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A Simultaneous Equations Model of Employee Attitudes to a Staggered Work Hours Demonstration Project

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**A Simultaneous Equations Model of Employee
Attitudes to a Staggered Work
Hours Demonstration Project**

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1.0 INTRODUCTION

Increasing emphasis is being placed on transportation demand management strategies as U.S. metropolitan areas seek solutions to urban congestion problems. These strategies focus on reducing peak-period travel demand by promoting actions such as ridesharing and transit use, flexible work hours programs, and working at home (telecommuting). Success of these strategies depends on the willingness of employees to adopt them. Thus attitudes and perceptions of these strategies are important indicators of their viability as transportation policy alternatives. This paper presents an analysis of employee attitudes towards one transportation demand management strategy: staggered work hours. The program was implemented as a demonstration project in downtown Honolulu, Hawaii.

The research problem here is one of establishing relationships between employee attitudes toward the program and their actual experiences. Because the attitudinal data involve ordinal and discrete choice variables, the analysis requires use of causal models that can incorporate endogenous variables that are not normally distributed. The approach is to specify a simultaneous system of dichotomous and ordered-response probit models and to make use of maximum and generalized least-squares methods in a multistage estimation procedure. The model is used to test relationships between participation in the Staggered Work Hours Program, travel experience during the Program, and attitudes toward participation in future programs.

The remainder of the paper is organized as follows: Section 2 provides a description of the Demonstration Project. Section 3 presents the research approach and methodology. Data is described in Section 4, analysis and results in Section 5, and conclusions in Section 6.

2.0 THE HONOLULU STAGGERED WORK HOURS DEMONSTRATION PROJECT

The downtown area of Honolulu, Hawaii is experiencing increasing traffic congestion as a result of continued population and employment growth. Rugged topography, environmental concern, and limited local financial resources make opportunities limited for construction of major new facilities to handle increased traffic demand. Transportation demand management (TDM) strategies offer low-cost ways to control traffic congestion by limiting peak-period demand.

The State of Hawaii conducted a Staggered Work Hours Demonstration Project in downtown Honolulu to determine whether a large-scale shift in work hours among downtown workers could reduce traffic congestion by spreading peak travel time over a longer time period. It is the first time that such a program has been implemented in an entire downtown. The Project took place during a four-week period from February 22 through March 18, 1988. During the Project, office hours for state, city, and county employees were shifted from 7:45 a.m.-4:30 p.m. to 8:30 a.m.-5:15 p.m. The shift to a later schedule was selected because of the very early peaking characteristic of

downtown-bound traffic. Participation in the Project was mandatory for all public employees. Nonparticipation required approval via a formal exemption process.

Participation by private sector downtown employers was encouraged but not required. Private sector employees participated on a voluntary basis, and, unlike state and city-county employees, were able to choose their Project work schedule.

Approximately half of all public sector employees shifted to the later work schedule. Slightly more than one-third of the employees at participating private sector companies changed their work schedule, and the majority of those who changed shifted to an earlier schedule (start work 7:30 a.m. or earlier). It was estimated that about 4,000 downtown workers, representing 6 to 7 percent of the downtown work force, shifted to the 8:30 a.m.-5:15 p.m. schedule (Giuliano and Golob, 1988).

A second purpose of the Demonstration Project was to evaluate the impact of staggered work hours on employees. It was anticipated that the change in work schedule would have effects both inside and outside the work place, and that employee experiences and attitudes would determine the viability of a possible future permanent staggered work hours program.

Analysis of employee commuting times before and during the Demonstration Project revealed that those who participated in the Project were less likely to have experienced a reduction in commute travel time than those who did not participate. Analysis also indicated that the Project impacts were geographically diverse; commuters from one area were affected differently from commuters in other areas (Giuliano and Golob, 1988). It was therefore concluded that these differing experiences could significantly affect employee attitudes toward the Project.

3.0 RESEARCH APPROACH AND METHODOLOGY

The task is to analyze employee attitudes toward possible future staggered work hours programs. It is hypothesized that employee attitudes are a function of several different factors: general perceptions regarding the worthiness of staggered work hours, participation in the Demonstration Project, conditions experienced, and perceptions of conditions experienced during the Demonstration Project. Furthermore, participation and perceptions of conditions experienced are themselves dependent upon general perceptions. There are no prior notions regarding causality between these factors. Therefore, a general model form is required that will allow for testing of all possible linkages among the endogenous variables.

Structural equations models have been developed for problems of this type. Structural equations is a specific type of simultaneous equations in which alternative relationships between variables can be readily tested. Structural equations assuming multivariate normal distributions have been applied extensively in sociology and psychology (as reviewed in Bentler, 1980; Fornell and Larcker, 1981; Hayduk, 1987; and Jöreskog and Wold, 1982), and most applications have employed the maximum-likelihood estimation method of the LISREL program (Jöreskog and Sörbom, 1984, 1987).

In this case, however, the multivariate normal distribution assumption does not hold. The attitudinal data consist of ordinal scale variables, and Project participation is a dichotomous variable. The approach is to treat the non-normal endogenous variables as probit submodels within the structural equations system. Distribution-free estimation

methods that allow non-normal endogenous variables to be incorporated in structural equation models in a theoretically consistent manner have recently been developed. These methods are based on asymptotically distribution-free generalized least-square estimators (Browne, 1982, 1984; Bentler, 1983a, 1983b; Muthén, 1983, 1984) and are implemented in at least two available computer programs, EQS (Bentler, 1985) and LISCOMP (Muthén, 1987). The LISCOMP program is used in the research reported here.

3.1 INCORPORATION OF NON-NORMAL ENDOGENOUS VARIABLES IN THE STRUCTURAL EQUATIONS MODEL

The present extension of structural equation models to non-normal endogenous variables begins with transformations from each ordered polytomous (ordinal) variable y with c categories ($y = 0, 1, 2, \dots, c-1$) to an unobserved (latent) continuous variable y^* . Dichotomous variables are a special case of such ordinal variables with $c = 2$ categories. The transformation is given in terms of a set of $c - 1$ thresholds, $k_1, k_2, \dots, k_{c-1}$, that are determined in the estimation procedure (Muthén, 1984; Golob, 1988):

$$y = \begin{cases} c-1 & \text{if } k_{c-1} < y^* \\ c-2 & \text{if } k_{c-2} < y^* \leq k_{c-1} \\ \vdots & \\ 1 & \text{if } k_1 < y^* \leq k_2 \\ 0 & \text{if } y^* \leq k_1 \end{cases} \quad (1)$$

The unknown thresholds in (1) can be determined by maximizing the joint probabilities that the latent variables are multnormally distributed conditional on any exogenous x variables in a structural equation system. The estimation parameters are expressed in,

$$\begin{aligned} P(y = j|x) &= P(k_j \leq y^* < k_{j+1}) \\ &= \Phi[(k_{j+1} - \pi'x) - (k_j - \pi'x)] \end{aligned} \quad (2)$$

where x is an $(m \times 1)$ vector of exogenous variables,

$$E(y^*|x) = \pi'x, \quad (3)$$

and Φ denotes the standard normal distribution function. This is the conventional ordered probit model (or, ordered-response probit model) developed by Aitchison and Silvey (1957) and Ashford (1959), or the conventional binomial probit model in the special case of $c=2$ categories (Maddala, 1983).

The structural equation model explains the normalized y^* variables in terms of each other and the exogenous x variables:

$$y^* = By^* + \Gamma x + \zeta \quad (4)$$

where B is a $(q \times q)$ parameter matrix of the structural coefficients among the q endogenous y^* variables, Γ is a $(q \times m)$ parameter matrix of structural coefficients relating the q endogenous and m exogenous variables, and ζ is a $(q \times 1)$ vector of disturbances. The variance-covariance matrix of the ζ disturbance terms is defined as,

$$\Psi = \zeta \zeta' \quad (5)$$

where Ψ is a $(q \times q)$ matrix.

Each element β_{ij} in the B matrix represents the direct causal effect of variable y_j on variable y_i^* (where the diagonal elements $\beta_{ii} = 0$, for all $i = 1, \dots, q$). Each element γ_{ij} in the Γ matrix represents the direct causal effect of variable x_j on variable y_i^* . Thus, there is a one-to-one correspondence between equation system (4) and a flow diagram in which there is a unidirectional arrow between each variable pair with nonzero elements in the B and Γ matrices.

The model parameters in the system given by equations (2) through (5) are the thresholds $k_1, k_2, \dots, k_{c-1}$ for each non-normal (dichotomous and ordinal) variable, and those elements of the B, Γ , and ψ matrices specified to be unconstrained. Necessary conditions for model identification are that $(I - B)$ be nonsingular, and the number of parameters be less than the sum of the number of free entries in the variance-covariance matrix of the y variables and the covariance matrix of the y and x variables.¹

3.2 ESTIMATION PROCEDURE

The LISCOMP estimation procedure involves three stages (Muthén, 1983, 1984; Golob and van Wissen, 1988). First, the thresholds of equation (2) are estimated in terms of cut points on the normal distribution using maximum-likelihood probit regressions. This establishes estimates of the first-order statistics of all non-normal y variables. In the

second stage, second-order statistics among the latent y^* variables are estimated conditional upon the first-order statistics. Again, a maximum-likelihood technique is used.

The structural parameters of the B , Γ , and ψ matrices are estimated in the third and final stage of the method using generalized least squares with a weight matrix based on the estimated second-order statistics of the y^* variables. These estimates are asymptotically unbiased regardless of the distributions of the observed y variables (Browne, 1974, 1982, 1984; Muthén, 1983, 1984). Due to the normalization in the first two stages, it is sufficient to consider only the first two moments of the model, which are given by

$$E(y^* | x) = (I - B)^{-1} \Gamma x \quad (6)$$

and

$$\Sigma(y^* | x) = (I - B) \Psi (I - B)'^{-1} \quad (7)$$

The objective function in the final stage estimation is thus

$$F = 1/2 (S - \Sigma)' W^{-1} (S - \Sigma) \quad (8)$$

where W is the positive-definite weight matrix generated from second-order statistics estimated in stage two of the procedure, S is the sample variance-covariance matrix, and Σ is the model variance-covariance matrix defined in Equation (7). Objective function (8) is minimized using a modified Fletcher-Powell algorithm.

3.3 TESTS OF GOODNESS OF FIT

The product of objective function (8) and twice the sample size N ,

$$v = NF = N (S - \Sigma)' W^{-1} (S - \Sigma) , \quad (9)$$

is chi-square distributed with degrees of freedom equal to the number of free entries in the sample variance-covariance matrices minus the number of model parameters (Browne, 1974). It can be used to test the hypothesis that the model can be rejected at a given confidence level. However, as with all chi-square statistics, it is proportional to sample size, and can indicate rejection of a model for large sample sizes even though the Σ matrix reproduced by the model is only trivially different from the S sample matrix.

An important use of statistic (9) is in testing hierarchical models (Bentler and Bonett, 1980): A test of the null hypothesis that a more restrictive model represents a significant improvement over a nested simpler one, is given by the difference between statistic (9) for the two models; this difference is chi-square distributed with degrees of freedom equal to the difference in the number of parameters in the two models. The chi-square difference test is used extensively in the present research.

4.0 DATA

4.1 THE PANEL SURVEY

The data used in the present research were obtained from a panel survey of state and city-county employees conducted as part of the evaluation of the Staggered Work Hours Demonstration Project. A twenty percent sample of employees was implemented by selecting every fifth employee within each governmental department from a list ordered alphabetically or by social security number.¹ The panel survey waves were two weeks apart and all were for the same day of the week (Wednesday). The first two waves of the panel took place before the Demonstration Project, and the last two waves took place during the Demonstration Project. The present analysis is based primarily on attitudinal data collected in the fourth panel wave, and on background data collected in the first panel wave. The survey is described in detail in Giuliano and Golob (1988).

The twenty percent sample involved 1,230 employees, of which 887 were state employees and 343 were city and county employees. The sample size for joint first and fourth wave responses was 1,047, representing a response rate of 85.1 percent. This high response rate indicates a representative sample and minimizes problems associated with nonresponse bias and panel attrition bias.

1 Employees in some private sector companies were also surveyed. These data were not included in the present analyses because private sector employees participated in the demonstration project on a different basis.

4.2 VARIABLES

The model is composed of eleven variables: six exogenous (x) variables, and five endogenous (y) variables. The x variables, computed from the background variables, are all dichotomous, as defined in Table 1: Five (x_1 through x_5) are dummy variables corresponding to five of the six residential areas shown in Figure 1. These six areas are aggregations of zip code zones and were defined on the basis of homogeneous travel conditions that characterize the major travel corridors into Downtown Honolulu (Giuliano and Golob, 1988); they are dictated in large part by the unique topology of Oahu. The last exogenous variable (x_6) denotes the employment sector of state versus city-county. Employees in the two sectors might have different attitudes regarding staggered work hours projects because of differences in working environments, prior (pre-Project) conditions, and local access and parking conditions.

The five endogenous y variables are of mixed dichotomous and ordinal types (Table 2). Variable y_1 denotes whether or not an employee participated in the Staggered Work Hours Project and changed his or her work hours during the course of the Demonstration Project. Variables y_2 and y_3 are five-category ordinal scales used to elicit employees' evaluations of the Demonstration Project's effects on traffic conditions for the home-to-work (y_2) and work-to-home (y_3) commutes. Finally, variables y_4 and y_5 are seven-category ordinal scales used to elicit employee's agreement or disagreement with statement that a staggered work hours program such as that of the Demonstration

TABLE 1
THE EXOGENOUS VARIABLES

VARIABLE	DESCRIPTION	CATEGORIES		SAMPLE PERCENTAGES
		<u>Value</u>	<u>Label</u>	
X ₁	AREA 1: East Honolulu	1	Resides in area	21.1
		0	Not in area	78.9
X ₂	AREA 2: Windward	1	Resides in area	13.9
		0	Not in area	86.1
X ₃	AREA 3: West Honolulu	1	Resides in area	15.2
		0	Not in area	84.8
X ₄	AREA 4: Leeward	1	Resides in area	20.0
		0	Not in area	80.0
X ₅	AREA 6: East Downtown	1	Resides in area	18.3
		0	Not in area	81.7
X ₆	Employment Sector	1	City-County	25.9
		0	State	74.1

Project should be made permanent on either a mandatory (variable y₄) or voluntary (y₅) basis.

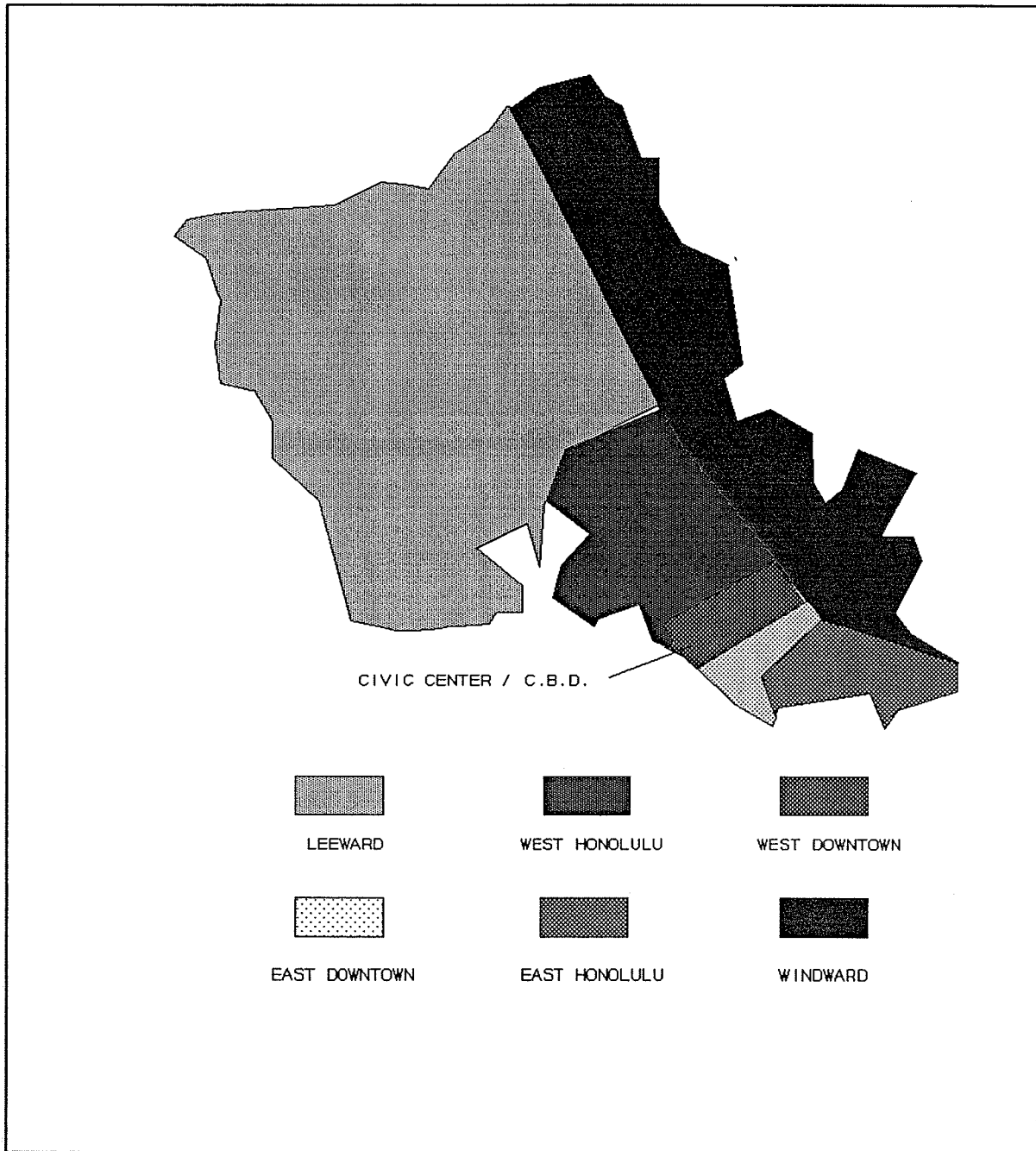


FIGURE 1
SIX RESIDENTIAL AREAS BASED ON ZIP CODE CLUSTERS

TABLE 2
THE ENDOGENOUS VARIABLES

VARIABLE DESCRIPTION		CATEGORIES		SAMPLE PERCENTAGES
		<u>Value</u>	<u>Label</u>	
y ₁	Participation in Demonstration Project	1	Participated	55.8
		0	Did not participate	44.2
y ₂	Evaluation of Project Effects on Home-Work Traffic Conditions	4	Much better	3.8
		3	Better	19.2
		2	The same	47.2
		1	Worse	18.9
		0	Much worse	10.9
y ₃	Evaluation of Project Effects Effects on Work-Home Traffic Conditions	4	Much better	4.8
		3	Better	17.2
		2	The same	46.5
		1	Worse	20.7
		0	Much worse	10.7
y ₄	Agreement with Statement: "A Program of staggered work hours...should be made permanent on a permanent MANDATORY basis"	6	Strongly agree	2.8
		5	Agree	3.4
		4	Agree somewhat	5.7
		3	Neither agree nor disagree	10.1
		2	Disagree	7.5
		1	Disagree somewhat	20.7
		0	Strongly disagree	49.8
y ₅	Agreement with Statement: "A Program of staggered work hours...should be made permanent on a permanent VOLUNTARY basis"	6	Strongly agree	28.0
		5	Agree	24.7
		4	Agree somewhat	17.5
		3	Neither agree nor disagree	13.0
		2	Disagree	3.8
		1	Disagree somewhat	6.5
		0	Strongly disagree	6.5

The nonlinear estimation submodel of the structural equations model allows each endogenous variable to be treated in a manner consistent with its scale properties. The first endogenous variable, the dichotomous indicator of Project participation, is treated as a binomial probit response variable. The four remaining endogenous variables, all attitudinal scales, are treated as ordered-response probits. Thus, the structural equations model represents a simultaneous system of discrete and ordered (scale) responses.

5.0 ANALYSIS

5.1 BASE MODEL SPECIFICATION

It may be recalled that the structural equation model is specified in terms of three parameter matrices: 1) the beta matrix, which represents causal relationships between the endogenous y^* variables; 2) the gamma matrix, which represents relationships between the exogenous x and endogenous variables; and 3) the psi matrix of covariances among the disturbance terms of the endogenous variables.

The approach is to specify a relatively saturated base model and then to remove any links that prove to be insignificantly different from zero in hypothesis testing. The links specified in the base model were chosen on the basis of the survey analysis results described in Giuliano and Golob (1988).

5.1.1 The Disturbance Term Covariances

The psi matrix represents the simplest part of the model. Two free elements are postulated in the psi matrix lower-diagonal form because of the similarities between questions corresponding to variables y_2 (evaluation of home-work traffic conditions) and y_3 (evaluation of work-home traffic conditions), and to variables y_4 (attitude toward mandatory future program) and y_5 (attitude toward voluntary future program). These elements represent free covariances between disturbance terms of the two pairs of y variables:

ψ_{32} = covariance between ζ_3 (corresponding to y_3) and ζ_2 (corresponding to y_2) and

ψ_{54} = covariance between ζ_5 (corresponding to y_5) and ζ_4 (corresponding to y_4).

5.1.2 Causality among the Endogenous Variables

The base model beta matrix is specified to have the form depicted in the flow diagram of Figure 2. Project participation (y_1) is postulated to affect all other endogenous variables: Those employees who participated in the Demonstration Project experienced different changes in their commuting times (both to and from work) than those who did not participate, as reported in their travel diaries (Giuliano and Golob, 1988). In addition, Project participation is expected to condition attitudes regarding possible future programs, independently of specific travel experiences. Evaluations of both inbound and outbound traffic conditions are expected to influence attitudes toward both mandatory and voluntary future programs, leading to links from y_2 to y_4 and y_5 , and from y_3 to y_4 and y_5 . Finally, it is possible that attitudes toward a mandatory future

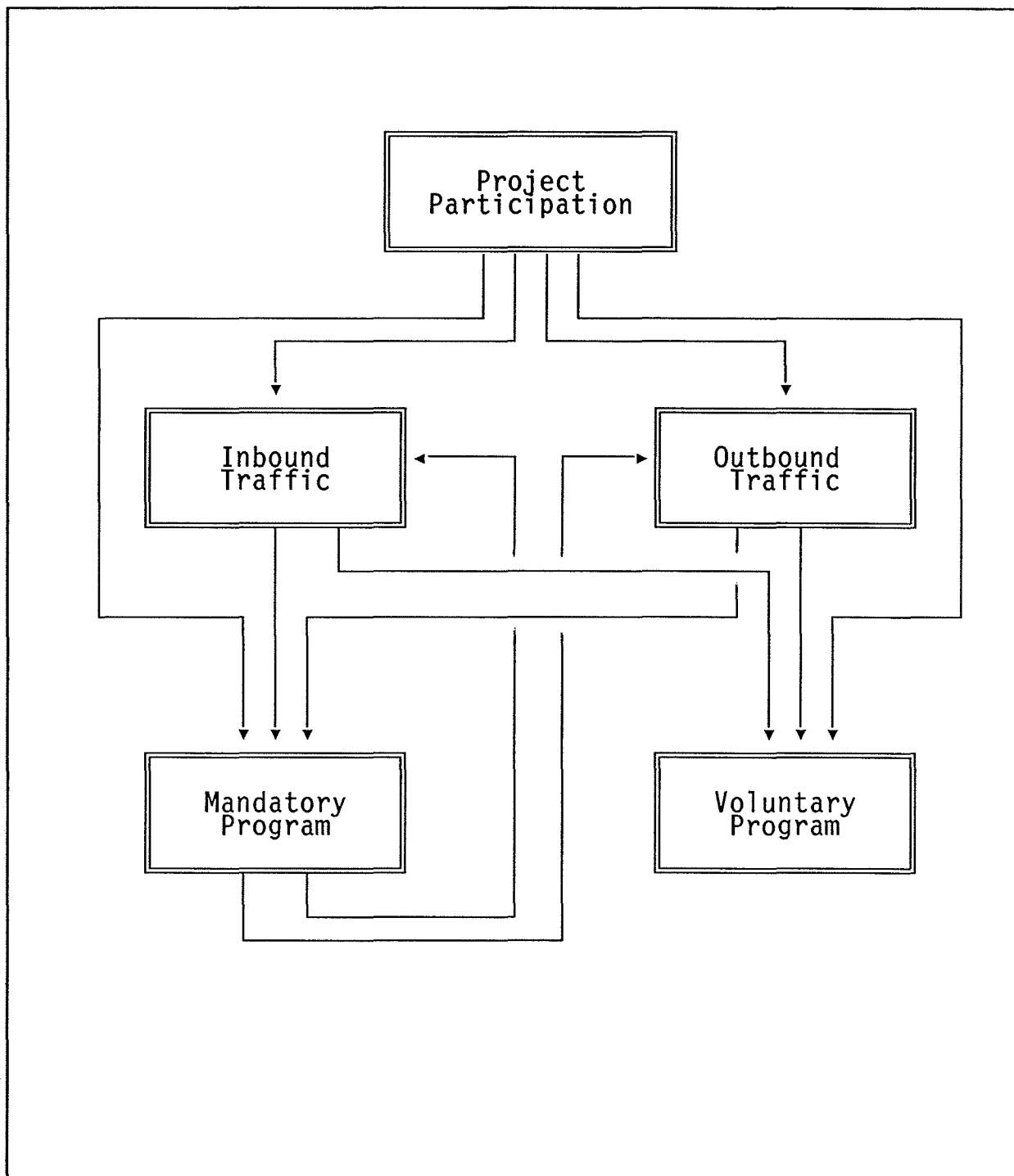


FIGURE 2

FLOW DIAGRAM FOR THE POSTULATED CAUSAL EFFECTS
LINKING THE ENDOGENOUS VARIABLES

program (y_4) might condition an employee's evaluations of the changes in traffic conditions due to the Demonstration Project; these influences are denoted by links from y_4 to both y_2 and y_3 . There are no influences postulated from attitude toward a voluntary future program (y_5), as most employees were in favor of a voluntary program (Table 2).

There are thus ten parameters in the postulated B matrix of Figure 2, and these are listed in Table 3. Summarizing these ten parameters and their expected signs:

- β_{21} = influence of Project participation on evaluation of Project effects on inbound traffic conditions (negative, implying participants express more negative evaluations);
- β_{31} = influence of Project participation on evaluation of Project effects on outbound traffic conditions (negative);
- β_{41} = influence of Project participation on attitude toward possible mandatory future programs (positive);
- β_{51} = influence of Project participation on attitude toward possible voluntary future programs (positive);
- β_{42} = influence of evaluation of inbound traffic conditions on attitude toward mandatory future programs (positive);
- β_{52} = influence of evaluation of inbound traffic conditions on attitude toward voluntary future programs (positive);
- β_{43} = influence of evaluation of outbound traffic conditions on attitude toward mandatory future programs (positive);
- β_{53} = influence of evaluation of outbound traffic conditions on attitude toward voluntary future programs (positive);
- β_{24} = influence of attitudes toward a mandatory program on evaluations of inbound traffic conditions (positive); and
- β_{25} = influence of attitudes toward a mandatory program on evaluations of outbound traffic conditions (positive).

TABLE 3
BETA MATRIX BASE MODEL FORM
 (β_{ij} DENOTES A FREE PARAMETER
 CORRESPONDING TO MATRIX ELEMENT (i,j))

		<u>LINK FROM:</u>				
<u>LINK TO:</u>		y_1	y_2	y_3	y_4	y_5
y_1	Project participation	defined zero	0	0	0	0
y_2	Evaluation of inbound traffic	β_{21}	defined zero	(covered by co-variance)	β_{24}	0
y_3	Evaluation of outbound traffic	β_{31}	(covered by co-variance)	defined zero	β_{25}	0
y_4	Attitude: Mandatory program	β_{41}	β_{42}	β_{43}	defined zero	(covered by co-variance)
y_5	Attitude: Voluntary program	β_{51}	β_{52}	β_{53}	(covered by co-variance)	defined zero

5.1.3 Exogenous Variable Influences

For the structure of the gamma matrix effects are postulated from all the x variables to variables y_1 (Project participation), y_2 (evaluation of inbound traffic conditions), and y_3 (evaluation of outbound traffic conditions). The potential effects from the five residential area dummy variables (x_1 through x_5) to y_1 account for any uneven distributions of Project participants versus nonparticipants among residential areas. The effect from employment sector (x_6) to y_1 accounts for any differences between participation rates for the state and city-county sectors. The potential effects from each residential area dummy to y_2 and y_3 capture differential influences of the Demonstration Project on traffic conditions on different travel corridors to and from the Civil Center in Downtown Honolulu, together with differential effects by trip length. Finally, the potential effects of x_6 on y_2 and y_3 account for any differences in evaluations between state and city-county workers that are not explained by Project participation and residential area.

No direct effects are postulated from any of the exogenous variables and attitudes toward future mandatory or voluntary programs (y_4 and y_5 , respectively). The objective is to explain such attitudes in terms of the other endogenous variables: Project participation (y_1) and evaluations of traffic conditions (y_2 , y_3). There are possible links from employment sector (x_6) to y_4 and y_5 , and these are explored in the hypothesis testing stage of the study.

5.2 FINAL MODEL RESULTS

The final model, determined through hypothesis tests applied to the postulated structure described above, involves seventeen parameters: seven B matrix parameters linking the endogenous variables; eight I matrix parameters linking the exogenous and endogenous variables, and two Ψ matrix disturbance-term covariance parameters. All parameters are significantly different from zero at the $p = .05$ level, and fourteen of the seventeen parameters are significantly different from zero at the $p = .01$ level (one-tailed tests). All signs for B matrix parameters are as expected.

The overall model χ^2 value (equation (9)) is 20.499 with 23 degrees of freedom. This corresponds to a probability value of $p = .612$, which indicates that the model cannot be rejected at either the $p = .01$ or $p = .05$ level. The model fit is excellent, especially in terms of the relatively large sample size.

The final model is depicted in flow diagrams of Figures 3 and 4; the equations represented by these two diagrams are estimated simultaneously, but the total structure is depicted separately in terms of the parameters of the B and I matrices to facilitate interpretation (Ψ matrix parameters being included in the flow diagram of the B matrix). The parameters are also listed in Tables 4 and 5, corresponding to Figures 3 and 4, respectively.

Focusing on the B matrix of causal influences among the endogenous variables, three of the postulated effects in Figure 2 and Table 3 were rejected on the basis of hypothesis tests of nested models. The results of these tests are listed in Table 6. Two

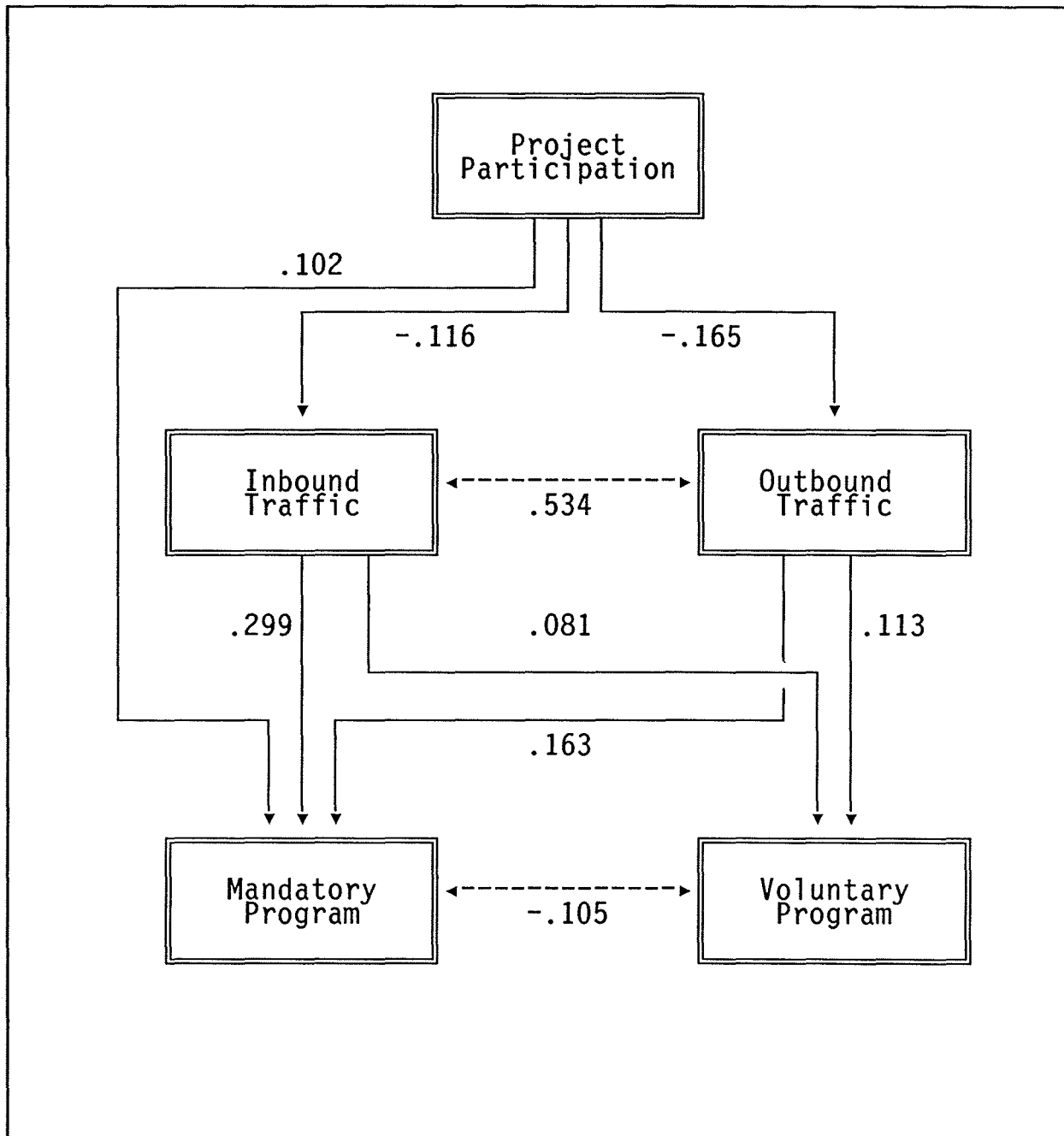


FIGURE 3

CAUSAL EFFECTS AMONG THE ENDOGENOUS VARIABLES
(B MATRIX)
INCLUDED IN THE FINAL MODEL

(Dashed arrow indicates included error-term covariances)

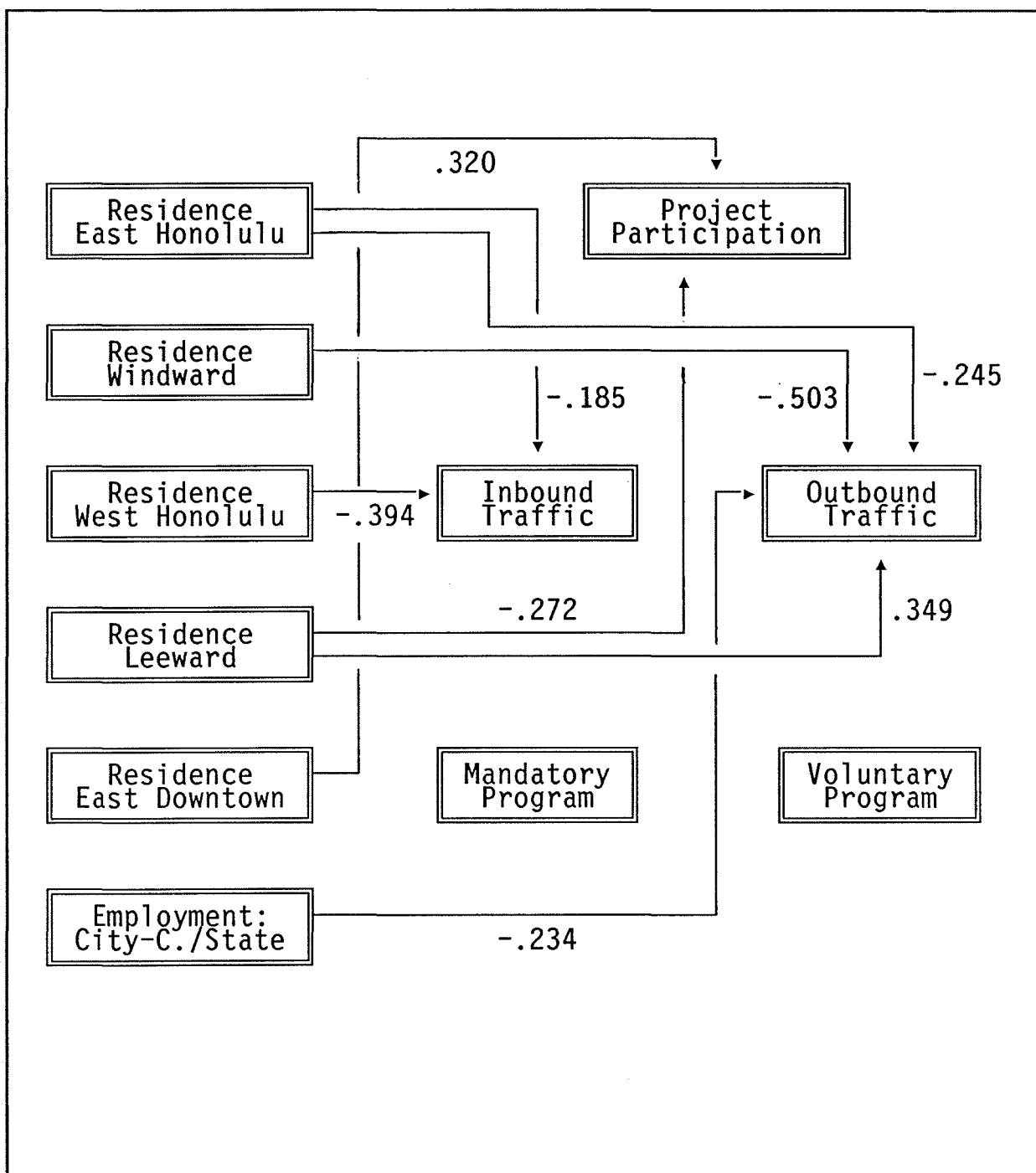


FIGURE 4

CAUSAL EFFECTS INCLUDED IN THE FINAL MODEL
FROM THE (I MATRIX) EXOGENOUS VARIABLES
TO THE ENDOGENOUS VARIABLES

TABLE 4
BETA MATRIX PARAMETERS
AND ASSOCIATED Z STATISTICS

		<u>LINK FROM:</u>				
<u>LINK TO:</u>		y ₁	y ₂	y ₃	y ₄	y ₅
y ₁	Project participation	defined zero	0	0	0	0
y ₂	Evaluation of inbound traffic	-0.116 (-2.75)	defined zero	0	0	0
y ₃	Evaluation of outbound traffic	-0.165 (-3.87)	0	defined zero	0	0
y ₄	Attitude: Mandatory program	0.102 (2.25)	0.299 (8.00)	0.163 (4.24)	defined zero	0
y ₅	Attitude: Voluntary program	0	0.081 (2.01)	0.113 (2.93)	0	defined zero

TABLE 5
GAMMA MATRIX PARAMETERS
AND ASSOCIATED Z STATISTICS

<u>LINK TO:</u>		<u>LINK FROM:</u>					
		X ₁	X ₂	X ₃	X ₄	X ₅	X ₆
		Residence E. Honolulu	Residence Windward	Residence W. Honolulu	Residence Leeward	Residence E. Downtown	Employment City-Co./State
y ₁	Project participation	0	0	0	-0.272 (-2.44)	0.320 (2.73)	0
y ₂	Evaluation of inbound traffic	-0.185 (-2.02)	0	-0.394 (4.59)	0	0	0
y ₃	Evaluation of outbound traffic	-0.245 (-2.66)	-5.03 (-5.07)	0	0.349 (3.84)	0	-0.234 (-3.54)
y ₄	Attitude: Mandatory program	0	0	0	0	0	0
y ₅	Attitude: Voluntary program	0	0	0	0	0	0

TABLE 6
HYPOTHESIS TESTS OF EXCLUDED CAUSAL EFFECTS
AMONG THE EXOGENOUS VARIABLES

PARAMETER			MODEL χ^2 VALUES		$\Delta \chi^2$
Element	From	To	Base: Without Parameter	Base: With Parameter	(Critical .01 = 6.637)
β_{51}	y_1	y_5	20.499	20.314	0.185
β_{24}	y_4	y_2	20.499	17.590	2.909
β_{34}	y_4	y_3	20.499	14.886	5.613

of the three excluded effects (β_{51} , β_{24}) can be rejected at the $p = .05$ as well as the more stringent $p = .01$ confidence level. The other effect, β_{34} from attitudes toward a mandatory program to evaluation of outbound traffic, can be rejected only at the $p = .01$ level, but the sign of the coefficient is opposite to that expected, leading to rejection of the equation in the system of the final model.

Hypothesis tests of excluded Γ matrix parameters are summarized in Table 7. The two excluded effects with the highest χ^2 values are those from employment sector (x_6)

to attitudes toward both mandatory and voluntary future programs (y_4 and y_5 , respectively). The z-statistics associated with each of the γ_{45} and γ_{56} parameters indicates rejection of significance for a $p = .05$ two-tailed test, but not for a $p = .05$ one-tailed test. The signs are negative, indicating that city-county employees might have more negative attitudes, but the effects are not statistically secure enough to be included in the final model.

5.3 INTERPRETATION

The model results are interpreted separately in terms of the causal influences among the endogenous variables and the influence of the exogenous variables, respectively. The interrelationships among the endogenous variables, given by the parameters of the beta matrix (Figure 3 and Table 4) has the following interpretation in terms of cause and effect:

1. Participants in the Demonstration Project evaluated Project effects on both inbound and outbound traffic more negatively than did nonparticipants (parameters β_{21} and β_{31}); the relationship was more strongly negative for evaluation of outbound traffic. These results conform to the actual experiences of Project participants and nonparticipants (Giuliano and Golob, 1988).

2. The direct effect from Project participation to attitude toward a mandatory future program was positive (parameter β_{41}). Given that attitudes toward a mandatory program were generally negative among both participants and nonparticipants, this means that

TABLE 7
HYPOTHESIS TESTS OF EXCLUDED CAUSAL EFFECTS
FROM EXOGENOUS TO ENDOGENOUS VARIABLES

PARAMETER			MODEL χ^2 VALUES		$\Delta \chi^2$ (Critical .01 = 6.637)
Element	From	To	Base: Without Parameter	Base: With Parameter	
γ_{11}	X_1	y_1	20.499	18.962	1.537
γ_{12}	X_2	y_1	20.499	19.389	1.111
γ_{22}	X_2	y_2	20.499	20.498	0.001
γ_{13}	X_3	y_1	20.499	19.760	0.739
γ_{33}	X_3	y_3	20.499	17.495	3.004
γ_{24}	X_4	y_2	20.499	20.455	0.044
γ_{25}	X_5	y_2	20.499	19.863	0.636
γ_{35}	X_5	y_3	20.499	20.231	0.268
γ_{16}	X_6	y_1	20.499	20.386	0.113
γ_{26}	X_6	y_2	20.499	20.455	0.044
γ_{46}	X_6	y_4	20.499	17.006	3.493
γ_{56}	X_6	y_5	20.499	17.340	3.159

participants had less negative attitudes toward a mandatory program. This could reflect the effort required to obtain an exemption for nonparticipants under the guidelines of the Demonstration Project, or it could reflect participant attitudes that, if there is a staggered work hours program, everyone should be required to participate.

3. There are positive effects from evaluations of both inbound and outbound traffic to attitudes toward both mandatory and voluntary programs (parameters β_{42} , β_{52} , β_{43} , β_{53}), indicating that perceptions of the effects of the Demonstration Project on traffic conditions influenced attitudes toward future programs. The strongest link is from evaluations of inbound traffic conditions to attitudes toward a mandatory program, followed by the link from evaluations of outbound traffic conditions also to attitudes toward a mandatory program. Attitudes toward a mandatory program are directly more sensitive to Demonstration Project experiences than are attitudes toward a voluntary program. Respondents might be expressing a heightened awareness that a mandatory program might negatively affect the commutes of a minority segment even if the commutes of the majority of workers are positively affected.

4. The total effects from Project participation to attitudes toward a mandatory future program involve both the direct effect (2) and indirect paths through the direct effects (1 and 3); and these paths have opposing signs. The resulting total effect is positive, but the magnitude is less than one-half that of the direct effect due to the negative paths through traffic evaluations. That is, participants tend to be less unfavorably disposed to a mandatory future program, but experiences partially mitigate their positive attitudes. These results mean that those who perceived better conditions on their commute to and from work during the Project were more likely to be favorable toward a mandatory

program than those who perceived worse conditions, and participants were more likely to perceive worse conditions.

5. Also, the error term covariance ψ_{32} indicates that evaluations of inbound and outbound traffic have a strong positive interrelationship. If the commute was perceived to have improved in one direction, it was perceived to have improved in the other direction as well. Attitudes toward mandatory and voluntary future programs (ψ_{54}) have a weaker negative interrelationship, suggesting that being favorable toward a mandatory program does not necessarily preclude being favorable toward a voluntary program.

The estimated relationships between the exogenous and endogenous variables are captured in the parameters of the gamma matrix (Figure 4 and Table 5). Regarding perceptions of inbound and outbound traffic, residential location has significant and diverse effects. Residence in the East Honolulu area was associated with negative perceptions of both *inbound* and *outbound* traffic conditions. Residence in West Honolulu was significantly related only to negative evaluation of *inbound* traffic conditions, while residence on the Windward side of the Island of Oahu was significantly and negatively related only to evaluation of *outbound* traffic conditions. In contrast, residence in the Leeward area of the Island was related to positive evaluation of *outbound* traffic. These results could be due to a variety of local effects, including traffic problems (bottlenecks) on specific routes as well as peaking and directional flow characteristics in different travel corridors.

Residential location was also related to Project participation. A higher proportion of employees residing in the East Downtown area participated in the Project, while a lower

proportion of employees from the Leeward area were Project participants. These results may reflect demographic differences among employees that are correlated with residential location.

Finally, the results show that city-county employees had a more negative evaluation of Project effects on outbound traffic than did state employees. This may reflect site specific traffic problems experienced by city-county employees, caused by the temporal concentration of work departures during the Project.

6.0 CONCLUSIONS

The application of a structural equations model with ordinal and dichotomous attitudinal variables has resulted in a highly significant explanation of the interrelationships among these variables and between these variables and certain exogenous variables. The final model showed that participation in the Demonstration Project, geographic location, evaluation of traffic conditions, and attitudes toward staggered work hours programs are heavily interrelated. Attitudes regarding future possible staggered work hours programs were affected by Project participation and evaluation of travel conditions experienced during the Project. The structural equations model provides an understanding of the causal relationships between these factors that can help to inform future policy decisions.

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