 7.

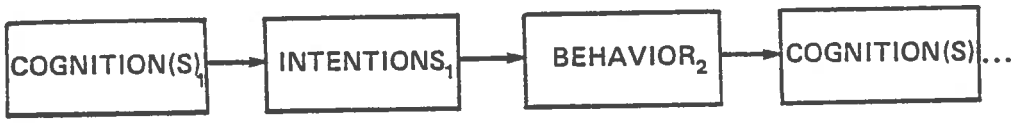
As indicated above, one of the most important findings is that the attitude-to-behavior effect is not incompatible with the behavior-to-attitude effect. It is possible to formulate model representations which explain traveler behavior but permit the independent study of causation in either direction. Therefore, mutual dependence between attitudes and behavior does not bound the variables so that causation in both directions must always be considered. The primary consequence of omitting behavioral feedback is to remove a source of multicollinearity among the antecedents of attitudes.

Various components of attitudes including cognitions, affect, and intentions, have been identified. Hierarchical models assume that cognitions influence behavior through intervening variables, such as affect and/or intentions. It was empirically demonstrated that intervening variables can add incremental explanatory power to cognitions with respect to behavior. This incremental improvement was observed for affect as well as intentions. Among several alternative arrangements of affect and intentions there was no empirical result which compelled the preference of one above the others. It is worth noting, however, that the intention and behavior data referred to the same time period, but that theoretically intention data is with reference to behavior at a future point in time. Empirical studies with a more suitable dataset are appropriate.

There are likely to be multiple sets of interrelationships among traveler attitudes and behavior. Consequently, there are numerous "correct" models, and the selection of a modeling

Figure 5-4

MODELS FOR SHORT-TERM NEEDS



The interrelationships permit tests of hierarchical assumptions for affect and intentions. In addition, by adjusting the time intervals for data through the subscripts i,j, and k, it is possible to evaluate diagnostic forecasting frameworks. The bottom flowgraph shows a model in which behavioral feedback is omitted in order to highlight the role of socioeconomic and system variable antecedents of cognitions. Since behavioral feedback to cognitions obscures the effects of other antecedent variables, it is removed from consideration.

Market Segmentation for Traveler Behavior Analysis

Market segmentation provides a framework for analyzing, interpreting, and accomodating fundamental similarities and differences among travelers. Within the context of our modeling orientation, segmented models are valuable because they can provide enhanced insight about traveler behavior. It is possible to quantify both different levels of attitudes and different kinds of interrelationships among attitude components and behavior across travel market segments. These quantitative findings can contribute to improved transport system design, operating policies, and marketing efforts.

It is readily possible to demonstrate *potential* segmentation effects by arbitrarily stratifying a sample with respect to one or more variables of interest. Several examples of this approach are presented in Chapter 4. There are, however, difficulties with this means of segmenting travelers. Among the most prominent are that observed differences may be due to chance. Dobson and Tischer used this approach, but they tested for the reliability of their segmented analysis through double cross validation.[1] While double cross validation can verify

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[1]Dobson and Tischer, "A Perceptual Market Segmentation Technique," *op. cit.*

Chapter 6
THEORETICAL AND RESEARCH EXTENSIONS

The structural equation approach which we have presented has been intentionally simplified with respect to a wide range of traveler attitude-behavior issues. The simplification has highlighted basic relationships and important concepts, including mutual dependence and market segmentation. Issues which have not been treated in any depth include situation-specific modeling, multimodal models, and longitudinal adaptations; below, they will be linked to the concepts presented in Chapters 4 and 5.

The final research extention utilizes the attitudinal model considerations as a basis of a procedure to perform decision simulation modeling for transportation policymakers.

Situation-Specific Modeling

The empirical analyses reviewed in Chapters 4 and 5 were based on a sample of work trips. Although the models are therefore most relevant to work trips, they were discussed in a general context. While some of the properties of work-trip

Multimodal Models

Traveler behavior is multifaceted in character. Therefore, while it is possible to develop separate mode usage models such as those discussed in Chapter 5, it is preferable that models which reflect the potential for diversity which exists in traveler decisionmaking be developed. Multimodal models are attractive because of their ability to depict tradeoffs among modes. To the extent that a commuter uses his or her private car less, he or she can use public transit more. A weakness of the models discussed in Chapters 4 and 5 has been their inattention to this multimodal aspect of traveler behavior.

Multiple modes can be incorporated directly into these models by adding equations to represent both the use of alternate modes and the tradeoffs among modes. The flowgraph in Figure 6-1 depicts one such model. Cognitions, affect, and behavior are denoted, respectively, by C, A, and B. Modes are depicted by subscripts A and B, which can be thought of as representing auto and bus alternatives. The exogenous variables are represented by EX. The equations for this flowgraph have the following form:

$$C_A = f(B_A, EX_1); \tag{6-1}$$

$$A_A = f(C_A, EX_2); \tag{6-2}$$

$$B_A = f(A_A, B_B, EX_3); \tag{6-3}$$

$$C_B = f(B_B, EX_4); \tag{6-4}$$

$$A_B = f(C_B, EX_5); \tag{6-5}$$

$$B_B = f(A_B, B_A, EX_6). \tag{6-6}$$

Equations (6-1) through (6-3) are for one modal alternative, and the remaining ones are for the other mode. The tradeoff between modes A and B is depicted in equations (6-3) and (6-6). It is anticipated that the coefficients for the right-hand variables B_B and B_A in these equations will be negative. The system of equations can be readily expanded to consider additional transport modes. It is also possible to link the modes at other points besides B (for behavior or mode usage). One interesting model involves reciprocating cross-modal influences from the usage of one model to the cognitions of the other. Another variation calls for interaction between modes with respect to cognitions rather than behavior. Models which exclude a link between B_A and B_B are only possible when changes in B_A do not require compensating changes in B_B in a functional form with a residual error of zero.

Traveler choice of mode is often represented by a logit function.[1] This notion can be incorporated into the framework depicted in Figure 6-1 by using a logit function instead of equations (6-3) and (6-6). The empirical merits of this adjustment can be evaluated by research such as that used to compare choice functions for nongrocery shopping trips.[2] A theoretical advantage of the logit function relative to a linear function lies in its representation of choice behavior by an S-shaped curve. The degree of preference or usage of an

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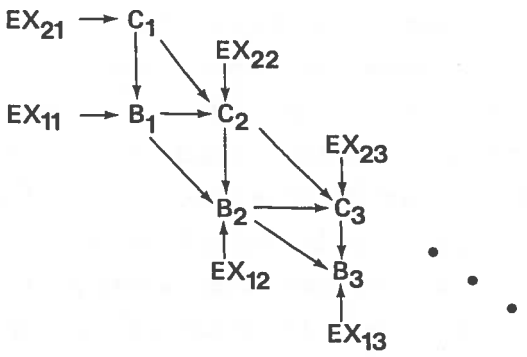
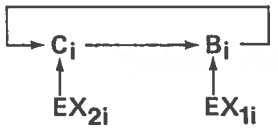
[1]See for example: Charles River Associates Incorporated, *A Disaggregated Behavioral Model of Urban Travel Demand* (Springfield, Va.: NTIS, 1972); and Stopher and Meyburg, "Behavioral Travel-Demand Models," *op. cit.*

[2]Frank Koppelman and John R. Hauser, "Destination Choice Behavior for Non-grocery Shopping Trips," paper presented at the 1978 Transportation Research Board meeting.

Figure 6–2

TWO MODELS OF TRAVELER BEHAVIOR OVER TIME





i = 1, 2, 3, ...

The model is cast in terms of a set of procedures shown in Figure 6-3. Each procedure is itself dependent on empirically derived relationships, as discussed below.

Market Segment Assignment

Based on our segmentation analysis framework, an individual (or household) is assigned a market segment. The estimated relationships which follow would possibly be different for each market segment.

Computation of Attitude Variables

Because attitudes are treated as functions rather than as exogenous variables, they are computed from estimated relationships, such as behavior and demographics in the arguments. Attitudes which had been actually measured would be inappropriate if a policy instrument changed one of the exogenous variables (e.g., availability of an alternative, objective attributes, knowledge, etc.). Perception variables may also be functions of objectively measured attributes.

Computation of Affect

Affect is also a function and is computed from estimated relationships. Again, measured affect cannot be used because policy instruments will cause a change in affect.

Determination of Available Choices

To the extent that market segment assignment has not isolated all the constraints on choices, the determination of available choices will eliminate alternatives which are both objectively and subjectively unavailable.

Determination of Behavior

Behavior is predicted as a function of affect with intervention from availability constraints. This relationship may

be appropriately a probability of choice. Under many applications, the model will have to be iterated to determine behavior because of the feedback to attitudes.

- Development of a theory of attitudes towards transportation should take place within the context of travelers making use of or choosing multiattribute alternatives.
- The theory of user attitudes must account for both attitudes affecting behavior and behavior affecting attitudes.
- Traditional attitude measures, including perceptions of attributes, evaluations of attributes, importance of attributes, affect toward mode and behavioral intentions toward modes, all have a role in attitudinal modeling, though the use of each variable depends upon the context and purpose of the model.
- Various theories of choice behavior and attitude formation can be synthesized into a more complete and flexible theory which would be of considerable value in travel behavior analysis.

This chapter will initially elaborate on the substantive research findings. The implications of our findings are analyzed with respect to consistency with existing theories of traveler behavior, to uses of attitudinal models and to data collection. The final portion of this chapter mentions policy recommendations which emerge from the empirical and theoretical research.

Implications of Findings

The results of this study indicate a substantive role for attitudinal modeling in transportation policy evaluation and travel behavior forecasting. The empirical and theoretical analysis supports an attitudinal modeling structure that can be reasonably well defined. This structure is consistent with several existing behavioral and attitudinal theories which were reviewed in previous chapters.

household survey data. The empirical analysis can also be compared to existing theories and procedures in probability choice and attitudinal modeling to indicate areas of inconsistency or generalization.

Consistency of Findings with Existing Theories

The hypotheses tested in this report have implications for the theoretical constructs used in attitudinal-behavioral modeling. Brief discussions of five such theoretical approaches follow.

Utility Maximization

Traditional demand analysis has been developed from theories of utility maximization (though assuming utility maximization is not necessary for specifying demand curves). In much consumer behavior research utility is an unmeasurable, noncardinal concept that is used to derive behavioral relationships between attributes of an alternative and the demand for that alternative. If choosing one alternative mutually excludes choosing another set of alternatives, then traditionally the operative theory has been random utility maximization. In this case, utility is most often presumed to be a linear function of the attributes of an alternative and the demographic descriptors of the decisionmaking unit. Randomness occurs because of unobserved attributes of the alternatives, unobserved characteristics of the household, and variations in the weights placed on the attributes among households. Systematic variation in tastes can sometimes be explicitly modeled by transforming individual attributes into mathematical combinations of both attributes and household characteristics (e.g., time spent on a trip is sometimes multiplied by income, or passenger capacity of an automobile might be divided by number of household members).

it is virtually impossible to develop a unique set of quantifiable relationships from the principle of cognitive dissonance.

Elimination by Aspects

Though the empirical research did not test whether elimination by aspects versus random utility maximization was a more suitable descriptor of behavior, the feedback effect between behavior and attitudes has implictions for specifying noncompensatory models. The elimination by aspects model implies a sequential decisionmaking process in which individuals eliminate alternatives on the basis of scaled values of their attributes. Presumably, elimination threshold values of attributes could be estimated from survey data using revealed preference arguments.[1] However, it is likely that these threshold values would not be constant across the population; rather, they would be dependent on choices actually made as well as on other exogenous variables such as household demographics. Moreover, subjective scales of attributes should be codetermined with observed choiced.

Adaptation

Adaptation models are most appropriate for dynamic processes and, consequently, the survey data analyzed in the empirical section of this report are not well suited to testing hypotheses about adaptive behavior. It should be noted, however, that the attitude-behavior feedback encountered in the structural models can be developed from a dynamic process of constraint application, behavior modification, learning, and attitude formation. Time-series data or before and after experiments are required to uncover these processes.

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[1]W. W. Recker and T. F. Golob, "A Non-Compensatory Model of Transportation Based on Sequential Consideration of Attributes" (Warren, Mich.: General Motors Research Laboratories, 1978).

empirically. Attitudes which form consumer preferences towards attributes can be made functions of exogenous descriptors of the household, and can be allowed to vary among realistically decomposed market segments. Of course, it should always be borne in mind that such variables need to be considered as codeterminant with behavior when used in the modeling context.

Data Collection Implications

The general specification of the attitudinal model has three important properties: 1) a feedback loop between attitudes and behavior; 2) input from social and economic variables; and 3) input from policy and/or transportation system variables. If these principles are not incorporated in specific data collection efforts, then specious or nonpractical relationships may result from empirical analyses of the survey data. These properties have implications for future data collection projects that have previously been ignored in attitude-behavior data acquisition efforts.

There are at least two primary data collection implications which can be inferred from our recommended modeling framework. First, sufficient attitudinal data must be collected to reveal the feedback loop. If only one type of attitudinal data (e.g., perceptions) is gathered, it may not be possible to differentiate attitudes which both influence and are influenced by behavior from those which are merely influenced by it. Previous empirical research has found that the impact of attitudes on behavior can disappear when models are not properly specified and/or leave out important attitudinal variables.[1] The second data collection implication for attitudinal surveys is that the sociodemographic and transportation system information should be coordinated both with each

[1]Dobson, *et al.*, "Structural Models," *op. cit.*

the implications of Chapters 4 and 5 will avoid the difficulty encountered in the example. These datasets will also lead to information bases with coordinated data which reinforce each other in facilitating the development of an understanding of attitude-behavior interrelationships.

Several data collection recommendations emerge from a review of attitude-behavior surveys and related theoretical concepts. First, it is desirable to uncover exogenous variables which are highly correlated with the endogenous variables in a system of attitude-behavior interrelationsips. This research will help to identify socioeconomic and transportation system data which clarify the roles of particular linkages between attitudes and behavior. Second, the importance of transportation system data can be easily noted, and such data should be collected in traveler attitude-behavior studies because of their logical relationship to endogenous variables and their natural policy implications. Although zonal transportation system data are probably readily available, system data at the level of the individual traveler or household are potentially much more valuable in accounting for traveler patterns.

Other recommendations relate to the usefulness of collecting more than one type of attitudinal information. Preliminary research conducted within the scope of the project has demonstrated the value of collecting perceptions of system attributes, modal affect and behavioral intention. Our literature review and integration of attitude-behavior studies in transportation and consumer research has pointed to a lack of explanatory power associated with consumer importance judgments for product or service attributes.

Policy Implications of Results

The most important results of this report are theoretical in nature because of the thrust of the objectives. However,

Appendix A
THE THREE SURVEY QUESTIONNAIRES

The empirical analysis was conducted using the FHWA, GM and Lovelock attitudinal transportation survey datasets; Appendix A provides the questionnaires from the three surveys. Reference to the actual questions will clarify the specific content and context of their data. The questionnaires also will be a useful tool in conjunction with Appendix B, which describes data coding practice. The FHWA questionnaire is not completely shown because of its length, but all relevant parts are included in this appendix. The GM and Lovelock questionnaires are presented in their entirety.

CENTRAL BUSINESS DISTRICT WORKER STUDY

SCREENING QUESTIONNAIRE

:et Facts' Representative _____ 5 [ ][ ][ ] 7

! Service Organization _____ 8 [ ][ ][ ][ ][ ] 12

Date _____ Time Interview Began: _____ AM/PM

ORD SAMPLE GROUP: 1 2 3 4 (13)

Hello, I'm _____ from Market Facts, Incorporated We're conducting a study for the U.S. Department of Transportation to obtain information for the design of better transportation systems in this and other areas throughout the country. In this study we want to find out about how people travel to work.

How many members of this household are employed, full time or part-time, outside your home?

None 0 (TERMINATE)

1 2 3 4 5 6(or more) (14)

(Does that person/Do any of those persons) work in the downtown area of Los Angeles? By "downtown area" we mean the area inside a border formed by the Hollywood Freeway on the north, the Harbor Freeway on the west, the Santa Monica Freeway on the south and Alameda Street on the east. Does anyone in your household regularly travel to work in that area?

Yes 1 No 2 (GO TO WORK TRIP STUDY-SCREENING QUESTIONNAIRE A-2) (15)

How many household members travel to the downtown Los Angeles area to work?

1 2 3 4 5 (16)

INTERVIEWER, CIRCLE NUMBER OF EACH PERSON WHO IS ELIGIBLE TO BE INTERVIEWED FOR ANY UNFILLED QUOTA. IF NO ONE IS ELIGIBLE, CIRCLE "0" FOR NONE ELIGIBLE AND TERMINATE.

		ELIGIBLE PERSON					
NONE	0	#1	#2	#3	#4	#5	(27)

IF MORE THAN ONE HOUSEHOLD MEMBER IS ELIGIBLE, CHOOSE THE "QUALIFIED RESPONDENT" BASED ON WAY EACH PERSON TRAVELS FROM HOME TO WORK. THE ORDER OF CHOICE IS SHOWN BELOW:

1. PASSENGER IN CAR
2. PASSENGER IN BUS
3. DRIVER OF CAR WITH OTHERS
4. DRIVER ALONE IN CAR

IF MORE THAN ONE PERSON IS ELIGIBLE AND USES THE SAME WAY TO TRAVEL FROM HOME TO WORK CHOOSE "QUALIFIED RESPONDENT" BASED ON HOUSEHOLD RELATIONSHIP OF PERSONS USING ELIGIBLE MODE.

1. Other Female
2. Other Male
3. Daughter
4. Son
5. Female Head of the Household
6. Male Head of the Household

CIRCLE NUMBER OF PERSON CHOSEN AS "QUALIFIED RESPONDENT".

	QUALIFIED RESPONDENT					
Person:	#1	#2	#3	#4	#5	(28)

ASK TO SPEAK WITH "QUALIFIED RESPONDENT". IF NOT AT HOME MAKE APPOINTMENT TO CALL BACK:

DATE_____ TIME_____

Qual. Resp. Name _____

Address _____

City _____

Phone _____

CENTRAL BUSINESS DISTRICT WORKER STUDY

QUESTIONNAIRE

(ASK TO SPEAK WITH "QUALIFIED RESPONDENT".)
Record Time Int. began _____AM/PM

Hello, I'm _____ from Market Facts. As you recall we are conducting a survey for the U.S. Department of Transportation and we made an appointment to come here to ask your opinions about the way you make your trip to work.

(HAND RESPONDENT CARD A)

6a. Which statement on this card comes closest to describing how often you travel from home to work by bus? (RECORD BELOW)

6b. About how often do you travel from home to work driving alone in a car, pickup, or van? (RECORD BELOW)

6c. About how often do you travel to work driving a car, pickup or van with passengers riding with you? (RECORD BELOW)

6d. About how often do you travel to work riding in a car, pickup or van that someone else is driving? (RECORD BELOW)

	Qu 6a. Bus (33)	Qu 6b Car Alone (34)	Qu 6c Car with Passenger(s) (35)	Qu 6d Passenger in Car (36)
• Never	1	1	1	1
• Less than once a month	2	2	2	2
• Once or twice a month	3	3	3	3
• Three or four times a month	4	4	4	4
• Two or three times a week	5	5	5	5
• Four or five times a week	6	6	6	6
• Over five times a week	7	7	7	7

7a. Is there any public bus service that you could use to travel from home to work if you had no other way to travel?

YES 1 NO 2 (SKIP TO INSTRUCTION BEFORE QU. 8a) (37)

IF PERSON SAID "NEVER" (CODE 1) TO BOTH QU. 6c AND 6d, SKIP TO QU. 9a.

8b. When you share a ride to work with others, including yourself about how many people are usually in the vehicle?

2 3 4 5 6 7 8 (or more) (60)

9a. Which of these ways did you use to travel from home to work (yesterday/last Friday)? (READ ALTERNATIVES)

		Qu. 9a (61)	Qu. 9c (62)
	Bus	1	1
	Alone in car, pickup or van	2	2
	Driving with passengers in car, pickup or van	3	3
	or, A passenger in car, pickup or van	4	4
(DON'T READ)	None of the above	0	0

RECORD WHICH DAY "YESTERDAY" WAS.

Monday	1	(SKIP TO QU. 9d)
Tuesday	2	
Wednesday	3	
Thursday	4	
Friday	5	
Saturday	6	
Sunday	7	(63)

9b. Was the way you traveled from home to work on Friday the same way you used most of the other days last week?

Yes 1 (SKIP TO QU. 9d)

No 2

(64)

9c. Which other way did you travel from home to work last week?

(READ ALTERNATIVES AND RECORD ABOVE)

9d. What time do you usually leave home to go to work? _____ AM/PM
(WRITE IN TIME)
65 68

9e. What time do you usually arrive at work? _____ AM/PM
(WRITE IN TIME)
69 72

12. Now, I would like to ask you some questions in a slightly different way. In Booklet B we have listed pairs of descriptions about work trips. Actually, each pair describes possible changes in selected characteristics of your trip from home to work. (HAND RESPONDENT SHEET 1). Let's read each of the descriptions together.

(READ SHEET #1)
As you read the choices you will notice that each choice is described in terms of two of these characteristics at a time. Read both choices in each pair then circle the letter indicating the choice you prefer most between those two. Please choose one or the other even if neither one is particularly appealing to you. Just choose the one you prefer most (or dislike least) if you had to choose one of them for your trip from home to work.

HELP RESPONDENT GET STARTED AND ANSWER ANY QUESTIONS UNTIL YOU ARE SURE THE RESPONDENT UNDERSTANDS WHAT WE ARE ASKING HIM/HER TO DO.

WHEN RESPONDENT HANDS BOOKLET B AND SHEET #1 TO YOU BE SURE YOU HAVE ONE ANSWER FOR EVERY PAIR. THEN SKIP TO QU. 14a.

13. Now, we would like to know how important various considerations are to you when you choose the way you travel to work. Booklet C contains several considerations other people have mentioned when they talk about choosing the way they travel to work. Please read the consideration then place an "X" in the appropriate boxes to describe how important each one is to you in deciding how you travel to work. There are no "right" or "wrong" answers. We'd like to have your own opinion.

(HAND RESPONDENT SHEET 1) Here is a sheet which defines some of the considerations which we feel may need further explanation. (READ SHEET 1 TO RESPONDENT)

Please notice there are seven boxes across from each word or phrase in Booklet C. At the top of the page there are labels describing different degrees of importance from "extremely unimportant" to "extremely important". Please read all seven labels as you give your opinion on each consideration then mark an "X" in one of the boxes that best describes your opinion.

TAKE BACK BOOKLET C AND SHEET 1. CHECK TO BE SURE YOU HAVE ONE ANSWER FOR EACH CONSIDERATION.

14a. (HAND RESPONDENT SHEET #2) Card #2 (Dupl 1-4)
Here are some descriptions of transportation plans now being considered here and in other areas around the country. Let's read the descriptions together . . .
READ SHEET #2.
Have you heard, read or seen anything recently about any of these plans being considered or started in the Los Angeles area?

Yes 1 (5)
No 2 (SKIP TO QU. 15a)

14b. Which plan or plans have you heard about that are being considered here?

Reserved Lane	1	Freeway Ramp Control	4	(6)
Park and Ride	2	Express Bus	5	
Parking Surcharge	3	More Frequent Busses	6	
		Subscription Bus	7	

15c. Now, please pick up the cards and this time lay them out in order based on how likely each plan would be to encourage you to use public transportation to travel from home to work, which would be next most likely, etc. until you have them all in rank order from your first choice to your seventh choice.

> WHEN RESPONDENT IS SATISFIED WITH CHOICES RECORD UNDER QU. 15c BELOW

15d. Starting with (READ 1ST CHOICE IN QU. 15c), do you think you would actually use public transportation to travel from home to work if this plan were used?

> REPEAT FOR OTHER PLANS IN RANK ORDER UNTIL YOU HAVE RECORDED A "NO" THEN ASK:

Would you use public transportation to travel from home to work if any of the other plans were used?

Yes ——► Which ones? (RECORD "YES" FOR EACH ONE)

No ——► (RECORD "NO" FOR ALL OTHER PLANS)

	Qu. 15c Public Transportation Ranking								Qu. 15d Yes	Qu. 15d No	
Reserved Lane	1	2	3	4	5	6	7	22	1	2	29
Park & Ride	1	2	3	4	5	6	7	23	1	2	30
Parking Surcharge	1	2	3	4	5	6	7	24	1	2	31
Freeway Ramp Control	1	2	3	4	5	6	7	25	1	2	32
Express Bus Service	1	2	3	4	5	6	7	26	1	2	33
More Frequent Buses	1	2	3	4	5	6	7	27	1	2	34
Subscription Bus	1	2	3	4	5	6	7	28	1	2	35

> (AFTER RECORDING BE SURE YOU HAVE RECORDED ONE NUMBER FOR EACH PLAN AND HAVE ONLY ONE CHOICE EACH FOR RANK: ONE, TWO, THREE, ETC. THROUGH SEVEN. TAKE BACK RANKING CARDS.)

(HAND RESPONDENT BOOKLET E)

17. We have been talking about how each of these plans might affect your future choice of the way you travel from home to work, but the planners also wish to know how each of these plans might affect your present trip from home to work.

At the top of each page in Booklet E there is a characteristic of your trip from home to work shown in a box. As you consider only that part of your trip from home to work please mark an "X" in one of the seven boxes next to each plan which best describes your own opinion of how each plan would affect that part of your trip.

In our example we have shown "Total Travel Time" at the top of the page -- How much would each of the plans shown in the example increase or decrease your total travel time relative to your present total travel time the way you travel from home to work most often?

TAKE BACK BOOKLET E AND SHEET 2. CHECK THROUGH TO BE SURE THERE IS ONE ANSWER FOR EACH PLAN ON EVERY PAGE

18a. How difficult would it be for you to find one other person in this area to share a ride to work with? Would it be . . . (READ ALTERNATIVES)

Very easy 1
Somewhat difficult.....2 (36)
Impossible 3

18b. How difficult would it be for you to find at least two other people to share a ride to work with? Would it be ... (READ ALTERNATIVES)

Very easy 1
Somewhat difficult..... 2 (37)
Impossible 3

21c. What about if some one picks you up and drives you to or very near work? How many blocks would you have to walk from where you would be dropped off?

Number of Blocks: _____ (write in) ☐ 48

22a. (HAND RESPONDENT CARD B)
Using this card please tell me which number best describes how satisfied you would be, overall, if you drove by yourself when you travel from home to work. (RECORD BELOW)

22b. How satisfied would you be to drive and have other passengers riding with you? (RECORD BELOW)

22c. How satisfied would you be to be a passenger in a car, pickup or van with someone else driving? (RECORD BELOW)

22d. How satisfied would you be to ride the bus to get from home to work? (RECORD BELOW & TAKE CARD B)

22a)	Drive alone	1	2	3	4	5	6	7	(49)
22b)	Drive with passengers	1	2	3	4	5	6	7	(50)
22c)	Ride with other passengers	1	2	3	4	5	6	7	(51)
22d)	Ride a bus	1	2	3	4	5	6	7	(52)

23. Now I'd like to ask you a few questions about you (and your household) so that we can combine the answers you've given us with those of other people. First, are you married, single, widowed, divorced, or separated?

Married 1 Single 2 Widowed/divorced/separated 3 (53)

24a. Including yourself, how many people live in this household?

1 2 3 4 5 6 7 8 9 or more (54)

(SKIP TO QU. 25)

24b. Are there any children 18 or younger in this household?

Yes 1 No 2 (SKIP TO QU. 25) (55)

24c. What is the age of the youngest child?

Under 6 1 6 to 16 2 Over 16 3 (56)

25. (HAND RESPONDENT CARD C) Which of these categories best describes your age? Just read off the letter that best describes your age.

A.	Under 18 ... 1	E.	35 - 44 5
B.	18 - 24 2	F.	45 - 54.....6
C.	25 - 29..... 3	G.	55 - 64.....7
D.	30 - 34 4	H.	65 or over..... 8

(57)

(TAKE BACK CARD C)

Respondent Name:_____

BOOKLET A

DESCRIBING WAYS OF TRAVELING TO WORK

EXAMPLE:

Riding in a Taxi

1. If the only way you could get a taxi is to call one in advance, you would "X" the box on the left.

Have to phone for taxi in advance ☒ ☐ ☐ ☐ ☐ ☐ ☐ Do not have to phone for taxi in advance

2. If there were many taxis waiting at a near-by cab stand you might "X" the box on the right.

Have to phone for taxi in advance ☐ ☐ ☐ ☐ ☐ ☐ ☒ Do not have to phone for taxi in advance

3. If you have to phone in advance about as often as not you might place an "X" in the box in the middle.

Have to phone for taxi in advance ☐ ☐ ☐ ☒ ☐ ☐ ☐ Do not have to phone for taxi in advance

4. If you have to phone in advance more than half the time but <u>not</u> every time, you might use one of these two boxes -- whichever one comes closest to describing just how often you have to phone.

Have to phone for taxi in advance ☐ ☐ ☐ ☐ ☐ ☐ ☐ Do not have to phone for taxi in advance

3 or more people, including the driver, sharing a ride in a car

• Worry about being harmed by others	☐	☐	☐	☐	☐	☐	☐	Do not worry about being harmed by others	(5)
• Easy to get where I am going after I leave the vehicle	☐	☐	☐	☐	☐	☐	☐	Not easy to get where I am going after I leave the vehicle	(6)
• Is not crowded	☐	☐	☐	☐	☐	☐	☐	Is crowded	(7)
• Usually do not have to wait a long time for vehicle	☐	☐	☐	☐	☐	☐	☐	Usually have to wait a long time for vehicle	(8)
• Do not feel relaxed in this vehicle	☐	☐	☐	☐	☐	☐	☐	Feel relaxed in this vehicle	(9)
• Am not exposed to weather	☐	☐	☐	☐	☐	☐	☐	Am exposed to weather	(10)
• Can avoid waiting in lines in traffic	☐	☐	☐	☐	☐	☐	☐	Cannot avoid waiting in lines in traffic	(11)
• Can come and go on my own schedule	☐	☐	☐	☐	☐	☐	☐	Cannot come and go on my own schedule	(12)
• Very little extra time spent waiting for others, walking to or from vehicle	☐	☐	☐	☐	☐	☐	☐	Much extra time spent waiting for others, walking to or from vehicle	(13)
• Would not cost much for parking	☐	☐	☐	☐	☐	☐	☐	Would cost a lot for parking	(14)
• Comfortable	☐	☐	☐	☐	☐	☐	☐	Not comfortable	(15)
• Not convenient	☐	☐	☐	☐	☐	☐	☐	Convenient	(16)
• Not expensive	☐	☐	☐	☐	☐	☐	☐	Expensive	(17)
• Not enough space for packages	☐	☐	☐	☐	☐	☐	☐	~~Enough space for packages~~	(18)
• Easy to use	☐	☐	☐	☐	☐	☐	☐	Not easy to use	(19)
• Cannot rely on it	☐	☐	☐	☐	☐	☐	☐	Can rely on it	(20)
• Usually arrive at work on time	☐	☐	☐	☐	☐	☐	☐	Usually does not arrive at work on time	(21)
• A slow way to travel during rush hour	☐	☐	☐	☐	☐	☐	☐	Not a slow way to travel during rush hour	(22)
• Can feel safe from vehicle accidents	☐	☐	☐	☐	☐	☐	☐	Cannot feel safe from vehicle accidents	(23)

TRIP TO WORK QUESTIONNAIRE

5-6

Section A

7

How often do you make a trip from your home to where you work? (CHECK ONLY ONE BOX)

5 or more days/week	☐ 1	8
3 or 4 days/week	☐ 2	
1 or 2 days/week	☐ 3	

How frequently do you now use the following types of transportation to get from your home to where you work?

	Days Per Week			Never or Almost Never	
	5 or More	3 or 4	1 or 2		
Drive auto alone	☐	☐	☐	☐	9
Carpool (drive or ride in a car with family or non-family members from your home to where you work). .	☐	☐	☐	☐	10
Bus	☐	☐	☐	☐	11
Commuter train (Northwestern, Milwaukee Road, etc.). . .	☐	☐	☐	☐	12
Rapid Transit (CTA Elevated Train, Subway, etc.) . . .	☐	☐	☐	☐	13
Walk	☐	☐	☐	☐	14
Other (Please Specify)					
_____	☐	☐	☐	☐	15
	4	3	2	1	

16

How far from your home is the nearest station of public transportation (bus, commuter train, subway, etc.) that you could take to get to work? _____ miles [5-7]

How many transfers would you have to make if you were using public transportation (bus, commuter train, rapid transit) to get to work?

- No transfer . . . . . ☐ 0
- One transfer . . . . . ☐ 1 [8]
- Two transfers . . . . . ☐ 2
- No public transportation available ☐ 9

How long, on the average would it take you to get to work by way of public transportation?

Minutes to walk or ride to transit station	____	[9-11]
Minutes to wait for bus, train or rapid transit . . .	____	[12-14]
Minutes to ride bus(es) and/or train(s)	____	[15-17]
Minutes to transfer, if necessary	____	[18-20]
Minutes to walk from your stop to work	____	[21-23]
Total	____	[24-26]
No public transportation available ☐		[27]

Estimate how much it would cost if you used public transportation to get to work?

Parking fee for car at transit station (if needed) . . . . . _____ No charge ☐ [28-30]

Transit fees--one way . . . . . _____ [31-33]

Don't know ☐

No public transportation available ☐ [34]

About how often do you stop on your way home from work for an errand--shopping, filling gas, bank, etc?

- Almost never . . . . . ☐ 1
- 1-3 times a month . . . . ☐ 2 [35]
- 3-4 times a week . . . . ☐ 3
- Always . . . . . ☐ 4

Are you currently a member of a carpool? A carpool is two or more people who ride together to and from work on a more or less regular basis?

Yes ☐ ⟶ GO TO SECTION B, page 4 [36]

No ☐ ⟶ GO TO SECTION C, page 8

B-5 How many people regularly ride in your carpool?

Yourself	1	
Other members of your household . . .		43
All others		44
Total Carpool members		45

B-6 In your opinion, what is the ideal number of members in a carpool?

Two . . .	☐ 2	
Three . . .	☐ 3	
Four . . .	☐ 4	46
Five or more .	☐ 5	

3-7 How many people in your carpool, including yourself, are males and how many are females?

Males.	47
Females	48

8 Who does the driving in your carpool?

I am almost always the driver of the car	☐ 1	
I am sometimes the driver and sometimes the passenger	☐ 2	49
I am almost always a passenger in the car. . . .	☐ 3	

9 Which of the following statements best describes the destination of your carpool?

The carpool ends at work or a place near work. . .	☐ 1	
The carpool ends at a transit station from which carpool members continue to travel by other means of transportation	☐ 2	50
Other (Please Specify)_____		
_____	☐	

How satisfied or dissatisfied are you with your current carpool?

Extremely satisfied	☐ 7	
Satisfied	☐ 6	
Slightly satisfied	☐ 5	
Neither satisfied nor dissatisfied	☐ 4	70
Slightly dissatisfied	☐ 3	
Dissatisfied	☐ 2	
Extremely dissatisfied	☐ 1	

2 In an average week, how many days are you a rider in a carpool and how many days are you the driver?

I am a rider _____ days a week		71
I am a driver _____ days a week		72

3 If you drove to work by yourself rather than using a carpool, how much time would you be saving?

_____ minutes 73-75

4 Other than members of your household, how many of the carpool members do you meet with socially on evenings and weekends? _____

None ☐ 76

PLEASE PROCEED TO SECTION D--PAGE 10

Listed below are some events that might change your mind about joining or not joining a carpool. For each, check the box to the right of the statement which best describes how the event would affect your feelings about carpooling.

	Definitely would change my mind in favor of carpooling	Probably would change my mind in favor of carpooling	Probably would not change my mind in favor of carpooling	Definitely would not change my mind in favor of carpooling
: company arranges a meeting of le who would like to carpool	☐	☐	☐	☐ 16
blic service (radio, TV, press, etc.) arranges tings between people who would like to carpool	☐	☐	☐	☐
se in the price of gas to 75¢ a gallon	☐	☐	☐	☐
se in the price of gas to $1.50 a gallon	☐	☐	☐	☐
se in the price of gas to $2.00 a gallon	☐	☐	☐	☐
ncome tax deduction equal to the value of the gas d by carpooling. For example, a person who d $100 a year in gas because he carpools could ct $100 from his taxable income	☐	☐	☐	☐
ress lanes provided strictly for carpools	☐	☐	☐	☐
e parking for drivers in carpools	☐	☐	☐	☐
erved parking spaces close to work for carpoolers	☐	☐	☐	☐
	4	3	2	1

Were you ever a member of a carpool? 25

Yes ☐ → IF "YES" (a) How long were you in a carpool?

_____ years _____ months 26-28

No ☐

IF "NO" PLEASE PROCEED TO SECTION D PAGE 10

(b) Why did you stop carpooling? (Please be as free and candid as you can so that future planning is improved.)

29-
30-
31-

40

I feel it is the people's civic obligation to help reduce air pollution	1 2 3 4 5 6 7	I do not feel it is the people's civic obligation to help reduce air pollution
I do not feel it is the people's civic obligation to help reduce gas consumption		I feel it is the people's civic obligation to help reduce gas consumption
I do not feel it is the people's civic obligation to help reduce traffic congestion		I feel it is the people's civic obligation to help reduce traffic congestion
Carpooling restricts personal freedom		Carpooling does not restrict personal freedom
I do not mind others smoking in the same car I am riding in		I dislike others smoking in the same car I am riding in
I dislike listening to radio stations selected by others		I do not mind listening to radio stations selected by others
Carpooling is a good way of replacing the second car in a household		Carpooling is not a good way of replacing the second car in a household

D-3 All things considered, estimate how similar or how different you consider the following by putting a checkmark in one of the boxes.

	Very Similar 1 2 3 4 5 6 7 Very Different
Carpooling and driving alone	
Carpooling and public transportation	
Driving alone and public transportation	

47

5 Below are some statements about people and carpooling. For each statement put a checkmark (✓) in the box to the right of the statement which best describes how much you agree or disagree with it.

	Agree Strongly	Agree Moderately	Agree Slightly	Neither agree nor disagree	Disagree Slightly	Disagree Moderately	Disagree Strongly	
								10
People who carpool are concerned about saving energy	☐	☐	☐	☐	☐	☐	☐	
Nervous and anxious people can never carpool together	☐	☐	☐	☐	☐	☐	☐	
Carpooling is mainly for people with low incomes	☐	☐	☐	☐	☐	☐	☐	
One has to be a tolerant individual to carpool with others	☐	☐	☐	☐	☐	☐	☐	
Carpooling is for people concerned about saving money	☐	☐	☐	☐	☐	☐	☐	
People who like to lead others prefer to carpool	☐	☐	☐	☐	☐	☐	☐	
Carpool members tend to be of the same background.	☐	☐	☐	☐	☐	☐	☐	
A person with a dominant personality can never be in a carpool	☐	☐	☐	☐	☐	☐	☐	
Young people like to carpool . .	☐	☐	☐	☐	☐	☐	☐	
Carpooling is for people who like companionship	☐	☐	☐	☐	☐	☐	☐	
Carpooling is great for people who have only one car . . .	☐	☐	☐	☐	☐	☐	☐	
It takes the right mixture of people to form a successful carpool	☐	☐	☐	☐	☐	☐	☐	
	7	6	5	4	3	2	1	27

PLEASE PROCEED TO SECTION E--PAGE 14

Including yourself, how many people in your household are in the following age groups:

Under 6 years	_____	35
6 to 17 years old	_____	36
18 years old and over	_____	37
Total number of people in household . .	_____	38

Are you presently a licensed driver?

Yes ☐ 1 No ☐ 2 39

How many licensed drivers live in your household (including yourself)?

_____people 40

How many cars are there in your household? _____cars 41

What type of car do you drive to work? 42- 43- 44-

Make (e.g. Chevrolet, Ford, Chrysler, etc.)_____ 45-

Model (e.g. Nova, Pinto, Duster, etc.) _____ 46-

Year. . . . . _____ 47-

Do not drive to work ☐

5 Please indicate the category that best describes your occupation by putting a checkmark in the box.

- ☐ 1 Professional, Technical, . . . (Engineer, scientist, doctor, teacher, clergyman, lawyer etc.)
- ☐ 2 Manager, Official, or Proprietor (Executive, store manager, manager, postmaster and other supervisory personnel)
- ☐ 3 Sales or Clerical Worker . . . (Secretary, bookkeeper, bank teller, cashier, mailman, telephone operator, salesman etc.)
- ☐ 4 Craftsman or Foreman . . . (Carpenter, plumber, engraver, lineman, radio and television mechanic, baker, upholsterer, etc.)
- ☐ 5 Operators . . . . . (Deliveryman, brakeman, factory worker, welder, parking attendant, Textile weaver, mine worker, etc.)
- ☐ 6 Service Worker . . . . . (Barber, policeman, practical nurse, janitor, cook, housekeeper, etc.)

9 Please check your highest level of education.

- ☐ 1 Attended grade school
- ☐ 2 Finished grade school
- ☐ 3 Attended high school
- ☐ 4 Graduated high school
- ☐ 5 Attended college
- ☐ 6 Finished college
- ☐ 7 Attended graduate school

Lovelock Attitudinal Transportation Survey

2. (a) If new and improved local bus services were introduced in your area, on routes matching your travel needs, do you think that you would use them? (check one):
☐Definitely ☐Probably ☐Unsure ☐Probably not ☐Definitely not

(b) If new and improved bus services to other Bay Area cities were introduced in your area, on routes matching your travel needs, do you think that you would use them? (check one):
☐Definitely ☐Probably ☐Unsure ☐Probably not ☐Definitely not

(c) If new rapid transit services to other Bay Area cities were introduced in your area, on routes matching your travel needs, do you think that you would use them? (check one):
☐Definitely ☐Probably ☐Unsure ☐Probably not ☐Definitely not

TRAVEL AND YOUR JOB

3. What is your occupation? (If you have a job, please be reasonably specific):

(Only those who have regular jobs or who are students answer the next few questions, others please skip to question 8 on page 4)

4. (a) How many days a week do you normally go to work? _____ days

(b) Where is your regular place of work or study located?

Street address (or nearest intersection if preferred) *City* *ZIP (if known)*

(c) Do people who commute there by car normally have to pay parking fees?
(check one): ☐Always ☐Sometimes ☐Never

5. (a) What mode(s) of transportation do you use, and how frequently, for commuting to and from you place of work or study? Exclude walking unless the walk at either end exceeds half a mile, or you live within walking distance of your workplace. Please check as many boxes below as are appropriate:

	FREQUENCY OF USE FOR COMMUTE TRIPS			
	5 or more days/week	3 - 4 days/week	1 - 2 days/week	Occasionally
Drive auto alone	☐	☐	☐	☐
Drive with family member	☐	☐	☐	☐
Carpool	☐	☐	☐	☐
Train	☐	☐	☐	☐
Bus	☐	☐	☐	☐
Ferry	☐	☐	☐	☐
Taxi/Limousine	☐	☐	☐	☐
Motorcycle	☐	☐	☐	☐
Bicycle	☐	☐	☐	☐
Walk	☐	☐	☐	☐
Other (specify)	☐	☐	☐	☐

DRIVING AND VEHICLE OWNERSHIP IN YOUR HOUSEHOLD *(Everybody)*

8. (a) Do you have a current driver's license? ☐ YES ☐ NO

   (b) Roughly how many miles would you say you drive per year? (Note: Someone who averages 100 miles a week drives around 5,000 miles annually.) Check one:

   ☐ Do not drive
   ☐ 5,000 miles or less
   ☐ 5,001 - 10,000 miles
   ☐ 10,001 - 15,000 miles
   ☐ 15,001 - 20,000 miles
   ☐ Over 20,000 miles

9. (a) How many persons, including yourself, are resident full-time in your household? (Please exclude anyone living away from home while at school or college.)

   _____ persons aged 17 and over; _____ persons aged 10-16; _____ persons aged 0-9.

   (b) How many of those aged 17 and over are regular drivers? _____ .

10. (a) How many of each of the following types of vehicles, in working order, are operated by resident members of your household (including yourself)?

   _____ autos (incl. campers, trucks); _____ motorcycles; _____ bicycles.

   (b) How many (if any) of the autos are company-owned or official vehicles? _____ .

   (c) To what extent do you normally have personal use of a car available to you? (check one):

   ☐ Always ☐ Most of the time ☐ Part of the time ☐ Occasionally ☐ Never

NON-COMMUTE TRAVEL

11. (a) For journeys other than commuting, how much do you use each of the following modes of transportation? (Check one box for each mode of transportation, but please exclude any journeys made outside Bay Area.)

FREQUENCY OF USE IN BAY AREA

MODE OF TRAVEL (as passenger or driver)	3 or more days/week	1 - 2 days/week	1 - 3 days/month	At least once in past year	Never, or not lately
Your own (or household) auto	☐	☐	☐	☐	☐
Bicycle	☐	☐	☐	☐	☐
Motorcycle	☐	☐	☐	☐	☐
Taxi	☐	☐	☐	☐	☐
Local buses around your city	☐	☐	☐	☐	☐
Buses to other Bay Area cities	☐	☐	☐	☐	☐
Train services	☐	☐	☐	☐	☐
S.F. Cablecars	☐	☐	☐	☐	☐
S.F. buses/streetcars ("Muni")	☐	☐	☐	☐	☐
Ferries	☐	☐	☐	☐	☐
Airport buses or limousines	☐	☐	☐	☐	☐
Other (specify)	☐	☐	☐	☐	☐

   (b) How often do you visit San Francisco? (Exclude commute trips if you work in The City)

   ☐ Once a week or more ☐ 1-3 times/month ☐ Occasionally ☐ Rarely ☐ Never

12. (cont)

Part (C)

Q: "Is there a regular train service from here to San Francisco?"

Your answer: ☐ YES ☐ NO ☐ UNSURE

If you answered "NO" or "UNSURE", skip to Question 13; if "YES", please continue below:

Q: "What is the name of the company that operates the trains?"

Your answer:_____ *or* ☐ UNSURE

Q: "What is the approximate distance from here (your house) to the nearest train station?"

Your answer:_____ *or* ☐ UNSURE

13. If your neighbors needed to obtain further information about public transit services and you agreed to help them, how would you personally go about obtaining the necessary information for the relevant services in your area? Please write below the sources (e.g. people, companies, other organizations, publications, etc.) that you would try first.

A. LOCAL BUS SERVICES (If applicable)

Sources of information you would try: _____

_____

B. BUS SERVICES TO SAN FRANCISCO (if applicable)

Sources of information you would try: _____

_____

C. TRAIN SERVICES TO SAN FRANCISCO (if applicable)

Sources of information you would try: _____

_____

YOUR USAGE OF PUBLIC TRANSPORTATION

14. Please check the one sentence below which best describes you:

☐ I don't use public transportation and I never have in the past.

☐ I don't use public transportation at the present time, although I have used it in the past.

☐ I occasionally use public transportation, but only when I have to.

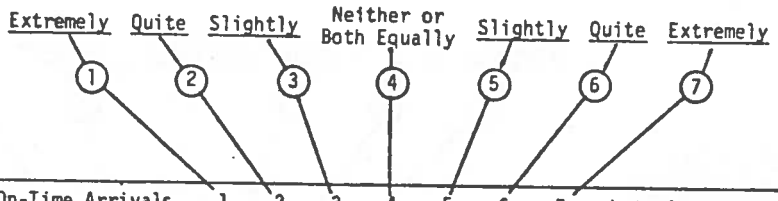
☐ I occasionally use public transportation by choice.

☐ I am a regular user of public transportation by choice.

☐ I am a regular user of public transportation because I have no alternatives.

YOUR OPINION OF BUS TRAVEL IN THE BAY AREA

16. In this section, we'd like you to indicate your general opinion of bus travel for the sort of journeys which people might make by bus within the Bay Area. Base your opinion on what you know or have heard about this type of travel in your area. Even if you never ride buses yourself, you can probably imagine what it is like -- obviously, you don't need to have tried something in order to be able to express just a general opinion. Please complete the scales below in the same way as you did in the previous question.



BUS TRAVEL CHARACTERISTICS									
PUNCTUALITY	On-Time Arrivals	1	2	3	4	5	6	7	Late Arrivals
SIMPLICITY	Simple to Use	1	2	3	4	5	6	7	Complicated to Use
SAFETY	Safe Form of Travel	1	2	3	4	5	6	7	Dangerous Form of Travel
MODERNITY	Modern Form of Travel	1	2	3	4	5	6	7	Old-Fashioned Form of Travel
COMFORT (Seats, Noise, Ride, etc.)	Comfortable	1	2	3	4	5	6	7	Uncomfortable
SPEED ON COMMUTE TRIPS	Fast	1	2	3	4	5	6	7	Slow
STATUS	High Status Form of Travel	1	2	3	4	5	6	7	Low Status Form of Travel
CONVENIENCE	Convenient Form of Travel	1	2	3	4	5	6	7	Inconvenient Form of Travel
SPEED ON NON-COMMUTE TRIPS	Fast	1	2	3	4	5	6	7	Slow
ENJOYABLENESS	Enjoyable Form of Travel	1	2	3	4	5	6	7	Unenjoyable Form of Travel
COST OF TRAVEL	Inexpensive	1	2	3	4	5	6	7	Expensive
RELIABILITY	Reliable Form of Travel	1	2	3	4	5	6	7	Unreliable Form of Travel

18. (a) How confident are you in the judgements you just made about the characteristics of train travel? (Please check one):

☐ Extremely ☐ Very ☐ Somewhat ☐ Only Slightly ☐ Not at All

(b) How confident are you in the judgements you just made about the characteristics of bus travel? (Please check one):

☐ Extremely ☐ Very ☐ Somewhat ☐ Only Slightly ☐ Not at All

TRANSIT ADVERTISING AND PUBLICATIONS

19. Can you recollect having seen or heard any advertising specifically for public transportation services in the Bay Area, during the last six months or so? (Please check one):

☐ YES ☐ NO ☐ UNSURE

If YES, please write down the name(s) of the transit company(ies), and also the media (e.g. radio, TV, papers) carrying the advertising:

TRANSIT COMPANY _____ MEDIA _____

_____

20. Which of the following do you presently have in your home?

Airline timetable(s)	☐ YES	☐ NO	☐ UNSURE
Bus timetable(s)	☐ YES	☐ NO	☐ UNSURE
Train timetable(s)	☐ YES	☐ NO	☐ UNSURE
Ferry timetable(s)	☐ YES	☐ NO	☐ UNSURE
Public Transportation Guide	☐ YES	☐ NO	☐ UNSURE

INFORMATION ABOUT YOURSELF

21. To conclude, may we ask you a few questions about yourself:

(a) How long have you lived at your present address? _____ years

(b) How long have you lived in the Bay Area? (Please exclude short absences).

(check one): ☐ 0-2 years ☐ 3-5 years ☐ 6-10 years ☐ Over 10 years

(c) Outside the Bay Area, in what other major cities or urban areas have you lived, for periods of two or more years, since your early teens?

_____

(d) What is your sex? ☐ MALE ☐ FEMALE

(e) And your marital status? ☐ SINGLE ☐ MARRIED ☐ OTHER

(f) Please check your age group:

☐ 20 or less ☐ 21-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65 +

(g) Have you attended college? ☐ YES ☐ NO

If YES, please check the highest level of college education achieved so far:

☐ Attended College ☐ Obtained Bachelor's degree ☐ Graduate Work

* * * * * * *

Thank you very much for taking the time and trouble to complete this questionnaire! Please feel free to write any additional comments you may have on the back of this sheet. The survey assistant will return at the agreed time to collect your questionnaire.

Appendix B
FHWA, GM, AND LOVELOCK DATA CODING PRACTICE

Table B-1 (Continued)
FHWA DATA CODING PRACTICE

Acronym	Question Designation	Treatment
PAV_{inv}	19a, 20b	The inverse of perceived riding time times 2.5 extra riding time.
PAV_{dum}	7a	0 = no perception that bus service is available 1 = bus service perceived as available.
CONV	Booklet A: Convenience; Ease of Use; Arrive on Time; Ease to Destination; Crowding; Waiting Time; Weather Extra Time.	The values range from -3 to 3, the greater value indicating higher rating on the individual service feature. The average is computed for CONV.
COMF	Booklet A: Comfort; Space for Packages; Reliability; Vehicular Safety; Personal Safety; Relaxing.	Same procedure as for CONV, but different service features (as noted).
Exogenous Variables		
INC	28.	Midpoint values of household income ranges were utilized.
NIH	24a.	Values as they are coded.
NW	1a. from Screening Questionnaire 26b.	1-6
AUTOS	26b.	0-4 or more as coded.

Table B-2

GM DATA CODING PRACTICE

Acronym	Question Designation	Treatment
BEH	A-2, Carpool	Values increase as frequency increases.
MA	D-1	Affect increases as values increase.
TIMCONV	D-4 Carpooling Comfortable; Pleasant; Reliable; Saves Time; Convenient.	Coded 1-7, low to high perceptions on each factor.
SOCOS	D-4 Expensive; Energy Consuming; Causes Traffic Problems; Pollution.	Coded 1-7, low to high perceptions for each factor.
INC	E-20	Total household income increases as code value increases.
NIH	E-6	Numerically identical to code 1-7, and 8 for eight or more.
AUTOS	E-9	Identical to value 1-7, 8 for light trucks or more cars.
NIHWAR	E-6, E-9	$\frac{\text{NIH-Autos}}{\text{NIH}}$.
TRES	E-16	Time at residence coded on a monthly basis.
TJOB	E-15	Time at job coded on a monthly basis.
COSTIMP	D-2: Carpooling Saves; I feel air pollution; Gas Consumption; Traffic Congestion.	Some scales inverted to insure that values increase in measure with more consideration of the cost importance.

Table continued on following page.

Table B-3
LOVELOCK DATA CODING PRACTICE

Acronym	Question Designation	Treatment
BEH	5a. (only commuting bus frequency).	All responses are changed to frequency per month and summed.
	11.a. Freq. of local bus; Buses to other Bay area; S.F. buses.	Summed with selected items from 5a. to compute overall frequency of bus use.
INT	2a. and 2b.	The responses are coded numerically and summed. The higher numbers signify higher intention.
CONV	16. Reliability; Convenience; Speed on Commuter Trips; Speed on Noncommuter Trips; Punctuality.	The scales were inverted: higher numbers indicate greater convenience.
PAV	6c.	Scale was inverted so they increase from no, unsure, . . . to yes fairly easy.
IDL	8a. and 8b.	IDL is a dummy variable; 0= no; 1- yes.
NIH	9a.	Sum of number in household from the different age groups.
AUTOS	10a.	Number of autos as is.

Table continued on following page.

Appendix C
FHWA SYSTEM VARIABLE DESCRIPTIONS

Introduction

The FHWA travel survey provides network system data in addition to attitudinal, demographic and behavioral data. The empirical analysis includes the system variables as exogenous variables in the carpooling and transit models. The transportation network data, developed from the origin-destination survey of the 1967 Los Angeles Regional Transportation Study (LARTS), are coded in accordance with input requirements for FHWA route assignment computer programs, as updated by the California Department of Transportation (Caltrans) in April 1975. Each respondent is designated according to zone placement and the respective data are applied to the respondent data.

The network data are recoded for our purposes. The automobile system data are comprised of zonal freeway distance and time, zonal city street distance and time, zonal egress distance and time, and zonal parking cost. Access and egress refer to the extra-network time and distance (e.g., access is

Automobile-sharing impedance is calculated from automobile impedances with adjustments for the additional pickup time for the ridesharers. Carpool impedance is calculated with the assumption that two minutes per carpooler would be added to access time. The mean carpool occupancy reported in the Los Angeles area is 2.28. The automobile access time was adjusted to account for the following: 2 minutes * (2.28-1) passengers. Carpool impedance is thus expressed as:

$$CI = 2.5a_1 + 1n + 2.5e \qquad \text{(C-2)}$$

where

CI = carpool impedance,
a_1 = adjusted access time,
n = freeway and city street time, and
e = egress time.

Transit impedance is calculated from the transit network system data. The component times for the transit trip are calculated on a zonal basis. The bus impedance components are access, waiting, linehaul and egress times. Thus:

$$TI = 2.5a + 2.5w + 1.0l + 2.5e \qquad \text{(C-3)}$$

where

TI = transit impedance,
a = access time,
w = waiting time,
l = linehaul time, and
e = egress time.

These impedances are instrumental in the development of exogenous variables for the transit models. The difference in the impedance measures is considered a factor in modal use.

the calculation of the basic egress operating costs. Adjustments to reflect the $.196 per gallon rise in gasoline prices from the $.391 per gallon reported in CUTS are effected in a similar manner. The gasoline price difference multiplied by the gas consumption on the street types at the proper speed (taking into account the automobile mix) is added to the basic operating cost, respectively, for access, egress, city and freeway travel to provide the actual automobile operating cost. The total automobile costs are the actual operating costs plus the reported zonal parking cost for daily parking.

Carpool operating costs are calculated from the total automobile operating cost. The total automobile costs were divided by the mean number of carpoolers (2.28 in the Los Angeles area) to compute the cost per person of the automobile-sharing commute trip.

The transit cost utilized is the actual fare for the commute trip. The cost data are utilized to develop exogenous variables -- specifically, the difference in bus and auto cost (DBCOST) and the difference in auto and carpool cost (DCPCOST). DBCOST is the bus cost minus the total automobile cost whereas DCPCOST is the total automobile cost minus the carpool cost.

Additional System Data

Additional system-type variables are calculated using the basic network data. DBOVT is defined as the difference between bus and automobile extra time. More specifically the bus extra time (extra linehaul time) is a composite of access time, waiting time and egress time. The automobile extra time, or extra network time, is the access and egress time.

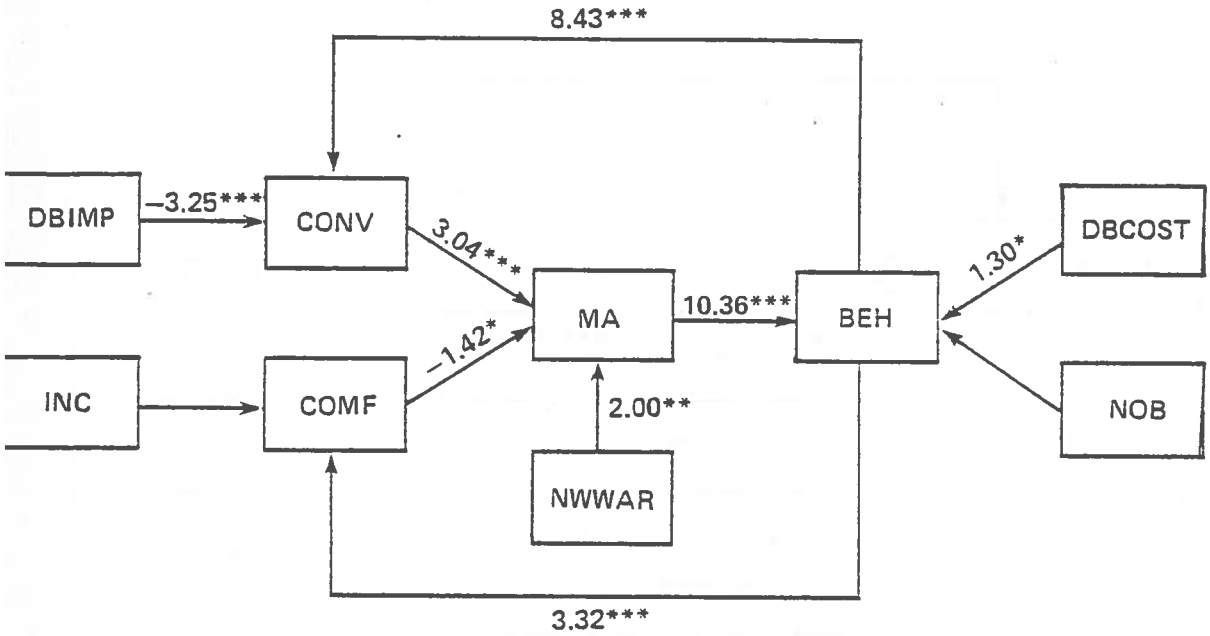
Appendix D
QUANTIFICATION METHODS FOR SEGMENTATION EFFECTS

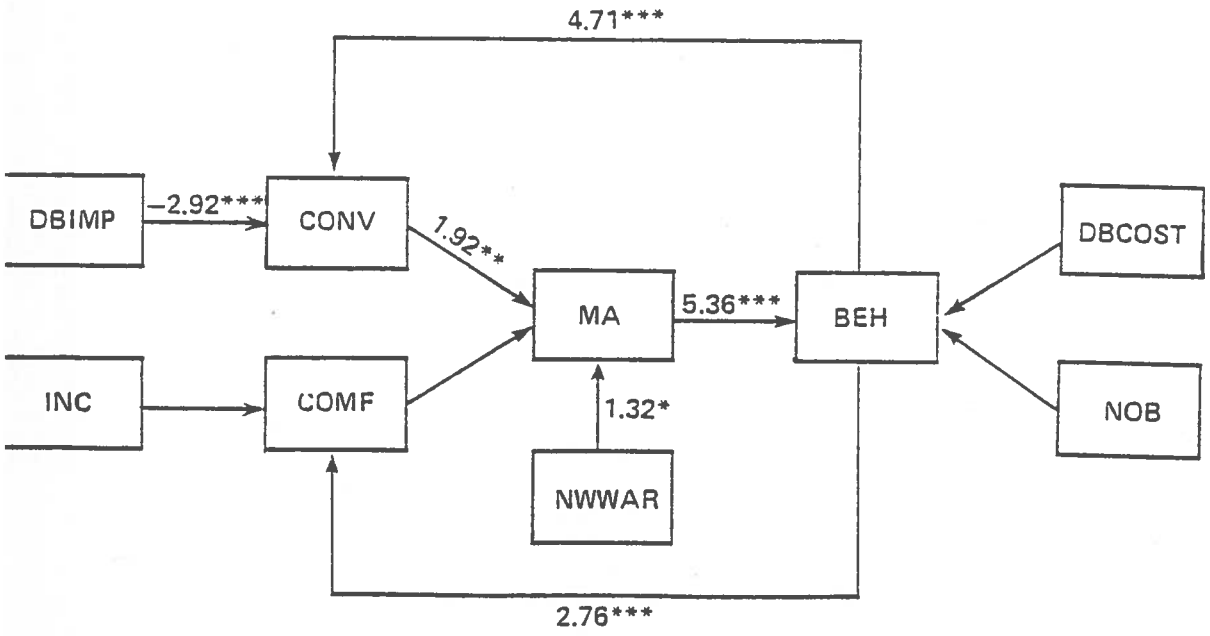
Market Segmentation for Traveler Behavior Analysis

The need for market segmentation in travel behavior analysis stems from the existence of fundamental, sometimes qualitative, similarities and differences among travelers. Market segmentation provides a framework for analyzing, interpreting, and accomodating these similarities and differences. Initially, this chapter will briefly investigate a representative segmentation from the preliminary results reported in Chapter 4. A discussion on the development of a rigorous, statistical technique for verifying the existence of segmentation effects will be followed by a number of applications. Finally, some potential implications for travel behavior analysis of market segmentation in a structural equations framework will be mentioned.

Figure D-1

COMPARISONS OF SEGMENTED INTENTION SAMPLES FOR BUSES





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

Figure continued on next page.

The importance of segmentation is reinforced in two ways by these findings. It is shown that the full sample estimates are not necessarily appropriate for individual segments. In addition, the attitude-behavior structures for the two sample segments, formed on a benefit segmentation basis, are shown to reveal distinct patterns of traveler attitude-behavior interrelationships.

A Statistical Test for Segmentation

While the above results show that when segmentation is performed different attitude-behavior structures can be observed, they do not demonstrate a statistical difference between the segmentation results and the full sample estimation. In addition, they do not assess statistically whether there is a difference between travel segments. Alternative traveler segments can be statistically contrasted with respect to the full sample and each other. A dummy variable segmentation technique will be discussed to indicate its ability to quantify differences between segments. The issue of a significant structural difference between the full sample and the segmented sample is addressed subsequently through an adaptation of the Chow Test.[1]

A Statistical Test Between Traveler Segments

Dummy variables have been used to quantify differences across traveler segments in prior transportation research.[2]

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[1]Gregory C. Chow, "Tests of the Equality Between Sets of Coefficients in Two Linear Regressions," *Econometrica* 28 (1960): 591-605.

[2]Dobson and Tischer, "A Perceptual Market Segmentation Technique," *op. cit.*

as a segmentation basis, $D3$ will be the dummy variable which takes the value of 1 when variable D satisfies certain conditions and 0 when it does not.[1]

In addition to the preparation of $D3$, the dummy segmentation basis, dummy variables for each of the endogenous and exogenous variables within the system of equations are constructed. These additional variables, which are indicated with a prime, are calculated as follows:

$$A' = A \cdot D3; \quad EX_1' = EX_1 \cdot D3;$$

$$B' = B \cdot D3; \quad EX_2' = EX_2 \cdot D3.$$

It is evident that each of these primed variables will be equal to zero when $D3$ is zero, but otherwise they will equal the value of the original variable. The primed endogenous variables and their exogenous counterparts are processed in slightly different ways to assess the segmentation effects.

The first stage of two-stage least squares analysis produces estimates of the endogenous variables as a function of the exogenous variables. With the incorporation of the dummy variables the representation of this step is:

$$A \simeq f_1(EX_1, EX_1', EX_2, EX_2', D3) = \hat{A}$$

$$B \simeq f_2(EX_1, EX_1', EX_2, EX_2', D3) = \hat{B}$$

---

[1]For instance, when $0<D<7$, then $D3 = 1$ if $D<3$ and 0 otherwise (i.e., when $D \geq 3$).

A Statistical Test Across Full Sample and Segmentation Samples

The alternative attitude-behavior structures for the full and segmented samples can be tested for significant differences between each other through an adaptation of the Chow Test. The adaptation is developed employing R^2 statistics rather than the residuals, the usual manner in which the Chow Test is presented.[1]

The segmentation analysis is performed according to the dummy variable segmentation technique described above. In order to develop a valid full sample goodness-of-fit statistic (R^2) for comparison with the segmentation results, the structural equation estimation is calculated similarly. The estimates of the endogenous variables to be substituted into the second stage are calculated identically to those for the segmentation technique:

$$A \simeq f\ (EX_1,\ EX_1',\ EX_2,\ EX_2',\ D3) = \hat{A};$$

$$B \simeq f\ (EX_1,\ EX_1',\ EX_2,\ EX_2',\ D3) = \hat{B}.$$

The second stage of the full sample estimation is similar to the regular structural equation estimation representation; it is denoted by:

---

[1]The relationship between R^2 and the residuals is noted:

$$R^2 = 1 - \frac{RSS}{TSS},$$

where

TSS = the total sum of squared deviations from the mean, and

RSS = the sum of squared residuals.

This statistic, applied in the denominator, is denoted by the subscript s, for instance, R^2_{us}. The ratio is computed with the following formula:

$$F_{[p(k-1),\ N-kp]} = \frac{R^2_{gr} - R^2_{ur}/p(k-1)}{1 - R^2_{gs}/N-kp}.$$

This ratio tests the null hypothesis that there is no difference between the full sample estimation and the segmentation estimation in the attitude-behavior structure. If the calculated F-statistic exceeds the critical value for statistical significance, then the null hypothesis can be rejected.

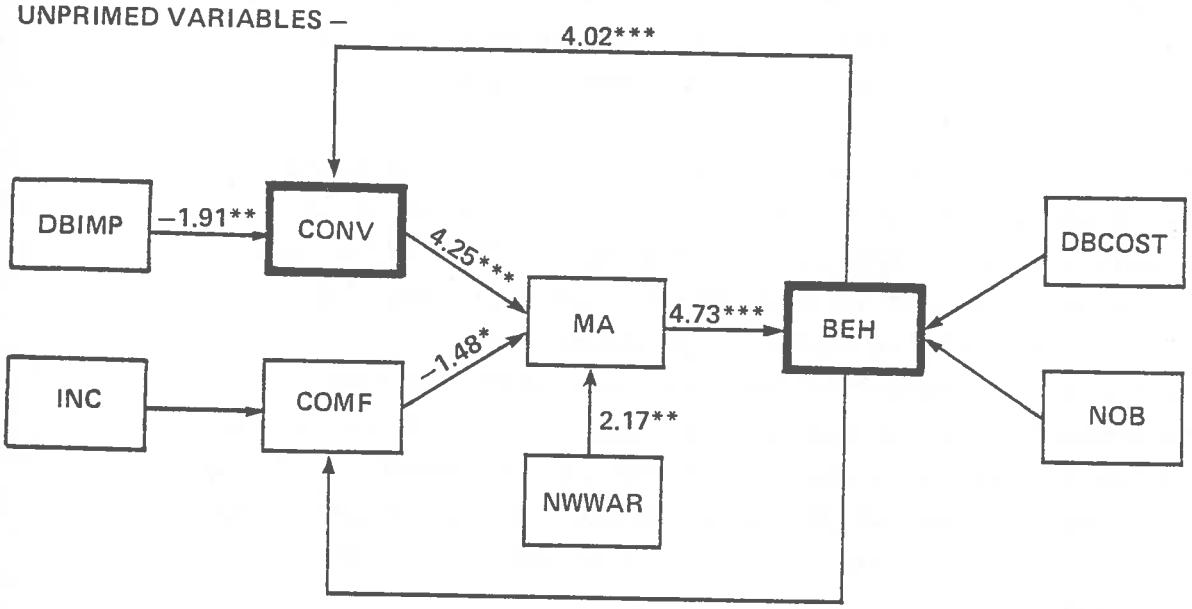
Applications of a Statistical Test for Segmentation

The two-fold statistical test for segmentation is applied to carpool and bus attitude-behavior model configurations. The dummy variable aspect of the test explores the difference between market segments with respect to linkages between pairs of variables, whereas the F-test illustrates whether the goodness-of-fit of the equation structure is significantly improved by the designation of traveler segments.

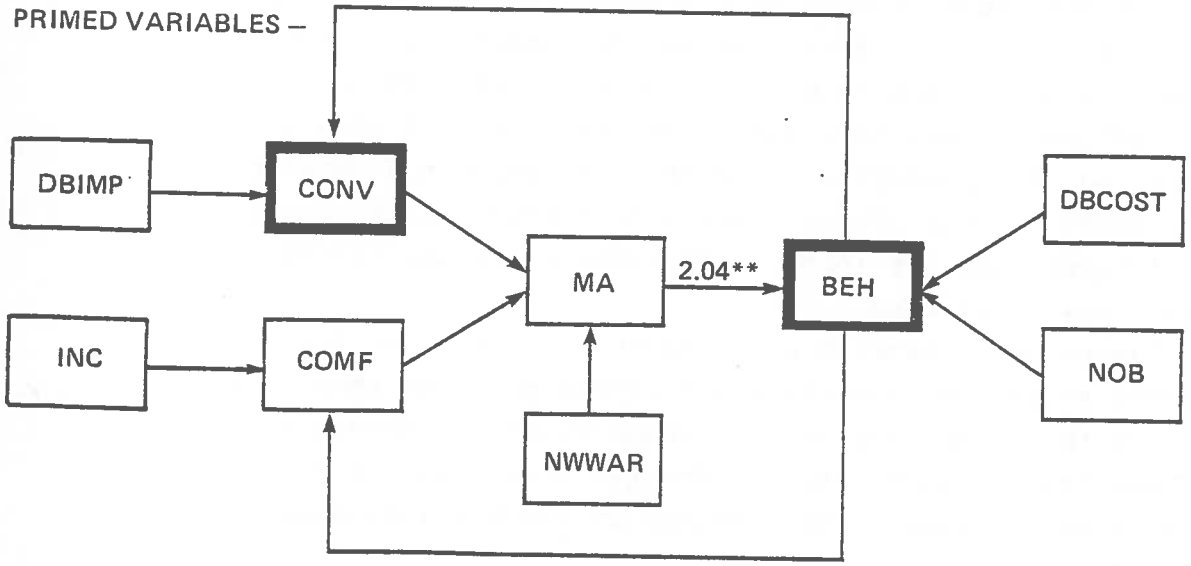
Figure D-2 presents a model of the interrelationships for behavior and attitudes toward buses which is representative of those considered in Chapter 4. The segmentation basis employed in this analysis is traveler intention of switching to buses. The dummy variable is constructed relative to the population mean for intention to switch. The dummy 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 utilizing the original variables and the primed variables. The top flowgraph of Figure D-2 presents

Figure D-2

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

variable for each equation are listed between flowgraphs, with a dependent variable subscript to describe its origination. The bus intention dummy variable (*D3*) indicates the level of effect of the segmentation base.

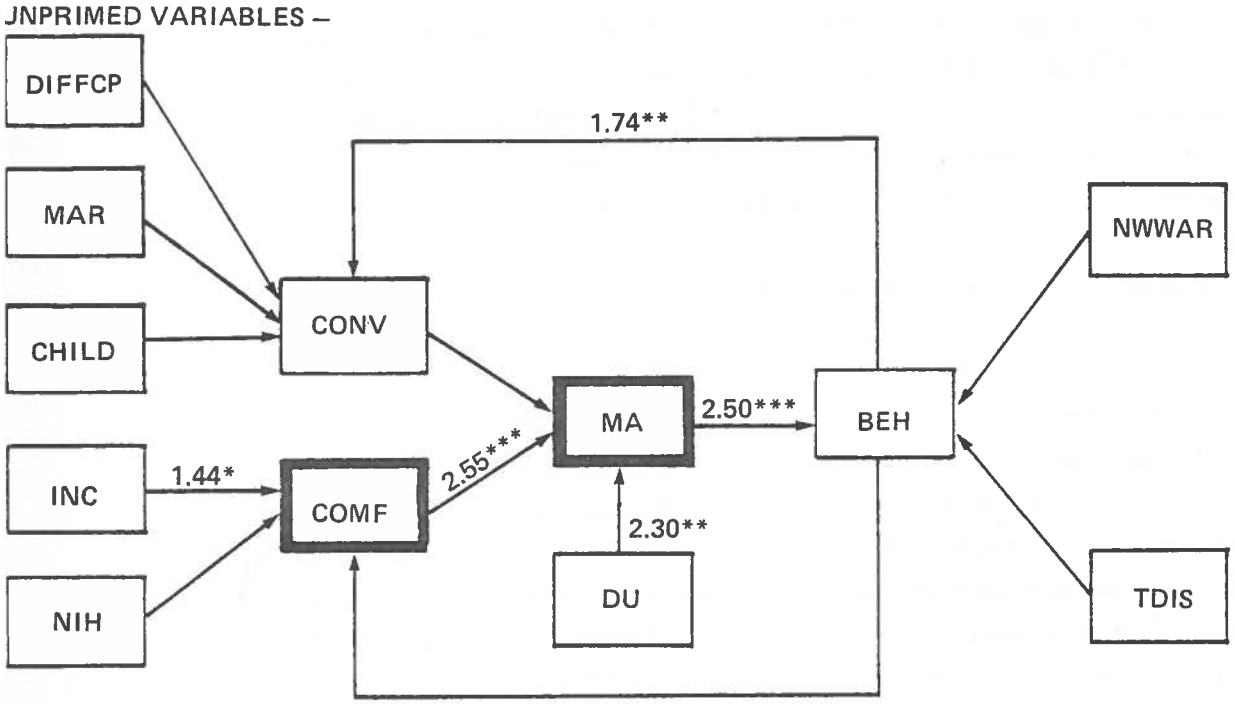
The *t*-statistics reported in the second flowgraph indicate the significance of the interrelationships for the low intention group (*D3=0*). Our analysis technique generates these statistics for one segment, but the same results can be obtained for all segments by any of several techniques (e.g., separate models can be run for each segment). The third flowgraph depicts the *t*-statistics for the primed variables. The statistical significance of these *t*-values reveals whether the high- and low-intention groups differ with respect to the regression coefficient for specific variables. Only one variable, modal affect, has statistically different values for each segment. The influence of modal affect on behavior differs substantially for the high- and low-intention segments.

Figure D-3 shows the result of a segmentation on intention to use carpooling. The mechanics of the segmentation analysis is identical to that used to study bus usage. The first flowgraph presents the *t*-values for the structure of the full sample estimation. The model is representative of carpool structures presented in Chapter 4. The mutual dependence hypothesis is strongly supported. The linkages from comfort and convenience cognitions to modal affect as well as from modal affect to behavior are statistically significant. In addition, the feedback of behavior to perceptions about carpools is statistically significant.

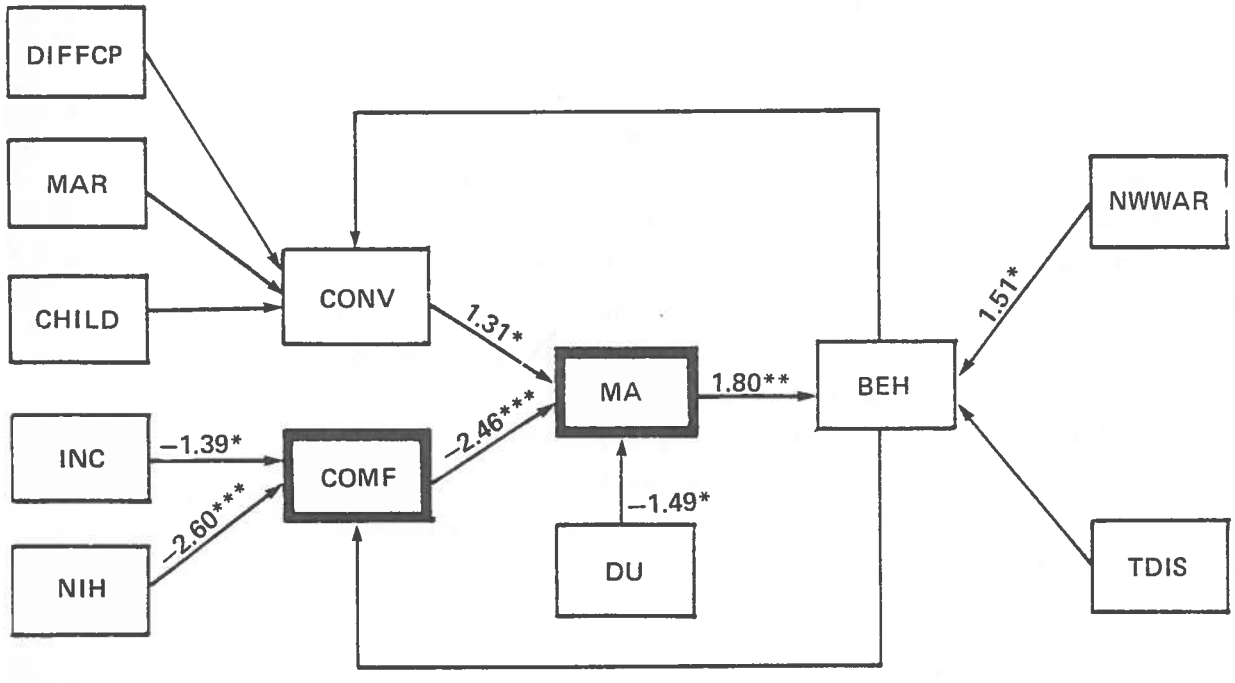
A number of exogenous variables are also significant antecedents in the attitude-behavior structure. Dwelling unit and NWWAR have the correct sign whereas the sign for marital status appears to be counterintuitive. The *t*-values for the

Figure D-3

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



$D3_{BEH}$: t = –1.42 $D3_{MA}$: t = 2.54 $D3_{CONV}$: t = .22 $D3_{COMF}$: t = 3.50



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

indicated by the magnitude of the auto size variable. The dummy variable is constructed around the mean of the auto size variable. The first flowgraph in Figure D-4 shows the *t*-values for the unsegmented sample while the second flowgraph represents the *t*-values for the smaller automobile size segment. A third flowgraph showing how segments differentially stress variables underlying attitudes and behavior is unnecessary since the segments are not found to statistically differ from the equations in the attitude-behavior structure.

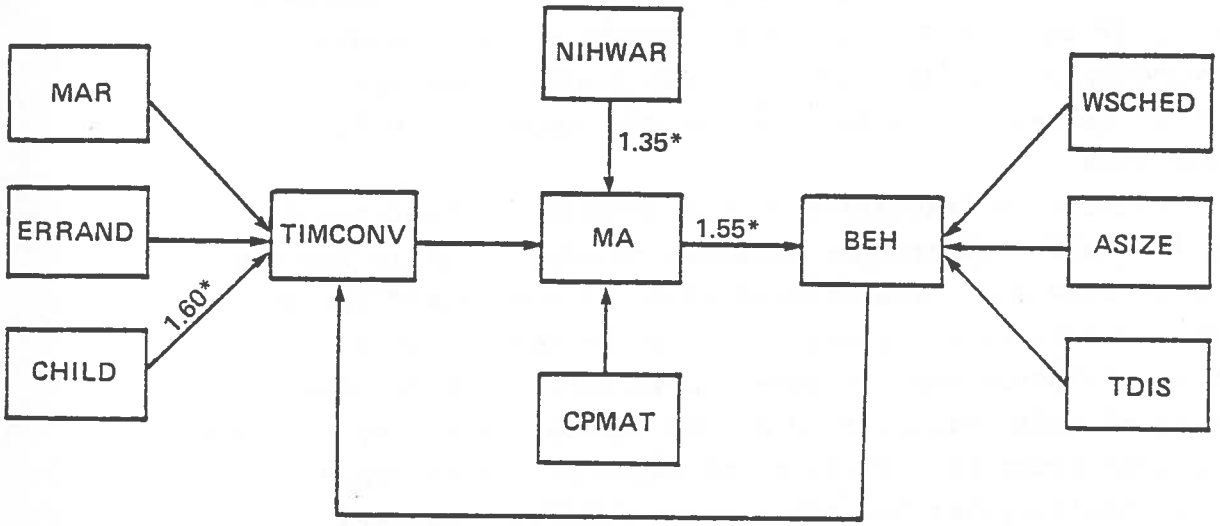
Figure D-4 presents a representative model for a carpool structure. The mutual dependence hypothesis is supported since the linkages of attitudes to behavior and behavior to attitudes are statistically significant in the first flowgraph. The *t*-values in this flowgraph are greater than a previous analysis of a similar structure due to the first-stage estimation process. The ASIZE exogenous variable is a significant right-hand variable for behavior in this full sample analysis, whereas that relationship did not have the same strength in the identical flowgraph from Chapter 4. In this equation system, none of the individual equations were determined to be significantly different in the unsegmented versus the segmented version of the *F*-test analysis.

The flowgraph representation of the *t*-statistics for the small auto size segment is shown in the second flowgraph. Some exogenous variable linkages are significant in this flowgraph, and modal affect again is found to be statistically related to modal usage. The values noted below this flowgraph indicate the *t*-statistics on the *D3*, the dummy segmentation level effect. None of the equations have statistically different intercepts between the two traveler segments.

Figure D-4

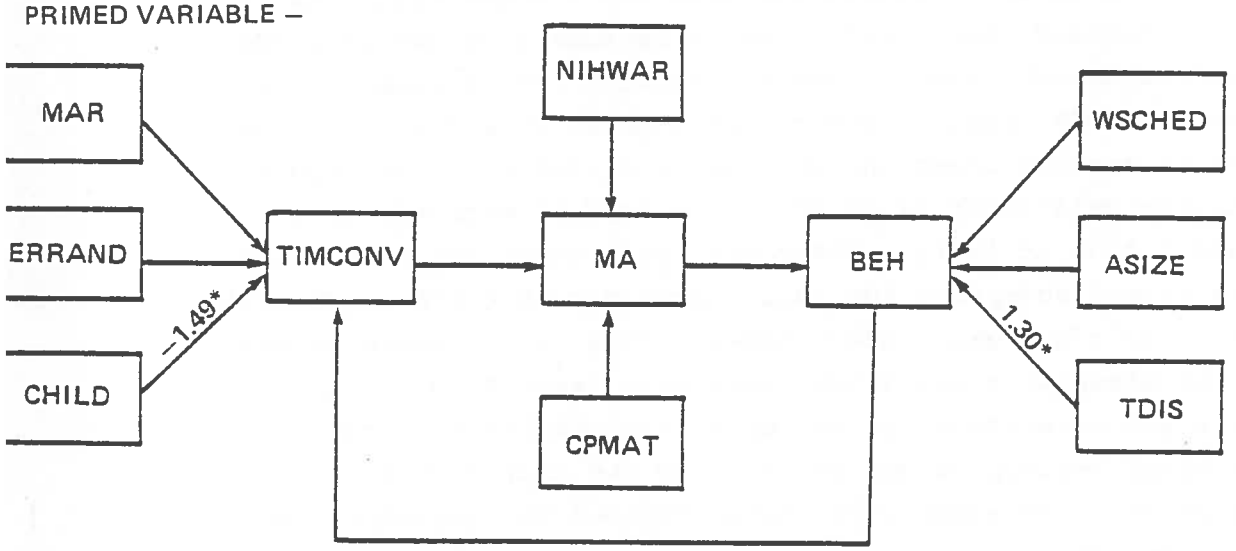
AN APPLICATION OF TEST TO SEGMENTED AUTO-SIZE SAMPLES FOR CARPOOLS
(continued)

UNPRIMED VARIABLES –



$D3_{BEH}$: t = .47 $D3_{MA}$: t = –1.10 $D3_{TIMCONV}$: t = –.85

PRIMED VARIABLE –



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

The Chow Test found two equations for both the bus and carpool modes in the FHWA dataset to be statistically different. The results do not support a similar interpretation across the two modes. The significant equations for the bus mode were those of convenience and behavior; for the carpool mode, they were modal affect and comfort. Assuming further research confirms this impact of segmentation, these cross-mode differences may be of particular importance.