

An Empirical Analysis of the Transportation Impacts of Telecommuting

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AN EMPIRICAL ANALYSIS OF THE TRAVEL IMPACTS OF TELECOMMUTING

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Travel behavior researchers have developed a number of hypotheses regarding the transportation impacts of telecommuting -- using telecommunications technology to work from home or another location remote from one's primary office. Until recently, there was little empirical data available to test these hypotheses. Now, however, a number of telecommuting projects are being evaluated with respect to changes in travel behavior. This paper reports work-in-progress on the transportation evaluation of four telecommuting projects in Southern California. The original findings from one of these projects are presented here, and related to previously reported results. The survey used in these projects obtains information on potential changes in mode choice, auto ownership, residential location, and activity patterns due to telecommuting.

Key words: telecommunications, demand management, mode choice, non-work travel, residential location

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I. INTRODUCTION

Telecommuting is frequently defined as the use of telecommunications technology to partially or totally substitute for the commute to work (1). It is hypothesized to have a variety of possible transportation impacts (e.g., 2, 3), such as the following:

- ▶ **frequency:** work trips should decrease; non-commute trips may increase.
- ▶ **time-of-day/day-of-week:** given the flexibility to do so, trips may be shifted to off-peak periods to avoid congestion delays, and/or to different days of the week.
- ▶ **destination/length:** work trips may be made to a local center rather than a downtown office building; non-work trips may be made closer to home rather than closer to work.
- ▶ **mode:** on the negative side, carpools and vanpools might dissolve if telecommuters drop out, and transit operators may lose revenue. Within the auto mode itself, trips made close to home may shift from a fuel-efficient vehicle used for commuting to a less fuel-efficient (and higher-emitting) vehicle. On the positive side, trips made closer to home may shift to non-motorized modes such as bicycle and walk. And if telecommuting helps flatten the peak for use of transit modes, greater operational economies may result.
- ▶ **trip chaining patterns:** eliminating the work trip may break up efficient linked activity patterns, creating several one-stop trips instead of one multi-stop trip.
- ▶ **person(s) making the trip:** household-level assignments may change, with the telecommuter perhaps taking on more trips because s/he is at home and "available", or making fewer trips because a commuting spouse now makes the stop on the way to or from work.
- ▶ **vehicle ownership:** in the medium term, the ability to telecommute may eliminate the need for a car -- or, more likely, a second car.
- ▶ **residential/job location:** in the long term, telecommuting may stimulate movement further from work to housing in more desirable and/or affordable outlying locations. The additional miles traveled on commuting days may or may not outweigh the miles saved on telecommuting days. Once the ability to telecommute has been established, the worker may change jobs, moving to a more distant employer.

Until recently, few sources of empirical data were available to test these hypotheses. Now, however, a number of telecommuting projects have been and are being evaluated with respect to changes in travel behavior (4 - 9). This paper reports work-in-progress on the transportation evaluation of four telecommuting projects in Southern California. The organization of this paper is as follows: Section II describes the motivation for the telecommuting projects, and Section III outlines the transportation evaluation method. Section IV presents the findings from analysis of a subset of the data collected, including a demographic profile

of the telecommuters, and a discussion of commute travel saved, new travel generated, and impacts on auto ownership, mode choice, and residential location. Section V is a summary.

II. MOTIVATION FOR THE TELECOMMUTING PROJECTS

Southern California has taken seriously the potential of telecommuting as a trip reduction/air quality mitigation strategy since at least 1982. At that time, it was the first region in the country to expect substantive trip reduction to occur via telecommunications substitution (10). The years since then have seen a steady increase in interest in telecommuting on the part of employers in the region. This interest has been stimulated in part by two public policy documents. The first is the *1989 Air Quality Management Plan* (11), which sets the goal of reducing work trips by 30% in the year 2010 due to the combined effect of telecommuting and alternative work schedules. The second is Regulation XV of the South Coast Air Quality Management District (12), which requires employers with more than 100 staff at a single site to submit plans for achieving target vehicle occupancy ratios (VORs) for peak-period commute trips. These targets range from 1.3 persons/vehicle in outlying parts of the region, to 1.75 in downtown Los Angeles. Telecommuting is on the menu of strategies an employer can use to achieve its target; the telecommuter is considered to report to work (increasing the numerator of the VOR) without requiring a vehicle (therefore not increasing the denominator). Penalties for failing to submit an acceptable plan can be up to \$25,000/day and/or six months in prison for company executives.

Regulation XV only applies to employers in the South Coast Air Basin -- that is, Los Angeles, Orange, and the urbanized portions of Riverside and San Bernardino Counties. However, San Diego County, further south, is not immune from the air quality and congestion problems of the region. The City of San Diego passed a Transportation Demand Management (TDM) ordinance in September 1989, which included telecommuting as a way to reduce peak period travel.

In response to these policies, a number of employers implemented telecommuting pilots or prototypes during the first part of 1990. The author was involved in evaluating the transportation impacts of telecommuting for two public-sector and two private-sector employers:

- ▶ the City of San Diego (21 telecommuters from the Water Utilities, Building Inspection, Purchasing, and Parks and Recreation Departments);
- ▶ the County of San Diego (13 telecommuters from the Department of Public Works);
- ▶ a large bank headquartered in San Diego (9 telecommuters); and
- ▶ a major aerospace company facility in Orange County (12 telecommuters in an information systems division).

III. TRANSPORTATION EVALUATION METHODOLOGY

A questionnaire was developed which obtained information on potential changes in mode choice, auto ownership, residential location, and activity patterns due to telecommuting. A parallel survey was developed for a control group. In general, one measure was taken before telecommuting, and two measures about three and six months after the program began, from telecommuters and controls. However, there were slight variations on this design, depending on individual circumstances. For example, the County of San Diego had already begun its program when the author was invited to participate in the evaluation, and had a very short time frame for analysis. Accordingly, only one "during" measure, with no control group, was made in that situation. The aerospace company initially declined to identify a control group, but reconsidered when it was pointed out that external events such as a 5-cent increase in the state gasoline tax (effective August 1, 1990), the Iraqi invasion of Kuwait (August 2), and, later, a 5-cent federal gas tax increase (effective December 1) could confound the effects of telecommuting on travel. Thus, no "before" control group measure was available in that case.

Several of the studies cited earlier (5, 8, 9) involve multi-day trip diaries being completed by telecommuters, their driving-age household members, and (5 and 8 only) a control group. The surveys used in the analysis reported here request only a one-day "snapshot" of trips made by telecommuters or controls during the hours they would normally be commuting or working. This approach yields a data base that is not as detailed as the trip diary approach. The tradeoff is that there was a much lighter burden on the respondent, perhaps lessening tendencies toward panel conditioning, fatigue, and attrition (13).

An additional feature of the surveys used here is that telecommuters were explicitly asked how their travel would have been different if they had not telecommuted that day, including the request to draw diagrams illustrating their trip patterns while telecommuting and if they had not telecommuted. While such self-reports of a hypothetical response cannot be taken completely as gospel, they supplement the comparative insights provided by the "before" measures and the control groups.

The surveys were conducted between May 1990 and January 1991. Table 1 tabulates the distribution of surveys across employers, type of participant, and time. At this point, only a subset of these data have been analyzed -- specifically, the 13 telecommuters at the San Diego County Department of Public Works. Accordingly, this paper should be viewed as a report on work-in-progress rather than a final, comprehensive analysis. While the generalizability of these interim, small-sample results is limited, they constitute an interesting case study of the potential travel impacts of telecommuting.

TABLE 1

DISTRIBUTION OF SURVEY RESPONSES

	Before		During 1		During 2		Total		
	Tele-com.	Control	Tele-com.	Control	Tele-com.	Control	Tele-com.	Control	Total
S. Diego County Department of Public Works	N/A	N/A	13	N/A	N/A	N/A	13	N/A	13
City of S. Diego (4 departments)	21	21	15	13	19	13	55	47	102
San Diego bank	9	8	6	3	7	6	22	17	39
Orange County aerospace co.	12	N/A	12	9	3	7	27	16	43
	42	29	46	25	29	26	117	80	197

IV. FINDINGS FROM COUNTY OF SAN DIEGO ANALYSIS

A. Profile of the Telecommuters

During the week of April 23, 1990, a self-administered questionnaire was distributed to the telecommuters in the County of San Diego pilot program. Thirteen surveys were completed and returned. There were 7 females and 6 males in the sample. Ages ranged from 30 to 51 years old; the average age was 38 and the median age was 37. Three of the thirteen (23%) were single (including never-married, widowed, divorced, or separated); the rest married. Four of the married respondents had one or more child under 18 living at home. There were no single parents in the sample.

All respondents were college graduates, with six having done some graduate work and one of those having completed at least one graduate degree. In terms of rank, two respondents (15%) classified themselves as "management"; the rest as "staff". By design, a variety of occupations were represented in the pilot, categorized as follows:

3	administrative	1	staff development specialist
2	computer analyst	1	transportation specialist
1	land surveyor	1	technical
1	legal	2	other
1	public communications/writer		

Auto ownership averaged one vehicle per licensed driver in the household, consistent with nationwide trends. Total before-tax household income responses ranged from "\$20,001 to \$40,000" to "more than \$100,000". The median response fell in the category "\$60,001 to \$80,000".

Distance lived from work ranged from 3 to 30 miles, with the average at 12.8 miles and the median at 12 miles. As is typical of telecommuting programs, this is higher than the general average home-to-work distance of about 10 miles. The assumption is that people who live further from work are more motivated to telecommute. However, as is seen here, even those who lived as little as 3 miles away can and did participate, and in this particular sample, 6 of the 13 respondents lived 10 miles from work or less.

B. Commute Travel Saved

A total of 155 telecommuting person-days (an average of 12 days per person) had taken place at the time the surveys were completed. Respondents had been telecommuting for between 1 and 3 months, about 10.5 weeks (2-1/2 months) on average. The frequency of telecommuting varied from 9% (i.e., slightly less than one day every two weeks, or about twice a month) to 58% (i.e., almost three days a week). The average frequency was 23%, or slightly more than one day a week per person.

The approximate total person-miles of travel saved since the beginning of the pilot project is computed by multiplying each person's round trip distance from home to work to home by the number of times s/he telecommuted, and adding across participants. (The total is only approximate because people don't always just go straight from home to work and back home again. As will be seen below, the way people link various activities together on the same trip affects the exact total.)

The total in question is 3,714 person-miles saved, an average of 24 miles per telecommute occasion. The fact that that average is slightly smaller than the sample average round trip distance between home and work ($2 \times 12.8 \text{ miles} = 25.6$) means that respondents who lived closer to work telecommuted slightly more often than those who lived further away. So again, there is little evidence in this sample to support the hypothesis that long-distance commuters are more motivated to telecommute.

It is important to distinguish between person-miles saved and vehicle-miles saved. If the commute trip that is eliminated is a drive-alone trip, the two quantities are equal. If the entire trip is made via carpool or transit, however, zero vehicle-miles are saved, because the vehicle still makes the trip. The impact of telecommuting on the choice of transportation mode is discussed in more detail in Section IV.D. At this point, the salient fact is that only

338 (9%) of the person-miles saved would not have been drive-alone miles. Thus, 3,376 vehicle-miles were saved, or 21.8 miles per telecommute occasion.

In terms of trips, an estimated 26 (17%) of the 155 telecommute occasions replaced carpool trips rather than drive alone trips. That is, person-trips but not vehicle-trips were eliminated on those occasions. As seen above, fewer than 17% of the miles were involved, because half of those occasions eliminated a round-trip commute of only 6 miles.

C. Travel Generated

While it is clear that commute travel is reduced to the extent that telecommuting does take place, there are a number of ways in which telecommuting can stimulate additional travel as well:

- ▶ Staying at home all day may lead to "cabin fever", and the telecommuter makes trips just to get out of the house.
- ▶ Telecommuting may make an automobile available to other members of the household, who use it to make new trips. This phenomenon has been encountered in some ridesharing situations, but as the vehicles-per-driving-age-household-member ratio approaches 1 (14), this effect is likely to be seldom seen.
- ▶ Telecommuting itself may create the need for trips, e.g. for office supplies, or to the post office or photocopy/public fax center.

But it is not reasonable to assume that all travel that occurs while telecommuting is totally new travel. We must differentiate between totally new trips, and trips that would have occurred anyway. It is the totally new trips that are the most "serious" in terms of generating travel. However, even trips that would have occurred anyway should be studied to see how they are affected by telecommuting. For example, they may take place at a different time, a different place, and/or be made by different people.

In the survey completed by the telecommuters, they were asked to describe the trips they made on the last day they telecommuted, and indicate how those trips would have been different if they had not telecommuted that day. This provides a sample of travel behavior affected by telecommuting. In this pilot situation, consistent with previously completed empirical studies of other telecommuting programs (4, 5, 9), the travel that is generated is far outweighed by the travel saved. Some summary findings are:

- ▶ On 6 (46%) of the 13 occasions in question, no trips at all were made during normal commute and working hours.
- ▶ Altogether, 11 trips were made, or an average of 0.8 per telecommute occasion.
- ▶ Fourteen destinations were visited, an average of 1.3 per trip or 1.1 per telecommute occasion.

- ▶ These 11 trips involved a total of 56.7 person-miles (an average of 4.4 per occasion), or 48.3 vehicle-miles (3.7 per occasion).
- ▶ Based on the respondents' reports of what would have happened if they hadn't telecommuted that day, those 48.3 vehicle-miles replaced 181.5 vehicle-miles of travel. In other words, nearly 4 times as much travel would have taken place (including commutes to work) if participants hadn't telecommuted.
- ▶ Only one trip was a completely new one, and that was a one-mile walk trip. All the other trips would reportedly have taken place anyway.
- ▶ There was a substantial impact on travel characteristics, however, particularly on the time at which trips were made. Changes were cited in:
 - time of travel (for 10 destinations);
 - mode of travel (for 3 destinations, and in every case the change was from the automobile to walking or biking);
 - destination (for 3 destinations); and
 - person/people traveling (for 3 destinations).

D. Other Travel-Related Impacts

Sections B. and C. assessed day-to-day changes in travel patterns induced by telecommuting -- potential changes in the number of trips, the number of miles traveled, destinations visited, time of travel, and so on. The effect of eliminating commute trips was balanced against that of generating other trips. However, there are several other transportation-related areas in which telecommuting might have an impact. In the short term, the ability to telecommute may affect one's choice of transportation mode (especially to work). In the medium term, household auto ownership might be affected, and in the long term, impacts on residential location may be observed. These three areas are discussed in the sections below.

i. Mode Choice

The difference between person-miles and vehicle-miles for a given trip, and the consequent difference in the estimate of travel savings due to telecommuting, has been discussed above. What is being explored here are potential changes in the (commute) mode choice selection patterns induced by telecommuting. That is, will telecommuters change the proportion of time they select a given mode for the work trip? The hypothesis is that telecommuters may be more likely than before to drive alone on the days they do commute, thereby potentially breaking up entire carpools or at least themselves creating new vehicle-trips.

Such effects were not seen to any great degree in this sample. One natural reason for that is that 10 of the 13 respondents (77%) already drove alone to work 100% of the time, and did not change that proportion during the study period. The

remaining three respondents, all of whom carpoled to work at least some of the time, are discussed one by one.

The first respondent carpoled 95% of the time, and said that mode choice patterns had not changed since beginning to telecommute. That would mean that about 19 out of 20 telecommute occasions would replace a carpool trip (meaning no vehicle-mile savings), and 1 out of 20 would replace a drive alone trip.

The second respondent drove alone 80% of the time, and indicated that telecommuting always replaced a drive alone trip. Conversely, the third respondent carpoled 80% of the time, and indicated that telecommuting always replaced a carpool trip.

In the first and third cases, then, telecommuting saved fewer vehicle-miles than person-miles. But there is no evidence that carpools were dissolved or carpooling discontinued because of telecommuting. Accordingly, there is also no evidence that vehicle-miles or trips increased, as would be the case if, say, three people that formerly carpoled began making two or three vehicle-trips instead of one. That is, the vehicle-miles that took place would most likely have occurred anyway -- just with one fewer passenger, on occasion.

ii. *Auto Ownership*

It has been hypothesized that the ability to telecommute may allow a household to eliminate an automobile. Accordingly, telecommuters were asked about changes in the number of vehicles used by the household since beginning the pilot. It is not surprising that no changes were reported. Plausible reasons for this include:

- ▶ People would be reluctant to make major changes if the pilot is viewed as a temporary program that could shortly be removed.
- ▶ Even if the program were considered likely to become permanent, the time frame was too short to see changes that may occur eventually.
- ▶ Telecommuting only one day a week on average is not enough to justify getting rid of a vehicle.
- ▶ A car may be considered a necessity (or "necessary luxury"), especially in Southern California, whether essential for commuting or not. Even nationwide, as mentioned earlier, auto ownership is at nearly one vehicle per driving-age household member (regardless of whether all drivers are commuting to work).

Even though no impacts on auto ownership were observed to date, it would be valuable to continue to monitor this transportation-related variable.

iii. Residential Location

The hypothesis here is that the ability to telecommute could motivate people to move further from work, to more affordable or desirable housing. In the extreme, the extra miles traveled on commute days could exceed the miles saved by telecommuting. Thus, telecommuters were asked if they had changed residential location, or were considering doing so, since beginning to telecommute. Ten respondents said "no" to both, 2 were considering relocation, and 1 had actually moved.

Of course, people move all the time, and generally for reasons that have nothing to do with telecommuting. Therefore, the latter three workers were asked about the role of telecommuting in their relocation decisions. The responses from which they could choose were:

- ▶ "It [the ability to telecommute] was not an important factor."
- ▶ "It was an important factor, but other factors were at least as important."
- ▶ "It was the most important factor."

The participant who had actually moved indicated that telecommuting was an important factor, but that there were other important factors as well. Interestingly, this person actually moved 5 miles closer to work. It is difficult to provide an explanation for the role of telecommuting in a move closer to work. However, the respondent indicated that congestion was also a key element of the decision; it may be that "reducing personal travel" was the real factor, and that telecommuting was reflexively included in that category along with shortening the actual commute trip.

Of the 2 people who were considering moving, one would move three miles further from work, and said that telecommuting had no influence on the decision. The remaining case, however, represents exactly the extreme possibility described above. The respondent cited telecommuting as the most important factor in the decision, and was considering quadrupling the home-to-work distance: from 10 miles to 40 miles.

To evaluate the kind of impact such a move might have on the travel savings we have presented so far, consider a simple before-and-after analysis. Before telecommuting, this person traveled 100 miles to and from work per week (both person-miles and vehicle-miles, since 100% of the trips were drive-alone). Interestingly, s/he only telecommutes twice a month (9.2% of the time). Now, it is almost certainly true that a long-distance move would not be seriously attributed to telecommuting unless the respondent planned to telecommute a great deal more than that in the future. But the breakeven point (i.e., the point at which weekly commute travel after moving equals that before moving) is for that person to telecommute 75% of the time, or nearly 4 days a week on average. That's quite a commitment to telecommuting on the part of both the employee and the organization.

To analyze the worst-case scenario, assume the employee continues to telecommute 9.2% of the time after moving. In that case, weekly commute travel would total 367 miles (91.8% of 400 miles), an increase of 267 miles per week over the pre-telecommute situation. Compare that to how much travel is saved by all the other telecommuters put together: they save 21.9 vehicle-miles/occasion x 1.21 occasions/week/person x 12 people = 318 vehicle-miles per week. Thus, in this worst-case scenario, one person moving that much further away can wipe out 84% of the vehicle-miles saved by 12 other people (although, for what it's worth, the same number of vehicle-trips would be saved in either case).

The actual outcome, assuming the respondent even moves at all, would most likely fall between these two extremes. Analysis of residential relocation for the State of California telecommuting pilot found that only 3% of participants had moved, or were considering moving, 45 or more miles away since beginning to telecommute (15). First, it was not reported what proportion of that 3% would have moved anyway, and second, any increases in travel seen by this tiny minority may have been compensated for by the overall savings for the other telecommuters. The point is, however, that telecommuting may have long-term effects not fully captured by a short-term "snapshot", and that these long-term effects should be monitored.

V. SUMMARY

Telecommuting can affect travel in obvious ways -- by reducing commute trips -- and in not so obvious ways. In the short run, telecommuting can create new travel; change the time, place, and frequency of travel; affect who makes the trip and what mode is used. In the long run, telecommuting can even affect residential location, with potentially large impacts from a small number of extreme moves. In this study, however, the news is essentially good; travel was clearly reduced due to telecommuting. Some key findings are:

- ▶ The average frequency of telecommuting was 23%, or slightly more than one day a week per person.
- ▶ On average, about 24 person-miles, or 22 vehicle-miles, of commute travel were saved per telecommute occasion.
- ▶ The amount of travel generated on telecommute occasions was far outweighed by the amount of travel saved. In the sample of trips studied, nearly four times as many vehicle-miles of travel were saved (182) as generated (48).
- ▶ Essentially no new trips were created because of telecommuting. Most activities would have occurred anyway.
- ▶ For non-work activities, telecommuting did affect the time of travel, the mode of travel (motivating a shift from the automobile to non-polluting modes such as bike and walk), the destination, and the people making the trip.

- ▶ Overall, the effect of telecommuting on commute mode choice was negligible, partly because 77% of the respondents drove alone to work 100% of the time.
- ▶ No impact on auto ownership was observed.
- ▶ There was an indication that telecommuting could, over time, induce changes in residential location. The particular move cited by one respondent would quadruple the distance from home to work. Such a move would most likely lead to an increase in work travel for that person. In the worst case, the increase would be so large that it would almost swamp out the savings in travel created by the other participants.

While these findings are generally encouraging, it is important to remember that they are short-term results from a small sample. It is likely that even day-to-day travel behavior will continue to evolve in response to the ability to telecommute, particularly when it becomes a permanent program in an organization, and some people are able to do it two to four days a week. Many related effects, such as residential relocation, may not be observed for some time to come. Accordingly, it is important to continue to monitor the travel impacts of telecommuting over a long period of time.

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