Transportation Demand Management Cost-Effectiveness Model for Suburban Employers

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Ordinances requiring employers and business complexes to reduce the number of commute trips arriving at the employment site by implementing transportation demand management (TDM) measures have been enacted in more and more cities in the last few years. Local trip-reduction ordinances are now a requirement in California to comply with the legislatively mandated Congestion Management Program. Although employers are required to comply with various ordinances, there may be little guidance provided to them other than a listing of possible strategies. This paper reports on a project performed for the City of Pleasanton, California, to develop a methodology to evaluate the cost-effectiveness of employer-based TDM measures in suburban settings. Pleasanton was the first city in the United States to adopt a comprehensive TDM ordinance, in October 1984, and has served as a model for many other communities throughout the nation. The methodology developed in this study was applied in a Lotus 1-2-3 spreadsheet-based model so that it is readily accessible to employers and staff at local agencies who may be inexperienced with using computers. Site-specific information for a given work site may be entered into the model, and the relative cost-effectiveness of up to 18 TDM measures may be evaluated. This is an extremely useful tool for employers to evaluate the potential cost-effectiveness of TDM measures. To demonstrate the use of the TDM Cost-Effectiveness Model, the model was tested for characteristics that represented a variety of suburban employers in the San Francisco Bay Area.

Many local jurisdictions throughout the United States are implementing trip-reduction ordinances (TROs) as a method to alleviate traffic congestion and improve air quality. In California, local TROs are a requirement of the legislatively mandated Congestion Management Program. These TROs are often aimed at employers in an effort to affect the commute trip, which is considered the easiest trip to influence because of its consistent origin, destination, and time of travel. Transportation demand management (TDM) measures are likely to be the key implementation tool required by the TRO or used by the employer to meet the requirements of the TRO. In addition to TROs, the Federal Clean Air Act requires that areas that are classified as severe or extreme implement an employer trip-reduction rule, which relies on the implementation of TDM measures.

Although employers are required to comply with various ordinances and rules to reduce travel to their work site, little guidance, other than a listing of possible strategies, may be provided to them. A significant amount of information is available in the transportation literature regarding the effectiveness of various TDM measures; however, employers may not know about or have direct access to this information. Of the literature that is available, the majority of the studies performed have focused on successful programs that have been implemented in urban areas and do not address cost-effectiveness. Although this information is useful to the general transportation community, it is not useful to an individual employer trying to determine what will happen at a particular work site. In addition, many employers affected by these ordinances are located outside urban centers in the surrounding suburban communities, and therefore, what will be effective for them may be quite different.

This paper reports on a project performed for the City of Pleasanton and FTA to develop a methodology to evaluate the cost-effectiveness of employer-based TDM measures in suburban settings. The purpose of this study was to provide information to employers on a site-specific basis to assist them in determining which TDM measures are the most cost-effective. The focus on suburban employers reflects the different travel-related characteristics of suburban areas as compared with most urban areas. For example, urban areas are more likely to be characterized by high employee densities and direct transit service. The TDM Cost-Effectiveness Model is an analytical tool developed in a user-friendly spreadsheet format to provide employers with a method to evaluate the cost-effectiveness of potential TDM measures that reflected their site-specific characteristics.

The suburban areas examined in the San Francisco Bay Area include a wide range of transportation service characteristics that are likely to have an impact on the effectiveness of TDM measures. Eight transportation environments were defined to represent various combinations of transportation service characteristics, such as availability of transit, employment density, and cost of parking. The combination of factors that define each transportation environment is provided in Table 1. The factors identified are those likely to influence travel behavior. Not included are factors that describe the employer, such as work force composition, although this could also be included. In a general sense, the availability of transportation service characteristics that would encourage TDM measure use decreases as the number for the transportation environment increases.

To make the methodology developed for this study transferrable to a variety of suburban communities and to ensure that it is readily accessible to employers and staff at local agencies who may be inexperienced computer users, it was

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TABLE 1 Description of Transportation Environments

	Transportation Environment							
	1	2	3	4	5	6	7	8
Bus/Shuttle Service	X	X	X		X	X		
Rail/Express Bus Service	X	X			X			
HOV Lanes	X			X			X	
Employment Density > 3,000 within 1 mile	X	X	X	X	X			
Employee Paid Parking	X	X						
Pedestrian/Bicycle Amenities	X	X	X	X	X			

applied in a LOTUS 1-2-3 spreadsheet. Fifteen employer-based TDM measures were evaluated in this study and included in the spreadsheet-based model. A description of each of the measures is provided next.

- *Commute information program.* Provision of information to employees on alternatives to driving alone, such as transit routes and schedules, ridematching services, and location of bicycle paths. Information may be posted on a bulletin board or be distributed to employees through new-employee packets, a company newsletter, or personal delivery.
- *In-house ridematching services.* Employees who are interested in carpooling or vanpooling provide information to a transportation coordinator on their work hours, availability of a vehicle, and place of residence. The transportation coordinator then matches employees who can reasonably rideshare together.
- *Transit pass subsidies.* For employees who take transit to work on a regular basis, the employer pays for all or part of the cost of a monthly transit pass.
- *Employee transportation coordinator.* The employee transportation coordinator is an individual responsible for administering and implementing the organization's commute alternatives program. These duties may be full-time or included with the individual's other duties for the organization, depending on the requirements of the program.
- *Home-based telecommuting.* Employees perform their regular work duties at home instead of commuting to the work site. The employee may telecommute full time, or commute to work on some days and telecommute on others.
- *Compressed workweeks.* Employees work their regularly scheduled number of hours in fewer days per week. The two most common forms are (a) 4/40—4 10-hr days per week and (b) 9/80—80 hr over 9 days in 2 weeks.
- *Reduction of employer-subsidized parking.* The portion of the cost of parking that is paid for by the employer is reduced, and the employee pays an increased cost for parking. The existing subsidy may be in the form of payments for the parking places to a third party (such as a parking garage) or may be included in the building or office lease.
- *Preferential parking for carpools and vanpools.* Certain parking spaces (usually those closest to employee entrances) are reserved for carpools and vanpools, parking costs are reduced for carpool or vanpool members, or both.
- *Bicycle lockers and showers.* Secure lockers or racks for bicycle storage, shower facilities, or both are provided for those who bicycle to work. These facilities could also be used by those who walk to work.
- *Guaranteed ride home.* A company-owned or leased vehicle or taxi fare is provided in the case of an emergency for employees who carpool, vanpool, or use transit.
- *Shuttle to transit stations.* A shuttle is provided for employees to nearby transit stations that are not within walking distance of the employment site.
- *Vanpool program.* A vanpool program organizes employees who live near each other into single vans for the trip to work. The employer also assists in the acquisition of the van and pays for its operating and maintenance cost.
- *Reduction of parking supply.* The number of parking spaces available to employees may be reduced by leasing fewer spaces or converting a portion of the parking lot into other uses.
- *Direct monetary incentives for use of alternative transportation.* The employer provides a monetary bonus to employees who commute to work by a mode other than driving alone.
- *Transportation allowance.* The employer provides an amount to the employee each month to be used for commute costs. The employee is also charged for parking at the work site, and the allowance usually equals this cost for parking. It is then up to the employee's discretion whether to spend the transportation allowance on parking, or to keep a portion of it by using a less expensive mode of commuting to work.

DATA COLLECTED

To provide a basis for the evaluation of employer-based TDM measures in suburban settings, a number of data collection methods were used. These included a review of the literature, an employer survey questionnaire administered to employers in suburban areas throughout the San Francisco Bay Area, and a review of existing data bases with information on employer-based programs. A brief description of each of these is provided here.

Before the development of the employer survey questionnaire and the development of the cost-effectiveness methodology, a review of local and national literature was performed. The literature review was focused on experiences of suburban employers, with emphasis placed on the reported costs and effectiveness of the implemented measures. However, most of the sources reviewed provided descriptions of successful programs and had relatively little cost information. The scarcity of cost data reported in the literature reflects

that this is a relatively new area of emphasis, although an important one. The data collected in the employer survey for this study is a significant addition to the literature on the costs incurred by the suburban employer in implementing TDM measures.

A survey was conducted of suburban employers in the San Francisco Bay Area. First, more than 100 firms with commute alternatives programs were identified to participate in the employer survey. A letter was sent to each of these firms to describe the purpose of the study and to elicit their cooperation in the employer survey. Approximately three-quarters of the firms agreed to participate, and a lengthy questionnaire was mailed to acquire characteristics of the firm and its commute alternatives program. Detailed questions regarding the costs associated with a variety of TDM measures were included. Some employers were not able to complete and return the questionnaire, and a few others were still in the process of implementing their program. For the completed surveys received, a detailed summary of the responses is provided in the report *Summary of Employer Survey Responses*. The survey results are based on the responses from 58 employers, representing a range of transportation service characteristics and employer sizes. In general, no assumptions were made about the employers who did not respond to a particular question. Most of the employers were not able to provide detailed cost information on the TDM measures that they had implemented. In follow-up conversations with the employers, it was found that the primary reason for this was that much of the cost data were not tracked separately from other operating costs. For example, the labor cost associated with providing the TDM measures to the employees was often not identified because the employer viewed this as a cost already incurred (i.e., the employee performing this function was already employed).

To supplement the data collected through the literature review and the employer surveys, two existing data bases with information on employer-based programs were reviewed. The existing programs are for areas that are a mixture of urban and suburban locations. These data bases were the South Coast Air Quality Management District's Regulation XV employer trip-reduction plan data base and the Pima Association of Governments Travel Reduction Program employer plan data base. Primarily, this information was used to provide guidance on the expected effectiveness of the TDM measures.

COST-EFFECTIVENESS METHODOLOGY

Each of the 15 employer-based TDM measures affect travel in different ways and have different cost characteristics. For these reasons, a single approach to calculating their cost-effectiveness was not adequate, and an individual set of equations was developed for each TDM measure. The characteristics that make each TDM measure unique are reflected in the variables chosen to evaluate its cost-effectiveness.

Where possible, calculations for the estimated trip reduction from the implementation of the TDM measure were developed. Unfortunately, few of the employers that responded to the employer survey were able to provide baseline information that would have allowed an analysis of the impact of the TDM measures on travel behavior. Calculations for the estimated trip reduction were developed, therefore, only for those measures for which sufficient information in the literature existed on factors that affect travel. For the remaining measures, the user must derive an estimate of the expected trip reduction outside of the model. In these cases, it is recommended that some sensitivity testing be performed on this variable. The measures for which trip reduction was calculated are the following:

- Transit pass subsidies,
- Home-based telecommuting,
- Compressed work hours,
- Reduction of employer-subsidized parking,
- Bicycle lockers and showers,
- Direct monetary incentives for use of alternative transportation, and
- Transportation allowance.

The next step was to determine the appropriate cost variables to include. First, a number of cost categories were identified to differentiate the impact of the cost variables. These categories are described next.

- *Annual labor cost.* The total amount spent on labor in a year for a TDM measure. This is a fully-burdened labor cost; that is, it includes employee benefits and other overhead costs as appropriate. Program administration costs fall into this category.
- *Annual capital cost.* The cost of capital facilities and equipment, such as vehicles purchased and bicycle lockers installed, amortized over the expected life of the facilities and equipment.
- *Annual direct operational cost.* The annual cost incurred to perform any operational tasks required for the TDM measure. An example of this type of cost is the amount spent on transit passes.
- *Annual overhead cost.* The annual overhead cost incurred for the TDM measure. For example, extending hours of operation to accommodate the longer days for compressed workweeks may result in increased energy usage for lights, computers, and the like.
- *Annual cost savings.* The annual savings that the employer may realize as a result of implementing the measure. The reduction in parking spaces that the employer leases would be included in this category.
- *Total daily cost.* This cost is calculated by summing each of the first four categories of costs, subtracting the cost savings, and dividing by the average number of work days in a year.

All of the costs are the incremental costs to the employer over those that would have already been expended. In many cases, the ability to calculate costs if the TDM measure is implemented in a variety of manners is included in the cost variables identified. For example, a company may provide a guaranteed ride home program by paying for a taxi, providing a company-owned vehicle, or providing a company-leased vehicle. Any one or a combination of these options may be evaluated, and the costs for the options not included must be set to zero.

Two measures of cost-effectiveness were estimated within the methodology: cost per daily trip reduced and cost per

peak-period trip reduced. In both of these cost-effectiveness measures, total daily cost is the cost variable used.

The results from the evaluation of each measure are independent of each other. Caution should be used in directly combining the results from more than one measure because the implementation of multiple measures may affect their total effectiveness. For example, individuals who would have participated in a vanpool program or a program to subsidize transit passes would have to choose between the two programs if they were both offered. Therefore, the net effect of implementing these two measures together would likely be less than the sum of their individual effects.

IMPLEMENTATION OF TDM COST-EFFECTIVENESS MODEL

A LOTUS 1-2-3 spreadsheet-based analytical tool was developed to make the cost-effectiveness methodology accessible to employers and staff of local agencies so that it could be applied on a site-specific level. The TDM Cost-Effectiveness Model requires only a rudimentary knowledge of LOTUS spreadsheets, and a user's guide has been developed that provides users with step-by-step instructions for operation of the model.

An important consideration in developing this model was that it not operate as a "black box," that is, that the user does not input values and receive results without access to any of the intermediate steps. The model takes the user through a series of steps that includes viewing any intermediate results and allows the user to view the components of individual calculations. This approach has the following advantages:

- The user is aware of the impact of any assumptions made;
- Each step in the methodology may be followed by the user;
- It is possible to review intermediate results to verify their reasonableness; and
- A more sophisticated user may review the calculations and assumptions and modify them to make them even more site-specific, if so desired.

An additional advantage of the spreadsheet-based model is that it makes sensitivity testing relatively simple. When new data are input into the model, it takes only a few seconds for results to be calculated. The user can easily and quickly perform sensitivity testing by varying one or more variables in the model and viewing the change in results.

To operate the model, the user first inputs descriptive information about the transportation characteristics of the areas being analyzed by selecting one of the eight transportation environments and entering characteristics that affect many or all of the TDM measures (e.g., total number of employees, percent of commute trips in the peak period). For each of the characteristics, referred to as spreadsheet-wide defaults, the user has the choice of using default values included in the model or entering site-specific values. The default values were estimated on the basis of the literature review and employer survey and included in the model so that employers without extensive data available can still make use of this model. For each of the 15 TDM measures, the user must input a number of variables, some of which have defaults specified. With this input, the cost-effectiveness of the TDM measure may be calculated. A summary of the procedure followed in the model is illustrated in Figure 1, and an example of the inputs required and the results for the TDM measure Transit Pass Subsidies is provided in Figure 2. The results reported by the model are as follows:

- Reduction in daily trips,
- Reduction in peak-period trips,
- Average daily cost,
- Cost per daily trip reduced, and
- Cost per peak-period trip reduced.

The model has been designed so that it may be revised easily. As more suburban employers implement TDM measures and document their results, it may be desirable to update the equations and default values included in the TDM Cost-Effectiveness Model. Changes of this sort could easily be made without altering the general structure of the model. To the user, there would likely be no difference in model operation.

SAMPLE APPLICATION

Using the data collected on suburban employers and the costs associated with TDM measures, the TDM Cost-Effectiveness Model was used to evaluate each of the 15 TDM measures. The findings presented in this section are for a base model

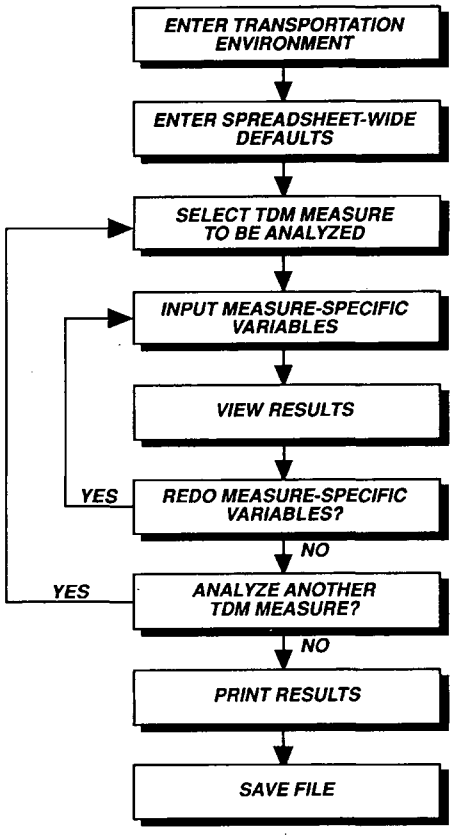

FIGURE 1 TDM cost-effectiveness model procedures.

TDM #3 Transit Pass Subsidies		
Is this TDM measure:		
- appropriate for the transportation environment		Yes
- being evaluated in this run? (Yes=1, No=0)		1
User-Defined Inputs		
percent of employees that currently use transit		3.1%
reduction in leased parking spaces		2
annual program administration cost		$2,250
monthly transit pass subsidy		$30.00
number of pass subsidies provided		16
Inputs With Default Values		
annual overhead cost of program accounting		$0
Default Value	$0	
User Override	$0.00	
cost of a monthly transit pass		$30.00
Default Value	$30.00	
User Override	$0.00	
% of employees offered transit subsidy		100.0%
Default Value	100.0%	
User Override	0.0%	
% of transit ridership that equals the trip reduction		80.0%
Default Value	80.0%	
User Override	0.0%	
Cost-Effectiveness of TSM Measure		
$/daily vehicle commute trip reduction		$4.63
$/peak-period vehicle commute trip reduction		$5.79
Travel Calculations		
average daily reduction in vehicle commute trips		6
Cost Calculations		
annual labor cost		$2,250
annual capital cost		$0
annual direct operational cost		$5,686
annual overhead cost		$0
annual cost savings		$911
average daily cost		$28

- Cells for User Input

FIGURE 2 Sample TDM measure inputs and results.

alternative that was defined using as inputs average values obtained from the employer survey to represent a suburban employer in the San Francisco Bay Area. These values may vary significantly from one employer to the next; therefore, it is recommended that these results be used to demonstrate the application of the model and to describe issues that arise in the analysis of the cost-effectiveness of employer-based TDM measures. To determine which measures to implement, the model should be applied for the specific site that is developing a commute alternatives program.

The base model alternative is referred to as Alternative 1A. The specification of the TDM measures for Alternative 1A combined the use of values obtained from the surveys, default values, and estimations of the likely impact of the TDM measures on travel. In general, values other than the default values were only used if there was some evidence obtained from the employer survey. A general description of each TDM measure evaluated for Alternative 1A is provided next. These descriptions are not meant to be representative of the preferred or likely measure as actually implemented.

- *Commute information program.* The program includes the development and dissemination of written materials describing alternative commute modes for traveling to work. As a general estimate, the program is assumed to encourage 5 percent of the employees to use an alternative commute mode. A general assumption used throughout the TDM measures, unless stated otherwise, is that the reduction in leased parking spaces is one-quarter of the average daily reduction in vehicle commute trips, or one-half of the number of vehicles that arrive at the work site. This assumes that employers are likely to be cautious about reducing the amount of parking available.
- *In-house ridematching services.* A computer-based ridematching service in which individuals interested in carpooling or vanpooling submit information on their residence location, work start and end times, and other factors. The average daily reduction in vehicle commute trips was calculated assuming that 10 percent of the employees would be encouraged to rideshare, and that the average size of the carpools and vanpools would be 2.5 persons per vehicle. Therefore, the reduction in trips accounts for the fact that trips are still made by the carpool and vanpool vehicles.
- *Transit pass subsidies.* Provision of a $30 per month transit pass subsidy to all employees by an employer with a current transit share of 3.1 percent. For this program, a cost is incurred for all transit pass users, not just new transit riders.
- *Employee transportation coordinator.* The provision of an individual in the organization whose responsibility it is to coordinate all TDM activities.
- *Home-based telecommuting.* Employees are allowed to work at home 1 day a week. This measure is offered to all employees, and, based on the participation rates in the employer survey, 4.6 percent of the employees participate in the program. It is assumed that the employee is provided with computer hardware and software and that telecommunications are paid for by the employer.
- *Compressed work hours.* For this alternative, employees are allowed to work 4 10-hr days each week and have the fifth day off from work. This measure is offered to all employees and, based on the results from the employer survey, 23.3 percent of the employees participate in the program. Because these employees are now at work for 11 hr a day instead of 9 hr, assuming 1 hr for lunch, the commute trip either to or from work will occur outside the peak period.
- *Reduction of employer-subsidized parking.* The monthly subsidy provided by the employer for parking is the difference between the monthly cost of leasing a parking space and the amount that the employee pays per month for parking. For this alternative, the subsidy is removed and all employees are required to pay $40 a month for parking.
- *Preferential parking for carpools and vanpools.* Parking spaces near the entrances to the building are reserved for carpools and vanpools, and signs are installed indicating this restriction. The average daily reduction in vehicle commute trips was calculated assuming that 8 percent of the employees would be encouraged to rideshare and that the average size of the carpools and vanpools would be 2.5 persons per vehicle.
- *Bicycle lockers and showers.* For this alternative, bicycle lockers and showers are installed to encourage 1 percent of employees who commute less than 6 mi to bicycle to work. No additional costs are incurred for maintaining the lockers and showers.
- *Guaranteed ride home.* For this alternative, the employer will pay the cost of a taxicab ride home in the case of an emergency in the middle of the day or if the employee is required to work late and misses his or her bus, carpool, or

vanpool home. It is estimated that the provision of this program will encourage another 2 percent of the employees to use alternative transportation modes.

- *Shuttle to transit stations.* If the employment site is located too far from the transit station for employees to walk, the employer provides two shuttle vehicles that operate between the nearest transit station and the work site. The costs for this program include the cost of the personnel operating the shuttle, maintenance of the employer-owned shuttle vehicles, and insurance coverage. The analysis assumed that an additional 5 percent of the employees would be encouraged to use transit.
- *Vanpool program.* For this alternative, the employer provides a vanpool program for its employees that includes the administration required to organize the vanpools. For this program, the employer purchases three vans and must pay insurance coverage and maintenance for the vans. The analysis assumed that approximately 7 percent of the employees would be encouraged to participate in the vanpool program.
- *Reduction of parking supply.* For this alternative, the employer reduces the constrained parking supply by 12 spaces, either by restriping or by using the designated area for some other purpose. The one-time cost for this reduction is assumed to be $5,000.
- *Direct monetary incentives for use of alternative transportation modes.* For all employees who commute to work by any mode other than driving alone, a monthly bonus payment is provided by the employer in the amount of $35 a month.
- *Transportation allowance.* For this alternative, all employees receive monthly transportation allowances of $40 each that they may use to pay their transportation costs at their discretion. If a transportation mode is used that costs less than $40 a month, the employee keeps the difference. A parking charge is also imposed that approximately equals the $40 a month allowance.

The cost-effectiveness for each measure was estimated for all trips reduced and for peak-period trips reduced. A summary of the results calculated for Alternative 1A is provided in Table 2 and illustrated for selected measures in Figure 3. For Alternative 1A, the most cost-effective measure for all trips and for peak-period trips was the reduction of employer-subsidized parking. A key reason why this measure is cost-effective is that there is a net income to the employer as a result of collecting parking fees from those who do not participate in the measure. Also, the economic incentive to not drive alone is a strong one when employees are faced with a charge for parking. Even when this alternative was evaluated under the assumption that the employer does not pay any lease costs for parking (as described later in this paper), reduction of employer-subsidized parking is the most cost-effective measure and results in a cost savings. Of course, the political difficulty of implementing such a measure is not accounted for in this analysis, especially for a suburban employer who may have acres of parking area and would have a difficult time justifying the parking charge to its employees. Unfor-

TABLE 2 Results of Cost-Effectiveness Analysis: Alternative 1A

TDM Measure	Average Daily Cost per Daily Trip Reduced	Ranking	Average Daily Cost per Peak-Period Trip Reduced	Ranking
Commute Information Program	$0.42	7	$0.53	7
Ridematching Services In-House	-$0.23	4	-$0.28	3
Transit Pass Subsidies	$4.63	13	$5.79	13
Employee Transportation Coordinator	$5.15	14	$6.44	14
Home-Based Telecommuting	$100.87	15	$126.09	15
Compressed Work Hours	-$0.59	3	-$0.01	5
Reduction of Employer-Subsidized Parking	-$6.48	1	-$8.10	1
Preferential Parking	$0.15	6	$0.18	6
Bicycle Lockers and Showers	$4.40	12	$5.50	12
Guaranteed Ride Home	-$0.14	5	-$0.18	4
Shuttle to Transit Stations	$3.84	9	$4.80	9
Vanpool Program	$4.04	11	$5.06	11
Reduction of Parking Supply	-$0.87	2	-$1.09	2
Direct Monetary Incentives	$4.02	10	$5.02	10
Transportation Allowance	$1.01	8	$1.26	8

Note: Ranking among measures with a negative cost per trip reduced may be misleading and should all be considered highly cost-effective.

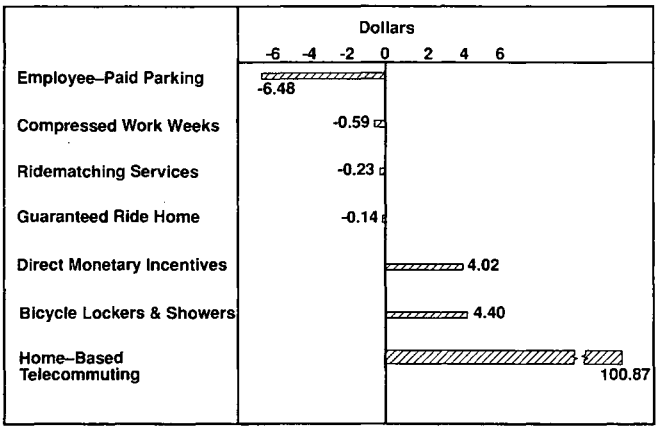

FIGURE 3 Daily cost per trip reduced: selected TDM measures.

tunately, many employees expect free parking as a benefit of their job, and it will take some cooperative effort on the part of public agencies and the employers to dispel this notion.

Four other measures were estimated to result in an overall cost savings to the employer per trip (daily or peak period) reduced. These measures were in-house ridematching services, compressed work hours, guaranteed ride home, and reduction of parking supply. Each of these measures does not require a great deal of monetary investment by the employer, and a cost savings is experienced as a result of the reduction of parking spaces that the employer must lease.

The least cost-effective measure for Alternative 1A is home-based telecommuting, for both total trips and peak-period trips. The primary reason for this is that it is assumed that a significant amount of computer and telecommunications equipment is required for the employee to telecommute, and this cost is proportional to the number of employees who telecommute. Also, only two trips a week are reduced for each employee who participates in the program. What this indicates is that telecommuting is an expensive option if significant capital investment is required; however, telecommuting would be more cost-effective if employees could work at home without a great deal of equipment-based support. As would be expected, those measures that include some sort of payment by the employer to the employee (transit pass subsidies, direct monetary incentives, and transportation allowance) are in the bottom half of cost-effectiveness rankings.

As indicated in Table 2, the relative cost-effectiveness of each of the TDM measures does not vary between daily trips and peak-period trips for those measures that have a positive cost per trip reduced. There is some difference in the ordering for the cost savings per trip reduced; however, this is misleading because it is a result of the cost savings being spread over a greater trip reduction. It should not be interpreted, therefore, that somehow compressed workweeks are more cost-effective for reducing total trips than for peak-period trips. Instead, this is an anomaly of evaluating the cost-effectiveness of measures that increase income to the employer.

The cost-effectiveness of a TDM measure would be expected to be greatly influenced by certain characteristics of the employer and of the measure as it is implemented. Various model alternatives, or scenarios, were tested in the TDM Cost-Effectiveness Model to determine the sensitivity of the cost-effectiveness estimation to different employer and TDM measure characteristics. The ability to perform sensitivity analysis on individual variables is an important and useful aspect of the model.

To test the sensitivity of the results to employer characteristics, the TDM measures defined for Alternative 1A were applied for seven other alternatives, Alternatives 1B through 1H. There were four variables that were varied among the alternatives to describe the employer, and each of these for Alternatives 1A through 1H are listed in Table 3. Alternative 1B represents an employer that is similar to Alternative 1A but that charges an average of $50 a month for parking. For this alternative, the TDM measure of reducing the employer-subsidized parking supply does not apply because no parking subsidy is offered. A smaller increase in the daily parking fee is also evaluated for the TDM measure of providing transportation allowances. Alternatives 1C though 1G vary only in the number of employees at the work site. Each of the inputs correlated to employer size, such as number of telecommuting employees, is increased or decreased to maintain its relative proportion. Alternative 1H is the same as Alternative 1A, with the exception that the employer does not pay a monthly lease cost for the parking spaces, that is, the employer owns the land.

Sensitivity testing was then performed on the definition of the TDM measures themselves in Alternatives 2 through 4, which used the employer description for Alternative 1A as the basis. A listing of the inputs for each of the alternatives and the results by alternative are not provided in this paper because of space limitations, although the conclusions presented reflect this portion of the analysis.

TABLE 3 Employer Characteristics for Model Alternatives 1A Through 1H

	Alternative							
	1A	1B	1C	1D	1E	1F	1G	1H
Transportation Environment	5	2	5	5	5	5	5	5
Number of Employees at Worksite	240	240	50	100	500	1,000	2,000	240
Daily Parking Charge at Employer-Provided Facility	$0	$2.38	$0	$0	$0	$0	$0	$0
Monthly Cost of a Leased Parking Space	$40	$50	$40	$40	$40	$40	$40	$0

CONCLUSIONS

The TDM Cost-Effectiveness Model developed represents a significant step forward in the evaluation of the cost-effectiveness, instead of just the effectiveness, of employer-based TDM measures in suburban settings. This model is available to employers and will assist them in determining which TDM measures are the most cost-effective for their work site. An important aspect of the model is the extent to which an employer may enter site-specific information that will have a direct impact on the cost-effectiveness calculations. For those employers that may not have access to the entire range of data required to operate the model, default values have been estimated for many of the variables and are included in the model.

A significant amount of data collection was performed in support of the methodology development. The literature review summarized in this report examined the costs and effectiveness of TDM measures that had been implemented by suburban employers. As was expected, there was much more information of the description of the particular measure implemented and on the program effectiveness than there was on program costs. One of the key goals of the employer survey administered to suburban employers throughout the San Francisco Bay Area was to supplement this cost data. There was a great deal of variation among the employers regarding the amount of cost data that they were able to provide. A few employers had the costs associated with their program well documented and were able to provide complete information. Most employers, however, were only able to give general cost information on a few measures, and even then did not necessarily know all of the costs for that measure. Where cost information was not reported, confidentiality was not the issue; instead, it was a matter of the employers having kept sufficient records to allow them to distinguish the costs associated with individual measures or the program as a whole. The cost data provided do provide some insight, however, into the costs associated with the implementation of TDM measures.

From the employer surveys, a significant amount of information was collected regarding the implementation of the TDM program itself and the characteristics of the transportation services available to the employees of each organization. Although this information is only representative of those who responded to the survey, it does provide a good background on the factors that affect program design and implementation. The data obtained through the employer survey performed for this study was also supplemented with an evaluation of two data bases that contain information on employer-based TDM programs.

The cost-effectiveness of each of the TDM measures was evaluated using the TDM Cost-Effectiveness Model. A variety of model alternatives were tested to determine which measures were the most cost-effective and which variables affect their cost-effectiveness. Before applying the findings of this report to a particular employment site, the assumptions made regarding the measure's impact on the average daily trip reduction should also be reviewed for their reasonableness compared with the particular situation being evaluated. Because there are so many possible combinations of employer and measure characteristics, it is best to run the TDM Cost-Effectiveness Model for the individual employer using site-specific data. Some general observations regarding the cost-effectiveness evaluation of the TDM measures follow.

- The most cost-effective measure for each alternative to which it is applicable is the reduction of employer-subsidized parking. This is primarily because the employer collects parking fees from employees who continue to drive to work.
- For Alternative 1A, which represented average employer and TDM measure characteristics, four other measures were estimated to result in an overall cost savings to the employer per trip reduced: in-house ridematching services, compressed work hours, guaranteed ride home, and reduction of parking supply.
- The least cost-effective TDM measures are home-based telecommuting, primarily because of the cost of the computer and telecommunications equipment, and measures that require a payment by the employer to the employees: transit pass subsidies, direct monetary incentives, and transportation allowances.
- Relative cost-effectiveness is not significantly affected by whether the effectiveness measure is daily trips or peak-period trips.
- As employer size increases, the measures become more cost-effective because fixed costs are spread over a larger number of employees and there is a greater savings because of the reduction of leased parking spaces.
- If employers with 500 or more employees implement the same TDM measures implemented by employers with 240 employees, two additional measures result in cost savings: commute information program and preferential parking. This is primarily because of the increased reduction in leased parking spaces.
- For an employer that charges its employees for parking, there are no TDM measures that result in a cost savings because the employer does not experience a direct cost savings when the number of parking spaces used is reduced. This is also true for employers that do not pay a monthly lease cost for parking spaces, with the exception of reduction of employer-subsidized parking.
- Despite the higher cash outlay by the employer, an increased monetary incentive from $35 to $50 a month is predicted to result in a slight increase in this measure's cost-effectiveness.
- When a compressed work hour program is implemented in which employees have an extra day off every 2 weeks instead of every week, the cost-effectiveness of the measure is reduced, however, the employer continues to experience an overall cost savings.
- Even by decreasing the reduction of the employer-subsidized parking by half, this measure remains one of the most cost-effective.
- If bicycle lockers and no showers are provided, and the same level of participation remains the same, this measure becomes highly cost-effective and results in a cost savings. This effect is greatly amplified if it is assumed that bicycles would be ridden to work for 10 percent of the trips less than 6 mi. This is not an unreasonable assumption in areas with flat terrain, temperate climates, and other bicycle amenities, such as bicycle lanes, in the surrounding area.

It should be noted that these findings are based on a technical analysis only and do not to take into account other factors, such as acceptability to unions, which may also affect an employer's decision regarding which measure(s) to implement.

AREAS FOR FUTURE RESEARCH

There is still a great deal to be learned as more suburban employers implement TDM measures. A list of areas in which future research or updates to the TDM Cost-Effectiveness Model would be worthwhile follows:

- Collect more detailed information on the costs associated with implementing TDM measures. For existing programs, this could be accomplished by visiting the employer and interviewing various members of the staff, including the employee transportation coordinator, a human resources representative, someone involved in facility operations, and a representative from the accounting department. For future programs, some guidance could be provided to the employer for how to accurately track costs related to measure implementation.
- Collect additional baseline information to evaluate the effectiveness of TDM measures. Before implementing TDM measures, survey employees to determine the baseline mode split and average vehicle occupancy.
- Customize the TDM Cost-Effectiveness Model to account for differences that would result from different transportation environments. With additional baseline information, some of these impacts could be determined. Then, instead of using estimates of the average daily trip reduction as an input to the model, equations could be included in the model to estimate this value.
- Develop calculations for additional TDM measures and include them in the TDM Cost-Effectiveness Model.
- Collect data and apply the model in other suburban areas of the country to determine possible geographical impacts on the cost-effectiveness of TDM measures.

Some of these data may become available over time as more local jurisdictions pass TROs that require data reporting by the employer. An effort must be made, however, to keep these data up-to-date and to consider cost-effectiveness when evaluating them.

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