dies to EPA's emissions offset policy can provide industry with a financial incentive to provide such programs. This linkage forms a policy that provides industry with the means of achieving more cost-effective pollution control while realizing significant savings in energy consumption.

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Transportation-Related Impacts of Compressed Workweek: The Denver Experiment

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This paper summarizes results of an evaluation of the federal employee compressed workweek experiment in the Denver area. In this experiment, more than 7000 federal employees changed from standard work schedules to either a four-day workweek or nine workdays in a two-week period. Emphasis is placed on transportation impacts related to air quality and energy issues, with particular attention given to quantifying the more-indirect impacts of compressed work schedules on overall weekly household travel patterns. The analysis approach developed to evaluate these issues essentially involves the measurement of a number of travel-related impacts prior to implementation of the compressed workweek and again one year later. Also involved is the use of experimental and control groups to isolate those impacts attributable to the compressed workweek from other impacts from factors exogenous to the experiment, such as changes in the price and availability of gasoline. The findings indicate that compressed work schedules lead to a reduction in weekly household vehicular travel. Further, reductions are observed not only for work travel but for nonwork travel as well. Results also suggest that the compressed workweek can be compatible with other regional transportation actions such as ridesharing and transit. Although not demonstrated conclusively in the Denver experiment, the compressed workweek also appears to have the potential for improving traffic flow conditions by reducing peak-hour traffic volumes.

The compressed workweek, a form of alternative work schedules in which employees work a full 40-h week in less than the standard five days, became popular in the early 1970s, particularly among small manufacturing and local government employers. From a relatively small number of employees in 1971, nationwide participation increased to more than 1 million workers by 1975 (1). Subsequent data, though, indicate that participation levels have stabilized or possibly decreased somewhat. By 1976, for example, national participation had dropped to 1.27 million workers.

Renewed interest in the compressed workweek has been expressed on the part of the federal government as evidenced by the Federal Employees Flexible and Compressed Work Schedules Act of 1978, which authorized federal employees to participate in alternative work schedules, either flexible hours or compressed workweeks, on an experimental basis for a three-year period (Public law 95-390, section 2). One of the most intensive efforts directed toward implementing this Act occurred in the Denver region, which has 93 federal agencies that employ nearly 30 000 employees in the metropolitan area and is second only to Washington, D.C., as a center of federal employment. Unlike most earlier applications in which compressed work schedules were viewed for the most part as a means of improving productivity or as an employee benefit, implementation of the compressed workweek in Denver was motivated primarily by its potential transportation-related energy and air quality impacts.

Initiative for the Denver compressed workweek experiment originated with the Denver federal executive board (DFEB), an organization of regional administrators of all federal agencies in the Denver region. The DFEB, after considering the air quality problem in Denver and feeling obligated to respond to the federal legislation that authorized variable work-hours experiments, conceived of a compressed workweek experiment to be conducted among all federal agencies within the Denver region. This organization provided both a forum for discussion of the concept itself and the mechanism needed for obtaining commitments from a number of federal agencies to participate in the experiment. Of critical importance in allowing the experiment to proceed was agreement by the affected labor unions to allow their employees to participate in the program. The unified commitment by the DFEB was also, no doubt, instrumental in securing this agreement.

Implementation of compressed work schedules among Denver's federal employees was quite extensive. A poll of Denver area federal agencies taken in December 1979 revealed that 35 agencies were participating in the compressed workweek experiment and that well over 7000 employees were actually on compressed work schedules of one sort or another. One year later, participation had increased to include more than 9000 federal employees in 42 agencies.

Participation within individual agencies ranged from about 50 percent to more than 95 percent; average participation was approximately 65 percent. In terms of specific form of compressed work schedule, participation appeared to be split almost evenly between the four-day workweek and the five/four-nine plan. With the former, employees work four 10-h days each week; with the latter, employees work 80 h in nine workdays and take an extra day off every other week. Not surprising, the most popular days off were Mondays and Fridays (chosen, respectively, by 36 and 60 percent of those employees on compressed work schedules) since this afforded the opportunity for three-day weekends.

SCOPE OF EVALUATION

The Denver Regional Council of Governments (DRCOG), as the designated transportation and air quality planning agency in the Denver region, viewed the participation of Denver's federal community in this experiment as an excellent opportunity to demonstrate the potential effectiveness of the compressed workweek, as one form of alternative work schedule, in improving air quality and reducing fuel consumption. Therefore, unlike the evaluation of this experiment at the national level conducted by the Office of Personnel Management (OPM), which addressed a number of impacts that ranged from the efficiency of government operations to the quality of life for individuals and families, objectives of the Denver study were more narrowly defined and focused primarily on the transportation-related air quality and energy issues associated with the compressed workweek that may be unique to the Denver area (2,3,). Specifically, in sponsoring the evaluation, DRCOG sought to address the following issues:

1. The effectiveness of the compressed workweek in reducing automobile emissions and fuel consumption and
2. The compatibility of the compressed workweek with other regionally accepted transportation measures such as ridesharing and transit.

A secondary area of investigation, not discussed in this paper, was the identification of factors important in determining employee acceptability of compressed work schedules.

POTENTIAL TRAVEL IMPACTS

Weekly Household Travel

In the context of transportation-related impacts, the basic motivation for promoting the compressed workweek is that, by revising work schedules so that employees work four 10-h days rather than five 8-h days, work travel and associated fuel consumption and vehicle emissions are reduced by 20 percent. To consider this 20 percent (or, with the five/four-nine plan, 10 percent) reduction in work travel as the bottom line in terms of vehicle emissions and fuel consumption, though, is somewhat naive; a number of potential changes in nonwork travel could occur as a result of compressed work schedules as well.

For example, many employees on compressed work schedules could use their extra day off to engage in activities that would result in an increase in nonwork travel that could partly offset or perhaps even exceed any savings in work travel. This was of particular concern in the Denver experiment in view of that area's abundance of nearby recreational facilities. However, although increased travel on the extra day off is certainly one possible response to compressed work schedules, a number of other more subtle impacts on household vehicular travel can be identified that could lead to an overall reduction in nonwork vehicle miles of travel (VMT).

For example, during the course of the normal five-day workweek, many employees on standard work schedules (i.e., eight-hour workdays) would probably make a number of trips for non-work-related purposes (e.g., shopping, recreation, doctor, or dental appointments) either as part of their normal trip to and from work or as separate trips in the mornings or evenings. One would expect that, for those employees who switch to compressed work schedules, the extent to which these additional trips are made would drop off markedly.

After 10 h of work, for example, it is not likely that many people would be particularly anxious to delay their trip home in order to run an errand or, once home, to set out again later in the evening.

Instead, the options of rescheduling the trip to the extra day off during the week, having another household member make the trip, or perhaps even eliminating the trip entirely may be much more appealing.

Another potential impact of the compressed workweek would be a shift in travel for non-work-related purposes from Saturday or Sunday to the weekday that the employee has off. For day trips to recreational areas, for example, this would be particularly attractive from the standpoint of avoiding crowds. Similarly, shopping trips and other household errands normally made on weekends might be shifted to the weekday off in order to take advantage of less-crowded conditions.

Because of the wide range of potential changes in household travel patterns that could occur in response to the compressed workweek, a focus only on changes in work travel and travel on the employee's extra day off would not provide a complete assessment of the VMT-related impacts of compressed work schedules. Instead, all household travel should be considered over a seven-day period.

Ridesharing

In addition to impacts related to the number of work trips and changes in nonwork travel patterns, other potential impacts associated with compressed work schedules can be identified that could adversely affect ridesharing. For example, because ridesharing arrangements among employees on compressed work schedules and those on standard work schedules would be quite difficult (if not impossible) to coordinate, the implementation of compressed work schedules on a limited basis could disrupt existing carpools and vanpools.

Transit

The compressed workweek could also have an adverse impact on transit ridership. For example, because of their longer workday, employees on compressed work schedules travel to and from work outside the peak hour. If the level of transit service outside the peak hour is considerably lower than that during the peak hour, transit would become less attractive relative to automobile. As a result, some of those employees that switch to compressed work schedules may also switch from transit to automobile.

However, even if those employees on compressed work schedules continue to ride transit, there still exist potentially negative impacts on transit fare revenues. For example, the 20 percent reduction in work trips associated with the four-day workweek could translate into a corresponding 20 percent reduction in fare revenues.

Reduced Peaking

The longer workdays associated with compressed work schedules could lead to potentially beneficial travel-related impacts as well. In terms of automobile travel, for example, those employees who arrive at work earlier and leave later in the day would be traveling outside the period of peak travel volumes. Depending on the severity of peak traffic congestion, then, substantial travel time savings could be realized. Further, if participation in the compressed workweek is high enough in areas of concentrated federal employment, improvements in traffic flow conditions throughout the peak period could result not only in travel time savings for other commuters but also in reductions in automobile emissions and fuel consumption. In the case of transit, longer workdays could serve to flatten peak-hour transit demands, which in turn could be viewed as either an increase in effective peak-hour capacity or a reduction in peak-hour transit supply requirements.

The potential travel impacts associated with the compressed workweek examined in the course of this study are summarized in the table below.

Item	Potential Impact	
	Positive	Negative
Weekly household travel		
Reduced work travel	X	
Induced nonwork travel on day off		X
Consolidation of nonwork travel	X	
Commuting		
Disruption of existing carpools		X
Reduced transit use		X
Reduced transit fare revenues		X
Reduced peaking		
Flattened peak transit demands	X	
Improved traffic flow conditions	X	

Evaluation Approach

The basic approach used in evaluating the transportation-related impacts of the compressed workweek involved comparing measurements of selected impacts obtained prior to the implementation of compressed work schedules in June 1979 with those taken one year later in June 1980. These measurements involved surveys of more than 2100 federal employees in 29 agencies located throughout the Denver area supplemented by traffic counts and bus ridership data.

Ideally, the impacts of the compressed workweek would be represented by observed differences before and after implementation of the compressed workweek for just those employees who actually switch to compressed work schedules. However, during the one-year period between surveys, a number of other events occurred that also had an effect on travel. In particular, there were some rather dramatic changes in both the price, and more importantly, the availability, of gasoline. June 1979 was the height of an energy crisis, during which time there were some relatively severe constraints on the availability of gasoline in the Denver area. One year later, though, although the price of gasoline had increased by about 25 percent, the supply situation had eased considerably.

In order to control for these and other factors, it was necessary to obtain measurements for those employees who remained on standard work schedules as well as those who switched to compressed work schedules. In an experimental design sense, then, employees in those agencies that participated in the compressed workweek experiment (i.e., agencies in which employees had the option of choosing compressed work schedules) served as the test group, and those in nonparticipating agencies (i.e., agencies in which compressed work schedules were not an option) served as the control group.

Data-Collection Considerations

The employee surveys, which served as the primary source of data used in developing the measures necessary to analyze potential impacts of the compressed workweek, involved two types of questionnaires. First, a relatively short questionnaire was used to obtain data on the employee's work trip, socioeconomic characteristics, and household composition. Second, included with each questionnaire was a set of three vehicle logs that were designed to measure changes in household vehicular travel that resulted from the compressed workweek. Employees were asked to keep one log in each household vehicle (up to a maximum of three) and record odometer readings, time of day, and trip purpose for travel over a seven-day period (or in some cases a three-day period).

The sample design that was developed for the employee survey, which was essentially a stratified cluster sampling approach, reflected the need to achieve a reasonable level of accuracy while at the same time minimizing both sample size and administrative requirements associated with the survey. Two stages of cluster sampling were involved. First, a sample of 29 of the 93 federal agencies in the Denver area was selected. Then, work units within each selected agency were sampled and all employees within each of the sampled work units were surveyed. The advantage of employing such a technique is clear. Rather than contacting and organizing separate survey efforts in each of Denver's 93 federal agencies, only a subset of these agencies had to be included in the sample.

This technique lowers the costs associated with survey administration; however, the possibility exists of a trade-off in terms of reduced sampling efficiency relative to a straightforward random sample. The extent to which sampling efficiency could be reduced is dependent on, among other factors, the degree to which variability among federal employees in Denver occurs between agencies versus within agencies. If most of this variability exists within agencies, for example, reduced sampling efficiency would be minimized. If most of this variability exists between agencies, though, sampling efficiency could be reduced considerably, since employees from only 29 of Denver's 93 federal agencies were surveyed.

To ensure that any interagency variability was captured, agencies were organized into groups or strata with the intent of minimizing the variation between agencies in any single stratum (i.e., ideally all interagency variation would be captured by interstratum variation). Three levels of stratification were used. First, agencies were grouped together based on their intent to allow their employees to participate in the compressed workweek experiment. Each of these groups then was stratified by location (CBD versus non-CBD). These four groups were further stratified by agency size (small, medium, and large), which resulted in a total of 12 strata from which agencies were selected in the first sampling stage.

The sample sizes used for the before-and-after employee surveys and the response rates for both the employee questionnaire and vehicle logs are presented in the table below.

Employee Survey	No. of Employees Surveyed	No. of Employees Returning Questionnaire or Vehicle Log	Response Rate (%)
Before			
Questionnaire	2309	2149	93
Vehicle log	2309	1504	65
After			
Questionnaire	2464	2150	87
Vehicle log	2464	1283	52

For the most part, the after survey was administered to employees in the same agencies and work units used in the before survey. As a result, it was possible to match the response of more than 800 employees in the after survey to their corresponding responses in the before survey.

TRAVEL-RELATED IMPACTS

Results from the seven-day vehicle logs for those employees in agencies located outside the CBD are presented in Table 1 and Figure 1. Unfortunately, it was not possible to evaluate the impacts of the compressed workweek on household VMT for those employees in CBD-located agencies due to an insufficient number of observations for this group. However, fewer than 600 of the 7000 or more employees who were actually on compressed work schedules were in CBD agencies; therefore, this does not significantly affect any of the key findings related to household travel patterns.

As shown, results are presented in Table 1 in terms of four categories of VMT:

1. Total VMT for the seven-day period,
2. Weekend VMT (two-day total),
3. Weekday VMT (five-day total), and
4. Weekday work VMT (five-day total).

Note that weekday work VMT includes the total VMT associated with any trip or tour for which work was indicated as one out of possibly several trip purposes. In the seven-day logs, entries were made only at those times that the vehicle was actually being driven from home. As a result, weekday work VMT would also include any VMT associated with additional nonwork travel made on the way to or from work as well as any trips made while at work during the day.

As shown, different sample sizes are used for certain VMT categories. This is due to a greater nonresponse rate for more-detailed information related to individual trips. For example, although total VMT is based on odometer readings recorded at the beginning and end of the seven-day period, weekend and weekday VMT are calculated by summing the appropriate entries in the vehicle log. In those instances where day-of-week information was missing for one or more trips, that log could not be used for estimating weekend versus weekday VMT. As a result, these VMT values are based on a subset of those seven-day logs used to calculate the mean value of total VMT, and their sum does not necessarily equal that indicated for total VMT.

In each case, estimates of total VMT are based on a larger sample of logs than the corresponding estimates for weekday and weekend VMT. Where differences exist, total VMT is always greater than the sum of weekday and weekend VMT, which would indicate that those logs that contain incomplete day-of-week information have, on average, a higher total VMT than those that have complete information. This is not totally unexpected, though, since when the amount of travel is greater there is also a greater chance that some information would be omitted in recording this travel.

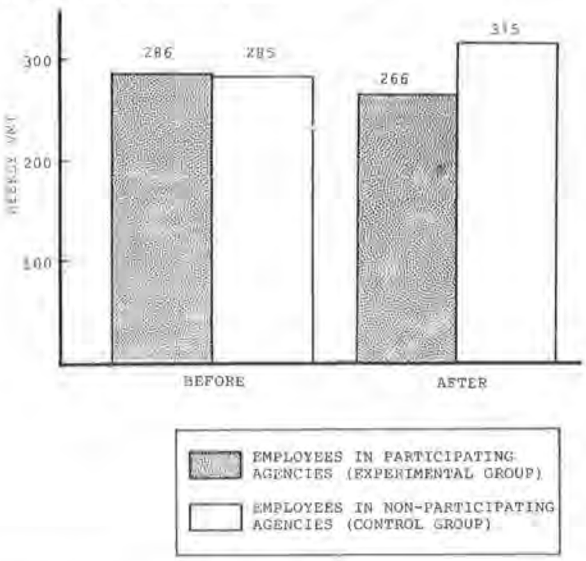
In assessing the impact of compressed work schedules on total household vehicular travel, employees in those agencies that participate in the experiment serve as the test group, and those in nonparticipating agencies serve as the control group. Based on the differences in VMT between the test and control groups for non-CBD agencies presented in Table 1 and Figure 1, a number of inferences can be made. First and foremost, the compressed workweek resulted in a significant decrease in average seven-day household VMT. Prior to compressed work schedules, total weekly VMT for employees in participating and nonparticipating agencies was, for all practical purposes, identical. One year later, though, average

Table 1. Changes in weekly household VMT: participating versus nonparticipating agencies.

	Employees in Nonparticipating Agencies			Employees in Participating Agencies			Difference[a]	
Item	VMT	No. of Observations	SE	VMT	No. of Observations	SE	VMT	SE
Before Compressed Work Schedules								
Total	285	154	15.8	286	594	8.3	+1	17.8
Weekend	75	129	6.6	79	490	3.6	+4	7.5
Weekday	210	129	13.4	202	490	6.5	−8	14.9
Weekday work[b]	133	111	9.7	145	432	6.2	+12	11.5
After Compressed Work Schedules								
Total	315	138	27.6	266	395	10.9	−49[c]	29.7
Weekend	86	110	13.2	75	320	5.9	−11	19.5
Weekday	204	110	15.1	185	320	8.6	−19	17.4
Weekday work[b]	156	91	14.4	124	286	7.2	−32[d]	16.1

[a]Difference is VMT for employees of participating agencies minus VMT for employees of nonparticipating agencies.
[b]Weekday work VMT as used here includes total VMT of any home-based tour that has work as one of several possible trip purposes.
[c]Significantly different from zero at the 90 percent level of confidence (two-tailed t-test). VMT of participating employees significantly less than that of nonparticipating employees at the 95 percent level of confidence (one-tailed t-test).
[d]Significantly different from zero at the 95 percent level of confidence.

Figure 1. Changes in weekly household VMT.



weekly household VMT for the test group was 49 miles less than that for the control group. This would imply that the compressed workweek resulted in a 15.6 percent reduction in total weekly household VMT among all employees in participating agencies.

Second, contrary to concerns that savings in work trip VMT would be offset to some extent by induced travel for nonwork purposes on the extra day off, nonwork travel also appears to have decreased somewhat. Although a difference in total VMT of 49 vehicle miles was observed between test and control groups, only about 65 percent of this difference can be attributed to a decrease in work-related travel. The implication, then, is that a number of shifts in the patterns of nonwork tripmaking occurred, with some trips either being rescheduled and combined more effectively or eliminated entirely.

The differences in VMT noted earlier in Table 1 are the net result of decreases in VMT on the part of employees in participating agencies and increases in VMT by employees in nonparticipating agencies.

Changes in Household Travel Patterns: Participating Employees

From the standpoint of obtaining an estimate of the aggregate change in household VMT attributable to compressed work schedules, the use of all employees in participating agencies (i.e., those employees that remained on standard work schedules as well as those that switched to compressed work schedules) as the experimental group is certainly appropriate. In order to gain some insight into the specific changes in travel behavior that have brought about this decrease in VMT, though, it is essential that not only the change in total seven-day VMT be isolated but also the relative contributions of changes in weekday, weekend, and work VMT as well. In this instance, the use of observed changes in VMT for all employees in participating agencies is not entirely satisfactory since any shifts on the part of those employees actually on compressed work schedules would be masked somewhat by the actions of those employees who remain on standard work schedules.

As mentioned earlier, more than one-third of the responses by employees in the after survey could be related to their corresponding responses in the before survey. For analyzing changes in household travel patterns, these paired observations are particularly useful in that responses prior to the experiment of those employees in participating agencies who eventually switched to compressed work schedules can be distinguished from those who remained on standard work schedules. The primary drawback to using this subsample is its decreased representativeness. Nonetheless, despite this potential difficulty, analysis of these matched responses is instructive. Although the specific magnitudes of observed shifts to VMT may be unique to this particular subset of employees, the general nature of these shifts is likely to be indicative of those that occurred in the sample as a whole.

Results from the seven-day vehicle logs for those responses that could be matched are presented in Table 2 and Figure 2 for those employees who actually switched to compressed work schedules. As shown, decreases are observed for each of the five VMT categories presented. Further, with the exception of average Monday and Friday VMT (defined as the sum of Monday and Friday VMT divided by two), these decreases are all quite significant.

A closer look at the specific changes shown in Table 2 shows a number of interesting points concerning some of the shifts in VMT that appear to have taken place.

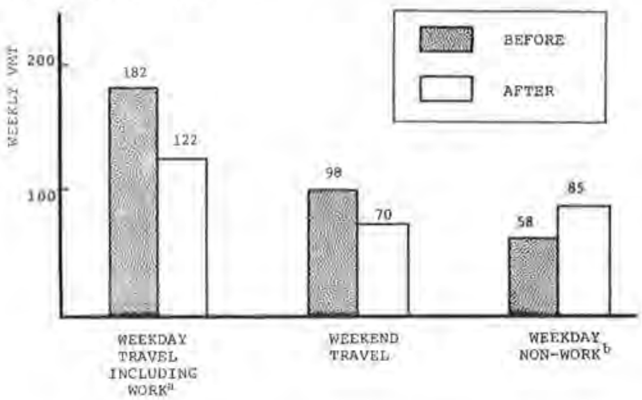
1. The change in total weekday work VMT (−60 vehicle miles) represents about one-third of its

Table 2. Changes in household VMT for employees who choose compressed work schedules.

VMT	Base VMT[a]	Change in VMT One Year Later	SE of Change	No. of Observations
Total for seven days	336	-59[b]	23.5	140
Weekend	98	-28[b]	10.9	72
Weekday	240	-33[c]	14.9	87
Weekday work[d]	182	-60[b]	15.9	65
Avg Monday and Friday	52	-6	5.1	85

[a]Prior to compressed work schedules.
[b]Significantly different from zero at 99 percent confidence interval.
[c]Significantly different from zero at 97.5 percent confidence interval.
[d]Note that weekday work VMT as used here includes the total VMT of any home-based tour that has work as one of several possible trip purposes.

Figure 2. Before and after household VMT for employees who choose compressed work schedules.



[a] Weekday Work VMT includes the total VMT of any home-based tour which as work has one out of possibly several trip purposes.

[b] Weekday Non-Work VMT includes the total VMT of any home-based tour for which work was not listed as one of the trip purposes.

base value (182 vehicle miles). Since at most only a 20 percent reduction can be attributed to the compressed workweek, this would indicate that, in addition to the elimination of one trip directly to and from work, at least some of the nonwork trips previously made in conjunction with work travel were either eliminated or rescheduled.

2. Although a reduction in weekday work VMT of 60 vehicle miles was observed, total weekday VMT decreased by only 33 vehicle miles, which suggests that some of the nonwork trips previously made in conjunction with work travel were in fact rescheduled to another weekday.

3. These differences between the reductions in weekday work VMT and total weekday VMT together with the reduction in weekend VMT of 28 vehicle miles suggest that there was also a shift in nonwork travel from the weekend to a weekday.

4. Although weekend VMT, weekday VMT, and weekday work VMT all exhibit relatively large decreases in VMT, the average decrease for Mondays and Fridays (the days that more than 95 percent of those employees on compressed work schedules take off) is only 6 vehicle miles, which suggests rather strongly that trips formerly made on the weekend and other weekdays were rescheduled to the employee's day off.

5. Given that average weekday work VMT was 182 vehicle miles for the standard five-day workweek, a maximum estimate of the VMT saved just by eliminating one work trip would be 20 percent of 182, or about 36 vehicle miles. Since the total reduction in weekly VMT was 59 vehicle miles, in addition to rescheduling nonwork travel to the extra day off, an overall reduction in nonwork travel also occurred as a result of the compressed workweek. This could be accounted for by more-efficient chaining of trips on the extra day off or by the elimination of some of the more discretionary trips previously made in conjunction with the trip to or from work.

Changes in Weekly Household VMT: Nonparticipating Employees

The differences in household VMT observed between test and control groups were due in part to an increase in VMT among nonparticipating employees as well as a decrease in VMT among participating employees. It is useful, then, to examine briefly those factors other than the compressed workweek that could have had a significant impact on travel. Since the two surveys were administered one year apart and with the same relation in time to school closings and holidays, seasonal effects can probably be ruled out. Weather, too, was quite similar during the periods covered by the vehicle logs. The most influential factors remaining, then, are the price and availability of gasoline.

Between June 1979 and June 1980, the average statewide price of unleaded fuel as reported by the American Automobile Association (AAA) increased from \$0.91 to \$1.29/gal. Adjusting for the increase in the cost of living during that period (up by 10.6 percent) and the increase in average fuel economy of vehicles used by federal employees (up by 3 percent), this would translate into a 25 percent increase in the per mile cost of gasoline. All else being equal, this should have resulted in a decrease in VMT.

Since VMT was observed to increase, though, all else was not equal. In particular, the availability of gasoline changed markedly between the two survey periods. June 1979 was near the height of the second energy crisis, and considerable publicity was given at that time to the severe shortfalls in California. In the Denver area, AAA was issuing weekly reports concerning station closings in the evenings and on weekends. During this period approximately 95 percent of those stations surveyed by AAA were closed on weekends and in the evenings on weekdays. One year later, though, the supply situation changed dramatically. The AAA was then issuing reports only once a month, and no mention was made of station closings at all. The widespread availability of gasoline at that time is probably best reflected in the stabilization (and subsequent drop) in gasoline prices that occurred. Based on the increase in weekly VMT observed for the control group (i.e., employees in nonparticipating agencies) presented in Table 1, it would appear that the effects of increased supply far outweighed those of increased price.

Ridesharing

The table below presents shared-ride mode shares for work travel prior to the implementation of compressed work schedules and again one year later for employees in participating agencies and those in nonparticipating agencies.

	Ridesharing			
	Before		After	
Employees	No.	Percent	No.	Percent
In participating agencies	1483	31	1432	29
In nonparticipating agencies	608	32	643	30

As shown, prior to the compressed workweek mode shares were similar between these two groups, although the changes after one year were identical. On the surface, then, compressed work schedules appeared to have no impact on ridesharing.

A closer look at just those employees in participating agencies, though, reveals that some rather dramatic changes in ridesharing did in fact occur. The table below presents shared ride mode shares for that subset of employees in participating agencies whose responses in the before and after surveys could be matched.

	Ridesharing			
	Before		After	
Employees	No.	Percent	No.	Percent
Who choose compressed work schedules	405	29	405	32
Who remain on standard work schedules	181	36	181	24

As shown, the aggregate decrease in shared ride for all employees in participating agencies, noted earlier in the preceding table, was the result of a moderate increase among those employees who switched to compressed work schedules (from 29.4 to 32.0 percent), which was more than offset by a very large decrease among those employees remaining on standard work schedules (from 35.5 to 24.4 percent).

These results would tend to indicate that compressed work schedules do indeed disrupt existing ridesharing arrangements involving employees who choose different work schedules. However, because such a large proportion of employees in participating agencies had chosen compressed work schedules (i.e., 65 percent), this group apparently was able to form new carpools. Those employees who remained on standard schedules, though, had more difficulty in forming new carpools since the number of employees with compatible work schedules was reduced considerably. Therefore, although the aggregate level of ridesharing was not adversely affected by compressed work schedules in the Denver experiment, the transferability of this finding to other applications would be contingent on similar levels of participation in compressed work schedules.

Impacts on Transit

Table 3 presents the transit mode shares for employees in participating and nonparticipating agencies. In addition, because the level of transit service available to those employees who work in the CBD was quite different from that available to employees whose work locations are outside the CBD, separate mode shares are presented for CBD and non-CBD employment locations. As shown, the transit mode shares remained essentially unchanged for non-CBD work locations. For CBD work locations, the transit mode share among employees in nonparticipating agencies rose from 0.32 to 0.37, a 16 percent increase. A somewhat smaller increase, from 0.28 to 0.31 (an increase of 11 percent), was observed among employees in participating agencies. Overall, though, the compressed workweek appears to have little impact on transit ridership among employees on compressed work schedules.

Impacts of the compressed workweek on transit fare revenues can be estimated based on the number of employees actually on compressed work schedules, the fraction that have a day off during a given week, and their current transit mode share. In the Denver experiment, the decrease in weekly transit ridership that resulted directly from the reduction in work travel was estimated to be 309 round trips. Assuming that this represents 618 revenue trips at an average fare of \$0.56/trip (25 percent pay \$0.75 express fare, 75 percent pay \$0.50 local fare), this translates into an average fare revenue loss of about \$348/week.

Note, however, that the compressed workweek also has the potential for flattening peak transit demand, since, because of longer work days, employees would be traveling outside the peak hour. Since transit service was not reduced at all during the experiment, the result of those employees on compressed work schedules shifting from the peak hour essentially would be to make additional bus capacity available for other employees who still travel in the peak hour. If a sufficient portion of this available capacity is used, the decrease in fare revenues that results from fewer work trips by those employees on compressed work schedules could be more than offset by an increase in ridership by other employees, both federal and nonfederal. For example, to the extent that transit service is characterized by crush load conditions during the peak hours, one could argue that the demand for transit service is sufficiently great that any increase in peak-hour capacity would be used immediately.

Clearly, such a situation would not be representative of all routes during the peak hour. However, if only one new, regular rider is attracted to transit for every five employees on compressed work schedules who shift their peak-hour transit trip, fare revenues would not change.

Table 3. Impacts on transit.

	Transit Mode Share			
	Before		After	
Agency	No.	Percent	No.	Percent
Non-CBD				
Participating	1175	2	1058	3
Nonparticipating	424	4	409	4
CBD				
Participating	308	28	374	31
Nonparticipating	184	32	234	37

Potential Improvements in Traffic Flow

Figure 3 characterizes the midweek (i.e., Tuesday-Thursday) time-of-day distributions for arrivals and departures prior to and again after implementation of the compressed workweek for the 775 employees in participating agencies located in the CBD. As shown, the implementation of compressed work schedules flattened somewhat the peak in arrival times. The maximum percentage of total arrivals in a 0.5-h period, for example, was reduced from 56 to 42 percent. In addition to being flattened, the peak in arrivals was also shifted earlier by one hour from 8:00 to 7:00 a.m. Similarly, the peak in departure times was also flattened, and the maximum one-half-hour percentage of total departures was reduced from 47 to 34 percent. In this case, though, the peak in departure times was shifted one hour later.

With respect to all CBD traffic, peak 1-h volumes occurred between 7:30 and 8:30 a.m. and between 4:30 and 5:30 p.m., with excess capacity available during 6:00-7:00 a.m. in the morning peak and 5:30-6:00 p.m. in the afternoon peak. Thus, the shifts in arrival and departure times that resulted from the compressed workweek among employees in CBD agencies, which tended to reduce peak volumes and take advan-

Figure 3. Distribution of arrival and departure times for participating CBD agencies.

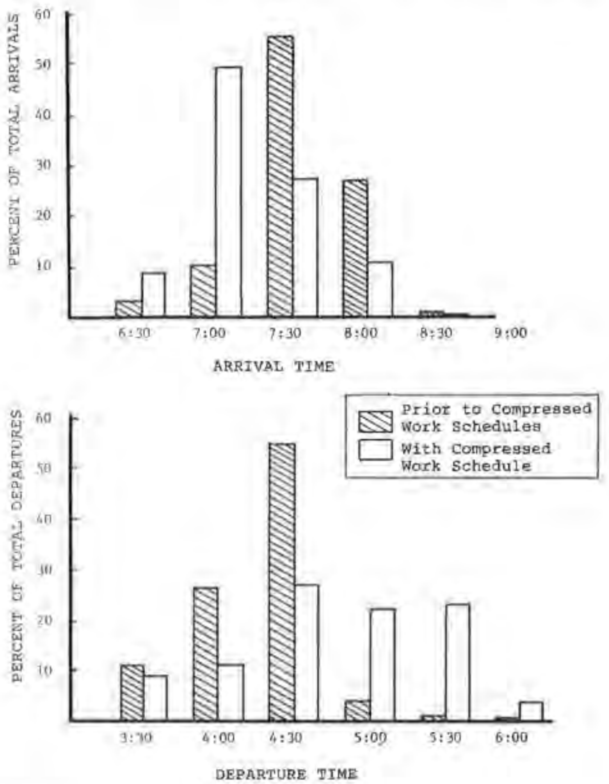


Table 4. Air quality impacts of compressed workweek: total seven-day impacts.

Affected Group	VMT[a] (%)	Emissions Reduction (%)			Fuel Consumption[e] (%)
		CO[b]	HC[c]	NO_x[d]	
Employees in participating agencies	15.6	15.7	15.8	15.4	15.6
All federal employees	5.6	5.7	5.7	5.5	5.6
Total regionwide travel	0.3	0.3	0.3	0.3	0.3

[a]Total reduction = 494 000 miles/week.
[b]Total reduction = 67 960 kg/week.
[c]Total reduction = 4970 kg/week.
[d]Total reduction = 1590 kg/week.
[e]Total reduction = 26 130 gal/week.

tage of this excess capacity, had the potential for improving traffic flow conditions in the CBD. However, because of lower participation levels among CBD agencies, extension of the compressed workweek concept to a larger number of CBD employees would have been necessary in order to realize this potential.

Air Quality and Energy Impacts

Table 4 presents the reductions in VMT and associated emissions and fuel consumption attributable to the compressed workweek experiment over a seven-day period. These results are also presented in percentage terms relative to the total weekly household VMT of

1. Just those federal employees in participating agencies,
2. All Denver area federal employees, and
3. All Denver metropolitan area residents.

As shown, the 15.6 percent reduction in total weekly VMT for employees in participating agencies translated into similar reductions in emissions and fuel consumption. Relative to all federal employees, these reductions represent about a 5.6 percent reduction in total weekly travel and related emissions and fuel consumption; on an areawide basis, this represents a 0.3 percent decrease.

CONCLUSIONS

As a transportation measure designed to reduce vehicle emissions and fuel consumption, the compressed workweek is attractive from several aspects:

1. It is an effective action for reducing total weekly household VMT. Results from the Denver experiment indicate that reductions occur not only in work travel but in nonwork travel as well.
2. Although not conclusively demonstrated in the Denver experiment, in addition to reducing VMT, the longer workdays associated with compressed work schedules could improve traffic flow by flattening the distribution of traffic volumes during peak periods.
3. Results in Denver indicate that the compressed workweek can be compatible with other, ongoing transportation measures oriented toward ridesharing, at least for participation levels similar to those achieved in federal agencies.
4. The widespread use of compressed work schedules among federal agencies that range in size from fewer than a dozen employees to several thousand and with very diverse operations goes a long way toward removing any uncertainty that surrounds its popularity among employees and at least the feasibility of its implementation, if not specific employer-related operational impacts.

Transferability of Results

Transferability of the results observed among Denver area federal employees to public and private sector employers in other urban areas raises several questions. First, if given the opportunity, to what extent would employee participation in other urban areas match that observed among Denver's federal employees? Second, for those employees who would participate, to what extent would shifts in travel patterns be similar to those observed for participating federal employees in Denver? Third, what characteristics are unique to the Denver experiment that would affect the transferability of its findings?

To answer the first question, an analysis of those factors important in determining employee acceptability of compressed work schedules indicates that participation rates among employees that have different socioeconomic characteristics can vary considerably. To a large extent, then, whether or not the overall participation rate observed for federal employees in Denver would be directly transferable to other urban areas would depend on similarities (or differences) in socioeconomic characteristics between federal employees in the Denver area and employment in other urban areas. Employer acceptability of compressed work schedules, particularly in the private sector, would also be a crucial factor in determining the level of participation in other urban areas.

Results of the Denver study indicate that similar shifts in travel patterns occurred among various groups of participating federal employees who represented a broad range of socioeconomic characteristics. With respect to the second question, then, it would seem reasonable to expect that similar shifts in travel patterns would also occur in other urban areas among employees who switch to compressed work schedules.

A number of characteristics of the Denver experiment and the Denver area in general could also affect the transferability of the results reported in this paper. Denver is somewhat unique in its abundance of nearby recreational facilities. The finding that nonwork travel decreased as a result of compressed work schedules despite the availability of numerous recreational opportunities would suggest that similar or perhaps even greater reductions in nonwork travel could be expected from applications in other urban areas.

Although the shifts in arrival and departure times that result from the compressed workweek had the potential for improving traffic-flow conditions in Denver's CBD, this potential was not realized because of lower participation among federal agencies located in the CBD. In other urban areas, if higher participation levels were to be experienced in areas of severe traffic congestion, more significant improvements of traffic-flow conditions could result.

With respect to ridesharing, the findings of the Denver experiment appear to be sensitive to the level of participation in compressed work schedules. If levels of participation in other urban areas were lower than those among Denver area federal agencies, ridesharing could be adversely affected. In terms of impacts on transit, the transferability of findings from the Denver experiment would be contingent on similar service levels outside the peak hour.

Implications for Future Transportation Decisionmaking

In Denver, the compressed workweek was promoted primarily on the basis of its potential air quality and energy impacts. Experience has shown that, in implementing any form of alternative work schedule, particularly in the private sector, such measures are seldom sold on their transportation benefits alone. Instead, employers are much more concerned with the impacts of such measures on the effectiveness of their particular operation. A key element in promoting these measures, then, is convincing upper management of the benefits associated with alternative work schedules in terms of increased employee morale, productivity, and reduced absenteeism.

The employer-related impacts of other forms of alternative work schedules (e.g., flex-time or staggered work hours) have been fairly well documented and are reasonably well understood. Experience with compressed work schedules, though, is not nearly as extensive. Further, based on what experience is available, results are somewhat mixed, which indicates generally that the compressed workweek is successful for certain work environments but not for others.

Given this relatively high level of uncertainty surrounding the potential employer-related impacts of compressed work schedules, many employers will be reluctant to implement such an action, particularly since the compressed workweek represents a more radical departure from standard work schedules than other forms of alternative work schedules. The experiences of the 42 federal agencies in the Denver area that participated in the compressed workweek experiment will be valuable in reducing some of this uncertainty. This information currently is being developed by the U.S. Office of Personnel Management as part of their nationwide evaluation of alternative work schedules among federal employees.

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