Employer-Provided Transportation Benefits, Public Transit, and Commuter Vanpools: A Cautionary Note

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The Comprehensive National Energy Policy Act of 1992 and Clean Air Act Amendments of 1990 create a new climate for ridesharing including the use of public mass transit. Under current operating conditions, certain bus routes may be at a competitive disadvantage to newly encouraged vanpool operations. The results of a study into the underlying reasons for commuting choices among public transit, carpools, and vanpools are reported. A set of hypothesized alternative situations involving realistic commuting costs and incentives based on the acts are developed. All participants in the study are currently public transit or carpool commuters. The research design uses the stated choice approach to disaggregated discrete choice analysis. A multinomial logit equation is fitted to the choice responses taken from the population of transit-carpool users at the study site. The results show that a $1.00 subsidy is required for transit to equal the utility found in an $0.83 vanpool subsidy. The latent demand for carpools and vanpools is demonstrated by the transfer penalty that ranges from $0.91 to $2.02 against transit for each transfer required to be used. When an effective transportation coordinator program at the employment site is combined with the maximum permitted tax-free employee benefit, the results show a decline in the use of transit by current users from 75 percent of the employee sample to 50 percent. Although the model does not show the propensity to form successful vanpools, there is nonetheless clear potential for a significant loss in transit ridership devolving from the successful implementation of both federal acts.

The Comprehensive National Energy Policy Act of 1992 provides an expanded commuting subsidy program for transit and vanpool users. The subsidy is a direct incentive to encourage the use of vanpools or public transit. Title XIX of the National Energy Policy Act permits employers to give employees a tax-free subsidy of $60/month. The subsidy is designed to aid regions in meeting the employer trip reduction requirements found in the U.S. Clean Air Act Amendments of 1990.

The subsidy amounts to an effective change in price for commuting services when using one of the qualifying modes. The congressional intent in both acts is to strengthen the use of alternative commuting modes as opposed to the single-occupant vehicle. The acts assume that both alternative modes will benefit from the price decrease; nothing is stated in either act regarding modal shifts occurring between the alternatives. Where public transit has the same level of underlying attractiveness to commuters as vans, no net loss in ridership will occur. However, when the marginal valuation of transit as currently used is less than that perceived for vanpools when made available, transit will experience a drop in ridership and the outright loss of trips and perhaps routes.

The research reported in this paper focuses solely on the potential loss of existing ridership devolving from the joint operation of the Clean Air Act and the National Energy Policy Act. The research does not address the overall or net impact derived from the growth of new transit ridership. Neither does it judge the ultimate economic efficiency for individuals in making the switch to vans from transit. Instead, it takes a transit system approach in which the present ridership is valued at a higher rate than the uncertain future ridership. The study will estimate the marginal rates of substitution for attributes, including the transit and vanpool subsidies, transfer penalty, and valuation of time saved. It concludes with a projection of the impact on existing transit ridership contingent on the implementation of a van subsidy program comparable to that received by transit.

RESEARCH DESIGN

The method used to measure the mode shift potential within the combined Energy and Clean Air Acts is the stated choice approach to discrete choice analysis (*1*). The method was chosen because of its ability to experimentally control the independent policy variables and its relatively efficient use of research resources (*2*). The target population selected for study consists of employees working at the Technical Center operated by the Port Authority of New York and New Jersey. The employees chosen for this part of the study currently use either public transit for the major portion of their commute or carpool to the site.

The data generation instrument was designed through a series of three focus groups held at the employment site. Each focus group contained at least 12 employees selected at large from the employees located at the site. Participants in the focus group sessions were asked to describe in detail their current commutes and previous experience with carpools, vanpools, or public transit and then to pilot test a draft survey instrument. After the draft survey instrument was completed, a critical review of the content and format of the document was held. Following the incorporation of the focus group findings into the draft survey instrument, simulation studies based on the new or accepted attributes and values were held to ensure that the range of values selected for the independent variables were capable of recovering hypothesized marginal utilities using the standard multinomial logit model (*3*). Finally, pilot tests of the penultimate instrument were run in order to ensure that employees understood the questionnaire and that fatigue and policy response bias could be controlled.

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The stated choice elements of the study consisted of 16 randomly ordered hypothetical choice tasks. Copies of the survey instrument are available from the authors on request. Employees chosen to complete the instrument were instructed to view each task as realistic future options for their commute. Each task gave employees the choice of three commuting options: using public transit, carpooling, and vanpooling.

DESIGN ATTRIBUTES

Two classes of attributes identify the commuting alternatives: constants and mutually orthogonal independent variables (*4*). Public transit was defined as public or private transit vehicles operating on fixed routes and schedules whose vehicles drop off the commuter within walking distance of the work site. The definition includes transfers to shuttle buses operated by the employer. Each employee was asked to assume that the fare and commuting time for their transit trip will remain at their current levels across all choice tasks found in the experiment. That is, transit fare and trip time are constants. Two independent variables complete the set of design variables for the transit alternative: a company-paid transportation fringe benefit and a guaranteed-ride-home program.

The transportation fringe benefit was defined as a tax-free payment valued at up to $3.00/day that must be used on public transit. The guaranteed-ride-home program is defined as one that is available only to transit and certified vanpool users. The program generates transport services when the employee is faced with an emergency either at home or at the office, or when a supervisor asks an employee to stay late and miss normal commuting connections. The program is qualified with the time delay in order to reduce the tendency on the part of respondents to interpret it as identical to their personal car. To use the service, employees are required to be prequalified, to make the telephone contact with an approved car service company, and to make the payment at the end of the trip. The employee will be reimbursed through the employer's transportation coordinator. The guaranteed-ride-home variable assumes one of three values throughout the choice tasks: none, a program that adds 5 min to the regular trip time, and a program that adds 25 min to the regular trip time. The employment site currently does not have a guaranteed-ride-home program for its employees.

The carpool alternative is defined as a commuting arrangement among two to six employees in which one employee's vehicle is used for the commute. Six variables are used to depict the carpool option to respondents. Carpool costs are implicitly built into the experiment. Respondents are instructed to identify out-of-pocket costs such as those for gas, tolls, and parking charges. No maintenance, depreciation, or insurance costs are to be considered in the cost-sharing arrangement. The out-of-pocket costs are assumed to be shared equally by all of the members of the carpool. Current carpool arrangements at the site have on average 2.3 persons per vehicle. From this finding and the desire to keep the model relatively simple, the value of out-of-pocket costs assigned to each carpooler in the choice tasks was constant, set at half the individual's drive-alone costs.

The second identifier for the carpooling option is the rideshare subsidy. Throughout this experiment, the respondents were told that no subsidy would be available for carpoolers. The third and fourth identifiers for the carpooling option reflect what may become a new parking management strategy at the employment site. Parking at the site will be free to carpoolers, and reserved parking will be available for certified carpoolers in protected lots within a 5-to 10-min walk from their work site.

All forms of ridesharing are given the same guaranteed-ride-home options that were defined for the transit users; therefore, each choice task in the experiment shows respondents the same value for the guaranteed ride home variable across all commuting options. The sixth carpool identifier specifies the time spent commuting by carpool in contrast to that spent commuting by the public transit alternative. Focus group meetings aided in establishing the range of values. The values are expressed as the time in minutes saved one way using the carpool over that spent on transit; they are 15, 25, and 55 min.

The third commuting option is vanpooling. It is defined as an arrangement among seven or more employees sharing a leased van. The employee vanpool is responsible for the lease payments as well as the operating costs. The choice tasks show the vanpool costs to be a constant $3.00/person/day. It must be recognized that this value, while feasible, is optimistic. Assuming a $900/month cost for the lease, insurance, and maintenance fee, each van will require 16 employees to subscribe in order to meet the fixed costs. The employee payment will leave $108/month for fuel costs.

The vanpool alternative has an independent but comparable qualified transportation fringe benefit, as does the public transit alternative. As with the transit alternative, the values range from $0.00 to $3.00/day. Employees choosing the vanpool alternative will be presented with the identical guaranteed ride home as shown in the other two commuting alternatives. As with the carpool option, two parking management policies are incorporated in the choice set design; these are parking charges and parking availability. Both policies enter the model as constants. Employee vans park at no charge and are given preferential parking in spaces either under or immediately next to their work sites. The walk to work from these spaces takes roughly 3 min.

The final design attribute identifying the vanpool alternative is travel time relative to transit time. Focus groups were again used to establish a range of realistic values for the experiment. The values were entered as the minutes saved using a vanpool for the commute instead of public transit. The time savings ranged from 5 to 20 min. Note that in most cases carpools save more time over public transit than do vanpools.

ANALYTICAL MODEL

The commuting decision is modeled as a rational process. Each commuter chooses one of the three commuting alternatives on the basis of the explicitly or implicitly stated costs and benefits shown in each choice task. The costs and benefits shown in each choice task form the design attribute subset of independent variables. An orthogonal fractional factorial design was used to select the values of the design variables. The second subset of independent variables consists of socioeconomic, demographic, and attitudinal indicators. Each stated choice made by an employee is combined with a comparable set from the other employees in the sample to form a multinomial dependent variable.

The underlying analytical model describing the outcomes of the commuting decision-making process is the multinomial logit (*5*). The model combines the discrete decisions of individual commuters into a choice probability for each alternative. The fundamental assumption underlying the use of this model is Luce axiom: independence of irrelevant alternatives. For the multinomial logit to be the basis of unbiased estimators, it is assumed that the ratio of the probability of choice for any two alternatives is independent of all other alternatives.

The multinomial model is

$$P_i = \frac{e^{V_i}}{e^{V_i} + e^{V_j} + e^{V_k}} \tag{1}$$

where P_i is the probability that an individual $\{n\}$ in the target population will choose one alternative from a choice set containing alternatives $\{i, j, k\}$, and V_i, V_j, and V_k represent a linear in parameters indirect utility function for each alternative (*6*). The indirect utility functions are shown in Equation 2.

$$\begin{aligned} V_i &= \alpha_0 + \alpha_1 X_1 + \ldots + \alpha_m X_m + \epsilon_{i,n} \\ V_j &= \beta_0 + \beta_1 Y_1 + \ldots + \beta_m Y_m + \epsilon_{j,n} \\ V_k &= \gamma_0 + \gamma_1 Z_1 + \ldots + \gamma_m Z_m + \epsilon_{k,n} \end{aligned} \tag{2}$$

The set of coefficients $\{\alpha, \beta, \gamma\}$ represents the alternative specific constants, the marginal utilities assigned by commuters to each design attribute, and the shifts in the alternative specific constants generated by individuals through their socioeconomic and attitudinal indicators. The coefficients $\{\alpha_m, \beta_m, \gamma_m\}$ are interpreted as marginal utilities linking a change in one unit of an attribute $\{X_m, Y_m, Z_m\}$ to the change in utility experienced by individual n, holding income constant. Given that the index of utility $\{V\}$ is not directly observed, only the signs of the coefficients have theoretical relevance. The coefficients provide insights into commuter behavior when they are treated as measures of goods or services that can be substituted for each other. Under the conditions shown in Equation 3, that an individual is to maintain a constant level of utility, Equation 4 shows that the ratio of any two marginal utilities taken from the set of utility equations provides an estimate of the marginal rate of substitution (MRS) of one attribute in terms of another.

$$\frac{\partial V_i}{\partial X_k} dX_k + \frac{\partial V_j}{\partial Z_k} dZ_k = 0 \tag{3}$$

$$-\frac{dZ_k}{dX_k} = \text{MRS}_{x \text{ for } z} = \frac{\partial V_i/\partial X_k}{\partial V_k/\partial Z_k} \tag{4}$$

The coefficients are estimated through the use of the maximum likelihood procedure. The multinomial model will produce asymptotically unbiased estimators under two conditions: first, the scaling factor linking real-world behavior to stated-choice behavior is known, and second, that the deviations from the utility functions occur because of random individual choice variations (*7*). The set of socioeconomic, demographic, and attitudinal indicators is used to control for aggregate patterns of like behavior found within the sample. The variables used for this purpose include household income, gender, current use of public transit, number of transfers currently needed for the journey to work, means used to get from home to the transit stop, and various measures of distance or time traveled to work.

The multinomial logit model is based on various assumptions; the basic among these is the property of independence of irrelevant alternatives (IIA). This property implies that if some alternatives are removed or added to the choice set, the ratio of the choice probabilities in the new choice set remain unchanged (*8*). Essentially, this assumption requires that the alternatives presented to decision makers be substantially different from one another. If the IIA property is found to be violated, then suitable changes must be made to remedy the violation; failure to remedy the violation will then require the use of alternative model forms such as the nested logit (*9*).

The simplest test for IIA amounts to a comparison of the standard errors of the common variables across two logit models. The first model is the unrestricted model in which all alternatives are entered into the logit equation. The second model is a restricted model in which one of the available alternatives is removed from the choice set. A comparison of the estimated marginal utilities and their standard errors showed that in no case were the differences between marginal utilities for the unrestricted and restricted models greater than one standard error. The hypothesis of IIA was therefore not rejected.

EMPIRICAL RESULTS

The sample of observations is taken from a larger study of commuting behavior undertaken at the Technical Center of the Port Authority of New York and New Jersey in Hoboken, New Jersey. The study was performed in two stages. The first stage consisted of a general employee transportation survey. Data generated from this survey produce estimates of the site's average passenger occupancy level, each employee's revealed preferences for commuting mode, and attitudes toward commuting alternatives. The second-stage survey instrument consisted of a set of choice tasks. Public transit and carpool users formed the target population for the survey.

Table 1 presents the socioeconomic characteristics of the employees taken from the transit and carpooling sample. Males represent three-quarters of the sample, and the average annual household income is \$50,000 to \$75,000. Approximately 80 percent of the sample use public transit for the main part of their commute, 10 percent occasionally use transit, and 7 percent never use transit. The sample was selected on the basis of transit or car- and vanpool use; therefore, 20 percent of the sample use car- or vanpools for their trips to work.

Last, the respondents were asked several questions about either their actual transit trips or their most recent commuting trips via public transit. The average respondent was found to use 2.5 transfers per one-way commute to work, and the average total transit cost is \$4.15; the average time required to go from home to the bus stop in order to start the journey to work was 12 min.

ANALYTICAL RESULTS

The multinomial logit equation fitted to the sample is presented in Table 2. Each of the three commuting alternatives has a separate indirect utility equation. When combined according to Equation 1, the mode choice probabilities are recovered. Only those variables that obtain a *t*-score within the 5 percent significance level and whose signs are theoretically correct are retained for the final

TABLE 1 Characteristics of Employee Sample from Technical Center of Port Authority of New York and New Jersey (*n* = 72)

Category	Percent of Sample
Gender	74.1 % male
non responses	16.6 % of sample
Annual Household Income	
< $25,000	1.8 %
$25,001 - $50,000	20.4
$50,001 - $75,000	27.8
$75,001 - $100,000	12.9
> $100,000	12.9
non respondents	24.0
Respondent Uses Transit	
Often	79.6 %
Occasionally	9.3
Never	7.4
non respondents	3.7
Average number of transfers required for commute if transit is used	2.5 transfers/one way trip
Average Transit cost when commute is made by transit.	$4.15/ one way trip
Average length of trip from home to bus stop	12 minutes

TABLE 2 Multinomial Logit Equation for Commuting Choice Decisions Made by Employees of Technical Center of Port Authority of New York and New Jersey, Spring 1993

Attribute	Logit Coefficient	t score
Public Transit Equation		
Household Income	-0.000011	5.3
Commuter Often Takes Transit	0.86	3.7
Commuter Never Takes Transit	-1.29	3.1
Commuter normally walks to transit stop	0.61	4.1
Time taken to get to bus or train stop	-0.021	3.9
Transit Subsidy	0.32	5.8
Carpool Equation		
Mode specific constant	-1.58	3.3
Time saved carpooling in comparison to transit	0.032	5.4
Number of transfers needed to complete transit trip to work	0.64	7.5
Drive alone travel time to work	-0.027	4.9
Vanpool Equation		
Mode specific constant	-0.91	2.1
Commuter is female	0.86	3.4
Time saved vanpooling in comparison to transit	0.027	2.1
Vanpool subsidy ($)	0.38	6.6
Number of transfers used for transit based trip to work	0.29	4.2
Initial Likelihood	-1103	
Final Likelihood	-877	
Rho bar squared	.20	

estimation. The use of the computed standard error assumed that each observation is independently distributed. It is recognized that this is less strict than the assumption that only the individuals providing data are independently distributed (*10*).

Most of the employees taking the survey are public transit users; therefore, their knowledge of commuting conditions should be strongest for the public transit alternative. The attributes that combine to generate the implicit value of utility are shown in the public transit equation. Six variables have been retained in the final estimation of this equation. The single socioeconomic variable that enters the equation is annual household income. The negative sign indicates that employees increase their valuation of public transit as their incomes decrease. Four variables reflect the impact of respondents' current commuting conditions on their valuation of public transit. Commuters who often take transit have a positive valuation for the future use of transit; alternatively, those commuters who never take transit have a strong negative valuation. Three alternative ways of getting to the future transit stop were presented to respondents: walk, drive to a park-and-ride lot, or have someone drop the respondent off at the station. The reference category is: have someone drop the respondent off at the station. The utility equation shows that the ability to walk to the station generates a positive marginal utility relative to the reference category. The final argument entered into the public transit equation is the value of a transit pass used as a qualified fringe benefit under the U.S. Energy Act of 1992. The transit subsidy is shown to be valued positively by the respondents.

The second utility equation is estimated for the carpool commuting option. Three variables and an alternative specific constant are retained in the equation. Respondents, currently transit or carpool commuters, show that a time savings will increase the desirability of carpooling relative to the other alternatives. The second variable shows that the number of transfers needed to complete the public transit journey acts to reduce the demand for transit and increases the desirability of carpooling. Finally, it shows that long driving times tend to reduce the desirability of carpools. It should be noted that socioeconomic variables such as gender and income were tested for entry into the carpooling equation. In no case were statistically significant coefficients recovered from the sample.

The final utility equation shows the attributes that produce significant coefficients for the vanpool option. Four variables were retained for the final model. In addition to the mode-specific constant, female respondents show a strong desire to use the vanpool option. As with carpooling, respondents increase their valuation of vanpooling as the number of transfers that they are forced to make when using public transit increases. Last, the existence of a vanpool subsidy program is positively related to the utility derived from vanpooling to work.

TRADE-OFF ANALYSIS

The ratio of marginal utility values shows the rate at which commuters trade off attributes either within an alternative or across alternatives. Table 3 gives seven marginal rates of substitution for the value of the transit subsidy and five other attributes taken from either the carpool or the vanpool alternatives. The values show the magnitude of the change in an attribute needed to offset a unit change in another attribute while keeping the commuters at the same level of utility or satisfaction with their commuting services as before the change.

The first value shows the level of a subsidy to vanpools that is equivalent to a $1.00 subsidy to transit users. The model shows that the subsidy to transit users must be $1.00 for each $0.83 subsidy given to vanpoolers for utility levels to remain unchanged. That is, where transit ridership is to remain stable, for each $0.83 subsidy per trip given to vanpoolers, a $1.00 subsidy must be given to transit users.

Similarly, as the tasks essential to mounting effective rideshare matching programs are understood, transportation coordinators will be increasingly able to identify successful matches. In part, this effort will shorten the total time required to rideshare. The MRS shows that for either commuting alternative, each minute of journey time that is reduced by a commuting alternative relative to transit will require an approximately 10-cent increase in the transit subsidy for utility to be left unchanged.

TABLE 3 MRSs for Attributes of Public Transit Use Compared with Attributes of Car- or Vanpool

Attribute	MRS
MRS between vanpool subsidy and a $1.00 transit subsidy	$0.83 vanpool/$1.00 transit
MRS between transit subsidy and a 1 minute commute time savings by carpool	$0.10 transit subsidy/1 min. saved
MRS between transit subsidy and a 1 minute commute time savings by vanpool	$0.09 transit subsidy/1 min. saved
MRS between a transfer and the transit subsidy (carpool users)	$2.02/transfer
MRS between a transfer and the transit subsidy (vanpool users)	$0.91/transfer
MRS between the necessity to transfer and additional time spent on public transit (carpool users)	19.7 minutes/transfer
MRS between the necessity to transfer and additional time spent on public transit (vanpool users)	10.5 minutes/transfer

The final trade-offs to be examined relate the value of the transit subsidy to the number of transfers required by commuters in their journeys to work. The MRS provides an estimate of the transfer penalty. Early work by Horowitz and Zlosel (*11*) show that satisfaction with a bus trip declines significantly with the introduction of a transfer. Han (*12*) shows that without capacity constraints, bus systems will suffer a loss of ridership with the introduction of transfers.

The transfer penalty differs in value depending on the alternative to which a trip with transit is being compared. Table 3 provides two measures of the transfer penalty: a money cost and time lost equivalent value. Where the alternative mode is the carpool, a transfer is valued at $2.02. That is, when one additional transfer is required, the transit subsidy required to maintain the commuter at an equal level of utility is $2.02; in contrast, the vanpool user values the transfer at $0.91. Measurement of the transfer penalty in terms of time lost compares the marginal utility of a transfer with that of time saved using one of the rideshare alternatives. Where the alternative is carpooling, the transfer penalty is valued as an additional 19.7 min spent on transit; where the alternative is vanpooling, the transfer penalty is equivalent to an additional 10.5 min spent on transit.

MODAL SPLIT

The advent of a subsidy program incorporating both transit and vanpool modes combined with the requirements of the Clean Air Act suggests that significant mode shifts may occur soon. Table 4 presents the results derived from the use of the logit model for forecasting purposes. The forecasts are derived using the probabilistic approach (*13*). In this approach, the market share for each mode is calculated as the weighted average of each individual's mode-specific probabilities. This technique has a tendency to overestimate the mode share probabilities for minor modes when compared with the strictly deterministic technique. The socioeconomic and demographic data used to estimate the logit parameters are now used to fix the policy forecasts to the employees of the site being studied.

The first scenario describes a situation similar to the current conditions surrounding the commute to work. The employees who have taken advantage of the $3.00/day transit subsidy are assigned that value, the others are assigned a subsidy of $0.00. The difference between car- and vanpool commuting times and that for public transit are assigned values on the basis of current perceptions

TABLE 4 Projected Modal Split for Employees Who Currently Take Transit and Carpool to Work

Scenario	Transit Subsidy $	Carpool shorter than Transit (min.)	Vanpool shorter than Transit (min.)	Vanpool Subsidy $	Percent Transit %	Percent Vanpool %
1	3*	10	-30	0	74.8	8.9
2	3	10	-30	0	79.7	7.1
3	3	20	0	0	71.4	13.6
4	3	30	10	0	66.1	16.1
5	3	30	10	1	61.8	21.7
6	3	30	10	2	56.7	28.4
7	3	30	10	3	50.6	36.2

by employees received in focus groups. On average, employees believe that carpooling will save them 10 min/trip and that vanpooling will add an additional 30 min. The reason for the high time cost applied to vanpools reflects the current high information costs associated with vanpool formation. The employee transportation coordinator's role in future programs will be to reduce this cost significantly by establishing and maintaining rideshare groups. Last, reflecting the current situation, the vanpool subsidy is set equal to 0. The result of this scenario finds 75 percent of the employees choosing transit, 16 percent choosing carpools, and 9 percent vanpools. The actual mode split under the baseline commuting conditions is 81 percent transit and 19 percent carpool.

Scenarios 2, 3, and 4 were constructed to determine the effect of an active or effective transportation coordinator on mode split. Scenario 2 shows the influence of a fully used $3.00 transit subsidy with all other policy variables set at their baseline values. The result is the rise in transit use to 79 percent of the employees. Scenarios 3 and 4 improve the information regarding ridesharing opportunities among employees of the site. In the first case, it is projected that the transportation coordinator will improve the carpool over transit time difference by 20 min, and they will bring vanpool travel times even with transit. The results show a significant rise in both forms of ridesharing.

The last three scenarios introduce a variable vanpool subsidy ranging from $1.00 to $3.00/day. The subsidy offsets the daily cost of $3.00 needed to reserve a place on the van. As was noted in the text, this is a relatively low value given the cost structure for leasing and operating a van and the tendency for employees to exit vanpools as a result of job or residential shifts. Scenario 5 displays the results of a $1.00/day tax-free vanpool subsidy combined with the transit subsidies and time differentials shown in Scenario 4. The $1.00 vanpool subsidy increases the vanpool share from 16 percent to just under 22 percent; the new vanpool riders are drawn mostly from existing transit riders. Scenario 6 shows the result of a $2.00 vanpool subsidy program; here the vanpool market share increases to 28 percent. The final scenario presents employees with the maximum tax-free subsidy of $3.00/day; the model shows that public transit usage declines to 50.6 percent while vanpools rise to 36 percent of the commuting trips.

The effective impact of the employee subsidy program must be reexamined in light of the cost structure for vanpool operation as well as the effectiveness of the transportation coordination program at an employment site. Assuming that a van operates 20 days a month, travels 100 mi/day, has a gas mileage of 8 mi/gal, and that gas costs $1.30/gal, the monthly cost of operating such a van is approximately $900 for leasing and insurance plus $350 for gas, oil, and service, for a total of $1,250. A 16-passenger van operating at capacity and charging $3/trip will generate a monthly revenue of $960; at $4/trip the revenue generated will be $1,280. When ridership declines to 10 passengers, the monthly revenue becomes $800 and an employer subsidy of $450/month will be needed to keep employees in the vanpool. Therefore, in order to maintain this level of vanpool operation, the employer must offer each employee the qualified transportation fringe at $3.00/day and an additional subsidy of $2.25/rider to the van leasing firm. Without the firm's willingness to support the lease directly, the $3.00 transportation fringe benefit will be effectively cut to $0.75/day. The consequences of the fringe benefit level, taken from the National Energy Act, and an effective transportation coordination program implemented at each employee site, brought about through the Clean Air Act, will result in a decline in ridership ranging from between 15 and 25 percent of the site's current transit ridership.

CONCLUSIONS

The demand for public transit in urban areas is in part defined by a set of captive riders. The gas crisis of the middle to late 1970s stimulated corporate sponsorship of car- and vanpools; with the increase in gasoline stocks during the 1980s, support for ridesharing waned. Suburban commuters returned to the single-occupant vehicles; urban commuters, depending on their economic conditions and urban locations, again became captive to their automobiles or to public transit. The decade of the 1990s presents a new set of challenges to the survival of urban public transit. The combined influence of the Clean Air Act of 1990 and the Energy Act of 1992 may stimulate the demand for public transit by shifting drivers out of single-occupant vehicles and into transit. However, the research presented in this paper shows that along with a shift to transit there could be a significant decay in ridership coming from current transit users. To the extent that there is a conscious policy supporting public mass transportation, efforts should be made to either stabilize or enhance transit ridership. It is clear from this research that demand suffers as the number of transfers increase and as the time required to get from home to the public transit stop increases. Any decline in ridership will undoubtedly increase headways and in turn lead to further declines in ridership. This suggests that a differential be established in the subsidy given to transit versus that given to vanpool users.

REFERENCES

1. Beaton, W. P., H. Meghdir, and F. J. Carragher. Assessing the Effectiveness of Transportation Control Measures: Use of Stated Preference Models to Project Mode Split for Work Trips. In *Transportation Research Record 1346*, TRB, National Research Council, Washington, D.C., 1992, pp. 44–52.
2. Kroes, E. P., and R. J. Sheldon. Stated Preference Methods: An Introduction. *Journal of Transport Economics and Policy*, Vol. 12, No. 1, 1988, pp. 11–26.
3. Fowkes, T., and M. Wardman. The Design of Stated Preference Travel Choice Experiments: With Special Reference to Interpersonal Taste Variations. *Journal of Transport Economics and Policy*, Vol. 22, No. 1, 1988, pp. 27–44.
4. Fowkes, A. S. Recent Developments in Stated Preference Techniques in Transport Research. *Boundary*, May 1991.
5. Domencich, T. A., and D. McFadden. *Urban Travel Demand: A Behavioural Analysis*. North Holland Publishing House, Amsterdam, The Netherlands, 1975.
6. MVA Consultancy Institute for Transport Studies (University of Leeds) and Transport Studies Unit (Oxford University). The Value of Travel Time Savings. *Policy Journals*, Newbury, 1987.
7. Akiva, M. B., and S. Lerman. *Discrete Choice Analysis*. MIT Press, Cambridge, Mass., 1985.
8. Small, K. A. *Urban Transportation Economics*. Harwood Academic Publishers, Chur, Switzerland, 1992.
9. Hensher, D. A., and L. W. Johnson. *Applied Discrete Choice Modeling*. John Wiley and Sons, New York. 1981.
10. Mannering, F. I. Analysis of the Impact of Interest Rates on Automobile Demand. In *Transportation Research Record 1116*, TRB, National Research Council, Washington, D.C., 1987, pp. 10–14.

11. Horowitz, A. J., and D. J. Zlosel. Transfer Penalties: Another Look at Transit Riders' Reluctance to Transfer. *Transportation,* Vol. 10, Elsevier Scientific Publishing Co., Amsterdam, The Netherlands, 1981.
12. Han, A. F. Assessment of Transfer Penalty to Bus Riders in Taipei: A Disaggregate Demand Modeling Approach. In *Transportation Research Record 1139,* TRB, National Research Council, Washington, D.C., 1987.
13. Fowkes, A., and J. Preston. Novel Approaches to Forecasting the Demand for New Local Rail Services. *Transportation Research-A,* Vol. 25A, pp. 209–218.

Publication of this paper sponsored by Committee on Ridesharing.