

Evaluation of Employer-Sponsored Ridesharing Programs in Southern California

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On the basis of a survey of employer-sponsored ridesharing programs in Southern California, firm size appears to be the most important explanatory variable for program choice and effectiveness. Larger firms were significantly more likely to offer direct ridesharing incentives to employees and to report direct benefits to the employer from ridesharing, and they were somewhat more likely to implement staggered work shifts and compressed work weeks but not flexible work hours. Significant economies of scale occur in providing personalized matching assistance to employees. The employees of larger firms were significantly more likely to rideshare, apart from other firm, program, and policy factors. These results strongly suggest that public policy on ridesharing, to produce less costly, more effective, and thus more efficient results, should focus on larger firms. Personalized matching assistance was highly effective in increasing the level of ridesharing, but direct ridesharing incentives were not. Alternative work schedules may hinder the formation of ridesharing arrangements, at least in some cases. The regional coordination of ridesharing promotional efforts may be necessary from a public policy perspective, but it is not sufficient, by itself, to ensure an efficient level of ridesharing. Employer-sponsored ridesharing programs may be the single most effective strategy to promote efficient levels of ridesharing on a regional basis. Most firms do not actively promote ridesharing on a voluntary basis, however. The participation of both the private and public sectors is necessary to maintain regional mobility through transportation demand management strategies such as ridesharing.

Although traffic congestion most often is experienced at the local level, traffic mitigation measures generally can be implemented efficiently only when coordinated at the regional level (1). Traffic congestion is an indication of spatial or temporal imbalance between transportation supply, measured as transportation system capacity, and demand, derived from proximate land uses and their associated economic activities (2). This disequilibrium condition can be addressed over the longer term only by coordinating transportation and land use planning and investment decisions, a process that is typically successful only at the regional level (3,4).

Ridesharing as a public policy tool was introduced during World War II to conserve rubber and other natural resources vital to the ongoing war effort (5). Largely neglected after the war, ridesharing was revived as a conservation measure in the aftermath of the first Arab oil embargo in 1974. At least in theory, ridesharing may also be a useful transportation demand management technique aimed at mitigating traffic congestion at the local and regional levels. Whether ride-

sharing is suitable in modern urban and suburban environments, and if so, under what conditions, is controversial, however (6).

Regional ridesharing programs have not been particularly successful in increasing the level of ridesharing regionally (7, p. 1,8,9). The best-documented regional ridesharing programs have reduced regional vehicle miles of travel (VMT) directly or indirectly by 1 percent or less overall (8). This level of historical regional ridesharing program performance is insignificant compared with the average annual rate of growth in VMT (2 to 3 percent) in rapidly growing communities, which would be those most interested in ridesharing as a traffic mitigation measure. Occasionally, regional ridesharing efforts have had more significant results, as during the 1984 Summer Olympics, but those results were short lived, even during the 2 weeks of the games (9).

Employer-sponsored ridesharing programs, at least in some instances, have produced far more spectacular results. One comprehensive employee transportation demand management program, CH2MHill in Bellevue, Washington, reduced solo driving from 85 to 60 percent in just a few months. This program featured an on-site ridesharing coordinator, computerized carpool matching services, public transit subsidies, parking fees for solo drivers, and free parking for carpools and vanpools (10). A similar program sponsored by the Nuclear Regulatory Commission in north Bethesda, Maryland, reduced solo driving from 54 to 42 percent in a period of just 6 months (11). The Lawrence Livermore Laboratories in Livermore, California, with a program having more emphasis on ridesharing services and less on parking management, reduced solo driving from 85 to 36 percent after 5 years (12). Driving alone at Lawrence Livermore Laboratories has reverted to about 51 percent, however, presumably because its new management places less emphasis on ridesharing (10). Some observers argue that these isolated instances of success are insufficient to justify the expectations from and major commitments to transportation demand management (TDM) programs currently underway in California and other high-growth areas (13).

Why are employer-sponsored ridesharing programs more successful than regional ridesharing programs, at least occasionally? Because regional ridesharing programs alone apparently are not sufficient to produce significant results, are they necessary at all? These and other questions are considered in the context of a detailed analysis of the results of a 1985 survey of large firms in Southern California, all clients of Commuter

Transportation Services, Inc. (CTS), the regional ridesharing agency for Southern California, except Orange County.

DATA AND RESEARCH METHODOLOGY

The influence of employer-sponsored ridesharing programs and alternative work schedules on employee mode choice was analyzed using a choice-based sample of Southern California firms. A mail survey of all CTS client headquarters worksites was conducted in early 1985. This sample plan controlled for external ridesharing assistance to each firm. At the time the survey was taken, CTS pursued a completely undifferentiated marketing strategy in providing its basic computerized ridesharing matching services to clients.

The sample included about 7 percent of all Southern California's manufacturing firms and 5 percent of its service firms with at least 100 employees. The average size of sample firms was 862 employees.

Of the 863 surveys mailed, 432 were returned. Responding firms had 372,206 employees among them, or just less than

10 percent of the entire Southern California regional work force. More than 90 percent of the responding firms had at least 100 employees (14).

Variables developed from the survey and used in the analysis are listed in Table 1. Endogenous variables include employee mode split, aggregated by firm, and the level of personalized matching assistance, types of direct ridesharing incentives, and alternative work schedules offered to employees. Exogenous variables include firm size, industry type, and location. Program organization and management attitudes toward ridesharing are also considered.

Employer location is identified at the regional level. Regional centers are defined on the basis of level of employment, a proxy for the average localized density of development. Downtown Los Angeles is the region's primary center, with more than 225,000 employees. Secondary centers include high-density inner suburban communities such as Glendale, Long Beach, Pasadena, Santa Monica, and the Wilshire corridor. Tertiary centers include all other areas of Los Angeles County. Areas outside Los Angeles County are treated separately. Site characteristics are identified on the basis of land tenure

TABLE 1 VARIABLES USED IN THE ANALYSIS

Variable	Mean	Definition
BUS_PRG	0.02	1 if buspool program offered, 0 else
VAN_PRG	0.13	1 if vanpool program offered, 0 else
CAR_PRG	0.12	1 if carpool program offered, 0 else
LN_PSH	4.13	ln (total annual program staff hours)
LN_HPE	0.67	LN_PSH/LN_EMP
LN_PSD	7.00	ln (total annual program staff dollars)
LN_DPE	1.15	LN_PSD/LN_EMP
STG_HRS	0.23	1 if staggered work shifts offered, 0 else
CMF_HRS	0.14	1 if compressed work weeks offered, 0 else
FLX_HRS	0.27	1 if flexible work hours offered, 0 else
STG_HRSN	0.10	1 if staggered work shifts offered in the absence of other work hours policies, 0 else
STG_HRSY	0.13	1 if staggered work shifts offered in the presence of other policies, 0 else
LG_DRV	1.64	logit (employee drive alone mode split)
LG_POL	-2.05	logit (employee ridesharing mode split)
LG_TRN	-3.62	logit (employee public transit mode split)
LN_EMP	5.92	ln (total number of on-site employees)
PUB_IND	0.18	1 if public agency, 0 else
SRV_IND	0.35	1 if service firm, 0 else
PRI_CEN	0.06	1 if primary center location, 0 else
SEC_CEN	0.18	1 if secondary center location, 0 else
NLA_CEN	0.16	1 if outside Los Angeles County, 0 else
MLT_OWN	0.09	1 if multiple tenant owner, 0 else
MLT_RNT	0.14	1 if multiple tenant renter, 0 else
SNG_RNT	0.17	1 if single tenant renter, 0 else
LOW_MAN	0.41	1 if lower/non-management, 0 else
TCH_DPT	0.24	1 if technical department, 0 else
REG_ONL	0.72	1 if regulatory compliance reasons only, 0 else
INT_CON	0.65	1 if internal program constraints reported, 0 else
EXT_CON	0.57	1 if external program constraints reported, 0 else
COM_BEN	0.12	1 if community ridesharing benefits reported, 0 else
FRM_BEN	0.16	1 if employer ridesharing benefits reported, 0 else
EMP_BEN	0.19	1 if employee ridesharing benefits reported, 0 else

and tenancy. Property owners generally have a larger stake in their location than renters, making them more sensitive to site-specific transportation problems. Multiple-tenant facilities are generally higher in density than single-tenant facilities and thus have higher land and parking costs, making them more likely candidates for employer ridesharing programs. Most other variable definitions are relatively straightforward or are addressed at appropriate places in the text. The analysis used a variety of techniques, including cross-tabulation for categorical variables, multiple regression analysis for impact analysis, and comparisons of elasticity measures for sensitivity analysis.

EMPLOYER-SPONSORED RIDESHARING PROGRAMS

The survey categorized employer-sponsored ridesharing programs along two dimensions: program content and the level of resource commitment on an annual basis. Program content, a discrete measure, was identified according to types of ridesharing incentives offered to employees; these included no direct incentives, carpool incentives, vanpool incentives, and buspool incentives (15). Resource commitment, a contin-

uous measure, was identified as the annual number of staff-hours and dollars spent on staff time devoted to promoting ridesharing (16).

Only 252 of the responding firms (58 percent) estimated the total annual number of staff hours spent on ridesharing, and 184 firms (43 percent) estimated the total annual dollar cost of such staff time. These firms spent an average of 339 staff-hours at a total cost of \$5,197 per year on the promotion of employee ridesharing. This amounted to an annual average of 0.31 hr and \$5.07 per employee. Clearly, employer-sponsored ridesharing programs in Southern California were not particularly expensive to administer.

Personalized Matching Assistance

The provision of personalized matching services to employees was found to exhibit significant economies of scale in production and distribution. Staff hours increased by an average of only 57 percent and staff dollars by 68 percent with every 100 percent increase in the number of employees served (Table 2). Thus, although total program costs increased with firm size, costs per employee declined. Larger firms were able to provide more services at the same cost per employee or the

TABLE 2 PERSONALIZED MATCHING ASSISTANCE BY FIRM AND PROGRAM CHARACTERISTICS

Independent Variables	Dependent Variables			
	LN_PSH	LN_HPE	LN_PSD	LN_DPE
CONSTANT	+0.30 (0.34)	+0.70 (6.94)	+2.79 (4.65)	+1.64 (15.7)
BUS_PRG	+1.30 (2.50)	+0.17 (2.00)	+0.65 (1.17)	+0.14 (1.43)
VAN_PRG	+0.65 (2.51)	+0.10 (2.27)	+0.66 (2.47)	+0.09 (1.98)
CAR_PRG	+0.17 (0.70)	+0.04 (0.97)	+0.26 (1.05)	+0.05 (1.09)
LN_EMP	+0.57 (6.50)	-0.02 (1.14)	+0.68 (7.52)	-0.08 (5.20)
PUB_IND	-0.39 (1.59)	-0.06 (1.50)	-0.56 (2.25)	-0.06 (1.49)
SRV_IND	-0.20 (0.95)	-0.04 (1.11)	-0.41 (1.85)	-0.06 (1.67)
PRI_CEN	+0.88 (2.26)	+0.12 (1.90)	+0.63 (1.65)	+0.10 (1.43)
SEC_CEN	-0.10 (0.44)	-0.01 (0.34)	-0.06 (0.26)	-0.01 (0.25)
NLA_CEN	+0.54 (2.30)	+0.09 (2.16)	+0.32 (1.38)	+0.06 (1.36)
MLT_OWN	+0.67 (2.03)	+0.10 (1.80)	+1.15 (3.29)	+0.18 (3.01)
MLT_RNT	+0.27 (1.08)	+0.03 (0.76)	+0.31 (1.18)	+0.04 (0.82)
SNG_RNT	-0.36 (1.48)	-0.07 (1.61)	-0.19 (0.72)	-0.01 (0.32)
LOW_MAN	-0.24 (1.41)	-0.05 (1.63)	-0.35 (1.98)	-0.06 (2.04)
TCH_DPT	+0.61 (2.94)	+0.09 (2.66)	+0.71 (3.21)	+0.10 (2.49)
REG_ONL	-0.20 (1.07)	-0.03 (1.09)	-0.46 (2.38)	-0.09 (2.56)
INT_CON	+0.16 (0.80)	+0.04 (1.17)	+0.12 (0.57)	+0.02 (0.66)
EXT_CON	+0.29 (1.46)	+0.06 (1.70)	+0.41 (2.06)	+0.09 (2.48)
EMP_BEN	-0.14 (0.73)	-0.02 (0.53)	-0.11 (0.57)	-0.02 (0.53)
Log likelihood	-416.83	30.14	-281.17	40.13
N	252	252	184	184

NOTES: Based on tobit regression analysis. Predicted values for all dependent variables were constrained to equal or exceed 0 using maximum likelihood estimation procedures. t-scores are in parentheses.

same level of services at a lower cost than smaller firms could. Other factors influencing the provision of personalized matching assistance included the type of direct ridesharing incentives offered, industry type, firm location, ridesharing program management and organization, and management attitudes toward ridesharing (Table 2).

Direct Ridesharing Incentives

Only 27 percent of the responding firms offered direct ridesharing incentives to employees. This was perhaps not too surprising, because fully 72 percent of responding firms listed compliance with regional air quality regulations as their sole reason for developing a ridesharing program in the first place (Table 1). Larger firms were significantly more likely than smaller firms to offer direct ridesharing incentives to employees (Table 3). In fact, the largest firms (2,000 or more employees) were almost 10 times as likely as the smallest firms (fewer than 250 employees) to offer direct ridesharing incentives. The likelihood of offering carpool incentives did not increase much for firms with more than 250 employees, but the likelihood of offering vanpool incentives increased rapidly with firm size for all categories. Only firms with 1,000 or more employees offered buspool incentives. Clearly, the level of direct ridesharing incentives offered to employees was strongly influenced by firm size, presumably because of economies of scale in the provision of ridesharing services.

Reported Benefits from Ridesharing

Ridesharing benefits may accrue to employees, employers, and the community (15). Employee ridesharing benefits include lower commuting costs, reduced wear and tear on commute vehicles, and less commuting stress. Employer ridesharing benefits include reduced employee parking requirements, less employee tardiness and absenteeism, improved employee morale and productivity, and enhanced employee recruitment and retention. Community ridesharing benefits include reduced air pollution, energy consumption, and traffic congestion.

Only 38 percent of the surveyed firms reported any benefits from ridesharing. Among these, 19 percent cited employee benefits; 16 percent, employer benefits; and 12 percent community benefits. Larger firms were significantly more likely than smaller firms to report direct employer benefits from ridesharing, but not employee or community benefits (Table 4). Employer ridesharing benefits should increase systematically with firm size if significant economies of scale are realized in the provision of ridesharing services to employees. Employee and community benefits, which are external to the firm, would not necessarily be related to firm size.

Both employer and community benefits from ridesharing increased significantly with the level of direct ridesharing incentives employers offered, although employee ridesharing benefits did not (Table 5). The meaning of this relationship is not entirely clear but may have something to do with general management and labor relations. If employees benefit from

TABLE 3 DIRECT RIDESHARING INCENTIVES OFFERED, BY FIRM SIZE

Firm Size	Direct Ridesharing Incentives Offered				Total Firms
	No Incentives	Carpool Incentives	Vanpool Incentives	Buspool Incentives	
<250 employees	154 (92%)	7 (4%)	6 (4%)	0 (0%)	167 (39%)
250-499 employees	82 (73%)	17 (15%)	14 (12%)	0 (0%)	113 (26%)
500-999 employees	47 (65%)	13 (18%)	12 (17%)	0 (0%)	72 (17%)
1,000-1,999 employees	24 (57%)	7 (17%)	9 (21%)	2 (5%)	42 (10%)
2,000+ employees	10 (26%)	7 (18%)	14 (37%)	7 (18%)	38 (9%)
Total Firms	317 (73%)	51 (12%)	55 (13%)	9 (2%)	432 (100%)
Chi-square ¹	81.55	15.69	36.31	58.69	
Degrees of freedom	4	4	4	4	
Level of significance	0.001	0.01	0.001	0.001	

1 Chi-square calculated for each column treated separately as the dependent variable.

TABLE 4 RIDESHARING BENEFITS REPORTED BY FIRM SIZE

Firm Size	Ridesharing Benefits Reported ¹				Total Firms ³
	Employee Benefits	Employer Benefits	Community Benefits	Any Benefits ²	
<250 employees	22 (13%)	18 (11%)	15 (9%)	47 (28%)	167 (39%)
250-499 employees	26 (23%)	15 (13%)	17 (15%)	46 (41%)	113 (26%)
500-999 employees	14 (19%)	8 (11%)	6 (8%)	26 (36%)	72 (17%)
1,000-1,999 employees	9 (21%)	13 (31%)	7 (16%)	22 (52%)	42 (10%)
2,000+ employees	9 (24%)	17 (45%)	7 (18%)	25 (66%)	38 (9%)
Total Firms	80 (19%)	71 (16%)	52 (12%)	166 (38%)	432 (100%)
Chi-square ⁴	5.62	34.81	5.68	23.36	
Degrees of freedom	4	4	4	4	
Level of significance	0.30	0.001	0.30	0.001	
¹ Multiple response possible. ² Employee, employer, or community benefits from ridesharing reported. ³ Rows do not add to 100% because some firms reported no benefits from ridesharing. ⁴ Chi-square calculated for each column treated separately as the dependent variable.					

ridesharing, then program participation might be expected to increase, perhaps engendering additional program costs to the firm.

Indirect Measures: Alternative Work Schedules

Alternative work schedules include staggered work shifts, flexible work hours, and compressed workweeks. Staggered work shifts, through appropriate scheduling by the employer, thin out employee peak-period travel at a single location by separating the arrival and departure times for each major shift's employees. Staggered work shifts are applied most often at large installations, such as military bases, hospitals, universities, and major manufacturing employment centers. Flexible work hours have a similar effect, but employees are allowed to choose start and end times to suit their own convenience, within specific employer guidelines. The potential result is congestion relief along major travel corridors leading to the employment site. Compressed workweeks increase the number of hours worked per day and decrease the number of days worked each week. The direct result is an absolute reduction in the total number of trips made and a shift in work arrival and departure times away from at least one daily peak-travel

period. The overall result may be a reduction in total regional VMT and in peak-period traffic congestion.

Of the responding firms, 43 percent offered alternative work schedules of one type or another (Table 6). Twenty-seven percent allowed flexible work hours, 22 percent staggered work shifts, and 14 percent compressed their workweek. Larger firms were more likely to offer staggered shifts and compressed work weeks, but the firm size difference was only slight for flexible work hours. The expectation had been that larger firms could more easily accommodate individual flexible work hours and still have adequate office coverage during normal business hours than could smaller firms. These results suggest that flexible work hours may have somewhat wider applicability as a TDM strategy than previously thought, at least for firms with 100 or more employees.

The relationship between the level of direct ridesharing incentives offered and alternative work schedules was not significant, with the weak exception of staggered work shifts (Table 7). The choice of program type was almost completely independent. Staggered work shifts and compressed workweeks were both moderately related to the level of ridesharing benefits reported, however (Table 8). More specifically, firms reporting direct employer ridesharing benefits were more likely to offer all types of alternative

TABLE 5 RIDESHARING BENEFITS REPORTED BY DIRECT RIDESHARING INCENTIVES OFFERED

Direct Ridesharing Incentives Offered	Ridesharing Benefits Reported ¹				
	Employee Benefits	Employer Benefits	Community Benefits	Any Benefits ²	Total Firms ³
No Incentives	57 (18%)	31 (10%)	29 (9%)	97 (31%)	317 (73%)
Carpool Incentives	10 (20%)	13 (25%)	4 (8%)	25 (49%)	51 (12%)
Vanpool Incentives	12 (22%)	21 (38%)	14 (26%)	37 (67%)	55 (13%)
Buspool Incentives	1 (11%)	6 (67%)	5 (56%)	7 (78%)	9 (2%)
Total Firms	80 (19%)	71 (16%)	52 (12%)	166 (38%)	432 (100%)
Chi- square ⁴	0.82	48.74	28.80	35.86	
Degrees of freedom	3	3	3	3	
Level of significance	0.95	0.001	0.001	0.001	
¹ Multiple response possible. ² Employee, employer, or community benefits from ridesharing reported. ³ Rows do not add to 100% because some firms reported no benefits from ridesharing. ⁴ Chi-square calculated for each column treated separately as the dependent variable.					

work schedules, significantly so in the case of staggered shifts and compressed workweeks.

Parking Management

Parking pricing and supply clearly are critical factors influencing employee mode choice (17). Parking management was not considered explicitly in this analysis, however. Virtually all of the responding firms (98 percent) offered free or subsidized parking to some or all of their employees. Of those few firms that did use parking pricing or supply control mechanisms, many charged relatively little for employee parking, and most (81 percent) did not have adequate records on which to base accurate parking cost estimates. Thus, for most surveyed firms, parking management consisted of providing free parking to all employees. Carpool and vanpool preferential parking spaces were identified in the analysis as direct ridesharing incentives.

EMPLOYEE MODE CHOICE

The true test of the effectiveness of employer-sponsored ridesharing programs should be in terms of their effects on employee mode choices (18). Unfortunately, data on disaggregate discrete employee mode choices are not available from the sur-

vey. Each firm, however, was asked to estimate aggregate employee mode split, including the percentage of employees commuting to work by driving alone, carpooling, vanpooling, buspooling, taking public transit, or using other modes of travel such as bicycling and walking. Overall, 291 of the responding firms (67 percent) supplied such an estimate. On average, 75 percent of their employees drove alone, 16 percent carpooled or vanpooled, 5 percent took public transit, and 4 percent used other modes of travel for their daily commute.

A comparison of employer policy measures, such as ridesharing programs, directly with employee mode choices, controlling simultaneously for the complex social, economic, policy, and environmental factors influencing these daily decisions is not possible given the limitations of the CTS data. A second-best alternative is to treat employee mode split, aggregated by firm, as a proxy for the sum of individual employee mode choices at each firm. This aggregate employee mode split variable (or variables) can be analyzed using the weighted least squares regression technique proposed by Theil (19). Dependent variables analyzed here include the drive alone, ridesharing (carpool and vanpool), and public transit mode splits for each firm, transformed into log-likelihood ratios, or logits, as follows:

$$\text{logit} = \ln \frac{P}{1 - P} \quad (1)$$

TABLE 6 ALTERNATIVE WORK SCHEDULES POLICIES BY FIRM SIZE

Firm Size	Alternative Work Schedules Policies ¹				Total Firms ³
	Staggered Work Shifts	Flexible Work Hours	Compressed Work Weeks	Any Policies ²	
<250 employees	31 (19%)	43 (26%)	17 (10%)	69 (41%)	167 (39%)
250-499 employees	19 (17%)	29 (26%)	14 (12%)	43 (38%)	113 (26%)
500-999 employees	19 (26%)	18 (25%)	8 (11%)	29 (40%)	72 (17%)
1,000-1,999 employees	16 (38%)	12 (29%)	12 (29%)	25 (60%)	42 (10%)
2,000+ employees	13 (34%)	14 (37%)	8 (21%)	19 (50%)	38 (9%)
Total Firms	98 (23%)	116 (27%)	59 (14%)	185 (43%)	432 (100%)
Chi-square ⁴	12.97	2.30	11.95	6.98	
Degrees of freedom	4	4	4	4	
Level of significance	0.05	0.70	0.05	0.20	
¹ Multiple response possible. ² Staggered work shifts, flexible work hours, or compressed work weeks policies reported. ³ Rows do not add to 100% because some firms reported no alternative work schedules policies. ⁴ Chi-square calculated for each column treated separately as the dependent variable.					

where P is equal to the percentage of a firm's employees using a particular mode of travel. Weights are applied to the left- and right-hand sides of each equation in summing error terms, to control for differences in sample size and in the likelihood that employees will choose a particular mode. The results are shown in Table 9.

Controlling for a variety of other firm, program, and policy factors, firm size still was associated with a significant increase in employee ridesharing, which occurred about equally at the expense of driving alone and public transit use. Firm size may be related indirectly to spatial interactions that are external to the firm. For example, firms may be so large that they directly create development density by virtue of their location decisions. This would apply principally in underdeveloped or low-density areas. A stronger hypothesis is that large firms are more likely to prefer high-density locations than are small firms. This is an agglomeration or external economies argument. Large firms may also use space more efficiently than smaller firms, creating the effect of high-density development. This is an internal economies argument. In any case, the employees of large firms were significantly more likely to rideshare than the employees of small firms in this analysis.

Personalized matching assistance was associated with a significant increase in the level of ridesharing at individual firms.

This supports the notion that the ridesharing coordinator plays a pivotal role in determining the success of employer transportation programs (16). By contrast, direct incentives were not associated with significant increases in ridesharing. The use of such incentives as preferential carpool and vanpool parking to encourage ridesharing, at least in the absence of parking pricing and supply control measures (20,21), is brought into question by these results.

Alternative work schedules were associated with increases, decreases, or no change in the level of ridesharing in this analysis, depending on the combination of alternative work schedules offered to employees. Compressed workweeks and flexible work hours were associated with increases in driving alone and decreases in ridesharing and public transit use. Staggered shifts in the presence of compressed work weeks or flexible work hours had the opposite effect—increases in ridesharing and public transit use and decreases in driving alone. Staggered shifts in the absence of compressed workweeks and flexible work hours were not significantly related to the employee mode choice. Alternative work schedules that employees may choose but then must adhere to apparently increase ridesharing by making potential carpool partners more dependable and predictable, useful characteristics when one is expected to arrive at work on time. Alternative

TABLE 7 ALTERNATIVE WORK SCHEDULES POLICIES BY DIRECT RIDESHARING INCENTIVES OFFERED

Direct Ridesharing Incentives Offered	Alternative Work Schedules Policies ¹				Total Firms ³
	Staggered Work Shifts	Flexible Work Hours	Compressed Work Weeks	Any Policies ²	
No Incentives	61 (19%)	84 (26%)	39 (12%)	129 (41%)	317 (73%)
Carpool Incentives	15 (29%)	10 (20%)	9 (18%)	21 (41%)	51 (12%)
Vanpool Incentives	20 (36%)	19 (35%)	10 (18%)	30 (55%)	55 (13%)
Buspool Incentives	2 (22%)	3 (33%)	1 (11%)	5 (56%)	9 (2%)
Total Firms	98 (23%)	116 (27%)	59 (14%)	185 (43%)	432 (100%)
Chi- square ⁴	9.33	3.23	2.19	4.33	
Degrees of freedom	3	3	3	3	
Level of significance	0.05	0.50	0.70	0.30	
1	Multiple response possible.				
2	Staggered work shifts, flexible work hours, or compressed work weeks policies reported.				
3	Rows do not add to 100% because some firms reported no alternative work schedules policies.				
4	Chi-square calculated for each column treated separately as the dependent variable.				

work schedules that are too flexible may discourage ridesharing by allowing daily travel decisions to vary sufficiently to reduce dependability (22,23). Compressed workweeks had a very negative impact on public transit use. This may have been related to the span and frequency of public transit service in Southern California. The longer work days associated with compressed workweeks might make public transit use outside normal peak travel periods too inconvenient. Ridesharing is less dependent than public transit on external agents for service delivery and would be less negatively affected by the time of day the commute is made.

Service firms and public agencies showed higher levels of public transit use than did manufacturing firms. This difference may be related to patterns of industrial location and the availability of public transit service. Public agencies showed a lower level of ridesharing than did private firms. Public agencies often are tied to particular locations, are more likely to own land, and are less likely to perceive land ownership as an opportunity cost. The availability of more abundant land for parking may account for the higher propensity of public employees to drive alone (24).

Levels of transit use were much higher among employees of primary and secondary center firms than among those less centrally located. This was undoubtedly related to the supply of transit service. Firms located outside Los Angeles County

showed less transit use but more ridesharing, providing some evidence that ridesharing may substitute for transit use in certain situations.

Site characteristics were only marginally related to employee mode choice. Employees of multiple-tenant owners were slightly more likely than other employees to drive alone. This may have occurred in response to public policy on parking. Federal regulations allow employee free parking as a nontaxable benefit. This policy may increase the supply of, and especially the demand for, employee parking spaces. Multiple-tenant owners may have insufficient parking because of dense development, and they may wish to retain as much as possible of this limited supply of parking for their employees to internalize the available tax breaks.

Overall, personalized matching assistance appears to have been effective in increasing the level of employee ridesharing at Southern California firms, while direct ridesharing incentives were not.

RIDESHARING PROGRAM COST-EFFECTIVENESS

Although a direct comparison of the costs and benefits of ridesharing would be useful, most employers have difficulty

TABLE 8 ALTERNATIVE WORK SCHEDULES POLICIES BY RIDESHARING BENEFITS REPORTED

Ridesharing Benefits Reported	Alternative Work Schedules Policies ¹				Total Firms ³
	Staggered Work Shifts	Flexible Work Hours	Compressed Work Weeks	Any Policies ²	
No Benefits	50 (19%)	68 (26%)	25 (9%)	105 (39%)	266 (62%)
Employee Benefits	17 (29%)	17 (29%)	11 (19%)	27 (47%)	58 (13%)
Employer Benefits	20 (36%)	18 (32%)	15 (27%)	30 (54%)	56 (13%)
Community Benefits	11 (21%)	13 (25%)	8 (15%)	23 (44%)	52 (12%)
Total Firms	98 (23%)	116 (27%)	59 (14%)	185 (43%)	432 (100%)
Chi-square ⁴	9.23	1.29	13.79	4.23	
Degrees of freedom	3	3	3	3	
Level of significance	0.05	0.80	0.01	0.30	
¹ Multiple response possible. ² Staggered work shifts, flexible work hours, or compressed work weeks policies reported. ³ Rows do not add to 100% because some firms reported no alternative work schedules policies. ⁴ Chi-square calculated for each column treated separately as the dependent variable.					

estimating ridesharing benefits, at least in dollar terms (25). Many believe the benefits of ridesharing clearly outweigh the costs (26). In place of cost-benefit analysis, transportation system effectiveness analysis can be used if benefits are difficult or impossible to ascertain (27). The equations shown in Tables 2 and 9 can be used to evaluate the cost-effectiveness of typical employer-sponsored ridesharing programs in Southern California by comparing ridesharing program staff expenditures with the percentage of employees shifting from one mode of travel to another. Typical ridesharing program staff expenditures can be estimated for firms of different sizes using the Table 2 equations. The average relationship of such expenditures to employee mode choice can be estimated using the Table 9 equations.

Only typical firm and program characteristics—those most often found in the survey itself—are used. The typical surveyed firm was engaged in private manufacturing (47 percent), offered no direct ridesharing incentives to employees (73 percent), reported no benefits from ridesharing (62 percent), had no alternative work schedules (57 percent), offered free or subsidized parking to some or all employees (98 percent), was located in a tertiary employment center of Los Angeles County (60 percent), owned the site it occupied and occupied the site exclusively (60 percent), developed its ridesharing program to comply with regional air quality regula-

tions only (72 percent), and reported significant constraints on program expansion, both internally, such as lack of management interest (65 percent), and externally, such as lack of employee interest (57 percent).

The variable definitions used in this analysis allow dramatic simplification of the equations shown in Tables 2 and 9. Specifically, the following equations can now be used:

$$LN_PSD = 2.86 + 0.68 * LN_EMP \quad (2)$$

$$LG_DRV = 2.91 - 0.12 * LN_EMP - 0.73 * LN_DPE \quad (3)$$

$$LG_POL = -3.65 + 0.17 * LN_EMP + 0.96 * LN_DPE \quad (4)$$

$$LG_TRN = -3.11 - 0.09 * LN_EMP + 0.02 * LN_DPE \quad (5)$$

In order to illustrate the complex effects of firm size on employer-sponsored ridesharing program costs and cost-effectiveness, firms with 100, 1,000, and 10,000 on-site

TABLE 9 EMPLOYEE MODE CHOICE BY FIRM AND PROGRAM CHARACTERISTICS

Independent Variables	Dependent Variables		
	LOG_DRV	LOG_POL	LOG_TRN
CONSTANT	+2.91 (3.67)	-3.65 (4.39)	-3.11 (3.26)
BUS_PRG	-0.32 (0.93)	+0.19 (0.56)	+0.23 (0.46)
VAN_PRG	-0.09 (0.45)	+0.22 (1.02)	-0.33 (1.28)
CAR_PRG	+0.02 (0.13)	+0.05 (0.29)	-0.29 (1.16)
LN_DPE	-0.73 (1.84)	+0.96 (2.31)	+0.02 (0.04)
CMP_HRS	+0.52 (2.27)	-0.35 (1.47)	-0.68 (2.39)
FLX_HRS	+0.39 (1.91)	-0.32 (1.54)	-0.39 (1.54)
STG_HRSN	-0.14 (0.56)	+0.15 (0.57)	+0.01 (0.03)
STG_HRSY	-0.50 (2.13)	+0.54 (2.21)	+0.36 (1.23)
LN_EMP	-0.12 (1.56)	+0.17 (2.05)	-0.09 (0.87)
PUB_IND	+0.29 (1.36)	-0.52 (2.39)	+0.65 (2.35)
SRV_IND	-0.25 (1.20)	-0.13 (0.59)	+1.36 (5.05)
PRI_CEN	-0.62 (2.23)	-0.16 (0.53)	+1.65 (5.30)
SEC_CEN	-0.22 (0.93)	-0.11 (0.44)	+0.91 (3.25)
NLA_CEN	-0.26 (1.45)	+0.38 (2.08)	-0.77 (2.89)
MLT_OWN	+0.32 (1.25)	-0.39 (1.44)	-0.12 (0.40)
MLT_RNT	-0.20 (0.86)	+0.19 (0.78)	-0.08 (0.28)
SNG_RNT	-0.04 (0.16)	-0.02 (0.07)	+0.47 (1.41)
R-Squared Adj.	0.05	-0.11	0.31
N	136	136	136

NOTES: Based on weighted least squares regression analysis. t-scores are in parentheses.

employees were evaluated. More than 90 percent of the surveyed firms had 100 or more employees, while all but three firms had fewer than 10,000 employees. These three size classes of firms thus illustrate the full range of economies of scale within the normal distribution of Southern California firms with ridesharing programs. The results are shown in Table 10.

Total ridesharing program costs to employers increased systematically with firm size, while costs per employee declined. The average level of effort of most firms was limited. For example, a firm with 1,000 employees typically spent a total of \$1,785, or \$1.79 per employee, on personalized matching assistance.

The average mode split for a firm with 1,000 employees and no personalized matching assistance was approximately 89 percent drive alone, 8 percent ridesharing, and 2 percent public transit use. Public transit use varies little with firm size. A firm with 10,000 employees would be expected to have more than twice the level of ridesharing as a firm with 100 employees, assuming no personalized matching assistance is provided and holding all else equal.

The average mode split for a firm with 1,000 employees that provides a typical level of personalized matching assistance was 78 percent drive alone, 19 percent ridesharing, and 2 percent public transit use. Once again, public transit use was little affected by the level of personalized matching assistance provided. The decrease in the percentage that drive alone produced by typical levels of personalized matching assistance was virtually identical across all firm size classes, varying only from 10.48 percent to 11.07 percent.

The absolute number of employees shifted out of driving alone by typical levels of personalized matching assistance was almost directly proportional to the size of the firm. That is, larger firms did not generate greater proportional shifts in mode split than smaller firms through typical levels of employer ridesharing program investment. Cost-effectiveness did improve with firm size, however, because per-employee ridesharing program costs decreased significantly with firm size. The cost per person diverted from driving alone to ridesharing was reasonable for all firm size classes, varying from as low as \$7.72 per employee of large firms to \$33.91 per employee of small firms (Table 10).

THE LIMITS OF EMPLOYER RIDESHARING PROGRAMS

These results on the overall cost-effectiveness of employer ridesharing programs are subject to two major limitations. First, the findings technically are valid primarily for within-group or within-range predictions only. Because most employer ridesharing programs in Southern California are fairly limited in scope at this time, extrapolating from these results to a future in which much more ridesharing promotion is being accomplished can be problematic. Second, the nature of the equations used suggests that costs per person placed into ridesharing increase continuously with the level of program effort. Personalized matching assistance helps to reduce transaction and information costs associated with the formation of

TABLE 10 EMPLOYER RIDESHARING PROGRAM COST-EFFECTIVENESS FOR A TYPICAL SOUTHERN CALIFORNIA FIRM¹

Firm size (number of employees)	100	1,000	10,000
Ridesharing program staff expenditures ²			
Per firm	\$373	\$1,785	\$8,544
Per employee	\$3.73	\$1.79	\$0.85
Mode split without personalized matching assistance provided ³			
Drive alone	91.38	88.94	85.81
Ridesharing	5.35	7.75	11.15
Public transit	2.87	2.35	1.91
Totals	99.60	99.04	98.87
Mode split with personalized matching assistance provided ³			
Drive alone	80.67	78.46	74.74
Ridesharing	16.30	19.11	24.23
Public transit	2.96	2.40	1.95
Totals	99.93	99.97	100.92
Shift in mode split with personalized matching assistance provided ⁴			
Drive alone	- 10.61	- 10.48	- 11.07
Ridesharing	+ 10.95	+ 11.36	+ 13.08
Public transit	+ 0.07	+ 0.05	+ 0.04
Number of employees shifted with personalized matching assistance provided ⁴			
Drive alone	- 11	- 105	- 1,107
Ridesharing	+ 11	+ 114	+ 1,308
Public transit	0	+ 1	+ 4
Cost effectiveness with personalized matching assistance provided (\$/person placed out of driving alone)	\$33.91	\$17.00	\$7.72

1 The typical surveyed firm offered no direct ridesharing incentives (73%) or alternative work schedules (57%) to employees, reported no benefits from ridesharing (62%), was engaged in private manufacturing (47%), was located in a tertiary center of Los Angeles County (60%), and owned the site it occupied, which it occupied exclusively (60%).

2 From Equation 2.

3 From Equations 3, 4, and 5. Percentages may not sum exactly to 100%, due to random as well as systematic errors in the parametric estimation of equations. As long as reasonable (e.g., normal) assumptions are made concerning the hypothetical attributes of firms and programs, systematic errors will remain slight.

4 These numbers may not sum exactly to zero. See note 3.

ridesharing arrangements but does not alter the relative price advantages of different modes of travel (28). Thus, personalized matching assistance, by itself, should have a dramatic initial impact, which tapers off with increases in effort beyond a certain point. The question is, How much personalized matching assistance is enough, or, conversely, How much personalized matching assistance is too much?

The following equations were used to evaluate this problem:

$$P = \frac{e^{2.91 - 0.12 \cdot \ln(E)}}{1 + e^{2.91 - 0.12 \cdot \ln(E)}} \quad (6)$$

$$P' = \frac{e^{2.91 - 0.12 \cdot \ln(E) - 0.73 \cdot \ln(\$)/\ln(E)}}{1 + e^{2.91 - 0.12 \cdot \ln(E) - 0.73 \cdot \ln(\$)/\ln(E)}} \quad (7)$$

and

$$C = \frac{\$}{E * (P - P')} \quad (8)$$

where

P = percentage of a firm's employees who drive alone before program implementation;

P' = percentage of a firm's employees who drive alone after program implementation;

E = firm size, measured as the number of employees working on-site;

$\$$ = total annual dollar cost of staff time spent on providing ridesharing services; and

C = index of cost-effectiveness, measured as dollars per person shifting from driving alone.

Equation 8 can be rewritten as

$$P' = \frac{C * E * P - \$}{C * E} \quad (9)$$

Equations 7 and 9, when set equal, produce an objective function for determining the minimum percentage of a firm's

employees driving alone after an employer has started a ride-sharing program, given firm size and a maximum acceptable value (or limit) for program cost-effectiveness. Thus:

$$\frac{e^{2.91 - 0.12 \cdot \ln(E) - 0.73 \cdot \ln(\$)/\ln(E)}}{1 + e^{2.91 - 0.12 \cdot \ln(E) - 0.73 \cdot \ln(\$)/\ln(E)}} - \frac{C * E * P * - \$}{C * E} = 0 \quad (10)$$

If E is given, P is determined (Equation 6), and C and $\$$ can be obtained through the iterative solution of Equation 10. Equation 10 is fundamentally nonlinear and cannot be solved algebraically, except for arbitrarily large or arbitrarily small values of $\$$, which are not relevant here. Once P and $\$$ are known, C and P' can be estimated, and the percentage of a firm's employees shifted out of driving alone ($P - P'$) may be found. This system of equations can be solved iteratively for various levels of cost-effectiveness using a simple spreadsheet formulation to avoid the tedium of repetitious calculations.

The maximum potential of personalized matching assistance to influence employee mode choice in Southern California, in the absence of parking management strategies or direct ridesharing incentives and on the basis of the iterative solution of Equation 10, is shown in Figure 1. Each curve represents the maximum shift in the percentage of employees driving alone that can be obtained, probabilistically, for a given level of cost-effectiveness. Cost-effectiveness is measured here in dollars spent per person placed out of driving alone for firms of four different size classifications, ranging

from 100 to 100,000 employees. Few if any individual employers have 100,000 employees at a single work site, but many urban and suburban employment activity centers, some of which have formed transportation management organizations to conduct ridesharing and related programs, approach or exceed this figure. As Figure 2 shows, personalized matching assistance has a clear but ultimately limited ability to shift employees away from driving alone and into ridesharing. Larger firms typically shift more employees into ridesharing for a given level of cost-effectiveness. At very low levels of cost-effectiveness (higher costs per person placed), these economies of scale tend to disappear. Within the typical range of costs found among current employer ridesharing programs, however, the provision of personalized matching assistance clearly has economies of scale.

Depending on the actual marginal social benefit to be derived from ridesharing, the acceptable cost per person placed out of driving alone as a result of personalized matching assistance has limits. Most employee parking spaces cost \$1,000 or less per employee per year. Thus, parking pricing or other TDM strategies may be more efficient than personalized matching assistance, at least beyond a certain level of effort. This finding strongly supports the idea that combinations of TDM strategies, rather than individual strategies implemented in isolation, may have the greatest effect on employee mode choice at the lowest costs. In the great majority of cases, personalized matching assistance certainly should be one of those elements.

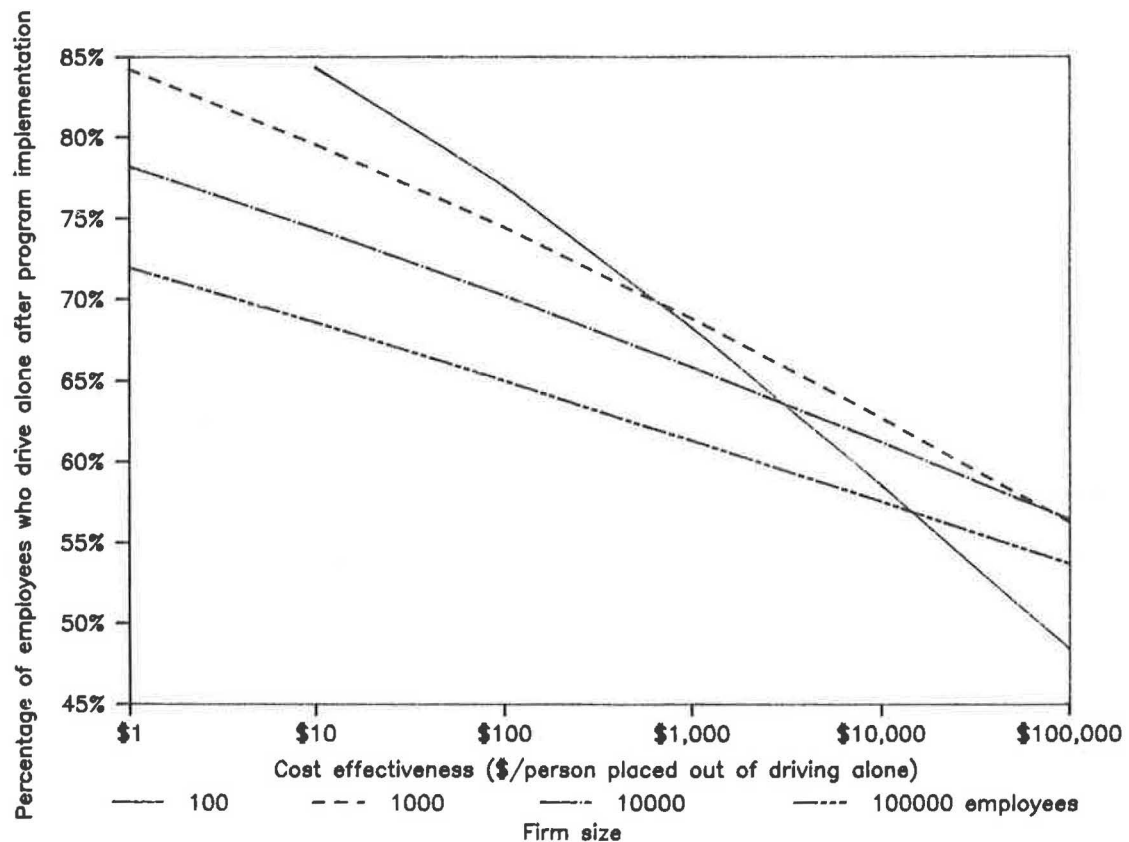


FIGURE 1 Employees driving alone after program implementation.

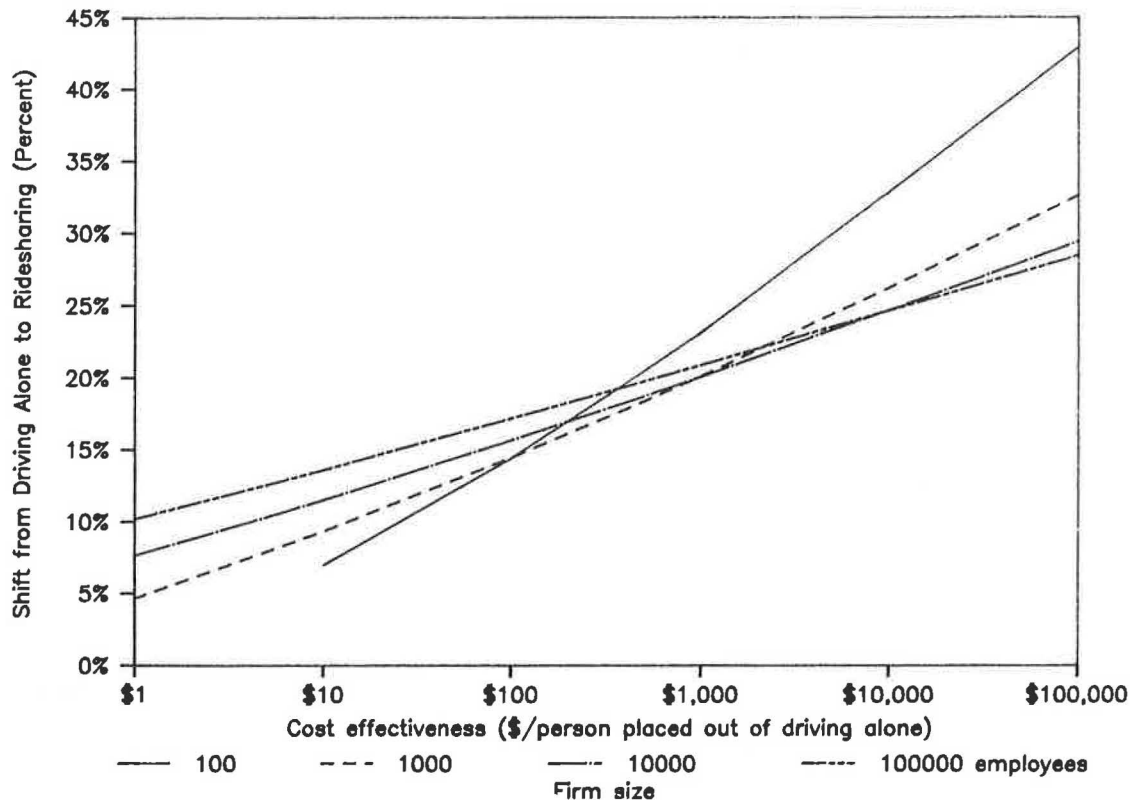


FIGURE 2 The effect of personalized matching assistance on employee mode choice.

CONCLUSIONS

The analysis presented here is increasingly relevant as urban areas develop along the lines of generalized dispersion with polycentric concentration of employment and other activities, which is characteristic of Southern California (29,30). Several points of interest to transportation researchers and public policy analysts are evident. Employer-sponsored ridesharing programs are limited to a large extent by both urban form and pricing constraints. Public policy based on such programs can have a significant impact on employee mode choice, however, if efforts center on appropriately identified markets and well-focused implementation strategies. The marginal costs of these programs tend to be small, while the marginal benefits appear to be great. Differences among employers must be taken carefully into account in designing employee ridesharing programs that are successful and cost-effective. The importance of firm size cannot be overstated in this regard. Ridesharing programs, with the economies of scale enjoyed by individual large firms, could be designed to serve groups of firms in large urban and suburban employment centers. Transportation management organizations may have the greatest potential of all because of their potential size and other institutional advantages (31). Evaluation results are still pending for many transportation management organizations, but this analysis appears to confirm the theoretical justification for their existence.

Regulatory efforts at the local and regional levels may be useful in inducing individual firms to participate in employee ridesharing programs (32). The tacit recognition of employee and community benefits may be achieved at a higher level

through regulatory efforts that seek to internalize some of these program costs within a market framework. Clearly, a market for employee ridesharing programs already exists in Southern California, at least in limited form. Regulatory efforts geared toward expanding and improving on these existing market interactions probably will be more effective or efficient than those that are not (33). Regional ridesharing agencies might well concentrate less on the direct delivery of ridesharing services to commuters and more on brokering higher level institutional services to employers, developers, and local public agencies.

Personalized matching assistance is effective because it meets the needs of commuters. Direct ridesharing incentives, such as preferential parking for vanpools and carpools, are not effective, at least not in situations where free parking for all employees is the rule rather than the exception. Alternative work schedules may help or hinder the formation of ridesharing arrangements, depending on the form such programs take. These results strongly suggest that transportation demand management cannot be carried out piecemeal and achieve its full potential. Only those programs that are coordinated, both internally and externally, will yield significant results over the long term.

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