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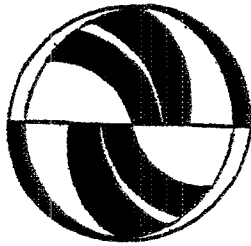
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**An Empirical Analysis
of the Transportation Impacts of Telecommuting**

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The University of California Transportation Center
University of California at Berkeley

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

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