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A Survey and Analysis of Employee Responses to Employer-Sponsored Trip Reduction Incentive Programs

Technical Appendix A
Model Calibration Report

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

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13. ABSTRACT *(Maximum 200 Words)*

The Technical Appendix A contains information on calibration of a travel demand management (TDM) model. The model was developed for the California Air Resources Board from employee data collected in the Los Angeles and Sacramento areas of California. The TDM model evaluates employer-based incentives to reduce trips. The model is also available as a software for an IBM PC.

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Technical Appendix A
Model Calibration Report

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Appendix A MODEL CALIBRATION

A.1 Introduction

The central effort of this study has been the development of a mathematical model that tries to explain the commuter's choice of travel mode in terms of various attributes of the employee, the transportation system, and the workplace. This approach is a significant departure from most of the previous efforts in Southern California to understand commuter behavior. Almost all of the earlier efforts focused on estimating a work site's Average Vehicle Ridership (AVR) directly, as a function only of the aggregate employer data that is in the South Coast Air Quality Management District's (SCAQMD) Regulation XV data file.

The current effort is based on the concept that it is more appropriate to seek to understand the behavior of the individual commuter and thus attempts to model the probability that an employee will choose each of the available travel modes. For a given employer, the sum of these probabilities constitutes each travel mode's *share* of the employees commuting to a work site. This technique of *disaggregate mode choice modelling* is presently the most commonly used method of analyzing travel behavior. Once the shares of each travel mode are calculated, they can be used to readily derive the AVR.

A calibrated mode choice model provides a good understanding of the behavior of travellers. The model's structure and parameters offer considerable insight into what factors are important in influencing travel mode selection, as well as the sensitivity of travellers to changes in those factors.

In addition to analyzing the factors that affect mode choice, this project has investigated the phenomenon of the employee's perception of those factors. Most travel behavior studies assume that over time, travellers have, or will develop, perfect information (or nearly so) about these various factors. While common sense suggests that this is a questionable assumption, few studies pursue this issue with any rigor. Prior research of Travel Demand Management (TDM) strategies has suggested that there can be significant discrepancies in employees' *awareness* of certain factors and that this (lack of) awareness is itself an important factor in travel mode choice. This study has examined this issue and has led to the development of an additional sub-model to estimate to what degree employees are likely to be aware of certain influential factors.

This report is a description of the development of the mode choice and awareness models. In this context, a *model* is a set of mathematical relationships that estimates a dependent variable (mode choice or awareness) in terms of various independent variables (travel cost, TDM incentives, etc.). The model consists of nothing more than equations that can be applied with a hand-held calculator, although that would prove rather tedious. This model is sufficiently complex that a microcomputer-based *application program* has been written to apply the model to a particular work site. That program is documented in the *User's Guide* shown in Appendix B.

There are five more sections in Appendix A:

2. Input Data:	preparation of the mode choice model calibration data file
3. Calibration Method:	techniques used to develop the mode choice model
4. Calibration Results:	mode choice structure and final parameter values
5. Awareness Model:	calibration and parameters of the awareness sub-model
6. Application Program:	some notes on software used to apply the model

A.2 Input Data

Two major surveys conducted in Southern California and the Sacramento area formed the primary data base for model development. The first covered 45 employers and the second covered 2,437 employees at the surveyed work sites. The employer survey provided information on the characteristics of the employer, the work location, and the type of TDM incentives that were offered to employees. The employee survey provided data on the characteristics of the employee, his family, commuting habits, and the type of TDM incentives that he was offered. The survey procedures and an overview of the results are presented elsewhere in this report. This section summarizes the effort to convert these files into a calibration data base for the mode choice model.

- Merge Files: First, the employer and employee files were merged so that each employee record also contained the relevant information from that employee's employer survey.
- Append Trip Information: The employee's home and work locations were defined in terms of the traffic analysis zone (TAZ) geographical systems of the Southern California Association of Governments (SCAG) and the Sacramento Area Council of Governments (SACOG). Next, data was obtained from those agencies describing the typical travel time between all pairs of zones in each region, by single-occupant auto, high-occupancy auto, and transit. This data included the highway distance and the transit fare for each zone-zone pair. If the employee could have either walked or driven to the transit system, the faster of those two paths was selected. This information was derived from 1990 peak hour synthetic highway and transit networks maintained by each agency and was used to describe the typical weekday travel conditions faced by each commuter. Transit level of service was described in terms of in-vehicle time, total out-of-vehicle time (walk + wait + transfer), auto access time, and fare.
- Transformations and Recodes: Various revisions to the data were made. Out-of-range values were reset. New variables were created, such as auto operating cost (= distance over the highway network multiplied by 14 ¢/mile). Dummy variables were created as binary values; for example, the Income1Dummy is 1 if the employee's response to the income question was "1", otherwise Income1Dummy is 0. Daily parking cost was computed from the employee's responses, or the employer's responses if the employee did not report anything. Cost and time for the carpool and vanpool modes were adjusted to account for the number of occupants in the vehicle.
- Missing Values: The calibration software is intolerant of missing values (a missing value for a variable invalidates the entire trip record, if that variable is used in the model). Thus, various techniques were used to infer a value for key variables that were missing. In some cases, a reasonable value could be deduced from other information provided by the respondent. Sometimes, the most frequently reported value or the average value was inserted. If neither of those methods was applicable and the proportion of missing values exceeded 5%, a value was assigned at random.
- Weighting Factors: The employee survey deliberately oversampled all alternative modes (i.e., carpool, vanpool, transit, walk/bike) in order to ensure enough observations for those modes. Although disaggregate model calibration normally uses unweighted observations, the researchers wanted to test a weighted sample. Thus, expansion factors were developed that weighted each employee observation according to the employer and mode. The "universe" of employees by employer and mode was the short form survey for those employers in the two-stage sample and the most recent Regulation XV report for the remaining Southern California employers.

As part of this survey processing, 96 records were dropped for one or more of the following reasons:

- no travel mode was reported (and none could be inferred)
- employee did not commute to work on the survey day
- employee's home Traffic Analysis Zone could not be identified
- employee reported using an "unavailable" mode (transit use where no service appears to exist, driving alone when no auto is owned, or bicycling or walking beyond a certain distance)

Thus, the final calibration file consisted of 2,341 records with a modal distribution as shown in Table A-1. One of the advantages of using a discrete choice model is the ability to calibrate it with relatively small data files. Each commuter is viewed as a separate opportunity to observe the choice that is made from the available range of alternatives. The calibration software considers the influences of each variable on the decision actually made by the commuter in estimating the importance of each influence (i.e., the variable's coefficient). Thus, discrete logit calibration makes very efficient use of the information contained in the survey data.

Table A-1
Calibration File Trips by Mode

Mode	Unweighted Trips	Percent	Weighted Trips	Percent
Drive Alone	1,434	61.2%	9,333	71.9%
Carpool	580	24.8	2,366	18.2
Vanpool	127	5.4	665	5.1
Transit	119	5.1	370	2.9
Walk or Bike	81	3.5	252	1.9
Total	2,341	100.0%	12,986	100.0%

Exhibit A-1 at the end of this Appendix presents the format of the calibration file and a description of the fields.

A.3 Calibration Method

A.3.1 Model Structure

For the purposes of this project, *model calibration* means identifying those variables that most significantly influence the travel mode choice and determining the coefficient value for each variable. The coefficients describe the relative importance of each variable on mode choice. By inserting these variables and coefficients into an appropriate model structure, it is possible to estimate the likely reaction of employees to a wide range of hypothetical changes in commuting conditions.

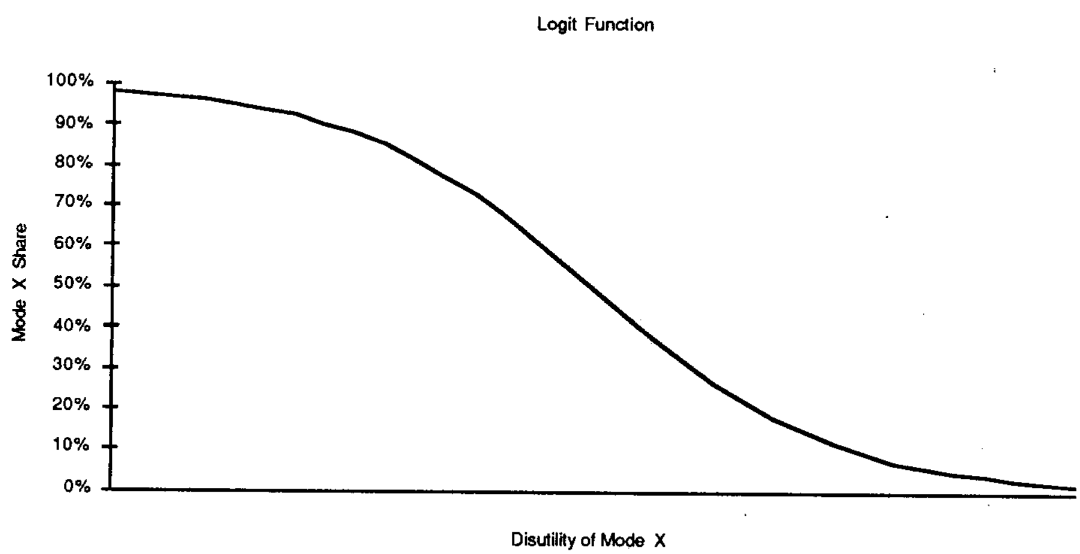
The *multinomial logit model* is the structure that has been selected for this project. This type of model is used in almost all urban area mode choice models in the U.S. The formulation of this model is as follows:

$$P_i = \frac{e^{U_i}}{\sum_m e^{U_i}} \quad (1)$$

where:
P_i = probability of using mode i
U_i = the "disutility" of mode i = $C_0 + C_1{*}Var_1 + C_2{*}Var_2 + \ldots$
Var_1, Var_2, etc. = influential variables (time, cost, etc.)
C_0, C_1, C_2, etc. = calibrated coefficients
Σ_m = summation over all available modes m

The logit model estimates that the probability that a commuter will choose a particular mode is directly proportional to the attractiveness of that mode (the numerator of equation [1]) compared to the overall attractiveness of all available modes (the denominator of equation [2]). "Attractiveness" is computed as the exponential of the disutility function, which is a composite of those attributes of a mode that travellers do not like. This equation yields the following S-shaped curve:

Figure A-1
Typical Logit Curve



This curve signifies that as the disutility of a mode increases, the use of that mode will decline. It is important to note that the slope of this curve (i.e., its sensitivity) is not constant, but varies with the disutility value itself. That is, at the far left of the curve, mode X's disutility is low and its usage is correspondingly high. The curve is also fairly flat in that area, indicating that it would be difficult to persuade travellers *not* to use mode X. Similarly, at the far right side, the curve is also flat, indicating that it would be difficult to persuade those travellers to use mode X. The curve is steepest in the middle, meaning that travellers in this area are the most sensitive to modal changes. These relationships are reasonably descriptive of actual mode usage in most urban areas and this is why the logit model is so widely used.

Note that when applied to a single traveller, P_i refers to the probability that the traveller will choose mode i. However, when applied to a group of travellers, P_i refers to the percentage *share* of those travellers who will choose mode i. (This is the same thing mathematically, but the distinction is useful from a logical point of view.)

One of the most important aspects of a mode choice model's structure is the definition of "mode". This project followed standard modelling practice and selected "mode used yesterday" as the appropriate definition. The intention of a mode choice model is to explain travel behavior on a typical day. However, on a typical day, many commuters may choose a mode that is different from the mode that they usually choose. Consequently, a typical day can be represented only with reported actual behavior on a specific day ("yesterday"), and not by asking respondents about their typical mode.

The other critical aspect of mode definition is to decide how to categorize the modes themselves. This is primarily a function of how the model will be used. For example, models that are to be used for detailed transit planning commonly use separate mode definitions for walk-access to transit and drive-access to transit. Detailed high-occupancy vehicle (HOV) planning requires that carpools be analyzed by occupancy category (2 persons/auto, 3 persons/auto, etc.). Although neither of those criteria apply in this case, this model is concerned with two alternative modes that are not often considered: vanpool and walk/bike. Identifying vanpooling as a separate mode is important because many TDM policies are explicitly designed to encourage vanpooling. Similarly, bicycling and walking are significant travel modes in the context of strategies that are designed to minimize vehicular traffic. Bicycling and walking are combined as one mode in this study because they share many of the same characteristics and because their individual mode shares are very small. (In this context, *alternative mode* is any mode other than Drive Alone.)

This model is then based on five travel modes:

- Drive Alone
- Carpool
- Vanpool
- Transit
- Walk/Bike

The model describes the disutility of each mode in terms of its important, measurable attributes. Typically, the disutility function of each mode is a linear combination of the mode's characteristics:

$$U_i = C_0 + C_1*Var_1 + C_2*Var_2 + \dots \qquad (2)$$

The *Var* terms in equation (2) are the characteristics of mode i and the C_x terms are the coefficients (or weights) of these characteristics. C_0 is a special coefficient called the *bias coefficient* or *bias constant* that represents the average effect of those characteristics that cannot be adequately measured (comfort, reliability, etc.). Since the coefficients are generally negative, an increase in a variable's value such as travel time leads to a larger (i.e., more negative) disutility, which according to equation (1) leads to a smaller probability of using that mode.

The characteristics in the disutility equation can include any measurable aspect of a mode, but are usually limited to travel times and costs, measured for each employee's trip to work. Disutility equations also often include variables that are not specific to the mode, but that nonetheless affect a commuter's perceptions of a mode's attractiveness. These include characteristics of the household (e.g., income), of the employee (e.g., age), and of the work site (e.g., surrounding land use). Since the emphasis of this study is on workplace incentives to use an alternative mode, it is hypothesized that the presence of such incentives exerts an influence that can be measured. Although Exhibit A-1 lists all variables on the calibration file, the project's schedule did not permit the testing of all possible variables. Experience with other mode choice models and the results of the early tests suggested appropriate directions for subsequent calibration runs.

A.3.2 Calibration Software

The microcomputer program ALOGIT (version 3.2), developed by the Hague Consulting Group, was used to calibrate the logit model. ALOGIT reads an ASCII calibration data file and a proposed model specification as input. It then calculates the coefficient values that best fit the data and provides numerous evaluation statistics to indicate how good the fit is. ALOGIT is a fast program that is not difficult to use once the calibration data file has been prepared. The calculation of the coefficient values is based on maximizing the likelihood function. The likelihood function is the estimated probability that the mode that the traveller actually used would be the mode chosen.

ALOGIT does not, however, automatically find the "optimum" model from the data. The user must apply considerable skill and experience in hypothesizing a model structure (i.e., a set of modes, variables, and coefficient definitions). In this study, extensive use was made of SAS survey crosstabulations to suggest relationships between variable values and observed mode usage. ALOGIT then merely indicates how well a particular model fits the observed data. The analyst must use his own judgement to compare successive calibration runs in terms of the evaluation statistics and logic of the relationships. Thus, model calibration in ALOGIT is a sophisticated trial-and-error process.

Three tests examine the significance of a variable in influencing the choice of travel mode. The first is simple inspection of the sign of the variable's coefficient. If the sign produces a counter-intuitive result, then the model must be modified, usually by eliminating the offending variable. An example of a counter-intuitive result is a positive coefficient on transit fare – this would suggest that higher fares lead to greater use of transit.

The second test indicates the degree to which we are certain that the variable indeed plays a role in mode choice behavior. This test uses the t statistic, which is defined as the coefficient divided by the coefficient's standard error. For t values above 2.0, there is a 95% chance that the variable is a significant determinant of mode choice. As a coefficient's t value drops below 2.0, the uncertainty associated with it increases. Coefficients with t values below 1.0 are usually dropped from the model unless there is compelling evidence that suggests they should remain.

The third test examines the change in the *likelihood statistic*, which is an indicator of the overall improvement in the explanatory power of one model compared to another. The best possible value for this statistic would be zero, which would represent a model that perfectly predicts the choice actually made by each commuter in the calibration file. This objective is unattainable, so all models generate negative likelihood values. Better models have algebraically larger likelihood values (i.e., closer to zero). (The negative values make it important to remember that -1 is a *larger* number than -2.)

By itself, the likelihood statistic has no units and no physical meaning. Consequently, this statistic is used only in a relative sense to compare one model to another and to compare a model to a "base" model composed of only modal constants.

In addition to meeting these statistical criteria, this analysis specifically sought to include as many TDM incentive variables as possible, because the explicit purpose of this mode choice model is to examine the effects of TDM incentives. The sign and magnitude of these coefficients were critically examined to ensure that they would produce reasonable results.

A.3.3 Calibration Procedure

As noted above, the analyst must hypothesize one or more initial models, apply ALOGIT, review the results, and decide how to proceed from there. Experience suggests that it is best to start with a "small" model (i.e., one with few variables) and then add variables in specific increments until the desired results are achieved. In this project, groups of variables were added according to the following hierarchy:

1. Transportation System Variables: travel time, travel cost, parking cost
2. Employee Variables: occupation, gender, age, etc.
3. Household Variables: vehicles per licensed driver, income, etc.
4. Workplace Variables: SIC Code, land use, parking spaces/employee, etc.
5. TDM Incentives: carpool preferential parking, guaranteed ride home, bus pass sales on-site, etc.

The procedure began with the variables describing the transportation system: the time and cost for the employee's commute trip. The differences between auto and transit time and cost are used in almost all urban mode choice models and are traditionally major factors in determining mode use. Most recent models have also found that variables describing the traveller (the employee) and the traveller's household affect the way in which different modes are perceived. For example, wealthy travellers tend to be less influenced by cost than poor travellers. Workplace characteristics have generally not been included in many mode choice models, mainly because little information is available on them (most mode choice models are calibrated using a home interview survey). However, analysts are starting to recognize that attributes of the workplace can have a direct influence on employee mode choice. Nationwide, only one or two other mode choice models have attempted to incorporate specific TDM incentives, because so few employers offer such incentives. However, with the increasing number of jurisdictions having Employee Trip Reduction (ETR) or Employee Commute Option (ECO) ordinances, more attention will be paid to this issue in the future.

A.4 Calibration Results

A.4.1 Candidate Models

Seventeen major model types were examined and several variations on each type were tested, leading to more than 100 ALOGIT runs. Table A-2 presents the results, focusing on the best model within each major type. As this table shows, the likelihood value became larger (less negative) with each successive model, indicating constant improvement. Although the ρ^2 values may appear to be low in comparison to the traditional r^2 statistic, the final value is within the range of previously calibrated logit models.

The substantial increase in ρ^2 for model 022 reflects the importance of the traveller's socioeconomic status (here, measured as income level), which has been confirmed by most other mode choice models. However, model 052 indicates that the employee's occupation category is a better measure of status than income level or car ownership (obviously, all three are somewhat correlated). This is a rather unusual outcome, and suggests that there is something inherent in certain job types, apart from income, that influences mode choice. For example, "managers" rarely use transit, whether they are a corporate CEO or a supervisor of a loading dock.

Models 063 and 073 indicate that other characteristics of the employee and his household are significant influences on mode choice, which is not surprising. For example, having only one worker in the household logically tends to reduce the opportunity to carpool. The noticeable improvement for model 162 resulted from testing numerous TDM incentives, both individually and in combinations. In addition, earlier runs had tested imposing various constraints on the coefficient values. When most of these were released, the model's performance improved dramatically.

The calibration was also tested both with unweighted data (each survey record represents one trip) and weighted data (each survey record represents approximately 5.5 trips, weighted to provide the modal distribution shown on the right side of Table A-1). The unweighted runs tended to produce more sensible results, which is consistent with the experience of other mode choice model projects.

A.4.2 Final Model

Model 172 is the final model resulting from the calibration effort. This model has excellent calibration statistics and was judged to include a very useful set of variables and reasonable coefficient values. Table A-3 presents this model. The following sections offer some observations about these values.

A.4.2.1 Transportation System Variables

The time and cost coefficients are similar to those of other mode choice models, as shown in Table A-4. The lower coefficients on transit in-vehicle time (IVT) and out-of-vehicle time (OVT) compared to auto suggest that travel time is a less important influence on transit use. Conversely, the higher coefficient on transit fare compared to auto operating cost indicates that fare is relatively more important to potential transit users. As can be seen from Table A-4, the TDM Model's time and cost coefficients generally fall within the range of coefficients from logit mode choice models in other urban areas. The only exception is that the coefficient on transit in-vehicle time is below any of those of other areas. This may reflect the more dispersed nature of the Los Angeles metropolitan area, which leads to somewhat longer transit travel times.

The bike/walk time coefficient is higher than the auto in-vehicle time value, which is logical, since the time spent walking or biking should be more onerous than driving. This coefficient would probably be even higher, if it were not for the fact that bikers and walkers are, as a practical matter, limited to short distances from the work site. The parking cost coefficient is 2.5 times the auto operating cost coefficient, indicating that motorists are more sensitive to parking cost than auto operating cost (gas, maintenance, etc.). It is fairly common for the parking cost coefficient to be approximately twice as high as the operating cost coefficient.

One measure of the coefficient values is the ratio of the time coefficient to the cost coefficient. This ratio (for the auto modes) is 11.7, implying that 11.7 cents is equivalent to 1 minute, in terms of the influence on mode choice. The average annual household income of the surveyed respondents is $54,300, which is equivalent to 43.5 cents/minute. Thus, the implied value of travel time is 27% of the average income (= 11.7/43.5). This ratio is typically within the range of 25-35%, and so 27% is an acceptable value.

One anomaly in the TDM Model's coefficients is the ratio of the OVT coefficient to the IVT coefficient. Typically, this is 1.5 to 3.0, with values around 2.0 most common. In this project, the survey data suggested that OVT is no more important than IVT in influencing mode choice. Because this is a rather unusual outcome, it was decided to fix the OVT coefficient at 1.5 times the IVT coefficient. This is a commonly used procedure.

Table A-2
Calibration Results

Model No.	Description	Likelihood Value	ρ^2	Significant Improvement?
018	basic time and cost	-2255.1	0.064	—
022	low income on CP and VP	-2224.2	0.077	yes
033	0 cars on TR and BW	-2230.7	0.074	yes
041	low income on CP, TR, high income on VP	-2215.4	0.081	yes
052	occupation category on CP and TR	-2190.3	0.091	yes
063	elderly; work schedule type; gender	-2157.7	0.105	yes
073	1 worker/HH on CP; marital status on VP	-2113.5	0.123	yes
083	land use type; no. of retail land uses	-2074.7	0.139	yes
09B	TDM financial incentives	-2038.8	0.154	yes
105	TDM incentives	-2042.6	0.152	yes
111	different coefficient on transit fare and auto cost	-2038.3	0.154	no
126	TDM marketing effort	-2022.4	0.161	yes
134	TDM incentives	-2013.5	0.164	yes
147	TDM incentive packages (combinations)	-2002.1	0.169	yes
15A	TDM incentive packages	-2020.5	0.162	yes
162	TDM incentive packages	-1960.4	0.186	yes
172	TDM incentive packages	-1969.2	0.183	yes

Notes:

ρ^2 ("rho-squared") is a statistic derived from the likelihood values. It is defined as:

$$\rho^2 = \frac{\text{Likelihood (this model)}}{\text{Likelihood (base model)}} \quad (3)$$

Where the "base" model is a model that includes only mode-specific constants. That model predicts that the chance that each commuter will choose a mode equals that mode's share of the overall market. For example, Drive Alone was chosen by 61.2% of the unweighted survey respondents. Thus, this base model would estimate that *each* individual commuter has a 61.2% chance of driving alone. Although this is not a realistic model, it does serve as a reasonable basis of comparison for the other candidate models. The ρ^2 formula is similar in appearance and interpretation to the r^2 statistic used in regression analysis, although its calculation is entirely different (hence the use of ρ instead of r).

The "Significant Improvement?" column is based on a statistical comparison of the change in Likelihood Values of successive candidate models. Each successive model should produce a significant algebraic increase in the Likelihood Value. If the change is large enough, the new model is a true improvement over the previous one. The statistical test is to calculate a *likelihood statistic* which is equal to twice the likelihood change between two models. That value is then compared to a critical value obtained from the χ^2 (chi-squared) distribution for a confidence level of 95%. The degrees of freedom is calculated as the difference in the number of coefficients between the two models. The critical value increases with the number of additional coefficients, so that a larger improvement is necessary when several variables are added to the model.

Modal abbreviations: CP = carpool, VP = vanpool, TR = transit, BW = bike/walk.

A.4.2.2 Employee and Household Variables

Usually, either income level or auto ownership is used to represent the socioeconomic status of the traveller. In this model, both indicators were tested, but slightly better results were achieved by using the occupation class of the respondent. This suggests that there is an element of an individual's status that is related to occupation that goes beyond his income or auto ownership level.

Other characteristics of the employee are reflected in the model. One is that men are much more likely to walk or bike to work than women. It is unclear if there is a true behavioral reason for this or whether it is just reflective of this particular sample, but the effect is unmistakable. It is also clear from this data that elderly employees (defined here as age 60 and above) do not particularly like to drive alone and other things being equal, prefer to use transit.

Certain types of work schedules have logical associations with mode choice as well. Employees who must make midday business trips (e.g., to call upon clients) are inclined not to carpool, which seems obvious. Employees who work staggered hours or are on a part-time schedule are inclined to use transit. Staggered hours may provide more flexibility to adapt one's work hours to transit schedules, while the part-time effect may be associated with lower income levels.

Of the various household variables, the presence of only one worker in the household had a strong negative association with carpool use. This is logical, since some surveys indicate that many carpools are composed of persons living in the same household. Similarly, being married is associated with increased vanpool use. This may reflect the need to leave an auto at home for the spouse's use.

A.4.2.3 Work Site Variables

The physical attributes of the work site did not exert a strong influence on modal use. This could be because after accounting for the characteristics of the trip, the tripmaker, and the tripmaker's family, there isn't much additional effect to be explained. Still, a few such variables remain in the model. The number of parking spaces per employee is negatively associated with transit use, although the association is statistically weak. Nevertheless, the relationship is sensible: the fewer spaces there are per employee, the more difficult it is to find a space, and the more likely employees will be to use transit. The type of development at the work site also has an influence: if the work site is in a suburban activity center or a campus or institutional setting, employees are less likely to carpool. This is probably because the lower density of trip ends makes it more difficult to match rides. Finally, the number of different nearby retail land uses (restaurant, video store, convenience store, dry cleaner, etc. within $^1/_2$ mile) was a positive influence on carpooling and transit use. Apparently, if employees can run midday errands on foot, they are less likely to need an auto at work and are thus more likely to use an alternative mode.

Table A-3
Final Mode Choice Model

Variable	Drive Alone	Carpool	Vanpool	Transit	Bike/Walk
Mode-Specific Constants		-1.517	-7.070	-3.048	-2.135
Transportation System Variables					
In-Vehicle Time	-0.0399	-0.0399	-0.0399	-0.0110	
Out-of-Vehicle Time				-0.0165[a]	-0.0441
Operating Cost, Fare	-0.0034	-0.0034	-0.0034	-0.0061	
Parking Cost	-0.0086	-0.0086	-0.0086		
Bike Lanes?					1.220
Employee Variables					
Laborer?		0.3999		0.9367	
Professional?		-0.2666	0.9054		
Manager?				-1.064	
Gender (1=male)					0.8727
Elderly?		0.5262	0.4355[b]	0.9089	
Midday Business Travel?		-0.7745			
Staggered Work Hours?				0.8148	
Part-time Worker?				0.5377[b]	
Household Variables					
1 Worker/HH?		-1.027			
Employee Married?			0.9944		
Work Site Variables					
Parking Spaces/Employee				-0.4155[b]	
SAC/Campus/Inst. LU?[d]		-0.8150			
No. of Adjacent Retail Land Uses		0.1069		0.1069	
TDM Incentives					
Transportation Coordinator AND Rideshare Matching Program		0.0777[c]	0.0777[c]		
Preferential Parking for Ridesharers		0.1214[b]	0.1214[b]		
Transit Info. Center AND Bus Pass Sales				1.083	
Bike Racks OR Showers/Lockers					0.4056[b]
Guaranteed Ride Home		0.4476	0.4476	0.4476	0.4476
Modal Subsidy		0.0125	0.0125		0.0125
Prizes, Free Meals, Certificates[e]		0.0826	0.0826	0.0826	
Use of Company Vehicles by Poolers		0.7861	0.7861		
Company-Provided Vans			2.586		

Notes:
a Value constrained to equal 1.5 times the in-vehicle time coefficient.
b Coefficient value statistically significant at the 80% confidence level.
c Coefficient value not statistically significant at the 80% confidence level.
d Is work site a Suburban Activity Center, Campus, or Institutional land use?
e Coefficient derived from other sources.
Unless otherwise noted, all coefficients are statistically significant at the 95% confidence level.
Negative coefficients mean that increasing values of the variable are associated with lower use of the mode. Positive coefficients mean that increasing values of the variable are associated with higher use of the mode.
Variables shown with a question mark are binary variables, with values: 0 = No, 1 = Yes.
All times are in minutes; all costs are in cents (1992 dollars).

Table A-4
Comparison of Time and Cost Coefficients

Urban Area	In-Vehicle Time*	Transit Out-of-Vehicle Time	Auto Operating Cost	Transit Fare	Parking Cost
TDM Model	-0.0399	-0.0165	-0.0034	-0.0061	-0.0086
Atlanta (suburbs)	-0.0145	-0.0488	-0.0037	-0.0037	-0.0079
Cincinnati	-0.019	-0.028	-0.004	-0.004	
Dallas	-0.030	-0.055	-0.0050	-0.0050	-0.0120
Minneapolis-St. Paul	-0.031	-0.044	-0.014	-0.014	
New Orleans	-0.0145	-0.0332	-0.0078	-0.0078	-0.0214
Phoenix	-0.0145	-0.0769	-0.0078	-0.0078	
San Francisco	-0.025	-0.058	-0.003	-0.003	
Seattle (1977)	-0.040	-0.044	-0.014	-0.014	-0.012
Seattle TDM (1991)	-0.0170	-0.0340	-0.0021	-0.0021	-0.0043
Washington, D.C.	-0.0173	-0.0583	-0.0035	-0.0044	-0.0094

* For the TDM Model, the auto in-vehicle time coefficient is shown. The transit in-vehicle time coefficient is -0.0110.

Note: the similarity of some of these coefficients is not coincidental. Some of these models were calibrated from survey data, while others were created by adapting model coefficients from other cities. For example, the Phoenix coefficients are derived from those of New Orleans.

Source: Various model calibration reports.

A.4.2.4 TDM Incentives

Exhibit A-2 at the end of this Appendix defines the TDM incentives that are included in this model. About the only general comment that can be made about these incentives is that they all have the proper sign: the presence of each incentive does tend to increase the use of the mode which it is intended to. Obviously, the relative influence of each incentive is related to the size of the coefficient. The fairly large coefficient on company-provided vans should be viewed with some caution – only one employer in the survey actually provided vans to its employees, and so this coefficient is based on a limited number of observations.

The coefficient on guaranteed ride home (0.4476) is very similar to that of the Seattle TDM model (0.4038) (the Seattle TDM model is the only other recent mode choice model which explicitly includes coefficients for TDM incentives). Unfortunately, the other incentives are defined differently in the Seattle model, making any further coefficient comparisons all but impossible.

The TDM incentive coefficients must also be viewed in terms of employees' awareness that such incentives exist. The coefficient values in Table A-3 assume that employees are completely familiar with these incentives. However, the results of the surveys indicate that this is a poor assumption. As a result, it is necessary to discount the coefficients by including a factor that represents the proportion of employees who are offered the incentive *and* who are aware that the incentive exists. This is discussed further in Section 5.

A.4.2.5 Validation

Table A-5 presents a comparison of observed and estimated trips by mode. This indicates the model provides a good overall fit to this data. Of course, given the use of modal bias constants, this result (in total) is to be fully expected. The more difficult test of a model's fit comes when a similar comparison is made, stratified by values of *exogenous* variables (independent factors that are not directly represented in the model). Such comparisons are shown in Table A-6.

Table A-5
Observed/Estimated Comparison

Travel Mode	Observed Trips	Estimated Trips
Drive Alone	1,434	1,433.3
Carpool	580	580.0
Vanpool	127	127.3
Transit	119	119.4
Bike/Walk	81	81.0

The stratified comparisons also indicate very close correspondence between observed and estimated trips by mode. The only anomaly is that transit trips by low income commuters are overestimated, while they are underestimated for high income commuters. This suggests that it might have been productive to further investigate income level as a descriptor of the traveller's "wealth". The comparisons by workplace ZIP Code reveal no major differences.

A.4.3 Sensitivity Analysis

The coefficients of a mode choice model should be examined to see if they exhibit an acceptable degree of sensitivity, that is, if the model produces approximately the results that the experienced observer might expect. One good way to do this is to apply the model in *pivot point* fashion (see more on this below) to estimate the effects on mode share of various hypothetical changes in commuting conditions.

In order to apply the model in pivot point fashion, the starting mode share must be known or assumed, some changes in the variable of interest must be hypothesized, and the logit coefficient for that variable must be known. Table A-7 presents six tables with the results of such an analysis.

In each table, a range of starting mode shares is shown along the left side. These range from 1 to 30%. Along the top of each table is shown some changes to a commuting variable. The first table tests various increases in the cost of parking for commuters who drive alone. This suggests that it would take a $2.00 per day increase in parking cost to cut the drive alone share in half. The second table tests decreases and increases in the number of parking spaces per employee. The model is not extremely sensitive to this variable, probably because there is a correlation between the availability and the cost of parking, and the model assigns much of the mode choice effect to the cost.

Table A-6
Stratified Observed/Estimated Comparisons

Variable	Ridesharing Trips Observed	Ridesharing Trips Estimated	Transit Trips Observed	Transit Trips Estimated	Bike/Walk Trips Observed	Bike/Walk Trips Estimated
Trip Distance (miles)						
4.9 or less	138	128	26	25	65	67
5.0 - 9.9	152	158	41	34	14	13
10.0 - 19.9	207	212	32	36	2	1
20.0 - 29.9	70	76	13	12	0	0
30.0 or more	140	133	7	12	0	0
Annual Household Income						
$24,999 or less	115	114	56	31	22	20
$25,000 - 49,999	204	194	22	32	26	26
$50,000 - 74,999	185	187	19	26	17	16
$75,000 or more	203	212	22	30	16	19
Workplace ZIP Code						
90xxx (L.A.)	391	388	65	68	35	42
91xxx (L.A.)	125	129	29	20	11	10
92xxx (L.A.)	48	59	9	8	10	6
956xx (Sac.)	34	37	2	4	4	6
958xx (Sac.)	109	95	14	19	21	17

Table A-7
Sensitivity Tables

Variable: Parking Cost   Coefficient: -0.0086

Original Share	New Drive Alone Share for Parking Cost Increase (cents/day) 10	25	50	75	100	150	200
1.0%	0.96%	0.90%	0.81%	0.73%	0.65%	0.53%	0.43%
2.5%	2.40%	2.25%	2.03%	1.82%	1.64%	1.33%	1.07%
5.0%	4.80%	4.51%	4.07%	3.67%	3.31%	2.69%	2.18%
7.5%	7.21%	6.79%	6.14%	5.55%	5.01%	4.08%	3.32%
10.0%	9.62%	9.07%	8.22%	7.45%	6.74%	5.51%	4.49%
15.0%	14.46%	13.68%	12.46%	11.33%	10.30%	8.47%	6.95%
20.0%	19.32%	18.34%	16.78%	15.33%	13.99%	11.60%	9.57%
30.0%	29.10%	27.79%	25.69%	23.69%	21.80%	18.36%	15.35%

Variable: Parking Spaces/Employee   Coefficient: -0.4155

Original Share	New Transit Share for Change in Parking Spaces/Employee -0.50	-0.25	-0.10	-0.01	0.10	0.25	0.50
1.0%	1.23%	1.11%	1.04%	1.00%	0.96%	0.90%	0.81%
2.5%	3.06%	2.77%	2.60%	2.51%	2.40%	2.26%	2.04%
5.0%	6.08%	5.52%	5.20%	5.02%	4.81%	4.53%	4.10%
7.5%	9.07%	8.25%	7.79%	7.53%	7.22%	6.81%	6.18%
10.0%	12.03%	10.97%	10.38%	10.04%	9.63%	9.10%	8.28%
15.0%	17.85%	16.37%	15.54%	15.05%	14.48%	13.72%	12.54%
20.0%	23.53%	21.71%	20.67%	20.07%	19.34%	18.39%	16.88%
30.0%	34.53%	32.23%	30.88%	30.09%	29.13%	27.86%	25.83%

Variable: No. of Adjacent Retail Land Uses   Coefficient: 0.1069

Original Share	New Carpool or Transit Share for Increase in No. of Retail Land Uses 1	2	3	4	5	6	7
1.0%	1.11%	1.24%	1.37%	1.53%	1.69%	1.88%	2.09%
2.5%	2.77%	3.08%	3.41%	3.78%	4.19%	4.64%	5.14%
5.0%	5.53%	6.12%	6.76%	7.47%	8.24%	9.09%	10.01%
7.5%	8.28%	9.12%	10.05%	11.06%	12.16%	13.34%	14.63%
10.0%	11.00%	12.10%	13.28%	14.56%	15.94%	17.42%	19.02%
15.0%	16.41%	17.93%	19.56%	21.30%	23.15%	25.10%	27.16%
20.0%	21.77%	23.64%	25.62%	27.71%	29.91%	32.19%	34.57%
30.0%	32.29%	34.67%	37.13%	39.66%	42.24%	44.87%	47.53%

Table A-7 (continued)
Sensitivity Tables

Variable: Preferential Parking for Ridesharers Coefficient: 0.1216

Original Share	New Carpool or Vanpool Share for New Incentive Implementation by Employee Awareness Level			
	50%	60%	70%	80%
1.0%	1.06%	1.07%	1.09%	1.10%
2.5%	2.65%	2.68%	2.72%	2.75%
5.0%	5.30%	5.36%	5.42%	5.48%
7.5%	7.93%	8.02%	8.11%	8.20%
10.0%	10.56%	10.68%	10.79%	10.91%
15.0%	15.79%	15.95%	16.12%	16.28%
20.0%	20.99%	21.19%	21.40%	21.60%
30.0%	31.29%	31.55%	31.82%	32.08%

Variable: Guaranteed Ride Home Coefficient: 0.4478

Original Share	New Carpool, Vanpool, or Transit Share for New Incentive Implementation by Employee Awareness Level			
	50%	60%	70%	80%
1.0%	1.25%	1.30%	1.36%	1.42%
2.5%	3.11%	3.25%	3.39%	3.54%
5.0%	6.18%	6.44%	6.72%	7.00%
7.5%	9.21%	9.59%	9.99%	10.40%
10.0%	12.20%	12.69%	13.20%	13.72%
15.0%	18.08%	18.76%	19.45%	20.16%
20.0%	23.82%	24.65%	25.49%	26.35%
30.0%	34.90%	35.93%	36.96%	38.01%

Variable: Modal Subsidy Coefficient: 0.0125

Original Share	New Carpool, Vanpool, or Bike/Walk Share for Increase in Modal Subsidy (dollars/month)						
	$1	$2	$5	$10	$20	$30	$50
1.0%	1.03%	1.06%	1.17%	1.36%	1.85%	2.51%	4.60%
2.5%	2.58%	2.66%	2.91%	3.39%	4.57%	6.15%	10.90%
5.0%	5.15%	5.31%	5.80%	6.71%	8.95%	11.85%	20.07%
7.5%	7.72%	7.95%	8.66%	9.98%	13.16%	17.15%	27.89%
10.0%	10.28%	10.58%	11.50%	13.18%	17.19%	22.10%	34.64%
15.0%	15.40%	15.81%	17.10%	19.43%	24.79%	31.06%	45.71%
20.0%	20.50%	21.02%	22.62%	25.47%	31.84%	38.96%	54.39%
30.0%	30.66%	31.33%	33.38%	36.94%	44.47%	52.25%	67.15%

The third table indicates that the carpool or transit share is somewhat sensitive to changes in the number of nearby retail land uses. In practice, though, it would be extremely difficult for an employer to experience a change of more than one or two retail land uses unless the employer physically relocated the work site. The fourth table predicts the effects of implementing a new program of providing preferential parking for carpoolers and vanpoolers. The values shown across the top of this table are different levels of employee awareness of this incentive (the survey data indicate that the awareness of this incentive varies generally from 50% to 80%). The fifth table shows the impact of a guaranteed ride home program at different levels of employee awareness. Not only is this incentive more effective than preferential parking, but it also affects the transit mode as well. The final table shows the estimated results for a straight modal subsidy (i.e., use the mode, get the cash). This table applies to carpooling, vanpooling, or the bike/walk modes.

These tables highlight the non-linear feature of the logit model. As the last table in Table A-7 demonstrates, the elasticity of commuters' mode choice with respect to changing conditions is not constant, but varies with the starting mode share and with the level of the change. The importance of establishing the proper starting mode share is also clear: at a starting 1% share, the $50 modal subsidy produces a 3.6% percentage point increase in modal usage (although this is almost five times the original share). But at a starting share of 30%, a $50 subsidy would be estimated to produce a 37.15% percentage point increase (but this is a proportional increase of "only" 124%).

A.4.4 Nested Logit Model

The multinomial nature of this model suggests that all five alternatives are completely separate, equally-competitive options for commuters and that there are no modal "sub-groups". Any improvement in one mode, e.g., transit, would be likely to draw commuters from each of the other modes in equal proportions. Many travel demand researchers believe that this is inaccurate, both intuitively and in practice. They suggest that travel modes are not independent, but are related in such a way that changes in one mode affect the other modes in unequal ways. For example, increases in vanpooling, for example, might be more likely to draw commuters from carpooling or transit than from driving alone. This feature of the multinomial logit model is sometimes referred to as the *independence of irrelevant alternatives (IIA)* property.

The use of the *nested* logit model is growing in popularity as a way to minimize the IIA problem. In this approach, certain travel modes are grouped ("nested") with other modes for estimation purposes. This nesting can occur two or even three layers deep. If the nests and levels are properly organized so that "like" modes (modes that are perceived to be similar) are kept together, a theoretically superior model structure is obtained that will produce results that better reflect real life.

Unfortunately, there are few examples of operational nested logit mode choice models to draw upon. Although ALOGIT can directly calibrate nested models, the time required to do so was beyond the limits of this project. This is a promising area for future research with this calibration data set.

A.5 Awareness Model

A.5.1 Concepts

A model can reflect only what commuters perceive their options to be. In other mode choice models, it is implicitly assumed that travellers accurately perceive and understand all factors which might influence their choice of mode, such as the travel times and costs for all potential modes. In practice, this is probably not true, but mode choice models are typically unable to cope with traveller perception or awareness as a variable, and so analysts tend to assume that over time, people will become sufficiently familiar with the true attributes of all modes and will make a reasonably informed choice of travel mode. While it might be acceptable to make this assumption with respect to, say, travel time, it is less clear that it is appropriate for a TDM incentive. In many cases, TDM incentives are not "hard facts", but "policies" or "programs". For example, an auto commuter can consult a bus schedule to determine the time he will likely spend waiting for and riding the bus to work. But that same commuter might not be aware that if he did ride the bus to work, his employer would sell him a bus pass at a discount and provide a taxi ride home if he missed the last bus.

This project's surveys were designed to analyze this issue by asking employers what kinds of alternative mode incentives are provided to employees and by asking employees what kinds of incentives they report having available. The tabulations of these responses suggest that there is a substantial gap between the reported reality and perception of TDM incentives, as shown in Table A-8.

Table A-8
Average Survey Awareness of Selected TDM Incentives

Incentive	Percent Awareness*
Bike Racks	55%
Bike Showers/Lockers	38
Bus Pass Discount	17
Bus Pass Sales On-Site	41
Carpool Preferential Parking	77
Company Vanpool Vehicles	67
Guaranteed Ride Home	36
Rideshare Matching	70
Rideshare Prizes	64
Transportation Coordinator	45
Transportation Fairs	15

* Calculated as the number of employees who reported having each incentive, divided by the number of employees whose employer reported providing the incentive. Excludes employees whose employer did not report providing the measure.

Research for this project and for a similar TDM study in Seattle have identified that employer-provided alternative mode incentives are not effective unless employees are *aware* that such incentives exist. The biggest improvements in AVR are invariably associated with employers who not only offer reasonable TDM incentives, but who also advertise and promote them to their employees. Note that awareness of an incentive is not the same as using it: in this context, *awareness* means only that employees know that the incentive exists. Whether or not an incentive is applicable to them and whether or not they actually take advantage of the incentive are separate matters. In the TDM Model, awareness refers to the percentage of employees who are aware that a particular incentive is being offered to them.

As Table A-8 indicates, offering an incentive is no guarantee that employees will perceive that they *have* the incentive. There are many reasons for this gap in perception, including:

- Inaccurate survey reporting by employers or employees.
- Employee misunderstanding or misinterpretation of the incentive.

- Inadequate marketing or promotion of incentive by employer.
- Employer intentionally offers incentive to only a select group of employees.
- Employee in fact knows about an incentive, but feels that it is irrelevant to his needs and thus reports not "having" it (e.g., bike racks, to someone who commutes 50 miles one-way).

Because awareness is such an important issue, it was decided to attempt to model the percent awareness for eight of the TDM incentives that were included in the mode choice model. This would be accomplished by calibrating an awareness sub-model that would accompany the mode choice model. This sub-model would be based on the same data collected for the main mode choice model. Several survey variables were examined to determine their relationship to awareness, including the number of ETR staff, number of staff hours, annual ETR marketing expenses, and annual ETR administrative expenses. It was theorized that increases in any of these variables should lead to increases in employee awareness of TDM incentives.

A.5.2 Calibration and Results

A calibration data file was assembled with one observation for each of the 45 surveyed employers. There were eight dependent variables: the reported percent awareness by employer for each of eight TDM incentives:

- transit pass sales on-site and information center
- use of company cars by ridesharers
- bike racks or showers/lockers
- guaranteed ride home
- carpool preferential parking
- rideshare matching
- company-provided vanpools
- rideshare prizes

The independent variables included the number of employees, SIC code, percent of employees by job category, annual ETR marketing cost, and annual ETR administrative cost. (Previous tabulations had indicated that the reported data for number of ETR staff hours was too unreliable for statistical analysis purposes.) Plots of the percent awareness against these independent variables indicated that annual ETR marketing plus administrative cost per employee provided the best explanation of variations in awareness and so this was selected as the primary variable. These costs include brochures, fairs, and other forms of advertising and promotion, as well as salaries, benefits, and other costs of program administration. The awareness sub-model was calibrated using linear and non-linear "least squares" fitting. In some cases separate curves are used for large and small employers, where the data suggested that this would be appropriate. A separate equation was calculated for each TDM incentive, as shown in Table A-9.

Some of these equations are linear, while some use the logit function. It is not known if there is a theoretical basis for this; most likely, it is just a matter of what happened to best fit the observed data. In two cases, there was a distinctive difference in the relationships between large and small employers and so two equations were developed. In both cases, awareness was higher (and increased at a faster rate) in the larger employers, possibly indicating greater effectiveness of the ETR marketing effort in such cases. No survey data were available for the "use of company cars by ridesharers" incentive, and so its awareness is estimated as the arithmetic average of the awareness values estimated for the other seven incentives. Special caution is urged in interpreting the equation for "company-provided vanpools", since it is based on one observation (only one of the 45 surveyed employers offered it).

Table A-9
Awareness Sub-Model

Incentive	Model Equation	
transit pass sales/info. center	$P = 0.1056 + 0.0064x$	
bike racks or showers/lockers	$P = 0.5035 + 0.0007x$	
guaranteed ride home	$P = \frac{0.78}{1 + e^{(0.7880-0.0267x)}}$	for SIC≥4800 or employees≥300
	$P = 0.0011x$	for SIC<4800 and employees<300
carpool preferential parking	$P = \frac{0.80}{1 + e^{(0.900-0.0800x)}}$	
rideshare matching	$P = \frac{0.92}{1 + e^{(0.7267-0.1149x)}}$	for employees ≥ 200
	$P = 0.2663 + 0.0015x$	for employees < 200
company-provided vanpools*	$P = 0.0047x$	
rideshare prizes	$P = \frac{0.80}{1 + e^{(0.900-0.0800x)}}$	

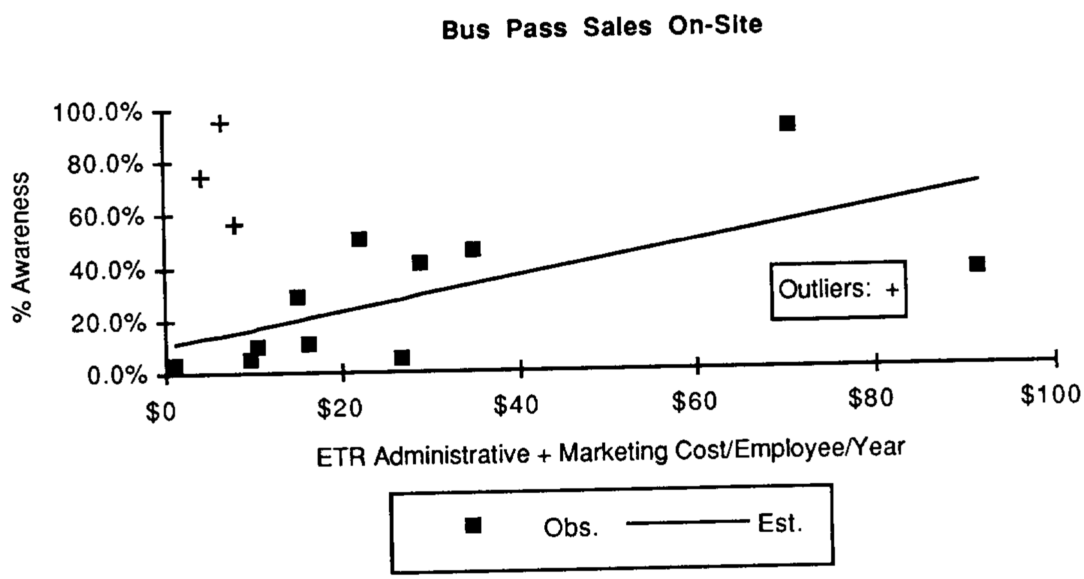
Notes:
No survey data were available on the awareness of "use of company car by ridesharers". Thus, the estimated awareness for this incentive is the arithmetic average of the awareness values calculated for the other seven incentives.
P = estimated proportion of employees who are aware of incentive (0.0 - 1.0)
x = annual ETR (marketing cost plus administrative cost) per employee
* Use with caution; based on only one observation.
Results of linear equations are capped at 0.90 (90%).

These equations produce awareness estimates that range generally from 30 to 80%. In actual application, the linear equations' results are capped at 90%, while the logit equations' results are self-limited to the value in the numerator of the right side of the equation. In the survey data, the value of the independent variable – ETR marketing and administrative cost per employee – ranged from about $1.00 to $180.00, with an average of about $32.00.

Figure A-2 presents the curves that result from six of the above equations. No curve is shown for "use of company cars by ridesharers" because no data were available. No curve is shown for "company-provided vanpools" because the equation for that incentive is based on one data point. As Figure A-2 shows, there is considerable scatter in the observed data points – none of the estimated lines can be said to adequately explain the variability in awareness to a satisfactory degree. This is because the survey probably did not capture the characteristics of employers and employees that truly influence employee awareness of TDM incentives. Indeed, it is difficult to imagine what kind of survey would be required to obtain data on all the influential factors.

Still, these curves suggest that there is at least some correlation of awareness with marketing and administrative cost per employee. This is a logical outcome and is entirely appropriate, given the scope of this model. Two important implications can be drawn from this result:

Figure A-2
Awareness Sub-Model Curves



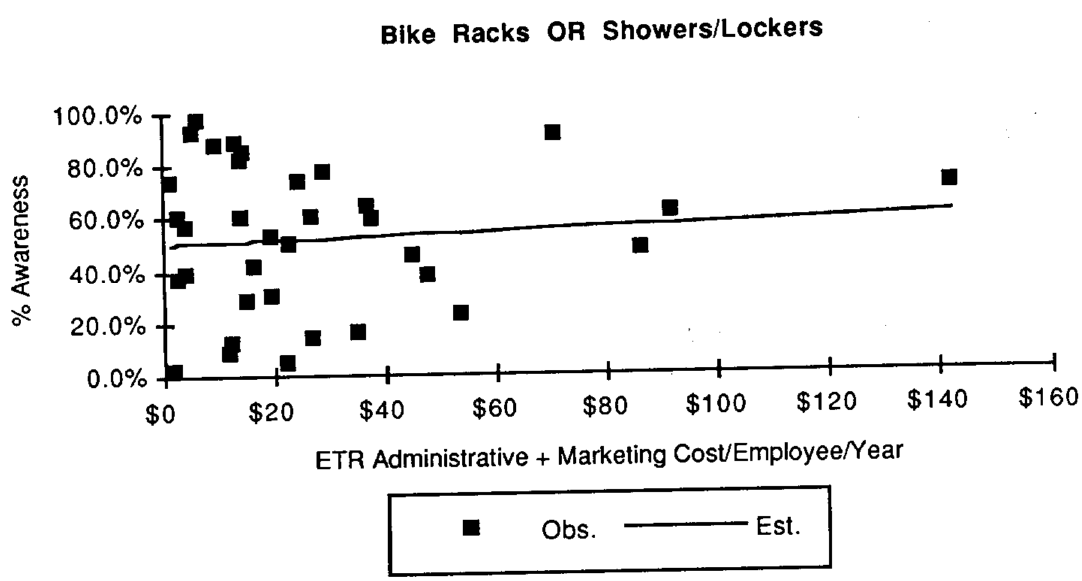
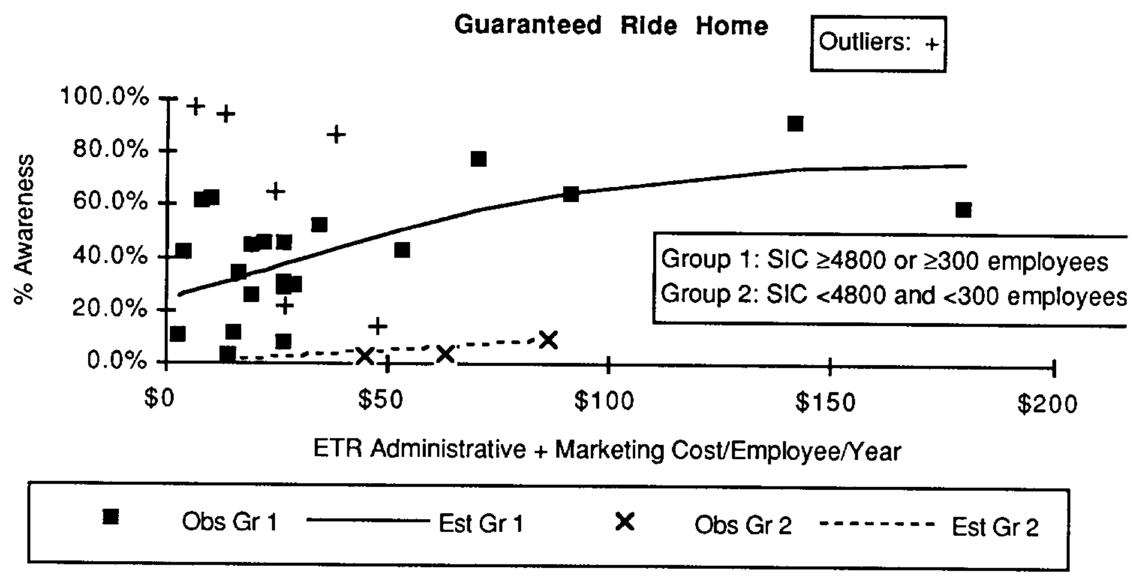


Figure A-2 (continued)
Awareness Sub-Model Curves



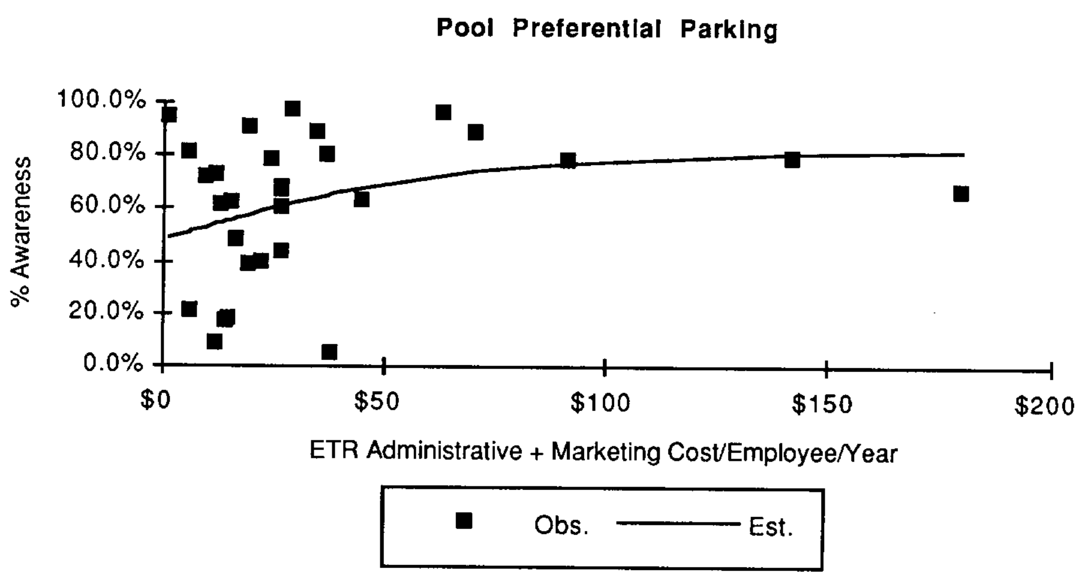
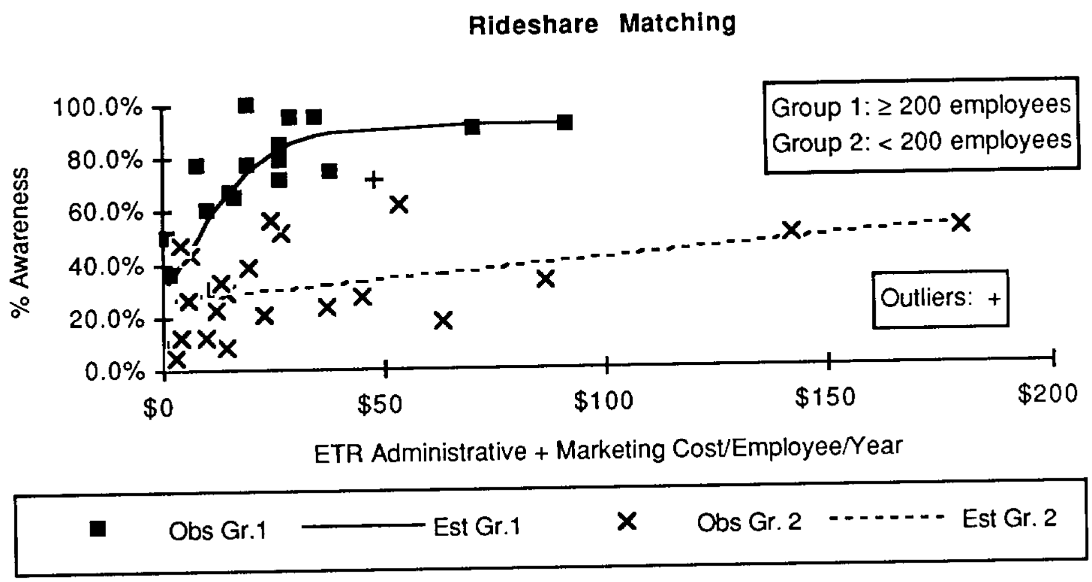
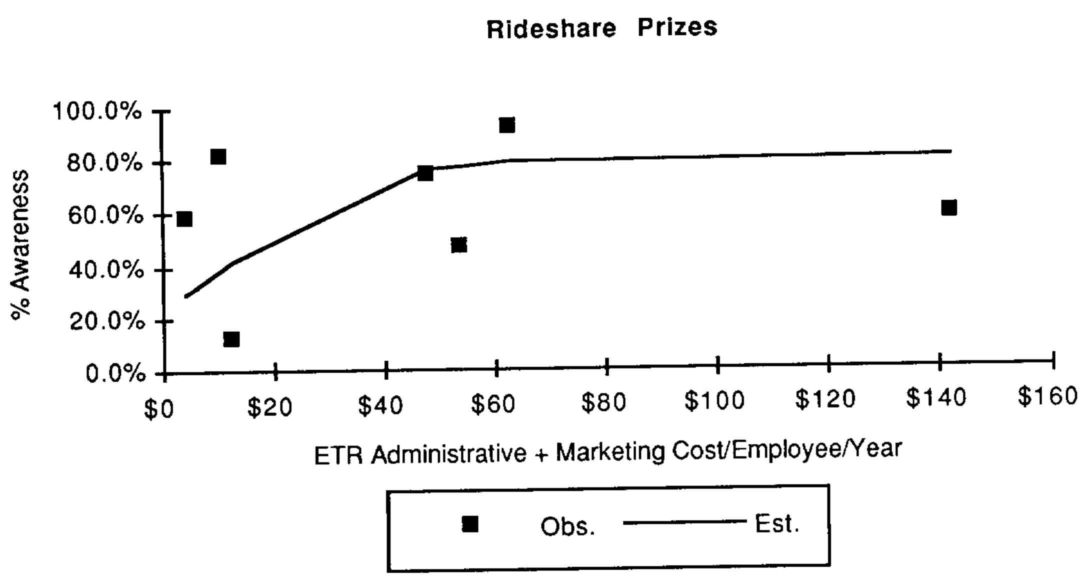


Figure A-2 (continued)
Awareness Sub-Model Curves





1) Not all employees will be aware of TDM incentives offered by an employer. The effectiveness of such incentives in encouraging commuters to use alternative modes is directly related to the degree to which employees are aware of the existence of these incentives.
2) Employee awareness of TDM incentives is a function of many complex relationships, but awareness can be logically related to the employer's effort to promote and advertise the incentives, as measured by the annual ETR marketing and administrative cost per employee.

A.6 Application Program

The previous sections of this Appendix describe the development of the mode choice model and incentive awareness sub-models. It is important to remember that a *model* is only a set of mathematical relationships, and as such, the two models are entirely described in Tables A-3 and A-9. These models can be applied with a calculator, a spreadsheet program, or a pencil and paper. However, due to the models' complexity, manual methods quickly become tiresome and so a separate piece of software called an *application program* has been written to apply the models in a simple, efficient fashion. The use of this program is documented in Appendix B: *Travel Demand Management Program User's Guide.* Those who are interested in running the application program should consult that Appendix, but some key points on the application of the model are given below.

The logit mode choice model described in Table A-3 is applied in pivot point (also called *incremental*) fashion. That is, it is not necessary to know all of the data items shown in Table A-3 in order to apply the model. Instead, the user provides a starting share for each of the five travel modes, generally from a survey representing all commute trips to a particular work site. A key benefit of the logit model formulation is that it can be used to pivot off of the starting mode shares, given absolute changes in the values of any of the variables. In this procedure, *all* of the existing characteristics of the work site are "contained" within the existing mode shares. By providing the change in value of any or all of the variables, compared to the (surveyed) base condition, the logit formula can estimate the new share of each mode that is likely to result from that change, given the starting mode shares. Remember that the TDM incentives are binary variables (1=incentive exists, 0=incentive doesn't exist). The mode choice application program also permits the user to enter changes in "hard" financial incentives (e.g., parking cost changes).

The sensitivity of the model to the variables is represented by the coefficient values. The sensitivity of commuters to the eight TDM incentives is related to their awareness of each incentive, and so the coefficients are multiplied by the awareness proportions in order to reflect the (lower) sensitivity that is associated with less than 100% awareness. This is done in two ways. First, the *change* in awareness from existing to future condition is used to give additional "credit" for any incentives that are already in place. In effect, this reflects a greater influence of existing incentives, if the employer increases his annual budget for marketing and/or administering the ETR program. Second, the forecasted awareness values are used to determine the sensitivity of employees to any new incentives that are proposed. This reflects the fact that without a substantial marketing effort, it is likely that many employees will remain unaware of new incentives, and thus their impact will not be significant.

Finally, the application program permits the consideration of alternative work hour (AWH) arrangements (telecommuting, 4 day/40 hour work week, 3 day/36 hour work week, etc.) and accounts for the possible interaction between commuting by an actual travel mode and "using" an AWH option.

Exhibit A-1
Calibration File Format

Field No.	Field Name	Field Width	Description
1	INTWNUMBER	5	employee interview number
2	COMPANYID	5	4-digit employer ID
3	Q5	3	gender (0=F, 1=M)
4	Q6	3	marital status (0=unmarried, 1=married)
5	Q7	3	age (6 categories*)
6	Q8	3	ethnic origin (5 categories*)
7	Q9A	3	children under 2 in day care? (0=No, 1=Yes)
8	Q9B	3	children 2-5 in day care? (0=No, 1=Yes)
9	Q9C	3	children in elementary school? (0=No, 1=Yes)
10	Q9D	3	children in high school? (0=No, 1=Yes)
11	Q12	3	people in household
12	Q13	3	people in household with driver's license
13	Q14	3	people in household who work outside home
14	Q15VEHICLE	3	vehicles in household
15	Q15BICYCLE	3	bicycles in household
16	Q16	3	annual household income (6 categories*)
17	HOMETAZ	5	home Traffic Analysis Zone
18	Q18	6	time arrived at work yesterday (0000-2400)
19	Q19	6	time departed from work yesterday (0000-2400)
20	Q22	3	travel mode to work yesterday (12 categories*)
21	Q22CARPOOL	3	other passengers in carpool
22	Q22VANPOOL	3	other passengers in vanpool
23	Q23	3	how arrived at rideshare or transit stop (4 categories*)
24	Q24	3	days/week usually commute to work
25	Q25	4	days/month usually commute to work
26	Q31A	3	times/week use car to drop off/pick up child
27	Q31B	3	times/week use car to shop or run errands
28	Q31C	3	times/week use car to eat lunch
29	Q31D	3	times/week use car to attend meetings
30	Q31E	3	times/week use car to conduct personal business
31	Q31F	3	times/week use car to engage in social/recreational activity
32	Q33	3	where did you park yesterday? (5 categories*)
33	Q34	3	how easy to find a parking space? (9 categories*)
34	Q35DAY	5.2	parking cost per day
35	Q35WEEK	6.2	parking cost per week
36	Q35MONTH	7.2	parking cost per month
37	Q35FREE	3	was parking free? (0=No, 1=Yes)
38	Q36	4	walk time from parking lot to building entrance (min.)
39	Q37	3	where park if usual parking space unavailable? (4 categories*)
40	Q39	3	possible to commute by transit? (3 categories*)
41	Q42	4	transit users: walk time from home to bus stop (min.)
42	Q43	4	transit users: walk time from bus stop to workplace (min.)
43	ID	7	survey ID code
44	WORKTAZ	5	workplace Traffic Analysis Zone
45	ZIPCODE	7	home Zip Code
46	SIC_CODE	6	workplace Standard Industrial Classification Code
47	DEV_TYPE	3	type of workplace land use (8 categories*)
48	BLDGTYPE	3	workplace building type (2 categories*)
49	LOC_BLDG	3	location of building on site (3 categories*)
50	IPC_WALK	3	ease of walking to bus stop (3 categories*)
51	RETAIL	3	number of retail services within 0.5 mi.†
52	LU_OFF	3	are there other offices adjacent to site?
53	LU_RET	3	are there retail land uses adjacent to site?
54	LU_RES	3	are there houses adjacent to site?
55	LU_IND	3	are there industrial land uses adjacent to site?
56	BUSROUTE	4	number of bus routes serving the site
57	BIKELANE	3	are there bike lanes or pedestrian routes nearby?
58	RIDEMTCH	3	are any kind of ridematching services available to employees?
59	RS_SUPP	3	number of ridesharing support incentives offered†
60	RS_PRPRK	3	is preferential parking offered to ridesharers?

Exhibit A-1 (continued)
Calibration File Format

61	RS_COCAR	3	are company cars available for ridesharers?
62	RS_CPSUB	3	are subsidies offered to ridesharers?
63	RS_PRIZE	3	are prizes offered to ridesharers?
64	RS_COUPN	3	are coupons offered to ridesharers?
65	RS_DOLLR	5	dollar amount of ridesharing subsidy per person
66	VANPOOL	3	number of vanpooling support incentives offered†
67	VP_START	3	is vanpool start-up assistance offered?
68	VP_ONGOI	3	are on-going vanpool subsidies offered?
69	VP_COVAN	3	does the company provide vans?
70	VP_MAINT	3	is the maintenance or insurance of vans subsidized?
71	VP_PRSNL	3	is personal use of vans allowed?
72	VP_DRIVR	3	is vanpool driver training offered?
73	VP_NUM_V	4	number of vanpool vans or routes to the site
74	TRANSIT	3	number of transit support incentives offered†
75	TR_SUBS	3	are transit user (fare) subsidies offered?
76	TR_INFO	3	is transit information (schedules, etc.) offered?
77	TR_PASS	3	are transit passes sold on-site?
78	TR_SHUTL	3	is transit shuttle service offered?
79	TR_PRIZE	3	are prizes offered to transit users?
80	TR_DOLLR	5	dollar amount of transit subsidy per person
81	BIKEWALK	3	number of bike/walk support incentives offered†
82	BIKERACK	3	are bike racks offered?
83	BIKESTOR	3	are covered bike storage areas offered?
84	BIKESHOW	3	are showers or lockers offered?
85	BIKESUBS	3	are bike/walk subsidies offered?
86	BIKECOUP	3	are bike/walk coupons offered?
87	BIKEDOLL	5	dollar amount of bike/walk subsidy per person
88	AWH	3	are any alternative work hour arrangements offered?
89	SSF	3	number of support services and facilities offered†
90	SSF_CHIL	3	is on-site child care offered?
91	SSF_GRH	3	is a guaranteed ride home offered?
92	SSF_CAFE	3	is a cafeteria/restaurant offered?
93	SSF_LNCH	3	are lunchroom facilities offered?
94	SSF_CONV	3	is convenience shopping offered?
95	SSF_BANK	3	are ATM or banking facilities offered?
96	SSF_TRCK	3	is a lunch truck offered?
97	TRANSALL	3	are transportation allowances offered?
98	MARKETNG	3	number of trip reduction incentive marketing strategies used†
99	MKT_ETC	3	is an Employee Transportation Coordinator used?
100	MKT_INFO	3	is an on-site information center used?
101	MKT_FAIR	3	are transportation fairs used?
102	MKT_NEWS	3	is a newsletter used?
103	MKT_ORNT	3	is an orientation for new employees used?
104	MKT_PRIZ	3	are prizes or drawings offered?
105	MKT_MAIL	3	are direct or targeted mailings used?
106	MKT_BULL	3	are bulletin boards used?
107	MKT_PRTY	3	are parties, rallies, or meetings used?
108	STAFF	4	number of trip reduction program staff
109	STAFF_HR	4	weekly person-hours spent by trip reduction program staff
110	MGT_SUPP	3	management support of trip reduction program (3 categories*)
111	INITIATE	6	year in which trip reduction program was initiated
112	COST_ADM	7	trip reduction program annual cost: administration
113	COST_MKT	7	trip reduction program annual cost: marketing, promotion
114	COST_SUB	7	trip reduction program annual cost: subsidies, incentives
115	COST_FAC	7	trip reduction program annual cost: facilities, capital costs
116	COST_TOT	7	trip reduction program annual cost: total cost
117	EMPLFULL	6	number of employees: full-time
118	EMPLPART	6	number of employees: part-time
119	EMPLCONT	6	number of employees: contract
120	EMPLOTHR	6	number of employees: other
121	EMPLOFFS	6	number of employees: off-site
122	MGRL	4	percent (0-100%) of employees who are managerial

Exhibit A-1 (continued)
Calibration File Format

123	PROF	4	percent (0-100%) of employees who are professional
124	TECHNICL	4	percent (0-100%) of employees who are technical
125	LABOR	4	percent (0-100%) of employees who are laborers, shop workers
126	CLERICAL	4	percent (0-100%) of employees who are clerical, support staff
127	SALES	4	percent (0-100%) of employees who are in sales
128	SKILLED	4	percent (0-100%) of employees who are skilled
129	SEMISKIL	4	percent (0-100%) of employees who are semi-skilled
130	UNSKILLD	4	percent (0-100%) of employees who are un-skilled
131	MAINT	4	percent (0-100%) of employees who are in maintenance
132	OTH_EMPL	4	percent (0-100%) of employees who are in another category
133	HOW_LONG	5.1	number of years at this location
134	PRKSRFON	5	number of parking spaces: surface, on-site
135	PRKSRFOF	5	number of parking spaces: surface, off-site
136	PRKGRGON	5	number of parking spaces: garage, on-site
137	PRKGRGOF	5	number of parking spaces: garage, off-site
138	PRKLEASE	5	number of parking spaces: leased
139	PRKPREF	5	number of parking spaces: preferential
140	PRKREST	2	do parking restrictions exist?
141	PRK_ENF	2	enforcement of parking restrictions (8 categories*)
142	PRK_ADEQ	2	is parking adequate now?
143	PRK_OTHR	2	is other parking available?
144	PRK_ONMT	2	if yes, is it on-street meters?
145	CHRG_ON	6.2	charge for on-street meters
146	CHRG_OND	3	duration of on-street meter charge (3 categories*)
147	PRK_ONFR	3	if yes, is it on-street free?
148	PRK_OFLO	3	if yes, is it off-street in a lot or garage?
149	CHRG_OFL	6.2	charge for off-street spaces
150	CHRG_OFD	3	duration of off-street charge (3 categories*)
151	PRK_OFFR	3	if yes, is it off-street free?
152	EMPL_PAY	3	do employees pay for company-provided parking?
153	PAY_SOV	6.2	if yes, monthly cost to single-occupant vehicles
154	PAY_2P	5.2	if yes, monthly cost to 2-person vehicles
155	PAY_3P	5.2	if yes, monthly cost to 3-person vehicles
156	PAY_4P	5.2	if yes, monthly cost to 4-person vehicles
157	PAY_VP	5.2	if yes, monthly cost to vanpools
158	WEIGHT	7.2	expansion factor for this trip record
159	LOVTM	5	LOV network highway time (0.1 min.)
160	LOVDS	5	LOV network highway distance (0.1 mi.)
161	HOVTM	5	HOV network highway time (0.1 min.)
162	HOVDS	5	HOV network highway distance (0.1 mi.)
163	TRNOVT	5	transit out-of-vehicle time (0.1 min.) (walk+wait+transfer)
164	TRNIVT	5	transit in-vehicle time (0.1 min.)
165	TRNFARE	5	transit fare (cents, 1992 $)
166	TRNAACC	5	auto access to transit time (0.1 min.)
167	NEWMODE	3	recoded "mode yesterday" (1=DA, 2=CP, 3=VP, 4=TR, 5=BW)
168	SPCEMP	5.2	parking spaces per employee (max. value: 3.0)
169	SENIORITY	5.1	number of years employee has been at this job
170	DRVAUTO	5.2	licensed drivers per vehicle in the household
171	INC1DUM	2	is employee from a low income household? (Q16 ≤ 3)
172	INC2DUM	2	is employee from a low-middle income household? (Q16 = 4)
173	INC3DUM	2	is employee from a high-middle income household? (Q16 = 5)
174	INC4DUM	2	is employee from a high income household? (Q16 = 6)
175	CAR0DUM	2	is employee from a 0-vehicle household?
176	CAR1DUM	2	is employee from a 1-vehicle household?
177	CAR2DUM	2	is employee from a 2-vehicle household?
178	CAR3DUM	2	is employee from a 3+-vehicle household?
179	MGRLDUM	2	is employee a manager?
180	PROFDUM	2	is employee a professional?
181	CLERDUM	2	is employee in a clerical job?
182	LABRDUM	2	is employee a laborer?
183	OTHRDUM	2	is employee in another job category?
184	PCTMGRL	4	percent of this employer's workers who are managerial (0-100%)

Exhibit A-1 (continued)
Calibration File Format

185	PCTPROF	4	percent of this employer's workers who are professional (0-100%)
186	PCTCLER	4	percent of this employer's workers who are clerical (0-100%)
187	PCTLABR	4	percent of this employer's workers who are laborers (0-100%)
188	PCTOTHR	4	percent of this employer's workers in another category (0-100%)
189	DAPCOST	5	daily parking cost per person for Drive Alone trips (1992 $)
190	OCMATCH	3	did employee report that carpool matching was offered?
191	OCOMOFC	3	did employee report that a commuter assistance office was offered?
192	OCOORD	3	did employee report that a transportation coordinator was offered?
193	OPREFPKG	3	did employee report that rideshare preferential parking was offered?
194	OPKGDISC	3	did employee report that a carpool parking discount was offered?
195	ORSPRIZ	3	did employee report that a cash prize for carpooling was offered?
196	OVANS	3	did employee report that company vanpools were offered?
197	OCPSUB	3	did employee report that a carpool subsidy was offered?
198	OVPSUB	3	did employee report that a vanpool subsidy was offered?
199	OSHOWER	3	did employee report that showers or lockers were offered?
200	ORACK	3	did employee report that bike racks were offered?
201	OBUSPOOL	3	did employee report that a buspool or subscription bus was offered?
202	OPASS	3	did employee report that transit pass sales on-site were offered?
203	OPASDIS	3	did employee report that transit pass discounts were offered?
204	OFAIR	3	did employee report that transportation fairs were offered?
205	OTELE	3	did employee report that telecommuting was offered?
206	OGRH	3	did employee report that guaranteed ride home was offered?
207	OALLOW	3	did employee report that a transportation allowance was offered?
208	ORMATCH	3	did employee report that regional ridematching was available?
209	OBLANE	3	did employee report that bike lanes were available?
210	UCMATCH	3	did employee report using carpool matching?
211	UCOMOFC	3	did employee report using a commuter assistance office?
212	UCOORD	3	did employee report using a transportation coordinator?
213	UPREFPKG	3	did employee report using rideshare preferential parking?
214	UPKGDISC	3	did employee report using (receiving) a carpool parking discount?
215	URSPRIZ	3	did employee report using (receiving) a cash prize for carpooling?
216	UVANS	3	did employee report using company vanpools?
217	UCPSUB	3	did employee report using (receiving) a carpool subsidy?
218	UVPSUB	3	did employee report using (receiving) a vanpool subsidy?
219	USHOWER	3	did employee report using showers or lockers?
220	URACK	3	did employee report using bike racks?
221	UBUSPOOL	3	did employee report using a buspool or subscription bus?
222	UPASS	3	did employee report using transit pass sales on-site?
223	UPASDIS	3	did employee report using (receiving) transit pass discounts?
224	UFAIR	3	did employee report using transportation fairs?
225	UTELE	3	did employee report using telecommuting?
226	UGRH	3	did employee report using guaranteed ride home?
227	UALLOW	3	did employee report using (receiving) a transportation allowance?
228	URMATCH	3	did employee report using regional ridematching?
229	UBLANE	3	did employee report using bike lanes?
230	DAOPCOST	5	drive alone auto operating cost (1992 $) (=distance * 14¢/mile)
231	CPOPCOST	5	carpool auto operating cost (1992 $) (=distance*14¢/mi./occupancy)
232	FLEX1DUM	3	did employee report having flex-time?
233	FLEX2DUM	3	did employee report being able to work from home?
234	FLEX3DUM	3	did employee report having a modified (4/40 or 9/80) schedule?
235	FLEX4DUM	3	did employee report having a staggered or shift schedule?
236	FLEX5DUM	3	did employee report being a part-time worker?
237	FLEX6DUM	3	did employee report having to make frequent travel to clients?
238	FLEX7DUM	3	did employee report having a set, inflexible schedule?
239	FLEX8DUM	3	did employee report not knowing if his schedule was adjustable?
240	CPPCOST	5	daily parking cost per person for Carpool trips (cents, 1992 $)
241	VPOPCOST	5	vanpool auto operating cost (1992 $) (=distance*14¢/mi./occupancy)
242	VPPCOST	5	daily parking cost per person for Vanpool trips (cents, 1992 $)
243	CPRUN	5	carpool highway time (HOV time + 1.1 min. per passenger, 0.1 min.)
244	VPRUN	5	vanpool highway time (HOV time + 1.1 min. per passenger, 0.1 min.)
245	BWAVAIL	3	is bike/walk mode available?°
246	BWTIME	5	alternative definition of bike/walk time (not used)

Exhibit A-1 Notes:

Fields whose description ends in a question mark are binary fields. If answer to question is "Yes", field value is 1; if answer is "No", field value is 0.

All fields are Numeric. Explicit decimal places are coded as shown (field width of w.d indicates a width of w total spaces with d places to the right of the decimal point). Explicit zeroes are always used (no fields are left blank).

All costs are coded in cents, in 1992 year dollars. All times are in 0.1 minutes. All distances are in 0.1 miles.

* See the survey description chapter for coding details.

† Recoded from original survey.

° Bike/walk mode unavailable if highway distance exceeds 16 miles, or if distance exceeds 10 miles and respondent either owns no bicycle or reported that he walked.

Exhibit A-2
TDM Incentive Definitions

• *Transit Information Center PLUS Bus Pass Sales*
The employer would provide a central location where employees could obtain transit route, schedule, and fare information. In addition, the employer would sell transit passes at the work site (if the employer also discounts the passes, the discount is reflected as a modal subsidy). Obviously, this is only applicable if the work site is (or will shortly be) served by a transit route. This incentive affects the transit mode.

• *Use of Company Vehicles by Ridesharers*
Employers which maintain a fleet of vehicles would make them available for use by ridesharers for midday errands, lunch trips, etc. This incentive affects all ridesharing modes (carpool and vanpool).

• *Bike Racks/Storage OR Showers and Lockers*
The employer would provide *either*: a) a place where employees could shower and change clothes after riding a bicycle or walking to work, or b) a convenient, covered place where employees who bicycle to work could store their bicycles during the day. Enough spaces must be set aside to accommodate all bicyclists. This incentive affects the bike/walk mode.

• *Guaranteed Ride Home*
The employer would provide a means of transporting employees home if they did not drive to work that day. They might need this service to return home for midday emergencies or if they are required to work late at night and miss their ride or the last bus. Usually, taxicabs or employer fleet vehicles are used for this purpose. This incentive affects all alternative modes.

• *Preferential Parking for Ridesharers*
The employer would reserve parking spaces close to the building entrance for use exclusively by carpools and vanpools. This is particularly effective if such spaces are clearly marked as being reserved, and are under cover. Enough spaces must be set aside to accommodate all ridesharing vehicles. This incentive affects all ridesharing modes (carpool and vanpool).

• *Transportation Coordinator PLUS Rideshare Matching*
One of the usual requirements of an ETR program is for employers to designate an Employee Transportation Coordinator (ETC), whose job it is to facilitate the use of alternative modes by employees. This project's research has indicated that an ETC is most effective if the employer also provides a rideshare matching program. Partial credit is not available for this incentive – both elements must be provided. This incentive affects all ridesharing modes (carpool and vanpool).

• *Company-Provided Vanpools*
The employer would provide vans to facilitate the formation of vanpools. This consists of purchasing or leasing the vehicles, and arranging for insurance and maintenance. Vanpool riders would pay a monthly fare that would cover these costs – by providing the vans, the employer is merely enhancing the convenience of vanpooling. (If the employer also subsidizes all or part of the fare, this would be reflected as a modal subsidy, as discussed above.) This incentive affects the vanpool mode.

Exhibit A-2 (continued)
TDM Incentive Definitions

• *Prizes, Free Meals, Certificates*

The employer would offer prizes, free meals, or gift certificates on a regular basis to employees who rideshare or use transit. These are assumed to be items of nominal value – if valuable items are involved, it may be appropriate to establish the cash value of the item and enter it as a financial incentive. This incentive affects the ridesharing and transit modes.