Telecommuting as a Transportation Planning Measure: Initial Results of California Pilot Project

RYUICHI KITAMURA, JACK M. NILLES, PATRICK CONROY, AND DAVID M. FLEMING

The travel impact of home telecommuting—the performance of work at home possibly using telecommunications technology—is evaluated using travel diary survey results from California's State Employee Telecommute Pilot Project. The data obtained from 185 state workers and their household members indicate that telecommuting reduces work trips as expected, and no indication is present that telecommuting induces new nonwork trips. In addition, the results suggest that family members of telecommuters may also reduce nonwork trips. The analysis offers strong empirical support for telecommuting as a means to mitigate traffic congestion and improve air quality.

Ever-worsening traffic congestion and air pollution have been major concerns of many growing urban areas. In particular, failure to meet the federal air quality mandates in most of the major metropolitan areas of California has forced planning agencies and air quality management districts to step up efforts to institute coordinated, effective, and enforceable programs for travel reduction. Among the options being considered by these agencies is telecommuting. Telecommuting refers to the performance of work outside the traditional central office, either at home or at a neighborhood center close to home.

Telecommuting is emerging as a feasible option because of two fundamental changes. First, the labor force has evolved from one whose workers were primarily involved in agricultural, industrial, and manufacturing processes to one in which information workers—those involved in the creation, collection, or handling of information—are a considerable portion. For these workers the conventional mode of work (i.e., being at the workplace to perform work functions) is less mandatory. Concurrently, advances in telecommunication technologies and greatly increased capabilities per unit cost have made location-independent work feasible and cost-effective.

In California, where information workers are almost 60 percent of the labor force, telecommuting first received attention as an energy conservation measure. A study done for the California Energy Commission (*1*) indicated that telecommuting had significant potential for mitigating both travel demand (particularly peak demand) and fuel consumption in the state—annual reductions could range up to 30 billion passenger-mi of travel and 700 million gal of fuel by 2000. However, the estimates contained in this study were based on scenarios of varying penetration rates for telecommuting (4 to 55 percent of the labor force) that assumed historical household travel behavior. Only direct substitution for the commute trip (by mode) was used in calculating travel and fuel reductions. Total household travel impacts were not addressed because no data were available. Without such data, the effectiveness of telecommuting as a travel demand management tool could not be adequately evaluated.

Another aspect of telecommuting, its feasibility as a business strategy (*2,3*), is equally important in assessing its role in demand management. If telecommuting is not feasible for a public agency or a private company, it makes no sense to promote it for transportation, energy, or air quality reasons. Earlier experience with telecommuting in the private sector appeared to increase worker productivity, but formal evaluations were proprietary and not available for analysis. Apparently, companies with telecommuting programs considered them part of their market competitiveness strategy.

An opportunity to assess both household travel impacts and business feasibility came with the establishment of California's State Employee Telecommute Pilot Project. Now nearing completion of its home telecommuting phase, this is the first large-scale telecommuting project in the United States from which nonproprietary data and analysis are available. The major goal of the project is to develop operating policies and procedures to permit expansion of telecommuting to all state agencies.

The project has involved more than 400 state employees from various departments. About 60 percent of them have been telecommuting, typically 1 or 2 days a week. The remaining employees have been participating in the project as control group members, providing data that aid in isolating the impacts of telecommuting on business-related performance and travel demand from the impacts of other factors that vary over time (e.g., organizational changes and gasoline prices).

To evaluate household travel impacts, project participants and their household members of driving age were surveyed before and after they began telecommuting. Three-day travel diaries were used in both surveys, which were conducted approximately 1 year apart in January through June 1988 and

R. Kitamura, Department of Civil Engineering, University of California at Davis, Davis, Calif. 95616. J. M. Nilles, JALA Associates, Inc., 971 Stonehill Lane, Los Angeles, Calif. 90049. P. Conroy, California Department of Transportation, Office of New Technology and Development, 1130 K Street, Sacramento, Calif. 94274-0001. D. M. Fleming, California Department of General Services, Telecommunications Division, 601 Sequoia Pacific Boulevard, Sacramento, Calif. 95814-0282.

April through June 1989. The resulting panel data set constitutes a unique and valuable information source from which the effect of telecommuting on mitigating traffic congestion, reducing energy consumption, and improving air quality can be empirically evaluated.

This paper summarizes the initial results from the two waves of the panel survey. The objective is to assess the impact of telecommuting on household travel behavior on the basis of observations obtained from this large-scale pilot project. Of particular interest is the effect of telecommuting on nonwork travel. It is conceivable that telecommuting leads to reduced needs to commute and added flexibility in trip making, which, together with the corresponding increase in discretionary time, may induce new nonwork trips.

The impacts and issues related to the business aspects of telecommuting are beyond the scope of this paper. However, telecommuting appears to be feasible from a business perspective given the results of the first year of the California project (*4*).

The paper is organized as follows. First, trip making at an abstract level is discussed and a conceptual framework for assessing the impact of telecommuting on travel demand is given. The objectives and history of the California pilot project and the process for selecting project participants are then described. Travel characteristics of the project participants before they commenced telecommuting are summarized and differences between telecommuters and control group members are discussed. The impact of telecommuting on household travel is discussed next by comparing mobility measures obtained before and after telecommuting began. Finally, conclusions are given.

BACKGROUND

The evaluation of the impact of telecommunications on travel demand is a complex task. Several hypotheses have been advanced. Of particular interest is whether telecommunications technologies act as substitutes for travel or whether a complementary relationship exists between telecommunications and travel (*3,5,6*). Little empirical evidence on the interaction between the two appears to exist (*7*).

Determining the impact of telecommuting on household travel demand presents difficulties because its impact on the telecommuter's nonwork trips and the travel patterns of household members is not known [see Jovanis (*8*) and Garrison and Deakin (*9*) for related discussions]. The panel travel survey data available from the California pilot project offer a data base to examine this secondary effect of telecommuting.

An immediate consequence of telecommuting is a reduced number of work trips, which contributes to reduced peak traffic and vehicle miles traveled. The reduction, however, may produce repercussions that partially offset the savings. The reduced need to commute and the added flexibility in work schedule that telecommuting brings about may induce discretionary activities and trips that the telecommuter did not make before. The impact of this on travel behavior can be complex. For example, shopping and other errands that were done during commuting trips with practically no additional distance traveled may be pursued independently from home, possibly at different locations and at different times of the day. Or the errands that were performed by other household members may now be assigned to telecommuters, who have gained flexibility in scheduling activities.

Telecommuting may also lead to changes in travel mode use by the telecommuters and household members. For example, irregular commuting schedules resulting from telecommuting may make carpooling impractical and lead to a work trip mode switch from carpooling to driving alone. The availability of a family car left at home by the telecommuter may not only induce new trips but also trigger mode changes by other household members.

Conceivable as a result of telecommuting are changes in car ownership and, in the long term, residential location (the latter may in turn lead to a new form of urban sprawl). With its 1-year evaluation period, the travel panel survey of the California Telecommute Pilot Project will not be of much help in assessing the longer-term land use implications of telecommuting. However, the data being collected are valuable in getting at least a first-cut assessment of most of the other household travel changes of concern.

CALIFORNIA TELECOMMUTE PILOT PROJECT

Objectives and History

The central objective of the California Telecommute Pilot Project is to "test the utility of telecommuting in State government" (*10*) by having selected employees telecommute during the 2-year project period. A number of factors motivated the experiment, including

- The cost of acquiring office space,
- Characteristics of the state work force (information functions and computer literacy),
- Workload increases without concomitant work force expansion, and
- Worsening traffic congestion and the need to reduce air pollution and energy consumption.

Currently 13 state agencies, including the energy commission, public utility commission, and department of transportation (Caltrans), are active in the pilot project.

The concept of telecommuting was presented to the California Department of General Services in early 1984 as a means to decrease demand for office facilities in major metropolitan areas. The proposal was endorsed and a 6-month planning phase was initiated in January 1985 by the department in cooperation with other state agencies. This led to a project plan (*10*), which formed the basis of the pilot project that commenced in July 1987.

Implementation began in January 1988 with training sessions for home telecommuters and their supervisors. The training sessions were held during a 6-month period. During the sessions the participants were requested to fill out detailed questionnaires, including 3-day travel diaries on prespecified survey dates. The questionnaires helped establish the baseline data against which the second-wave survey data would be compared. The second-wave survey was conducted using similar questionnaires and diaries approximately 1 year after the first survey. The development of the instruments for this

panel survey was directed by a special team including staff from Caltrans, the energy commission, and the air resources board (*11*).

Selection of Project Participants

Participants in the pilot project are all volunteers who expressed interest in telecommuting in response to the solicitation by the project coordinators. The initial set of volunteers comprised 1,039 potential telecommuters and their 413 supervisors, who were both requested to fill out an extensive questionnaire prepared by JALA Associates.

Two sets of questionnaires were prepared, one for prospective telecommuters and the other for their supervisors. The objective was to evaluate the likelihood of successful telecommuting for each employee-supervisor pair. The criteria used in the selection process can be grouped into three categories: the nature of tasks performed, sociopsychological characteristics, and managerial style and role. For example, in the first category, employees performing tasks that require high concentration are particularly suited for telecommuting, whereas those who need to maintain high levels of face-to-face interaction or who require access to special resources or sensitive information that requires physical security can best perform their tasks in the traditional office environment (*10*).

Each recommendation prepared by JALA Associates included the form and duration of telecommuting that was estimated to be initially suitable for each supervisor-telecommuter combination. The possible forms of telecommuting were (*a*) home-based, (*b*) satellite, and (*c*) none. The possible durations were (*a*) at least 3 days per week, (*b*) 1 to 3 days per week, (*c*) 1 day or less per week, and (*d*) none.

On the basis of these recommendations, the supervisors selected who would telecommute. Volunteers with similar job characteristics were requested to participate in the project as a control group. Initially, 230 telecommuters and 192 control group members from 16 agencies were selected. Their demographic, occupational, and employment characteristics are summarized elsewhere (*4*).

The selection process appears to have successfully identified employees suitable for telecommuting. Although a discernible number of the initial participants left the project, most did so because of promotions, job changes, reorganizations, new supervisors, retirement, or similar reasons. In only a few cases did participants leave because telecommuting was not workable. Furthermore, in most of the cases the participants attempted to telecommute against the recommendations offered by the project coordinator.

An analysis of the survey questionnaire by JALA Associates indicated that the telecommuters and control group members have similar job, socioeconomic, and personality characteristics. Control group members are not necessarily unsuitable for telecommuting. The similarities arise in part because both telecommuters and control group members are volunteers who share an interest in the pilot project. It is believed that the similarities aid in isolating the effect of telecommuting on travel patterns because the two groups are likely to respond to changes in the travel environment in similar manners.

A note is due here on the self-selected nature of the survey sample. Comprising volunteer participants, most of whom are mid-level professionals, the survey sample is not likely to be representative of the population of California. Likewise, their responses to telecommuting may not represent what would be exhibited by the population of information workers. The study may contain biased results because of the self-selected sample, and their immediate generalization is not warranted.

PRETELECOMMUTING TRAVEL CHARACTERISTICS

Three-day travel logs were available from 212 project participants and 135 driving-age members of their households before telecommuting began. Of the 212 state employees, 113 (53 percent) are home telecommuters and 99 (47 percent) are control group members. Summary statistics of the respondents to the pretelecommuting survey are given in Table 1 by status (home telecommuter and control group member) and person category (project participant, spouse, other household members).

Pretelecommuting travel characteristics of the project participants and their household members are shown in Table 2. The trip rates, trip lengths (in miles), and trip times (in minutes) shown in the table are all considerably greater than the corresponding statewide averages (3.00, 5.7, and 18.6, respectively) for each of the three person categories. This is partly because the sample of this study consists of individuals of driving age from households with (mostly professional) state workers. It is also plausible that those who volunteered to telecommute tend to have long commute distances for which telecommuting is particularly appealing.

There are certain differences between the telecommuters and control group members in travel characteristics. For example, control group members are more transit oriented than telecommuters, with much more frequent use of public transit for commuting (Table 3). This is the case for not only

TABLE 1 PRETELECOMMUTING TRAVEL SURVEY PARTICIPANTS BY STATUS AND PERSON CATEGORY (EXCLUDES INDIVIDUALS WITH UNKNOWN PERSON CATEGORIES)

	Self	Spouse	Others	Total
Telecommuters	113	66	12	191
Control Group Members	99	51	6	156
Total	212	117	18	347

TABLE 2 PRETELECOMMUTING TRIP CHARACTERISTICS OF PILOT PROJECT PARTICIPANTS

	Pilot Project Participants			
	Employee	Spouse	Other	Average
Person Trip Rate[1]	3.74	3.40	3.69	3.62
Average Trip Length (miles)	13.0	9.5	8.9	11.7
Average Trip Time (min.)	32.7	29.8	23.8	31.3
Number of Participants	212	117	18	
Number of Trips[2]	2380	1194	199	

[1]Trip rates are per person per day.
[2]The number of trips is a total for the three survey days.

TABLE 3 DISTRIBUTION OF PRETELECOMMUTING WORK TRIP MODES: TELECOMMUTERS VERSUS CONTROL GROUP MEMBERS

	Telecommuters			Control Group		
	Transit	Other	%Transit	Transit	Other	%Transit
Employee	58	544	9.6%	75	427	14.9%
Spouse	5	215	2.3%	7	163	4.1%
Others	0	23	.0%	1	5	16.7%
Total	63	782	7.5%	83	595	12.2%

the state employees themselves but also their spouses and other driving-age household members. The same result appears in the slight but meaningful difference in car ownership between the two groups (Table 4). The percentage of households without a car available is 8.4 percent (7 out of 83) for the control group, whereas the corresponding number is less than 1 percent (1 out of 109) for the telecommuter group (*12*).

MEASURED IMPACT

The results of the panel surveys conducted before and after telecommuting using 3-day travel diaries were the basis of the empirical analysis of this section. Matched before-and-after diaries were available from 194 persons categorized as follows:

Category	*Number*
Telecommuters	
State employees	66
Household members	39
Control group	
State employees	57
Household members	32
Total	194

The results indicate that negative effects were minor and that telecommuting contributed to an overall reduction of trips. The reduction in work trips was as expected (Table 5). During the 3-day diary periods, the telecommuters' home-to-work trip rate decreased by more than 40 percent, from an average of 1.11 trips per day before telecommuting to 0.62 trips after telecommuting (the reduction is significant at a confidence level of 1 percent, or $p = 0.01$). The control group members maintained similar trip rates of 1.14 and 1.02 in the before and after surveys, respectively.

This result was expected because most telecommuters in the pilot project telecommute 1 to 2 days per week. The average number of telecommuting days in this sample was 1.25 days per 3-day diary period, or approximately 2 days per week (the telecommuting respondents were requested to select three consecutive weekdays for the second survey such that the period contained at least one telecommuting day). Assuming this rate of telecommuting, weekly trip rates were estimated as shown in the second half of Table 5, where the reduction in work trips approximately equals the number of telecommuting days. [Statistics available from JALA Asso-

TABLE 4 DISTRIBUTION OF PRETELECOMMUTING HOUSEHOLD CAR OWNERSHIP: TELECOMMUTERS VERSUS CONTROL GROUP MEMBERS

	Telecommuters		Control Group	
No. of Cars	Frequency	Percent	Frequency	Percent
None	1	.9%	7	8.4%
One	48	44.0%	34	41.0%
Two	47	43.1%	30	36.1%
Three or More	13	11.9%	12	14.5%
Total	109	100.0%	83	100.0%

TABLE 5 CHANGES IN HOME-TO-WORK TRIP RATE BEFORE AND AFTER TELECOMMUTING (STATE EMPLOYEES ONLY)

Trip Rates During Three-Day Diary Periods

	N	Before	After	Δ
Telecommuters	66	1.11	.62	-0.49*
Control Group Members	57	1.14	1.02	-0.12

*Difference significant at p = 0.01.

Estimated Weekly Trip Rates

		Before	After	Δ
Telecommuters	2 Days/Week[1]	5.55	3.45	-2.10
	1 Day/Week	5.55	4.55	-1.00

[1]Estimated using trip rates by day type (telecommuting vs. commuting) and assuming the number of telecommuting days as shown.

ciates indicate that the average number of entire days in a week that the pilot members telecommute from home is 1.64. Most participants telecommute either 1 day (50.7 percent) or 2 days (23.9 percent) per week. In addition, they telecommute some part of the day on the average on 0.43 day per week.]

The reduction in work trips implies a reduction in trips made in peak periods (Table 6). Telecommuting employees reduced their morning peak period trips by 0.40 trip per day (a 34 percent reduction, significant at $p = 0.02$), whereas control group members reduced theirs by less than 4 percent.

The survey results offer no indication that either telecommuters or their household members increased nonwork trips after the telecommuting experiment commenced (Table 7). The extended flexibility and increased discretionary time brought about by telecommuting does not appear to induce additional nonwork trips. In particular, the family members of telecommuters had a much larger reduction in nonwork trips than their control group counterparts (significant at a confidence level of 5 percent). Possibly this was in part due to underreporting of trips caused by "panel fatigue," in which participants become less accurate when responding to questionnaires in later waves of repeated surveys. It is plausible, however, that additional flexibility in trip scheduling due to telecommuting leads to streamlined travel patterns by all household members, which in turn lead to a much-reduced nonwork trip rate by the household. Comments given in brief interviews with telecommuters indicated that they believed that the household members can be better organized and their trips can be better planned.

Table 8 shows the trip rates by telecommuters on the days they telecommuted and on the days they commuted to their offices, together with the trip rate among control group members. The average trip rate (including all trips) was only 1.92 trips per telecommuting day, which is approximately 2 trips

TABLE 6 CHANGE IN MORNING PEAK PERIOD TRIP RATE[1] BEFORE AND AFTER TELECOMMUTING (STATE EMPLOYEES ONLY)

Trip Rates During Three-Day Diary Periods

	N	Before	After	Δ
Telecommuters	66	1.18	.78	-0.40*
Control Group Members	57	1.20	1.16	-0.04

[1]Morning peak trips are defined as those that either begin or end between 7 am and 9 am.
*Difference significant at p = 0.02.

Estimated Weekly Trip Rates

		Before	After	Δ
Telecommuters	2 Days/Week[2]	5.90	3.97	-1.93
	1 Day/Week	5.90	4.86	-1.04

[2]Estimated using trip rates by day type (telecommuting vs. commuting) and assuming the number of telecommuting days as shown.

TABLE 7 CHANGE IN NONWORK TRIP RATE BEFORE AND AFTER TELECOMMUTING (STATE EMPLOYEES AND HOUSEHOLD MEMBERS)

Trip Rates During Three-Day Diary Periods

	N	Before	After	Δ
Telecommuters				
Employees	66	1.57	1.51	-0.06
Household Members	39	2.25	1.31	-0.94*
Weighted Average	105	1.82	1.44	-0.38
Control Group				
Employees	57	1.91	1.81	-0.10
Household Members	32	1.65	1.56	-0.09
Weighted Average	89	1.82	1.72	-0.10

*Difference significant at p = 0.05.

Estimated Weekly Trip Rates

		Before	After	Δ
Telecommuter Employees	2 Days/Week[1]	7.85	7.47	-0.38
	1 Day/Week	7.85	8.01	0.16

[1]Estimated using trip rates by day type (telecommuting vs. commuting) and assuming the number of telecommuting days as shown.

TABLE 8 TOTAL PERSON TRIP RATE PER DAY ON TELECOMMUTING DAYS VERSUS COMMUTING DAYS (STATE EMPLOYEES ONLY)

	Day of the Week					
Telecommuters	Mon	Tue	Wed	Thur	Fri	Total
Telecommuting Day						
Trip Rate	1.50	1.56	1.96	2.04	1.95	1.92
N	4	9	26	27	21	87
Commuting Day						
Trip Rate						4.08
N						99
Control Group Members						
Trip Rate						3.96
N						168

The sample size (N) is shown in person-days.

less than the average of 4.08 trips for commuting days. The latter average is close to the average of 3.96 trips for control group members. The results confirm the findings above and are another indication that the trip rate was reduced significantly (by two trips) on days that employees telecommuted, whereas there was no appreciable increase in trip making on days that they commuted to work.

The reductions in nonwork trips, however, must be subjected to further scrutiny before a conclusion can be drawn. The reductions by the control group members and the household members of telecommuters (Table 7) may be due to sampling variations if the large numbers of nonwork trips they reported in the first survey represent extreme trip making. Also, the reductions may in part be a result of underreporting of trips. This can be attributed to panel fatigue. An example of panel fatigue was reported for a large-scale Dutch panel study using weekly travel diaries (*13*). Analysis is currently underway to determine whether the apparent reductions reflect a genuine change in nonwork trip making.

CONCLUSIONS

The preliminary results obtained from the panel travel diary survey are encouraging. Telecommuting reduces work trips

as expected, and no indication that it induces new nonwork trips has been observed. In addition, the results suggest that family members of telecommuters may also reduce nonwork trips. Together with the finding of feasibility for business (*4*), the analysis offers strong empirical support for telecommuting as a means to mitigate traffic congestion and improve air quality. Effort is currently under way to extend the scope of analysis to include changes in vehicle miles traveled, mode use (transit use and carpool participation), destination choice, trip linkage and timing, and other pertinent elements of household travel behavior.

The next phase of the California Telecommute Pilot Project being considered for funding involves telecommuting at multiagency neighborhood centers. This phase will allow researchers to analyze changes in travel behavior beyond home-based telecommuting. The Washington State Energy Office is pursuing a large public-private telecommuting demonstration program for the greater Seattle metropolitan area. The evaluation of this effort will add to the data base and help clarify telecommuting's role as a travel demand management tool. With time, evidence should become available as to the influence of telecommuting on land use and development.

REFERENCES

1. JALA Associates, Inc. Telecommunications and Energy: *The Energy Conservation Implications for California of Telecommunications Substitutes for Transportation*. Final report to the California Energy Commission. Los Angeles, Calif., 1983.
2. J. M. Nilles. *Managing Teleworking: Final Report*. Center for Futures Research, University of Southern California, Los Angeles, 1987.
3. J. M. Nilles. Traffic Reduction by Telecommuting: A Status Review and Selected Bibliography. *Transportation Research A*, Vol. 22A, No. 4, 1988, pp. 301–317.
4. JALA Associates, Inc. *The State of California Telecommuting Pilot Project: Midterm Report*. Los Angeles, Calif., 1989.
5. I. Salomon. Telecommunications and Travel Relationships: A Review. *Transportation Research A*, Vol. 20A, No. 3, 1986, pp. 223–238.
6. P. L. Mokhtarian. An Empirical Evaluation of the Travel Impacts of Teleconferencing. *Transportation Research A*, Vol. 22A, No. 4, 1988, pp. 283–289.
7. I. Salomon. Transporting Information and Transporting People. *Transportation Research A*, Vol. 22A, No. 4, 1988.
8. P. Jovanis. Telecommunications and Alternative Work Schedules: Options for Managing Transit Travel Demand. *Urban Affairs Quarterly*, Vol. 19, No. 2, 1983, pp. 167–190.
9. W. L. Garrison and E. Deakin. Travel, Work and Telecommunications: A View of the Electronics Revolution and Its Potential Impacts. *Transportation Research A*, Vol. 22A, No. 4, 1988, pp. 239–245.
10. JALA Associates, Inc. Telecommuting: A Pilot Project Plan. Department of General Services, State of California, Sacramento, 1985.
11. K. Goulias, R. Pendyala, H. Zhao, and R. Kitamura. *Telecommuting and Travel Demand: An Activity-Based Impact Assessment*. Interim report 2, panel survey questionnaire updating. Transportation Research Group, University of California at Davis, Davis, 1989.
12. R. Pendyala, H. Zhao, and R. Kitamura. *Telecommuting and Travel Demand: An Activity-Based Impact Assessment*. Interim report 1, baseline travel characteristics. Research Report UCD-TRG-RR-89-2. Transportation Research Group, University of California at Davis, Davis, 1989.
13. H. Meurs, L. van Wissen, and J. Visser. Measurement Biases in Panel Data. *Transportation*, Vol. 16, No. 2, 1989, pp. 175–194.

Publication of this paper sponsored by Committee on Traveler Behavior and Values.