AN EVALUATION OF TELECOMMUTING
AS A TRIP REDUCTION MEASURE

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ABSTRACT

Telecommuting, which is the performance of work at home or at a center close to home using telecommunications, has attracted growing interest among planners and researchers as a strategy for reducing travel demand. This paper investigates the potential of telecommuting as a trip reduction measure, using data obtained from a telecommuting pilot project involving State of California government employees.

In this pilot project, a three-day trip diary was administered, before and after telecommuting began, to telecommuters, a control group, and driving-age household members of both groups. A sample of 219 "stayers" is analyzed in this paper.

Findings include: telecommuting leads to a substantial reduction in trip generation, vehicle-miles traveled, peak period travel, car use, and freeway travel. It does not lead to an increase in non-work trips.

1.   INTRODUCTION

The evaluation of the impact of telecommunications on travel demand is a highly complex task. In the past, a variety of hypotheses have been advanced on this issue. An issue of particular importance is whether telecommunications technologies act as substitutes for travel or whether a complementary relationship exists between telecommunications and travel (e.g., Salomon, 1986; Mokhtarian, 1988; Nilles, 1988). Little empirical evidence appears to exist at present on the interaction between the two (Salomon, 1988).

The use of telecommunications to substitute for the commute to work has recently drawn extensive attention as a strategy for reducing travel demand. This came to be known as telecommuting, broadly defined as "the performance of work outside the traditional central office, either at home or at a neighborhood center close' to home" (Kitamura, et al., 1990).

The potential of telecommuting as a means to mitigate urban traffic congestion, reduce transportation energy consumption, and improve air quality has motivated this study. The

objective of the study is to empirically measure the impact
of telecommuting on household travel in conjunction with
the State of California Telecommuting Pilot Project.   The
Pilot Project has offered the first opportunity to gather
non-proprietary data on household travel behavior to assess
the impact of telecommuting.   Other potential benefits of
telecommuting (e.g., reduced office space requirements,
increased worker productivity) have been examined by JALA
Associates (1990), the principal contractor of the Pilot
Project, and are not discussed in this paper.

Many hypotheses can be formulated on the impact of tele-
commuting on household travel (for related discussions, see
Jovanis, 1983; and Salomon, 1986).   It is convenient to
classify these hypotheses according to the time frame into
short-term and long-term hypotheses.   The most direct short
term hypothesis is that the number of trips generated by
telecommuters will decrease due to the reduction in commute
trips to and from work.   Because work trips are most often
made during the peak period, a decrease in peak-hour trips
will follow as a direct consequence.

Furthermore, the eliminated need to travel to work would
lead to savings in both time and monetary cost.   This would
in turn result in an increased availability of discretionary
time, flexibility in activity scheduling, and some monetary
saving.   One may then hypothesize that these changes prompt
new, discretionary trips such as social and shopping trips.
Indeed, if the assumption is true that a person budgets a
fixed amount of time for travel, then those commute trips
eliminated by telecommuting may be replaced by new trips.
Also, other destinations, timing and modes could be chosen
for the existing non-work trips to reach more desirable
destinations, or to travel at more convenient times, while
using up the time saved.

Another consideration is that the absence of commute trips
by itself may lead to changes in the location and timing of
certain out-of-home activities, hence the destination and
timing of trips.   For example, grocery shopping which used
to be done on the way home from work at a shopping center
along a commute route, may be performed at a grocery store
near the home in the late morning.   One may surmise that the
spatial distribution of trip ends may be concentrated around
the home location rather than the work location when the
worker telecommutes.   This redistribution of trips may af-
fect (suburban) congestion and air quality if telecommuting
is widely implemented.

An important consequence of telecommuting is the removal of
some of the work-related constraints -- a worker must report
to work by 8:00 a.m., a lunch break must be taken between 12
noon and 1:00 p.m., and so on.   Relaxation of these con-
straints is likely to reduce the need to link trips, i.e.,
consolidation of several stops into one home-to-home jour-

As noted earlier, volunteer State employees also partici-
pated in the Pilot Project as members of a control group.
The intent of forming the control group was to measure
changes in travel patterns, energy use, and other measures
of effectiveness that are due to changes in economy, gaso-
line prices, and other such factors that influence all
individuals. The group would aid in separating the effect
of telecommuting from the effects of these factors in the
background. The control group members did not change their
usual work schedules between the two waves.

Description of the Survey Sample

The travel survey involved State employees from 14 agencies
and their household members of driving age. The partici-
pants live and work mostly in the Sacramento area. In
Wave 1, information about the participants and their house-
hold members of driving age was available from 430 persons
out of the original group of 447 individuals. Of the 430
individuals, 252 were state employees, and 178 were their
driving-age household members. Of the 252 state employees,
137 (54.3%) were scheduled to telecommute in the second wave
and 115 (45.7%) were assigned to the control group.

Table 1 compares the number of respondents between the two
waves. The number of respondents is 257 persons in Wave 2.
The number of respondents who dropped out of the survey is
not negligible. Of the 252 employees and 178 household
members in Wave 1, usable travel diaries are available from
138 employees and 81 household members (these respondents
will be referred to as "stayers" in this paper). It is
unknown to what degree this rather high rate of attrition
represents employees and their household members who: (i)
were no longer participating in the Pilot Project due to
outside factors such as retirement, promotion, reassignment,
relocation, or organizational change; (ii) chose (or were
asked by the manager) to stop telecommuting for internal
reasons -- i.e., reasons related to telecommuting itself
(family issues, lack of self-discipline, etc.); or (iii)
continued to telecommute (or remain control members) but did
not return the Wave 2 survey.

In addition to the stayers, 38 new people submitted Wave 2
surveys that had not participated in Wave 1.

TABLE 1: COMPOSITION OF STUDY SAMPLE ACROSS THE TWO SURVEY
WAVES

Group	Wave 1	Wave 2	Stayers
TC Employees	137	79	73
CG Employees	115	75	65
TC Household Members	93	56	45
CG Household Members	85	47	36

Two types of data files were created to analyze the travel
characteristics of the project participants and their house-
hold members. One file contains personal and household in-
formation while the other contains trip information. The
person file provides information on the respondent's project
participation status (telecommuter, control group member,
etc.), age, gender, employment, and relation to the State
employee. This file also contains the respondent's home,
work, school, and other activity locations frequently vis-
ited by the respondents, transit lines frequently used and
household car ownership. This information has been geo-
coded for the analysis of spatial changes in urban travel
patterns.

The trip files contain characteristics of each trip made by
the respondent in each wave. The information includes trip
origin and destination, trip beginning and ending times,
trip purpose, approximate trip length in miles, mode used,
and, if a car were used, beginning and ending odometer
readings, the number of passengers, and the percentage of
the trip spent on the freeway. The Wave 1 trip file con-
tains 4808 trips reported by 430 persons in 269 households
while that from Wave 2 contains 2389 trips reported by 257
respondents in 159 households.

3.   IMPACT OF TELECOMMUTING

The impact of telecommuting is statistically analyzed in
this section using the sample of 219 participants who res-
ponded to both Wave 1 and Wave 2 surveys. These respondents
consist of 73 telecommuter employees, 45 telecommuter house-
hold members, 65 control group employees and 36 control
household members. Wave 2 travel characteristics of the
telecommuters are further examined by day type (telecom-
muting or commuting day). On average, respondents telecom-
muted 1.3 days out of the three-day diary period.

The control group is used as a reference group in this
assessment. The changes exhibited by telecommuters are
evaluated relative to those shown by the control group
members. Two types of comparisons are made: First, the
travel characteristics are compared between the telecom-
muters and control group members within each wave, and
second, comparison is made across the two waves for each
group. For the first type of comparison, the pooled t-test
is appropriate as the two groups can be considered as in-
dependent samples of different sample sizes. For the sec-
ond comparison, the paired t-test is used as it allows for
possible correlation among repeated observations of the same
individuals (Snedecor and Cochran, 1989).

Daily Average Trip Rates

Based on the daily average trip rates, the control group
employees display a higher level of mobility in both waves

(Table 2). In Wave 1, the control group employees made an average of 4.30 trips per day, compared to 3.99 trips made by the telecommuters (this difference is not statistically significant at a 5% level). In Wave 2, the control group employees made 3.95 trips per person per day, while the telecommuters made a much lower daily average of 1.94 trips on telecommuting days. The difference, statistically significant at a 5% level, is expected because the telecommuters made at least two trips less (trips to and from work) than the control group on a telecommuting day.

On a commuting day in Wave 2, telecommuters averaged the same number of trips as in Wave 1. On a telecommuting day, the telecommuters make a significantly smaller number of trips when compared with Wave 1. The reduction in trip making shown by telecommuter household members across the two waves is also significant and noteworthy.

TABLE 2: NUMBER OF TRIPS PER DAY

Group	Wave 1	Wave 2-TC	Wave 2-C
Telecommuter Employees	3.99	1.94*	4.00
Control Group Employees	4.30	n/a	3.95
Telecommuter Household	3.98	n/a	3.08*
Control Group Household	3.53	n/a	3.30

*   significantly different from Wave 1 at a 5% level
Wave 2-TC: Telecommuting Day in Wave 2
Wave 2-C: Commuting Day in Wave 2

Trip Rates by Purpose

In Table 3, average daily trip rates are presented for each wave by purpose and by project participation status. The "other" trip purposes include return home, social-recreation, visit friend/relative, personal business, shopping, serve passengers, medical, eat meal, and change mode.

Telecommuters make virtually no work trips on telecommuting days. On commuting days, they make the usual one work trip. All other groups showed statistically stable work trip rates across the two waves.

Contrary to what was hypothesized in the introduction, no increase in "other" trips, which include discretionary non-work trips, is observed for the telecommuters. Apparently, decreased travel needs, increased availability of discretionary time, and flexibility in work schedule brought about by telecommuting, did not lead to an increase in non-work trips.

In fact, between Wave 1 and Wave 2 a significant decline in the number of "other" trips is observed for telecommuters on telecommute days, and for telecommuter household members. For the telecommuters, this decline is explained by the fact that one fewer "return home" (i.e., returning home from

work) or "work-to-elsewhere" trip will be made on telecommuting days. The finding for household members, though, is unexpected. The indication is that telecommuting reduces trip generation for the entire household. Before this result can be generalized, however, further examination of the data and possibly a supplementary survey of household members are needed to examine the mechanism underlying this apparent reduction.

In any case, the result is encouraging because it indicates that telecommuting effectively serves as a trip reduction measure by eliminating some work trips without increasing non-work trips, at least in the short term.

TABLE 3: NUMBER OF TRIPS PER DAY BY PURPOSE

Group	Wave 1		Wave 2-TC		Wave 2-C	
	Work	Other	Work	Other	Work	Other
TC Employees	1.02	2.97	0.09*	1.85*	1.11	2.89
CG Employees	1.10	3.20	n/a	n/a	1.07	2.88
TC Household	0.74	3.24	n/a	n/a	0.70	2.38*
CG Household	0.60	2.93	n/a	n/a	0.77	2.53

*   significantly different from Wave 1 at a 5% level
Wave 2-TC: Telecommuting Day in Wave 2
Wave 2-C: Commuting Day in Wave 2

Mode Use

Trip rates by car are summarized in Table 4. Car trips are defined here as those made in personal vehicles or State vehicles, and exclude carpooling or vanpooling. The decrease in car trips by telecommuters on a telecommuting day is noteworthy. This is a direct consequence of the reduction of commute trips by the introduction of telecommuting.

There is no indication that the availability of the car previously used by the telecommuters to commute, is inducing more car trips by household members. The household members of telecommuters have not increased car usage even though additional family cars have become available for their use. This may be because, in California and nationwide, there are about 0.99 personal-use vehicles per driving-age person (Lave, 1990). An idle vehicle will not be used by other family members if they already have vehicles of their own.

There is, however, some indication that changes in mode choice are greater among the telecommuters than the control group employees. Table 4 also presents the percentage share of car trips. The share of car trips among the control group employees shows practically no change between the waves. Among the telecommuter employees, the share increased somewhat from 81% to 91%. Associated with this increase is a chi-square statistic of 7.01, which, with one

degree of freedom, indicates an increase significant at a 5%
level.

In this context, it is important to note that telecommuting
can induce a series of changes in transport related deci-
sions, including car ownership, residence location, and
other life-style related choices. These changes, which tend
to be observed only in the long run, could cause measurable
changes in travel patterns, including mode use. It is de-
sirable that the validity of the findings here, which are
based on short-term data, be examined using observations
obtained over a longer time span.

TABLE 4:   CAR TRIPS PER DAY

Group	Wave 1	Wave 2-TC	Wave 2-C
TC Employees	3.25 (81)	1.77* (91)	3.25 (81)
CG Employees	3.17 (74)	n/a	2.88 (73)
TC Household	3.53 (89)	n/a	2.83* (92)
CG Household	2.72 (77)	n/a	2.69 (81)

* significantly different from Wave 1 at a 5% level
( ): As a percentage of Total Trips per Day
Wave 2-TC: Telecommuting Day in Wave 2
Wave 2-C: Commuting Day in Wave 2

Peak Period Trip Generation

Telecommuting substantially reduced peak hour travel by the
telecommuters, whereas the control group did not show any
substantial reduction. Table 5 presents the number of de-
partures during the morning and afternoon peak periods. The
morning peak period is defined in this study as 7:00 to 8:59
a.m. and the afternoon peak period as 4:00 to 5:59 p.m.

TABLE 5:   NUMBER OF PEAK PERIOD TRIPS PER DAY

Group	Wave 1		Wave 2-TC		Wave 2-C	
	AM	PM	AM	PM	AM	PM
TC Employees	0.89	0.99	0.24*	0.46*	0.82	1.16
CG Employees	0.86	1.13	n/a	n/a	0.98	1.15
TC Household	0.79	0.84	n/a	n/a	0.64*	0.65*
CG Household	0.62	0.60	n/a	n/a	0.50	0.83

* significantly different from Wave 1 at a 5% level
Wave 2-TC: Telecommuting Day in Wave 2
Wave 2-C: Commuting Day in Wave 2

The decrease in the number of peak-hour departures made by
the telecommuters on telecommuting days in Wave 2 is sig-
nificant for both morning and afternoon peak periods (at a
5% level). They made 73% fewer morning-peak departures and
about 54% fewer afternoon-peak departures. The reduction in
peak-hour trips is significant for the telecommuter house-
hold members as well. A decrease in peak hour trip genera-

tion appears to be a direct consequence of the introduction of telecommuting.[1]

Total Distance Traveled

The estimated average distance traveled decreased significantly in Wave 2 on telecommuting days. The average total distance traveled per day for each group is presented in Table 6. In Table 6, the average distance traveled is computed from the trip lengths reported by the respondents.

The telecommuters reduced the total distance traveled by about 40 miles per telecommuting day. This decrease is found to be highly significant. On commuting days, the telecommuters showed no increase in vehicle miles traveled over Wave 1. The control group employees showed relative stability in their vehicle miles traveled per day. The results thus clearly show that telecommuting leads to a reduction in total travel distance.

TABLE 6: AVERAGE TOTAL DISTANCE TRAVELED PER DAY (MILES)

Group	Wave 1	Wave 2-TC	Wave 2-C
Telecommuter Employees	53.7	13.2*	56.1
Control Group Employees	50.0	n/a	45.1
Telecommuter Household	36.4	n/a	33.1
Control Group Household	25.7	n/a	23.8

* significantly different from Wave 1 at a 5% level
Wave 2-TC: Telecommuting Day in Wave 2
Wave 2-C: Commuting Day in Wave 2

TABLE 7:   FREEWAY PERCENTAGE PER TRIP

Group	Wave 1	Wave 2-TC	Wave 2-C
Telecommuter Employees	53	10*	49
Control Group Employees	35	n/a	40
Telecommuter Household	31	n/a	30
Control Group Household	30	n/a	25

* significantly different from Wave 1 at a 5% level
Wave 2-TC: Telecommuting Day in Wave 2
Wave 2-C: Commuting Day in Wave 2

Freeway Percentages

The percentage of the trip spent on the freeway is shown in Table 7. The telecommuters are found to significantly re-

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[1] The reduction in morning peak period trip generation for telecommuter and control group household members may, in part, be due to seasonal effects. While the entire Wave 1 survey occurred before closing of schools (i.e., before June), a portion of the Wave 2 survey took place in June after schools were closed. No school trips (which usually occur in peak periods) were observed during this period.

duce their freeway use on telecommuting days while showing
stable freeway use on commuting days. All other groups also
show relative stability in freeway use. The conjecture that
telecommuters are choosing different destinations which are
reachable by different routes is supported by this finding.

4. CONCLUSIONS

The impact of telecommuting on travel demand is examined in
this study, using three-day travel diary data obtained from
State employees participating in the State of California
Telecommute Pilot Project, and from their household members
of driving age. Travel data were collected twice, before
and after telecommuting started. The main body of the
analysis presented in this report is based on trip records
obtained from 219 respondents, of which 73 are telecom-
muters.

The results of the statistical analysis presented in this
report offer strong empirical evidence that telecommuting is
a viable trip reduction measure. The salient findings of
this study can be summarized as follows:

--   Telecommuting leads to a substantial reduction in trip
generation. The observed reduction of two trips per tele-
commuting day corresponds to the two commute trips elimin-
ated by telecommuting each day. Virtually no work trips
were generated by the telecommuters in the Pilot Project on
the days they telecommuted.

--   Telecommuting does not lead to an increase in non-work
trips. On the contrary, the evidence suggests that telecom-
muting leads not only telecommuters but also their household
members to be more efficient in traveling.

--   The total travel distance was reduced by 40 miles per
telecommuting day in the study sample. On a telecommuting
day, telecommuters traveled about 20% of the distance they
normally traveled on commute days.

--   Telecommuting reduces peak-period trips. On telecom-
muting days, morning-peak trips are reduced on the average
by 73%, and afternoon-peak trips by about 54%.

--   The household members of telecommuters do not increase
car use even when additional family cars have become avail-
able for their use.

--   Although the total number of car trips is lower, the
proportion of trips made by car tends to be slightly greater
among telecommuters. This is in part due to the reduced
number of work trips, where transit is more likely to be
used. Another contributing factor is the frequent use of
the car for non-work trips made on telecommuting days.

-- Trips made on telecommuting days are much shorter and involve less freeway travel. This presumably reflects changes in the spatial distribution of trips as a result of telecommuting.

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