Assessing the Effectiveness of Transportation Control Measures: Use of Stated Preference Models To Project Mode Split for Work Trips

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Five policies used to increase the level of ridesharing among employees of a large New Jersey firm are evaluated using stated preference techniques. The work shows that performance measures for policies such as guaranteed ride home, parking fee, rideshare coupon, and flexible starting times can be recovered through the administration of a stated choice instrument. The derived estimates of performance effectiveness are sensitive to both the local conditions and the constraints experienced by employees as well as to the unique opportunities brought to the program by the employer. A mix of the guaranteed-ride-home program, a rideshare coordinator and rideshare-matching program, a \$0.75 per day parking fee, and a rideshare coupon of \$1.00 to each participant combined with an average of 15 min lost time ridesharing is projected to meet the Clean Air Act's 25 percent increase in average vehicle occupancy. At the same time, this mix of transportation control measures will distribute the costs and benefits of the combined program across all employees and generate revenue to offset the program costs.

Major changes in commuting behavior face the drivers in at least eight of America's metropolitan areas. In order for states to avoid federal sanctions, the Clean Air Act Amendments of 1990 will require employers to reduce their employees' vehicle trips or increase their employees' vehicle occupancy rates. Employers must prepare plans indicating the effectiveness of the measures they take. This paper presents a method by which employers and transportation planning agencies can determine the effectiveness of transportation control measures (TCMs) proposed for use in compliance with the act. On the basis of an empirical study made in northern New Jersey, a set of performance estimates is reported for several TCMs.

Sixteen TCMs are currently available under the statute for use in meeting an employer's goals. The list includes parking fees, availability of third-party vanpools, transportation allowances, and changes in work hours. In theory, when each of these measures is implemented in the appropriate fashion, commuting behavior will change such that there will be less reliance on the single-occupant vehicle than is currently the case.

To date, little is known regarding the performance of TCMs. Evidence comes from several case studies of existing transportation management programs. These studies (*1,2*) provide important insights into the aggregate properties of selected subsets of TCMs. Aggregate changes in driving behavior over time can be inferred from these studies. However, they do not show if or how local constraints will alter TCM effectiveness, how various combinations of measures will alter commuting behavior, or how different segments of the commuting public will respond to the TCMs.

Like any proposed new product or service on the market, the use of TCMs by the driving public must be evaluated indirectly. Only after a significant track record has been compiled on each TCM will a set of conclusive performance ratings be available. During the interim, the effectiveness of TCMs can be evaluated through methods taken from marketing and psychology (*3*) and from the economics of revealed preferences (*4*). The synthesis of these ideas has produced a method known collectively as the stated preference approach to discrete choice analysis (*5*).

STATED PREFERENCE

Initial research on stated preference (SP) was done in the United States and is exemplified by the work of a group led by Kocur (*6*). With the advent of cheap gasoline, research in the use of SP shifted. This approach is now used extensively in the United Kingdom, on the Continent, and in Australia. Its uses include the projection of market demands for major events such as cultural expositions (*7*) and modal shifts conditioned by new policy or transportation improvement programs (*8*). The U.K. Department of Transport's value-of-time studies showed SP to be accurate and stable relative to existing revealed preference research (*9*). British rail has an extensive inventory of SP studies, which have been used to project ridership changes linked with changes in quality of service (*10*) and to examine new local rail service (*8*). SP has been used to explore the demand for intermodal services (*11*) and the value of parking services (*12*); Euronett has used it to examine the impact of intelligent highway systems and toll rings on transportation policy in Norway (*13*).

SP is a branch of disaggregate or individual-based experimental research that seeks to explain discrete choices made by individual decision makers in the face of hypothetical but realistic constraints and opportunities. Its theoretical and sta-

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tistical foundations are based in the field of revealed preference (*4*). SP consists of a set of data generation procedures and supporting theory. In the case at hand, the data consist of individual choices in hypothetical travel situations represented by a set of alternative travel modes; each alternative is defined in terms of values assigned to cost and level-of-service attributes. The theoretical model used to estimate the attractiveness of each attribute associated with an alternative mode is random utility theory combined with the multinomial logit choice process (*14*).

The design of an SP study is a three-step process: (a) identification of the target population and appropriate sampling procedures, (b) preparation of the data generation instruments, and (c) selection of the survey administration method.

Identification of Target Population

The first step is the most important. Transport decisions are known to be affected by type of trip; social characteristics of the trip makers; home, work, and infrastructure constraints; and the attributes of the trip mode. Careful attention to this step ensures a valid inference from the sample to the target population. If segments of the population are hypothesized to have distinct systematic utility functions, provisions can be established to sample from each of the population's subsets (*15*).

Preparation and Testing of Data Generation Instruments

The preparation and testing of the survey instrument place the researchers in direct contact with the target population. Focus groups are often utilized to identify those properties of the commute that are of greatest importance to drivers as well as the constraints facing the commuters. The type and magnitude of these constraints determine the attributes for each alternative and set the range of values to be used for each attribute in the SP model.

Each decision maker selected for the SP experiment completes a number of SP tasks. It is common for a respondent to evaluate from 9 to 27 separate choice tasks consisting of a set of two or more commuting alternatives. Each alternative possesses a set of attributes through which each alternative is recognized by the traveler. Finally, each attribute is assigned a value; these values allow the traveler to combine the partial utilities into a summary value for the alternatives.

The decision maker must examine a sufficient number of choice tasks such that estimates of the marginal utility weights for each attribute can be recovered from the multinomial logit model. When a utility function is hypothesized to contain all of the attributes as well as all forms of interaction among the variables, a full-factorial model results. When the goal is to recover all possible direct and indirect impacts on a commuter's utility function, all combinations of the attributes' values must be evaluated by the decision maker. In a study with seven attributes, each with three value levels, the total number of choice tasks each respondent would be required to examine is $3^7 = 2487$. It is unlikely that many respondents would be willing to examine this many choices. The experience gained from numerous transport-related SP studies indicates that the results derived from choice sets that exclude consideration of interaction among the attributes are reasonable. Consequently, most choice sets used in transport studies are main-effects orthogonal fractional-factorial designs (*6*). In the case of the seven attributes with three value levels per attribute example, 18 choice sets are needed to recover the coefficients from a main-effects-only design in which all interaction effects are assumed to be negligible.

The final element in the design of the SP instrument is the selection of the form of the dependent variable. Three types of dependent variable are commonly found in the SP literature: the nominal variable indicating a discrete choice, the ordered categorical or ranking dependent variable, and the rating variable (*16*). The rating and ranking forms of the dependent variable are found in many early studies (*6*). Both rating and ranking alternatives place great burdens on respondents; evidence exists that shows that heteroscedastic disturbances occur in ranking exercises (*17*). The simple choice process, represented in the binomial discrete choice form of the dependent variable, is favored by those seeking to reduce respondent fatigue. The term *stated choice* is now being used to identify the explicit use of the choice-dependent variable. In general, the discrete form of the dependent variable is appropriate for use in intermodal demand forecasting studies. The term *stated preference* is linked directly with the ranking and rating scales and is most appropriately used in intramodal studies in which an evaluation of quality-of-service variables is required.

Selection of Survey Administration Method

The final component in the SP study is the selection of the administration technique. Here, the researcher must trade off the costs and relative precision of the several methods that can be employed to administer the survey instrument (*18*). The most popular survey technique continues to be the self-completion mail-back instrument; when resources are available, the face-to-face interview is often preferred with the caveat that affirmation bias—the tendency in respondents to detect and affirm the perceived views of the interviewer—can influence the results (*19*). Recently, researchers have employed computer-aided and computer-designed and computer-administered instruments (*20*). Little in the way of comparative analysis is available to guide in the selection of a specific administration technique.

APPLICATION OF SP TO EVALUATION OF TCM PERFORMANCE

In this section, an SP model is estimated for the mode-choice decision related to the journey to work. Performance measures are estimated for five classes of TCMs: preferential parking, parking costs, guaranteed ride home (GRH) program, rideshare adjustments, and flex-time programs. Each of these TCMs can be implemented by individual corporations independent of the actions of public agencies and transit companies. Of greatest interest is the ability of each TCM to increase the average vehicle occupancy (AVO) level for an employment site. The site chosen to perform the SP experiment is located in the Hackensack Meadowlands of northern New Jersey. This is an area of severe nonattainment for the ozone air quality standard. Employers in the area will be required to demonstrate a 25 percent increase in their AVOs.

The test site is the corporate headquarters of the Matsushita Electric Corporation of America (MECA), which is the largest single employer in the Meadowlands. At the time of the study, MECA employed 1,948 individuals.

The SP study had two data generation components: an employee transportation survey and a stated choice experiment. The first component was administered to all MECA employees. The survey instrument was designed to collect socioeconomic, demographic, and attitudinal information, and required the name of the respondent to be placed on the document. The second survey consisted of two versions of a stated choice instrument. All instruments used in this study are available on request from the authors.

Preparation of Stated Choice Survey Instrument

The survey instrument developed for the MECA study evolved over a 3-month period. During its early design stage, two focus groups were held at the MECA site. These meetings brought the researchers in contact with the concerns and impressions of clerical, professional, and administrative employees, on which the first draft of the survey instrument was based. The draft instrument was then presented to a technical advisory group consisting of professional transportation planners and administrators working in the area.

The stated choice instrument was designed to support two commuting alternatives: the single-occupant vehicle (SOV) and ridesharing. The focus groups showed that alternatives such as public transit, park-and-ride facilities, and shuttle buses had little applicability to the majority of the employees. They were therefore excluded from the list of alternatives. Retaining the binomial choice problem has the advantage of simplicity over more complex multinomial designs. Before the SP experiment was carried out, a pilot test was made of the draft version.

Choice Set Design

The concept underlying the execution of the stated choice experiment is relatively simple. The researcher presents the respondent with a set of information-processing tasks. Each task requires the respondent to examine two commuting alternatives: SOV and ridesharing. The respondent must make a decision on the basis of the design values assigned to the attributes of each alternative. The MECA study required each employee in the sample to examine and make 16 choices.

The 16 choice tasks were constructed to form an orthogonal fractional-factorial research design (*21*), the use of which permits the marginal utility of each attribute to be estimated independently of the remaining attributes. As a practical matter, orthogonality of the design is less important to the successful estimation of the model than is the reasonableness of the trade-offs (*15*). The trade-offs built into each task must be accepted by the respondent as a potential situation worthy of serious consideration. A small amount of intercorrelation inevitably enters the model either through design considerations or through post-survey review of the raw data. The former includes the removal of choice sets presenting the respondent with no reasonable trade-offs, whereas the latter involves either the removal of completed choices that contradict revealed or observed behavior or the effective removal of choice tasks through the selective refusal of a respondent to indicate a choice.

Specification of Utility Functions

From the point of view of the SP experiment, the attributes and their values provide the information for the respondent to distinguish one alternative from another. From the point of view of the logit model, the attributes are the independent variables used to specify the utility functions. The logit model requires that variables representing the attributes and the socioeconomic characteristics be assigned to each alternative's utility function. Each commuting policy's attributes represent characteristics of the journey to work that can be altered by the employer. The remaining characteristics are used to account for systematic variation in choice behavior resulting from social and demographic characteristics of the respondents.

The attributes used to define the SOV alternative are preferential parking, parking charges, and flexible starting hours. Parking space allocation ranges from the current first-come, first-served practice to the assignment of the SOV driver to a parking space on the periphery of the parking facility. Under extreme conditions, parking at the fringe of the facility can require the employee to make a 10-min exposed walk to get to work, but under normal conditions, the walk takes 3 min. The second attribute is parking cost. A fee schedule was presented to employees ranging from free parking to \$7/day parking. There are six steps in the parking charge schedule; however, no employee examines more than three parking charge values in any choice set. This was done in order to keep the number of choice tasks required of the employee at a minimum. The final attribute linked with the SOV alternative is the starting hours. Although both alternatives were assigned the same starting time, the research interest centered on the impact that more flexible or staggered starting times would have on mode-choice behavior. Starting times were allowed to range from 8:00 to 10:00 a.m.; current starting time is 9:00 a.m. For the purpose of model specification, socioeconomic characteristics are also assigned to the SOV.

According to the stated choice instrument, all TCMs used to promote ridesharing are implemented with the aid of a permanently assigned transportation coordinator and an up-to-date rideshare-matching program. The alternative specific variables representing the ridesharing alternative include independent parking space allocation, parking charge, the time required to pick up riders, the GRH program, and rideshare adjustment. The two values given to the parking space allocation attribute are preferential parking and parking on a first-come, first-served basis. Parking charge is also entered as an attribute for the ridesharing alternative; however, it is held constant at a value of \$0.00 per space per day. The opportunity cost of ridesharing in time required to pick up riders is included, with values ranging from 0 to 45 min. Two incentives are also included as attributes. First, a GRH program is de-

TABLE 1 ATTRIBUTES AND CONTEXT VARIABLES TESTED FOR USE AS ARGUMENTS IN JOURNEY-TO-WORK UTILITY FUNCTIONS FOR MECA EMPLOYEES (*22*)

Attributes	Utility Function	Sample Mean or Design Values	Remarks
Design Variables			
Starting time	SOV	8:00, 8:30, 9:00, 10:00 (a.m.)	
Parking charge	SOV	$0.00, 0.50, 2.00, 3.00, 7.00	
Extra time to pick up rider	RS	0, 5, 10, 15, 25, 45 (minutes)	
Guaranteed ride home program	RS	yes, no	
Rideshare coupon	RS	$0.00, 0.25, 0.50, 1.00, 1.25, 3.50	
Socioeconomic Variables		Mean of sample	
Age	SOV	36 years	
Male	SOV	52%	
Spouse	SOV	54.9%	
Spouse at home	SOV	15.3%	
Commuting distance	SOV	15 miles	
Congestion	SOV	34%	Percent of index commuting time wasted due to congestion
Clerical	SOV	19.5%	
Administration	SOV	29.6%	
Professional	SOV	35.0%	
Home constraints that will prevent ridesharing	SOV	23.3%	
Unlikely to commute index	SOV	6.25	Seven level index where 7=unlikely
Pleasantness index	SOV	4.07	Seven level index where 7=pleasant
Week of survey	SOV	Started during 27th week, ended in 37th week of 1991	
Household size	SOV	3.2 persons	
Automobiles/household	SOV	1.56	
Walk time from parking space to work	SOV	2.4 minutes	

fined as a free service that is given to the certified ridesharing employee. It provides a ride home when a home or office emergency arises; when a supervisor requires an employee to stay late, the GRH also applies. The GRH attribute is specified in the model as a nominal variable (available/not available). In future research the performance characteristics of the GRH program must also be modeled. The final attribute specific to the ridesharing alternative is ridesharing adjustment. This consists of a coupon given to each member of a certified ridesharing team and refundable at face value when presented at the corporate cafeteria. Its value ranges from $0.00 to $3.50 per day. As in the case of the parking charge attribute where six values were presented to the sample as a whole, each respondent examined three values per attribute.

The complete set of individual characteristics and design attributes is shown in Table 1 (*22*). The first set of attributes is the design variables that represent the commuting scenarios. The second set identifies the social and economic variables available for use in the model. The social and economic context variables represent characteristics that change the propensity to use the SOV by subgroups of employees. The focus groups indicated that men and older persons have a relatively high propensity to stay with their SOV commute. Household size was presented as a characteristic that could represent competition for scarce transportation resources; therefore, household size as well as variables representing the number of drivers and cars in the household were included in the model as surrogates for budget constraint. Focus group meetings showed that clerical employees living in households where more persons have driver's licenses than there are cars are likely to be positively disposed to ridesharing.

Attitudes expressed in the employee transportation survey were also used as predictors of commuting choice. The existence of home constraints, such as children to take to school or elderly parents to take to a treatment center, will increase the threshold at which the costs and incentives would bring a driver into the ridesharing category. Similarly, a predisposition not to rideshare or to have ridesharing viewed as relatively unimportant will reduce the observed utility in ridesharing. On the other hand, the perception that ridesharing is pleasant will add to the utility of the option.

The final two context variables used in the commuter choice model represent the attributes of the link between home and office. Distance to work represents the cost of time involved in the travel. The distance variable was transformed using several operators; the transformation that best showed its impact on driving choice was the natural logarithm. Congestion is measured as the percent of the total travel time perceived by the employee to have been spent in congestion. This attribute of the trip is used to represent the discomfort associated with stop-and-go driving. The transformation that best represents perceived congestion with commuting choice is exponentiation to the base (e). The last variable entered into the logit model is the week during which the SP survey was completed by the employee. Since the first surveys were returned in early August and the final surveys in late October, the weather and traffic situation will vary and may influence the commuting decision.

Survey Administration

The data-generating process consisted of two temporally separated survey instruments. The employee transportation survey was distributed to all 1,948 employees working at the Hackensack Meadowlands facility during June 1991. The company's mail facility was used to distribute and collect the surveys. The package contained a self-addressed return envelope, a cover letter from the firm's vice president, and the survey. Of the 1,948 surveys, 762 were returned, giving an overall response rate of 39 percent. However, 12 surveys were returned without the respondent's name; these were discarded, leaving 750 usable surveys and a net response rate of 38.5 percent. The respondent's name was essential for the commuter choice study. This is the identifier that links the socioeconomic characteristics of the respondent with his or her stated choices. Without these characteristics, the statistical estimators for the commuting attributes become unstable and the possibility of bias is likely (*15*).

The 750 usable surveys were coded and a random sample of 300 employees, exclusive of general managers or higher-level employees, was selected for administration of the stated choice instrument, which began during the first week of August and ended in October 1991. The surveys were distributed in groups of 50.

The SP experiment was administered to the respondents through a mail-back technique guided by the Total Design Method (*23*). Each packet of experiments consisted of an individually addressed, large envelope containing a cover letter from the principal investigator on university stationery, the 16 SP tasks, an explanatory note reminding the respondents of the issue being explored and their previous cooperation, a glossary of terms, and a return envelope. The 16 choice tasks were identified through randomly chosen sequences of uppercase letters; the sequence in which the respondents saw each task was randomized. A follow-up thank-you letter was sent to respondents 1 week after they received the experiment.

CHARACTERISTICS OF MECA WORK FORCE

The employee transportation survey provided data that permit a broad description of the MECA work force. Table 1 shows the average or median value for the variables used in the experiment. Most of the MECA employees are in management, administration, or professional positions (60 percent), another 20 percent have clerical jobs, and the rest are technical or service workers. As is common throughout the region, most MECA employees drive alone to work (89.1 percent); for these drivers the median time spent driving to and from work is 35 min, and their median distance from home to office is 15 mi. Ridesharing, defined as commuting with more than one person but not in public mass transportation, is found in 8.4 percent of the work force. Ridesharing that does occur at MECA is strongly related to commuting distance. For ridesharers, the median distance to work is 38 mi, and the median trip time is 60 min.

Economic status of the employee is represented by several variables: job category, working spouse, and number of cars per person in the household. In order to keep response rates as high as possible, household income was not included in the questionnaire. The lowest income category included in the survey is clerical. This group of employees is more likely to consist of women than is the total work force, is younger than average, and is less likely to have a spouse.

ESTIMATION OF LOGIT COEFFICIENTS

Two data bases were combined for the estimation of the logit stated choice equation. From the set of completed and returned stated choice experiments, each employee contributed up to 16 commuting-choice observations. From the employee transportation survey, employees also reported their socioeconomic characteristics and attitudes toward ridesharing. The two data sets were merged and input into the Alogit linear logit program (*24*).

Given that only two commuting alternatives are available to the MECA commuters, a binomial logit model was estimated. In a search for the best-fitting set of utility functions, the data base was sectioned by job category, and logit models were constructed for each section. Similarly, interval-level variables such as parking charge, congestion, and commuting distance for the journey to work were transformed into quadratic, logarithmic, and exponential functional forms and tested for the form that would best reproduce the shape of the utility function. Partitioning the data base into a subset of clerical workers and the residual set of professional, administrative, and technical workers offered the most promise; however, the number of observations in the clerical subset was too small to effectively span the remaining number of socioeconomic variables thought necessary for inclusion in its utility function. As a result, adjustments for the unique disposition of clerical workers toward commuting options are built into the reported logit equation.

The final equation reported in this paper required five iterations to converge to a stable set of estimates. The initial value of the likelihood function was -831.78, the final value was -592.13, and the rho-squared term was reported to be 0.29. Using the Hensher criteria for inclusion of variables in the final equation, only those socioeconomic variables whose coefficients have the theoretically correct sign and are statistically significant at the 0.05 level were retained in the model (*25*). A similar criterion was used for the design variables.

Table 2 gives the coefficients of the MECA employees' commuter choice logit model (*22*). The data show that the binomial logit model applied to the commuting-choice behavior of MECA employees returns a set of coefficients that agree with the theoretical expectations derived from utility maximization. The design variables will be examined first. The SOV option was evaluated through the use of parking charges and variation in the starting time of the headquarters facility. An increase in parking charges reduces the utility

TABLE 2 UTILITY COEFFICIENTS ESTIMATED FOR TWO JOURNEY-TO-WORK ALTERNATIVES, SOVs, AND RIDESHARING, FOR MECA EMPLOYEES BELOW GENERAL MANAGER GRADE, AUGUST 1991 (*22*)

Attributes	Drive Alone	Rideshare
Employee age	0.022 (3.17) **	
Unlikely to rideshare index	0.20 (3.5)	
Ridesharing is pleasant index	-0.14 (2.9)	
Trip length (natural log)	-0.35 (3.6)	
Drivers licenses per car (clerical employee households)	-0.50 (6.3)	
Date experiment held (week in 1991)	0.064 (4.9)	
Parking cost	-1.065 (9.4)	
Parking cost squared	0.074 (4.9)	
Flextime (early arrival in hours before 9:00 a.m.)	0.31 (1.4)	
Time lost ridesharing		-0.033 (5.8)
Guaranteed ride home		1.33 (9.0)
Rideshare coupon		0.85 (3.0)
Rideshare coupon squared		-0.15 (2.1)

*Analysis is based on 1,200 observations.

**"T" Ratio displayed in parentheses. The flexible starting time estimators are not significant at the 0.05 level, however, they are reported in order to bring more information to bear on their use as TCM.

associated with the journey to work, whereas a shift in the starting time 1 hr earlier than the current 9:00 a.m. increases the utility of the drive-alone option.

The ridesharing option was evaluated through the use of the GRH program, the added time it takes to pick up riders, and the value of the rideshare coupon. The GRH program produces positive utility for the rideshare alternative. Similarly, the rideshare coupon is also a stimulus to ridesharing; however, the additional time consumed linking the rideshare team together acts to discourage ridesharing. The GRH program was described to employees without any time loss or discomfort relative to the SOV option. Therefore, its coefficient must be treated as unconstrained and biased toward a positive response to ridesharing.

The signs of the coefficients representing the socioeconomic variables point to subsets within the employee work force at which efforts to encourage ridesharing at MECA should be targeted. The general categories of employees most willing to try ridesharing are those who are younger and those who are a part of the clerical staff. In particular, clerical employees who are members of households in which the number of driver's licenses exceeds the number of cars also have a strong predisposition toward the ridesharing option.

Those employees who find ridesharing to be a pleasant experience are also more likely to rideshare than those who have found it unpleasant. On the other hand, those employees who expressed a strong likelihood to drive alone, as shown in the employee transportation survey, consistently favor the SOV option in the stated choice experiments. It is interesting to note that the statement made in June that home- or work-related mobility needs would prevent them from ridesharing was not a significant indicator of stated choice behavior.

Forecasting Selection Probabilities

The direct output of the logit model is a set of selection probabilities for the commuting alternatives. The transformation of the selection probabilities into the percent change in AVO is direct. A data matrix consisting of employees by socioeconomic variable and the attributes for the commuter options is constructed. The values of the attributes are fixed for each scenario and combined with the values of the socioeconomic variables obtained from each individual in the sample. The utility function derived for each alternative is used to calculate the probability of ridesharing and driving alone. The probability of using a given alternative for the sample as a whole is taken to be the average of each individual's selection probability.

Forecasts of AVO using the unconstrained GRH program attribute will produce unrealistically high values similar to values acquired through a stated intentions survey (*8*). In order to counter this tendency, an adjustment factor related to the expected lost time experienced when using the GRH program was developed. The factor is based on the assumption that the disutility of time lost in the daily ridesharing experience is the same as the disutility experienced waiting for the GRH. For each observation where GRH is provided the employee, 30 min of lost time is assumed to occur. The marginal disutility of ridesharing is computed for the 30 min lost, and the unconstrained marginal utility for the GRH is reduced by the disutility of time lost.

AVO levels were calculated by taking the ratio of the number of employees who arrive at MECA to the number of cars that bring them to MECA and park in the MECA parking lot (Equation 1). The number of employees arriving at the site is fixed by the size of the sample and by the current employment level. The number of vehicles entering the parking lot with employees is the sum of the SOVs and the vehicles used for ridesharing. The model does not predict the number of employees to arrive in each vehicle used in ridesharing. Since calculation of the AVO requires this value, it is assumed to be the current average number of employees entering the MECA parking lot in a ridesharing vehicle, which was determined from the employee transportation survey made in June 1991 to be 2.2.

$$\mathrm{AVO} = E/V \tag{1}$$

where E is the number of employees employed at MECA, and V is the number of vehicles used to bring MECA employees to work and park in the MECA parking lot.

$$V = P(\mathrm{SOV}) * E * a + P(\mathrm{RS}) * E * b \tag{2}$$

where

a = 1/(1 employee/vehicle),
b = 1/(2.2 employees/vehicle),
P(SOV) = average selection probability for employees to choose the SOV alternative,
P(RS) = average selection probability for employees to choose to rideshare, and
* = notation used for multiplication.

TCM Levels Needed To Meet Clean Air Act Standard

The set of outcome indicators most relevant to evaluating performance shows the values of one or more of the TCMs needed to generate a percentage change in AVO. Table 3 shows the percentage change in AVO given combinations of three measures: parking charge, rideshare coupon, and the adjusted GRH program. The reader must be reminded that the behavior projected in Table 3 is predicated upon the existence of a transportation coordinator and an up-to-date rideshare-matching program. The upper half of the table describes the joint effect of parking charges and rideshare coupons on the relative change in AVO. At zero parking change, none of the possible values of the rideshare coupon will generate the required 25 percent change in AVO. In contrast, a \$2.00 parking charge with no rideshare coupon will produce the required change in AVO.

The lower half of Table 3 shows the joint effects of the GRH program adjusted for 30 min of lost time, combined with parking charges and rideshare coupons. Given the GRH program, the 25 percent increase in AVO is achieved at lower values of parking charges and rideshare coupons. A parking charge of approximately \$1.50 now generates the required change in AVO, as does a \$1.00 parking fee and rideshare coupon.

Once the set of TCMs that produce the 25 percent change in AVO is determined, the final mix of costs and incentives must be derived from a cash-flow analysis of the program.

TABLE 3 PROJECTED PERCENT CHANGES IN AVERAGE VEHICLE OCCUPANCY LEVELS FOR THREE TCMs (22)

NO GUARANTEED RIDE HOME PROGRAM

		Parking Charge			
		\$0	\$1	\$2	\$3
Rideshare Coupon	\$0	0%	10.4	25.3	41.4
	\$1	6.6	22.5	41.6	58.9
	\$2	12.1	31.0	51.6	67.7
	\$3	13.7	33.6	54.5	70.0

GUARANTEED RIDE HOME PROGRAM

		Parking Charge			
		\$0	\$1	\$2	\$3
Rideshare Coupon	\$0	2.8%	15.5	32.7	49.5
	\$1	10.9	29.4	49.8	66.5
	\$2	17.5	38.8	59.6	74.5
	\$3	19.3	41.4	61.9	76.5

*Each mode choice scenario contains a 15 minute time loss for ridesharing over the driving alone option and a starting time of 9:00 a.m.

Total costs include the salary of the transportation coordinator, matching program, and incentives. The revenues are essentially those derived from parking fees and subsidies given by the firm.

CONCLUSIONS

Estimates of the performance of TCMs can be recovered through the use of stated preference techniques. In a practical application of SP, employees of a large firm in northern New Jersey were able to respond to a hypothetical set of commuting situations in a fashion that is both realistic to professionals in the area and consistent with hypotheses derived from utility theory. The results show that the traffic reduction plan of a firm or agency can be evaluated on the basis of their employees' stated commuting behavior.

In its empirical application in northern New Jersey, a combination of a GRH program, a $1.00 ridesharing coupon, and a $0.75 daily parking charge for the SOV commuter generates the 25 percent increase in AVO required by the Clean Air Act and distributes the costs and benefits throughout the firm's employees. In reality, this must be viewed as an upper bound for the assessment of performance. Not only must the firm enact the $0.75 parking fee and $1.00 rideshare reward, but the rideshare coordinating and matching programs must also link all individuals who said they were willing to rideshare under these conditions, and the distribution of willing rideshare drivers and riders on average must perceive this time lost ridesharing to be 15 min per trip.

As a general method for exploring policy issues of mode or route choice, SP appears to be a valuable addition to the widely used class of discrete choice analysis developed under the theory of revealed preference. It can also be seen as a method for assessing nonmarket demand for many classes of public goods such as quality-of-service characteristics of public transit, recreational and park improvements, as well as airport expansions and improvements.

FUTURE WORK

Future testing is still needed. The instrument developed for the MECA study did not define the GRH program by its performance attributes: time, comfort, security, and convenience. The range of values assigned to the rideshare coupon does not reach the levels required to shift the commuting decisions of many respondents. The value range should be extended beyond the $3.50 per person per day. New TCMs, such as the availability of a day-trip vehicle for company use, should be considered, as should shuttle buses linked to local shopping centers and transportation terminals.

The results from the MECA study must be compared with similar studies performed both within the region and beyond, with firms having similar and different distributions of employee categories, and with firms in a broad range of industrial categories and locations within metropolitan areas.

Future research must also be performed to construct and validate new forms of survey administration. The pilot study required two separate approaches to the firm and its employees. Although remaining as unobtrusive as possible, the researchers still posed a distraction to management and labor. It was initially intended that 150 employees would be called at the work site and interviewed personally using a combined employee transportation survey and stated choice instrument. Discussions with management suggested that such a procedure would be difficult to implement under current conditions. A two-stage, mail-back procedure was chosen instead. Unfortunately, the use of mail-back techniques for the administration of the instruments does nothing to protect the results from nonresponse bias. New techniques being tested at the Institute for Transportation Studies at Leeds University in the United Kingdom are integrating stated preference with the hand-held microcomputer and offer the promise of new breakthroughs in sample selection and survey administration. These techniques should be studied by the U.S. Department of Transportation.

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