

# Changes in Regional Travel Characteristics and Travel Time Expenditures in San Francisco Bay Area: 1960–1990

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An update of a 1984 study by Kollo and Purvis is presented. Results from the 1990 household travel survey conducted in the San Francisco Bay Area are compared with results from surveys conducted in 1965 and 1981 and decennial census data. The study shows a decline in trip frequency per household and per person between 1981 and 1990, which is offset by an increase in average trip duration, yielding an apparent constant travel time expenditure per person and per household. Regularities in average travel time expended per household vehicle are also analyzed. Changes in Bay Area demographic characteristics from 1960 to 1990 are described to provide context to the changes in aggregate travel characteristics. Changes in household trip rates by trip purpose and travel mode are also summarized. Findings show a decline in home-based non-work-related and non-home-based trip rates per household and increases in home-based work-related trips per household.

This research project is an update to the 1984 study by Kollo and Purvis (1). The authors' 1984 study compared results from the 1965 and the 1981 household travel surveys conducted in the nine-county San Francisco Bay Area. Comparison was also made with journey to work characteristics from the 1960, 1970, and 1980 U.S. decennial censuses. The present study updates the information provided in the 1984 paper to provide results from the 1990 Bay Area household travel survey and includes new information related to changes and regularities in travel time expenditures of Bay Area households based on analysis of the 1965, 1981, and 1990 household travel surveys.

There is a basic need for a careful and comparative review of results from metropolitan area household travel surveys to detect survey strengths and weaknesses, devise strategies and methods for correcting problems and biases, and planning strategies for estimation of new sets of regional travel demand forecasting models. A thoroughly structured travel survey analysis project related to cleaning, editing, weighting, expanding, linking trips, and flushing out survey idiosyncrasies and data outliers is a critical precursor to travel demand model development activities. The study described here is but one element of the 1990 household travel survey analysis project.

This research also adds to a growing genre of literature related to comparative aggregate analyses of metropolitan travel characteristics. Most of this research is related to the temporal stability or regularities of travel characteristics, typically focusing on the basic presumption of constancy of trip generation, trip distribution, and mode choice model coefficients. Selected studies of this genre include Kannel and Heathington's (2) study of Indianapolis travel characteristics based on household surveys conducted in 1964 and 1971, Yunker's (3) 1963 and 1972 survey analysis of Milwaukee,

Smith and Cleveland's (4) analysis of the 1953 and 1965 Detroit surveys, Cohen and Kocis's (5) study of Buffalo and Rochester, the aforementioned study by Kollo and Purvis (1) for the San Francisco Bay Area, Norris and Shunk's (6) analysis of 1964 and 1984 travel characteristics in the Dallas region, and Walker and Peng's (7) study of changes in the Philadelphia region between 1960 and 1988. Other collections of results related to metropolitan area household travel surveys include an ITE committee report (8) from 1979 and the *Characteristics of Urban Transportation Demand* (9) manual published by the Urban Mass Transportation Administration.

Findings from this aggregate analysis of Bay Area household travel surveys generally supports theories related to travel time budget research conducted between 1961 and 1985. On the other hand, analyses of travel time expenditures by market segment (e.g., household size and vehicle availability) show notable instability and irregularities in travel time expenditures. The vast research heritage related to travel time budgets includes early works by Tanner (10) and numerous efforts by Yacov Zahavi (11–14), Zahavi and Ryan (15), Zahavi and Talvitie (16), and Zahavi and coworkers (17).

Interest in travel time budget research apparently peaked in the late 1970s and early 1980s, culminating in a 1-day conference on personal travel budgets held at the University of Leeds in the United Kingdom in May 1979 (see the special issue of *Transportation Research A*, Vol. 15A, No. 1, published in January 1981). Precious little research related to transportation travel time or money budgets has appeared in the professional literature after 1985, perhaps because of the passing of a principal proponent of travel budget models, Yacov Zahavi, in the early 1980s or perhaps because of the lack of research material (or research budgets) for the continuing analysis of travel time budgets. The information included in this paper may help to rekindle interest in travel budget and travel time expenditure research.

The Bay Area household travel surveys for 1981 and 1990 are apparently showing a real decline in trip frequency per household and per person. This is offset by a real increase in average trip duration (average trip time), yielding, on an aggregate basis, an apparent constant travel time expenditure of approximately 2.7 person-hr of travel per household per weekday and 1.0 person-hr of travel per person per weekday. This finding of an inverse relationship between trip frequency and trip duration is consistent with much of Zahavi's analyses conducted in the 1970s.

The remainder of this paper discusses comparability issues related to the 1965, 1981, and 1990 household travel surveys, changes in Bay Area demographic and economic characteristics between 1960 and 1990, changes in travel time expenditures and related characteristics between 1965 and 1990, and changes in regional household trip rates from 1965 to 1990.

## COMPARABILITY ISSUES RELATED TO 1965, 1981, AND 1990 HOUSEHOLD TRAVEL SURVEYS

In any comparative analysis of household travel surveys it is advisable to provide the reader with information to help in the understanding of similarities and dissimilarities related to survey design, sample design, and survey analysis methods. Fortunately, the Bay Area household travel surveys of 1965, 1981, and 1990 are quite similar in design and analysis, and excellent documentation of all three surveys has been developed. This analysis required revisiting the 1965 and 1981 survey files, especially in terms of calculating mobile persons, mobile households, and travelers versus nontravelers.

The study area for the three Bay Area travel surveys has remained constant, including the same nine counties and the entire region of 6,900 mi<sup>2</sup> (17 900 km<sup>2</sup>). Other regions, such as Atlanta, Buffalo, Rochester, and Philadelphia (5,7), have increased their study area sizes between survey years and require careful analysis to ensure appropriate comparisons between comparable areas.

The 1965 household travel survey, conducted by the Bay Area Transportation Study Commission (BATSC), was a home interview (face-to-face, in-person) survey of 20,486 households as to their weekday travel behaviors. An additional 10,200 households were queried as to their average weekend daily travel behaviors.

The 1981 household travel survey, conducted by the Metropolitan Transportation Commission (MTC), was a telephone survey of 6,209 households for weekday travel and an additional 882 households for weekend travel. Detailed survey methodology is included in the report by Crain and Associates (18) and in a report by Reynolds et al. (19).

The 1990 household travel survey, conducted by the MTC during the spring and fall of 1990, was also a telephone survey of more than 10,800 households for weekday travel behavior. Of the 10,838 usable household samples collected by MTC, 9,438 households provided single weekday daily travel diaries, and 1,486 sample households provided either 3-day or 5-day (weekday) travel diaries. The survey results reported here represent the single-day sample only, not the multiple-weekday sample. The detailed survey methodology for the 1990 MTC travel survey is included in a previous report (20).

All three surveys were administered to all persons in households ages 5 years and older. All three surveys collected basic household information (household income, vehicle availability, length of residence, structure type, owner/renter tenure), data on each person (age, sex, race/ethnicity, relationship to head of household, employment status), and trip data (detailed means of transportation, origin and destination location and trip purposes, trip start time, trip finish time, vehicle occupancy). Certain "households" in all three surveys were actually group quarters units (boarding houses, fraternities, convents, prisons, etc.) and were excluded from all three sets of analyses. The analysis for all three surveys is of weekday, intra-regional personal travel made by residents (age 5 years and older) of Bay Area households. Therefore, the analysis excludes the following travel submarkets: interregional travel made by Bay Area residents, travel made by nonresidents (visitors and commuters), travel made by persons living in group quarters, and commercial travel.

### Trip Linking

The trips reported in this analysis are based on linked trip records. Trip linking procedures for the 1965 home interview survey (21), the 1981 telephone survey (22), and the 1990 telephone survey (23)

are quite comparable. Trip linking is a technical necessity to remove incidental stops such as changing travel modes (e.g., walk to bus and drive to rail) and serving passengers (e.g., dropping off kids or spouse on the way to work and picking up carpool passengers). Mode-of-access and mode-of-egress trip leg information is retained in special extended versions of the linked trip files for future work in estimating mode of access to transit submode choice models. It is critical in a comparative survey analysis to identify whether unlinked or linked trips are used. The Philadelphia and Dallas studies clearly indicated the use of linked trips in their analysis and also provided a general description of trip linking procedures.

### Sample Weighting and Expansion

Weighting and expansion procedures were different for the three surveys. The 1965 survey was expanded to backcast estimates of households by single-family/multiple-family breakdown by 290 regional travel analysis zones of residence (24). The 1981 survey was expanded to the 1980 census count of households by household size by 45 districts of residence (25). The 1981 survey weighting method reflected the fact that one-half of the 6,200 household samples were from the city of San Francisco. The 1990 survey was expanded to the 1990 census count of households by household size, owner/renter tenure, auto-mobile ownership level, and 34 districts of residence (26). All of the results reported in this analysis reflect weighted survey results.

### Adjustments for Trip Underreporting

A report (24) on the 1965 travel survey discusses screenline adjustment factors to account for trip underreporting in the travel diaries. These adjustment factors were calculated by county and three general trip purposes (home-based work, home-based non-work, and non-home-based) and were applied only to the in-vehicle trips (not the transit trips). Screenline adjustment factors ranged from 3 to 10 percent for home-based work in-vehicle trips and from 5 to 25 percent for non-work in-vehicle trips. No screenline adjustment factors were required for the 1981 survey analysis, and the issue of screenline adjustment factors for the 1990 survey will be addressed in future MTC analyses. The results reported here are for reported travel characteristics before any screenline adjustment factors were applied.

Adjustment of household travel surveys to account for underreporting is discussed by Clarke et al. (27) and Barnard (28). Clarke and colleagues' summaries of U.S. and U.K. household travel surveys shows expanded survey data at 79 to 99 percent of screenline counts. Barnard's analysis of Australian household travel surveys shows expanded survey data at 55 to 95 percent of screenline counts. Both Clarke et al. and Barnard note the differential underreporting by trip purpose and travel mode, with non-work vehicle trips the most likely trip market to be underreported and with transit trips the least likely to be underreported. The basic conclusion of Clarke et al. and Barnard is that the standard household travel survey tends to underreport household travel on the order of 10 to 15 percent.

### CHANGES IN REGIONAL DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS

A summary of key regional, aggregate demographic and economic indicators is provided in Table 1. These characteristics provide a

TABLE 1 Regional Demographic and Economic Characteristics, 1960-1990

| Variable                         | 1960   | 1965     | 1965         | 1970     | 1980     | 1981       | 1990     | 1990       |
|----------------------------------|--------|----------|--------------|----------|----------|------------|----------|------------|
|                                  | Census | (ABAG)   | BATSC Survey | Census   | Census   | MTC Survey | Census   | MTC Survey |
| Total Population (000s)          | 3,639  | 4,216    | --           | 4,628    | 5,180    | --         | 6,024    | --         |
| Population in Households (000s)  | 3,515  | 4,106    | 4,331        | 4,501    | 5,059    | 5,051      | 5,870    | 5,870      |
| Households (000s)                | 1,174  | 1,387    | 1,387        | 1,553    | 1,971    | 1,970      | 2,246    | 2,246      |
| Total Vehicles (000s)            | 1,315  | --       | 1,942        | 2,078    | 3,317    | 3,350      | 3,950    | 4,020      |
| Employed Residents (000s)        | 1,433  | 1,664    | 1,697        | 1,882    | 2,555    | 2,639      | 3,152    | 3,072      |
| School Enrollment (000s)         |        |          |              |          |          |            |          |            |
| Total                            | 904    | --       | --           | 1,380    | 1,464    | --         | 1,504    | --         |
| Kindergarten - High School       | 811    | --       | --           | 1,108    | 975      | --         | 913      | --         |
| College                          | 93     | --       | --           | 232      | 419      | --         | 591      | --         |
| Mean Household Income (curr. \$) | --     | \$9,400  | \$9,600      | \$11,300 | \$24,400 | \$26,500   | \$52,100 | \$48,700   |
| Mean Household Income (1989 \$)  | --     | \$38,600 | \$39,400     | \$39,800 | \$44,200 | \$48,000   | \$52,100 | \$48,700   |
| Household Size                   | 2.99   | 2.96     | 3.12         | 2.90     | 2.57     | 2.56       | 2.61     | 2.61       |
| Employed per Household           | 1.22   | 1.20     | 1.22         | 1.21     | 1.30     | 1.34       | 1.40     | 1.37       |
| Drivers per Household            | --     | --       | 1.67         | --       | --       | 1.75       | --       | 1.76       |
| Vehicles per Household           | 1.12   | --       | 1.40         | 1.33     | 1.68     | 1.70       | 1.76     | 1.79       |
| Vehicles per Licensed Driver     | --     | --       | 0.84         | --       | --       | 0.97       | --       | 1.02       |
| Vehicle Ownership (%)            |        |          |              |          |          |            |          |            |
| Households with no vehicle       | 20%    | --       | 14%          | 16%      | 12%      | 11%        | 10%      | 10%        |
| Households with one vehicle      | 53%    | --       | 44%          | 44%      | 36%      | 35%        | 33%      | 32%        |
| Households with two vehicles     | 24%    | --       | 34%          | 33%      | 33%      | 36%        | 36%      | 37%        |
| Households with three-plus vehs. | 3%     | --       | 8%           | 7%       | 19%      | 18%        | 21%      | 21%        |

context for later discussions on changes in travel time expenditures, trip frequency, and aggregate travel characteristics. As appropriate, weighted and expanded household travel surveys are compared with data from the respective census or, as in the case of the 1965 survey, with independent demographic backcasts prepared by the Association of Bay Area Governments, the council of governments for the region.

The nine-county San Francisco Bay Area is a large metropolitan region in Northern California with more than 6 million persons residing in an area of more than 6,900 mi<sup>2</sup> (17,900 km<sup>2</sup>). The total population of the Bay Area increased by 16.3 percent between 1980 and 1990. The number of households increased by 14.0 percent between 1980 and 1990, and the total number of workers residing in the Bay Area increased by 23.4 percent in the 1980s. The recent upswing in regional average household size between 1980 and 1990 (2.56 to 2.61 persons per household) was the first census since 1960 in which Bay Area household size has shown an increase, not a decrease, with respect to the previous census year.

Growth in personal vehicle availability (+19.1 percent from 1980 to 1990) has outpaced growth in total population. The share of households owning zero vehicles has declined from 20 percent of all households in 1960 to 10 percent of all households by the year 1990. Communities with the highest shares of zero-vehicle households are San Francisco (30.7 percent of households with zero vehicles in 1990), Oakland (23.3 percent), and Berkeley (19.0 percent). The number of vehicles per licensed driver is apparently approaching one vehicle available per driver, although state De-

partment of Motor Vehicle records indicate that the actual number of drivers per Bay Area 1990 household is on the order of 1.87 drivers per household (contrasting to 1.76 vehicles per household).

Census data indicate a gradual decline in total school enrollment in kindergarten through grade 12 in the Bay Area between 1970 and 1990. On the other hand, college enrollments increased steadily between 1960 and 1990.

Regional mean household income increased 11 percent in 1989 constant dollar terms between 1970 and 1980 and increased 17.9 percent between 1980 and 1990. Mean household income for households in the 1981 survey is lower than the mean income from the 1980 census. In contrast the 1990 survey reported that incomes are slightly higher than those from the 1990 census.

#### CHANGES IN TRAVEL TIME EXPENDITURES AND RELATED CHARACTERISTICS

Key summary statistics that are reviewed as results are obtained from weighted, linked trip files and are the total count of expanded trips and trip rates per household and per person. Sample expansion and trip linking for the 1990 MTC household survey were completed in spring 1993. Soon thereafter the unpleasant reality of a major (-13.3 percent) decline in total trips per household and per person revealed potentially embarrassing results, that is, an absolute decline between 1980 and 1990 in the total number of trips made by Bay Area residents.

### Bay Area Comparison with Other Metropolitan Areas

As shown in Table 2, total the number of trips per household (all purposes and means of transportation) gradually declined from 8.78 trips per household in 1965 to 8.71 trips per household by 1981 and then dropped to 7.55 trips per household in 1990. Trips per capita (total persons in household) increased from 2.81 trips per person in 1965 to 3.39 by the year 1981 and then dropped back to 2.93 trips per capita by 1990. All trip rates are expressed in trips per weekday.

One of the first reactions was the following: how does the Bay Area compare with other areas that conducted travel surveys in the early 1990s? Results were compared with those of the Nationwide Personal Transportation Survey (29), Los Angeles (30), Sacramento (31), California (32), Dallas (6), Philadelphia (7), and other U.S. metropolitan areas (9). Other metropolitan areas, namely, Los Angeles, Dallas, and Denver, showed modest declines in the numbers of trips per household when their 1960s and 1970s travel surveys were compared with their 1980s and 1990s travel surveys. Only the San Francisco and Los Angeles regions appear to be showing declines in trip rates per person. If they are taken alone and not compared with the earlier 1965 or 1981 travel surveys, results from the 1990 Bay Area travel survey appear generally in line with those for other metropolitan areas.

Although the evidence from Los Angeles and other metropolitan areas suggests that the Bay Area is not unique in terms of declining trip rates, this predicament of dropping trip rates has disconcerting

implications for the stability of trip generation model parameters. Survey-based, expanded "person" trips (mechanized modes only: vehicle driver, vehicle passenger, transit passenger) were compared with a recently completed year 1990 model simulation, using the 1981 survey-based travel demand models. The number of survey home-based-work person trips, shown in Table 3, was within 1 percent of the number of model-simulated home-based-work person trips. This was encouraging. On the other hand, the number of survey-based home-based-shop (other) person trips was 20 percent less than the number of model-simulated trips, and the number of survey-based home-based social/recreation trips was 39 percent less than the number of model-simulated trips, and the number of non-home-based (NHB) person trips was 20 percent less than the number of model-simulated person trips. This was discouraging. The non-work trip generation models basically responded to increasing household sizes, increasing automobile ownership levels, and increasing real household income levels. Standard non-work trip generation models would only show an ever-increasing trip frequency based on these situations and could not respond to the shifts in travel behavior that apparently occurred in the Bay Area between 1980 and 1990. Norris and Shunk's (6) comparative analysis also noted declines in home-based non-work household trip rates in San Francisco, Dallas, Denver, and Atlanta.

The survey and model results for San Francisco and elsewhere indicate structural problems with non-work trip generation models. The results suggest the need for a better linkage between non-work

TABLE 2 Comparative U.S. Metropolitan Area Person Trips per Capita, Person Trips per Household, and Average Household Size

| Region                 | Year    | Trips per Capita | Trips per Household | Average Household Size |
|------------------------|---------|------------------|---------------------|------------------------|
| San Francisco Bay Area | 1965    | 2.81             | 8.78                | 3.12                   |
| San Francisco Bay Area | 1981    | 3.39             | 8.71                | 2.57                   |
| San Francisco Bay Area | 1990    | 2.93             | 7.55                | 2.61                   |
| NPTS                   | 1969    | 2.02             | 6.36                | 3.16                   |
| NPTS                   | 1977    | 2.33             | 6.59                | 2.83                   |
| NPTS                   | 1983    | 2.46             | 6.60                | 2.69                   |
| NPTS                   | 1990    | 2.63             | 6.74                | 2.56                   |
| Philadelphia (PJTS)    | 1960    | 1.50             | 5.03                | 3.36                   |
| Philadelphia (PJTS)    | 1987/88 | 2.34             | 6.25                | 2.67                   |
| Los Angeles            | 1976    | 2.90             | 8.10                | 2.80                   |
| Los Angeles            | 1991    | 2.40             | 7.60                | 3.11                   |
| Dallas                 | 1964    | 2.83             | 9.12                | 3.22                   |
| Dallas                 | 1984    | 3.40             | 8.68                | 2.60                   |
| Denver                 | 1971    | 2.81             | 8.69                | 3.09                   |
| Denver                 | 1985    | 2.87             | 7.33                | 2.54                   |
| Chicago                | 1979    | 2.40             | 7.20                | 3.00                   |
| Detroit                | 1980    | 2.59             | 7.47                | 2.90                   |
| Sacramento             | 1991    | 3.71             | 9.72                | 2.62                   |
| California             | 1991    | 3.90             | 10.60               | 2.70                   |
| Atlanta                | 1972    | 2.49             | 7.20                | 2.90                   |
| Baltimore              | 1977    | 2.90             | 8.30                | 2.80                   |
| Buffalo                | 1973    | 2.50             | 7.50                | 3.00                   |
| Seattle                | 1987    | 4.04             | 9.89                | 2.45                   |

**Notes:**

*NPTS and Los Angeles data exclude bicycle and walk trips.*

**TABLE 3 Comparison of Person Trips in 1990 Survey with Those in 1990 Model Simulation (person mode trips, in thousands)**

| Trip Purpose                 | 1990                         | 1990                | Percent Difference |
|------------------------------|------------------------------|---------------------|--------------------|
|                              | Model Simulated Person Trips | Survey Person Trips |                    |
| Home-based work              | 4,335                        | 4,271               | -1%                |
| Home-based shop/other        | 4,825                        | 3,864               | -20%               |
| Home-based social/recreation | 2,598                        | 1,594               | -39%               |
| Nonhome based                | 5,025                        | 4,011               | -20%               |
| <b>Total</b>                 | <b>16,783</b>                | <b>13,740</b>       | <b>-18%</b>        |

*Note: Person mode trips are by mechanized modes: vehicle driver, vehicle passenger, or transit passenger.*

trip generation models and work trip distribution models (i.e., total work trip duration). One hypothesis to be advanced and tested is that increases in work trip duration in a household are linked to lower non-work trip generation rates.

#### Mobile Versus Immobile Survey Respondents

Another initial concern that warranted further analysis was the potential problem of survey respondents falsely claiming that they did not travel during the assigned travel day, basically to avoid the hassle of filling out trip diaries. The term *mobile* is used to denote persons or households who reported travel—by any means of transportation, including walking or bicycling—during their assigned travel day. The mobile share of population, by age of respondent, is reported for the 1981 and 1990 San Francisco Bay Area surveys and is compared with Wigan's (33) analysis of the 1981 Sydney, 1978 Melbourne, and 1977 Adelaide, Australia, surveys (Table 4). The mobile share patterns of the Bay Area travel surveys are quite similar to those for the Australian metropolitan areas, averaging 82 percent mobile (18 percent immobile) for the two Bay Area surveys and 78 percent mobile (Sydney), 85 percent mobile (Melbourne), and 87 percent mobile (Adelaide) in Australia. Children ages 5 to 11 years show the highest mobility share, ranging from 86 to 89 percent mobile in San Francisco and from 86 percent in Sydney to 96 percent in Adelaide. Elderly persons, ages 65 years and over, show the lowest mobility share, ranging from 60 to 65 percent in the Bay Area and from 56 percent in Melbourne to 63 percent in Adelaide. These results are encouraging and suggest that the 1990 Bay Area

travel survey is not biased because of excessive numbers of respondents falsely claiming no travel.

#### Changes in Average Trip Duration

The analysis then turned to a review of average trip duration. It was believed that a real drop in household trip rates could make logical sense if the drop in trip frequency was offset by an increase in average reported trip duration. The 1990 survey indicated a modest (10.4 percent) increase in average trip duration between 1981 and 1990 (19.3 to 21.3 min, all trip purposes and modes) that offset a 13.3 percent decline in the total number of trips per household (Table 5). The 1984 study by Kollo and Purvis (1) did not dwell too long on the changes in trip frequency or trip duration, basically because of an insignificant decline in the total number of trips per household between 1965 and 1981 (8.77 to 8.71) and a subtle increase in the total average trip duration between 1965 and 1981 (18.6 to 19.3 min). Given the lumpy or spiky distributions of reported travel times, differences of less than 1 min in reported trip duration are probably not significant from a planning or statistical perspective.

The average reported trip duration for home-based work trips in the 1981 survey (26.6 min) is about 9 percent higher than the mean travel time for commuters as reported in the 1980 census (24.3 min). The average reported trip duration for 1990 survey home-based work trips (29.2 min) is 14 percent higher than the mean travel time for commuters according to the 1990 census (25.6 min). These increasing discrepancies between commute travel times reported in

**TABLE 4 Share of Population Reporting Travel by Age Group in Household Travel Surveys in Four Cities**

| Region        | Year | Age Group (Percent Share of Population Reporting Travel) |       |       |       |       |       |       | (Total) |
|---------------|------|--|-------|-------|-------|-------|-------|-------|---------|
|               |      | 5-11   | 12-16 | 17-25 | 26-34 | 35-59 | 60-64 | 65-99 |         |
| San Francisco | 1981 | 89%  | 87%   | 82%   | 86%   | 84%   | 76%   | 60%   | 82%     |
| San Francisco | 1990 | 86%  | 85%   | 81%   | 85%   | 86%   | 73%   | 65%   | 82%     |
| Sydney        | 1981 | 86%  | 84%   | 77%   | 81%   | 78%   | 71%   | 61%   | 78%     |
| Melbourne     | 1978 | 95%  | 95%   | 89%   | 89%   | 84%   | 70%   | 56%   | 85%     |
| Adelaide      | 1977 | 96%  | 96%   | 91%   | 91%   | 86%   | 75%   | 63%   | 87%     |

TABLE 5 Changes in Trip Duration (in minutes) by Trip Purpose in San Francisco Bay Area in 1965, 1981, and 1990 Household Travel Surveys

| Trip Purpose                 | 1965 Survey | 1981 Survey | 1990 Survey | Percent Change 1981 - 1990 |
|------------------------------|-------------|-------------|-------------|----------------------------|
| Home-based work              | 25.8        | 26.6        | 29.2        | 9.8%                       |
| Home-based shop/other        | 15.2        | 15.4        | 17.1        | 11.0%                      |
| Home-based social/recreation | 19.7        | 19.2        | 20.7        | 7.8%                       |
| Home-based school            | 18.5        | 20.5        | 20          | -2.4%                      |
| Nonhome based                | 15.6        | 16.7        | 18.3        | 9.6%                       |
| Total                        | 18.6        | 19.3        | 21.3        | 10.4%                      |

the survey and the census bear further detailed analysis at a more precise geographic level to discern biases in either or both data sets.

#### Travel Time Expenditures—Households and Persons

Much of the confusion in the travel time budget literature is with respect to the definition of terms. Goodwin (34) makes a good case that travel time budgets should be based on all households, on all persons in the households, and for all travel, including nonmotorized travel. Much of Zahavi's research focused either on vehicle travel or travel by motorized means (vehicle driver, vehicle passenger, or transit passenger). The present study analyzes total travel time expenditures per total household and for total population, as well as the more restrictive definitions related to travel time per traveler or travel time per mobile person.

For reporting purposes here, the term *mobile* is used to denote persons or households who reported travel—by any means of transportation, including walking or bicycling—during their assigned travel day. The term *traveler* is used to denote persons or households who reported motorized travel (vehicle driver, vehicle passenger, or transit passenger) during the assigned travel day. The term *total trip* refers to trips made by persons, ages 5 years and older and residing in households, by any and all means of transportation. The term *person trip* is a more restricted definition (similar to the person trips used in travel demand forecasting models) and refers to trips made only by motorized means of transportation.

The basic input data and resulting travel time expenditures and trip frequency rates are presented in Table 6. The share of the population traveling (i.e., making motorized trips) increased from 67 percent of the population in 1965 to 76 percent of the population in 1990. The share of households traveling (i.e., one or more persons in the household making motorized trips) is rather stable at 88 to 90 percent of all households. The mobile household share (i.e., one or more persons in the household making trips by any means of transportation) is also stable at around 91 to 94 percent of all households.

All trip rates per person (total, mobile, and traveling) and per household (total, mobile, and traveling) increased between 1965 and 1981 and decreased between 1981 and 1990.

Total travel time expenditure per mobile person increased 19 percent between 1965 and 1981, from 72 min per mobile person per day (1.2 hr) to 86 min per mobile person per day (1.44 hr). Total travel time per mobile person decreased slightly between 1981 and 1990, from 86.3 to 82.5 min. The total travel time expenditure per

traveler is quite similar to the average travel time per mobile person. The average travel time per traveler increased 15.8 percent between 1965 and 1981 and decreased by 5.5 percent between 1981 and 1990, dropping from 84.9 to 80.2 min.

Average travel time expenditure per mobile household increased by 8 percent between 1965 and 1981, from 173 min (2.88 hr) per mobile household in 1965 to 187 min (3.12 hr) per mobile household in 1981. Average travel time expenditure per traveling household showed a 10.7 percent increase between 1965 and 1981 and a 5.5 percent decrease between 1981 and 1990.

Average travel time expenditures per total household and per total household population are shown in Table 7. Travel time expenditure per total household was 2.7 hr per household in 1965 and 1990 and 2.8 hr per household in 1981. Travel time expenditure per total persons in households increased from 0.86 hr per person in 1965 to 1.07 hr per person by the year 1981. Travel time expenditure per total persons in households apparently declined to 1.03 hr per person in 1990. This represents a 2.1 percent decrease in average travel time expended per household from 1965 to 1990, and a 19.8 percent increase in average travel time expended per person in the household from 1965 to 1990.

The three sets of travel surveys were further stratified by automobile ownership level and by household size to detect any other regularities in travel time expenditures by market segment. Average travel time expenditure per person by automobile ownership level increased between 1965 and 1981 and generally remained constant between 1981 and 1990. The most significant changes, from 1981 to 1990, is an 11 percent drop in travel time per person in zero-vehicle households (1.10 to 0.98 hr/person).

Average travel time per person by household size is also shown in Table 7. Average travel time per person decreases with increasing household size. This is because single-person households must perform all household travel chores, whereas multiperson households can share household travel chores between household members. A single-person household in 1990 spent 1.30 hr per day traveling (any means of transportation). A five-or-more-person household in 1990 spent 5.06 hr per day per household, or 0.86 hr per person in the household. The travel time expenditures per person show moderate increases between 1965 and 1981 and a general stability between 1981 and 1990. The travel time expenditure for two-person and three-person households increased between 1981 and 1990; travel time expenditures decreased for one-person, four-person, and five-or-more-person households over this same period of time.

TABLE 6 Mobile Population, Travelers, and Travel Time Expenditures in San Francisco Bay Area in 1965, 1981, and 1990 Household Travel Surveys

| Variable   | 1965              | 1981              | 1990              | Percent Change |
|--|-------------------|-------------------|-------------------|----------------|
|  |                   |                   |                   | 1965 - 1990    |
| Household Population (age 5+)  | 3,920,000         | 4,727,400         | 5,330,400         | 36%            |
| Mobile Population (age 5+)   | 3,124,500         | 3,871,700         | 4,378,900         | 40%            |
| Mobile Population Share (%)  | 80%               | 82%               | 82%               |                |
| "Travellers" (age 5+)  | 2,610,200         | 3,503,300         | 4,071,400         | 56%            |
| "Traveller" Population Share (%)                                     | 67%               | 74%               | 76%               |                |
| <b>Total Households</b>  | <b>1,386,800</b>  | <b>1,970,400</b>  | <b>2,246,300</b>  | <b>62%</b>     |
| Mobile Households  | 1,302,700         | 1,786,000         | 2,072,500         | 59%            |
| Mobile Household Share (%)   | 94%               | 91%               | 92%               |                |
| "Travelling" Households  | 1,231,500         | 1,730,400         | 2,011,300         | 63%            |
| "Travelling" Household Share (%)                                     | 89%               | 88%               | 90%               |                |
| <b>Total Trips, All Modes</b>  | <b>12,172,400</b> | <b>17,168,100</b> | <b>16,966,700</b> | <b>39%</b>     |
| Person Hours of Travel, All Modes                                    | 3,763,500         | 5,569,300         | 6,021,200         | 60%            |
| Average Trip Duration, All Modes                                     | 18.6              | 19.5              | 21.3              | 15%            |
| <b>Person Trips (Mechanized Modes)</b>                               | <b>9,737,200</b>  | <b>14,527,400</b> | <b>14,811,400</b> | <b>52%</b>     |
| Person Hours of Travel, Person Trips                                 | 3,188,200         | 4,957,000         | 5,444,600         | 71%            |
| Average Trip Duration, Person Trips                                  | 19.6              | 20.5              | 22.1              | 12%            |
| <i><u>Trip Rates (Average Weekday)</u></i>                           |                   |                   |                   |                |
| Total Trips per Mobile Pop.  | 3.90              | 4.43              | 3.87              | -1%            |
| Person Trips per "Traveller"   | 3.73              | 4.15              | 3.64              | -2%            |
| Total Trips per Mobile HH  | 9.34              | 9.61              | 8.19              | -12%           |
| Person Trips per "Travelling" HH                                     | 7.91              | 8.40              | 7.36              | -7%            |
| Total Trips per Total Household                                      | 8.78              | 8.71              | 7.55              | -14%           |
| Person Trips per Total Household                                     | 7.02              | 7.37              | 6.59              | -6%            |
| <i><u>Travel Time Expenditures (Average Weekday, in Minutes)</u></i> |                   |                   |                   |                |
| Total Travel Time per Mobile Person                                  | 72.3              | 86.3              | 82.5              | 14%            |
| Total Travel Time per "Traveller"                                    | 73.3              | 84.9              | 80.2              | 9%             |
| Total Travel Time per Mobile HH                                      | 173.3             | 187.1             | 174.3             | 1%             |
| Total Travel Time per "Travelling" HH                                | 155.3             | 171.9             | 162.4             | 5%             |

Careful examination of the coefficients of variation by market segment is required to understand the statistical significance of these minor to moderate changes in mean travel time expenditures per household and per person. Errors in the reporting (and coding) of trip start and trip finish times are prone to occur in household travel surveys and can significantly affect average travel times in the aggregate and by market segment.

#### Travel Time Expenditures—Vehicles

Changes in aggregate regional vehicles available, vehicle trips, and vehicle hours of travel per household are summarized in Table 8. The surveys show a more than doubling in the number of vehicles available and the vehicle hours of travel in the Bay Area between 1965 and 1990. Average vehicle trip duration decreased slightly between 1965 and 1981, from 18.4 min per average vehicle trip in

1965 to 18.0 min by the year 1981. Average vehicle trip duration increased 14 percent between 1981 and 1990, from 18.0 to 20.5 min.

Vehicle trips per vehicle has shown a steady decrease over the three survey time periods, declining from 3.24 trips per vehicle according to the 1965 survey, to 3.08 trips per vehicle in the 1981 survey, to 2.71 trips per vehicle in the 1990 household travel survey. Vehicle hours of travel per vehicle available is rather stable at around 0.92 to 0.99 hr expended by each vehicle each day. The 1990 travel survey indicated that the average vehicle was on the road approximately 0.93 hr (56 min) per day.

Further analysis of vehicle travel time expenditures in the Bay Area should investigate changes in average trip length, in miles, per vehicle for the three household travel surveys. A network-based evaluation of vehicle miles of travel and average trip speeds using travel survey records is needed for a careful outlier analysis to edit and correct or to delete trip records and as a precursor step for trip distribution model development.

**TABLE 7 Total Travel Time Expenditures per Household and per Person by Automobile Ownership Level and Household Size in San Francisco Bay Area in 1965, 1981, and 1990 Household Surveys**

| <i>Auto Ownership Level</i> |  |      |      |             |   |      |      |             |  |
|-----------------------------|--|------|------|-------------|---|------|------|-------------|--|
| Auto<br>Ownership<br>Level  | Avg. Total Travel Time/Household/Weekday (Hours) |      |      |             | Avg. Total Travel Time/Person/Weekday (Hours) |      |      |             |  |
|                             |  |      |      | Pct. Change |   |      |      | Pct. Change |  |
|                             | 1965   | 1981 | 1990 | 1965-1990   | 1965  | 1981 | 1990 | 1965-1990   |  |
| 0                           | 1.71   | 1.95 | 1.79 | 4.7%        | 0.86  | 1.10 | 0.98 | 14.0%       |  |
| 1                           | 2.32   | 2.04 | 1.96 | -15.5%      | 0.80  | 1.05 | 1.02 | 27.5%       |  |
| 2                           | 3.21   | 3.15 | 2.90 | -9.7%       | 0.88  | 1.06 | 1.01 | 14.8%       |  |
| 3+                          | 3.93   | 4.13 | 3.81 | -3.1%       | 0.95  | 1.09 | 1.07 | 12.6%       |  |
| Total                       | 2.71   | 2.83 | 2.68 | -1.1%       | 0.86  | 1.07 | 1.03 | 19.8%       |  |
| 1+                          | 2.84   | 2.93 | 2.78 | -2.1%       | 0.86  | 1.07 | 1.03 | 19.8%       |  |

| <i>Household Size</i> |  |      |      |             |   |      |      |             |  |
|-----------------------|--|------|------|-------------|---|------|------|-------------|--|
| Household<br>Size     | Avg. Total Travel Time/Household/Weekday (Hours) |      |      |             | Avg. Total Travel Time/Person/Weekday (Hours) |      |      |             |  |
|                       |  |      |      | Pct. Change |   |      |      | Pct. Change |  |
|                       | 1965   | 1981 | 1990 | 1965-1990   | 1965  | 1981 | 1990 | 1965-1990   |  |
| 1                     | 1.25   | 1.34 | 1.30 | 4.0%        | 1.25  | 1.34 | 1.30 | 4.0%        |  |
| 2                     | 2.13   | 2.33 | 2.30 | 8.0%        | 1.06  | 1.13 | 1.15 | 8.0%        |  |
| 3                     | 2.63   | 3.09 | 3.06 | 16.3%       | 0.88  | 1.00 | 1.02 | 16.3%       |  |
| 4                     | 3.23   | 4.24 | 3.79 | 17.3%       | 0.81  | 1.03 | 0.95 | 17.3%       |  |
| 5+                    | 4.17   | 5.76 | 5.06 | 21.3%       | 0.72  | 0.99 | 0.86 | 19.4%       |  |
| Total                 | 2.71   | 2.83 | 2.68 | -1.1%       | 0.86  | 1.07 | 1.03 | 19.8%       |  |

#### CHANGES IN REGIONAL HOUSEHOLD TRIP RATES, 1965-1990

Changes in regional household trip rates, comparing the 1965, 1981, and 1990 Bay Area household travel surveys, are summarized in Table 9. Changes in household trip rates by trip purpose and travel mode are shown in Table 9.

The only trip purpose showing an increasing number of trips per household between the 1981 and 1990 surveys is home-based work trips. The 5.3 percent increase in home-based work trips per household between 1981 and 1990 represents a 20.1 percent increase in regional, aggregate home-based work trips. This compares with a

20.0 percent increase in regional, aggregate employed residents. This simply means that the number of work trips per worker did not change between 1981 and 1990.

Home-based non-work trips are broken down into three trip purposes: home-based shop (other), home-based social/recreation, and home-based school. Home-based shop (other) is a catchall trip purpose and includes shopping, personal business, medical/dental, unlinked serve passenger and change travel mode purposes, and so forth. Home-based social/recreation trips include indoor and outdoor recreation trips, visiting, and eating meals. Home-based school includes student trips from home to school and school to home, regardless of grade level.

**TABLE 8 Characteristics of Vehicle Travel in San Francisco Bay Area in 1965, 1980, and 1990 Household Travel Surveys**

| Characteristic                    | 1965      | 1981       | 1990       | Percent Change<br>1965 - 1990 |
|-----------------------------------|-----------|------------|------------|-------------------------------|
|                                   | Survey    | Survey     | Survey     |                               |
| Vehicles Available                | 1,941,600 | 3,349,700  | 4,020,100  | 107%                          |
| Vehicle Trips                     | 6,288,000 | 10,307,000 | 10,914,300 | 74%                           |
| Vehicle Hours of Travel           | 1,928,300 | 3,093,200  | 3,738,000  | 94%                           |
| Average Trip Duration (min.)      | 18.4      | 18.0       | 20.5       | 12%                           |
| Vehicle Hours of Travel / Vehicle | 0.99      | 0.92       | 0.93       | -6%                           |
| Vehicle Trips / Vehicle           | 3.24      | 3.08       | 2.71       | -16%                          |



**TABLE 9 Weekday Regional Trips per Household by Purpose and Mode in San Francisco Bay Area in 1965, 1981, and 1990 Household Travel Surveys**

| Mode                     | Home-Based |             |                    |        | Nonhome Based | Total |
|--------------------------|------------|-------------|--------------------|--------|---------------|-------|
|                          | Work       | Shop/ Other | Social/ Recreation | School |               |       |
| <b>In-vehicle person</b> |            |             |                    |        |               |       |
| 1965                     | 1.518      | 2.307       | 0.915              | 0.295  | 1.499         | 6.535 |
| 1981                     | 1.558      | 1.964       | 1.011              | 0.387  | 1.894         | 6.814 |
| 1990                     | 1.701      | 1.643       | 0.682              | 0.393  | 1.695         | 6.115 |
| % Diff. 65-90            | 12%        | -29%        | -25%               | 33%    | 13%           | -6%   |
| <b>Transit</b>           |            |             |                    |        |               |       |
| 1965                     | 0.220      | 0.085       | 0.035              | 0.086  | 0.060         | 0.486 |
| 1981                     | 0.206      | 0.085       | 0.044              | 0.126  | 0.097         | 0.558 |
| 1990                     | 0.200      | 0.077       | 0.028              | 0.084  | 0.091         | 0.479 |
| % Diff. 65-90            | -9%        | -9%         | -20%               | -2%    | 52%           | -1%   |
| <b>School Bus</b>        |            |             |                    |        |               |       |
| 1965                     | --         | --          | --                 | 0.146  | --            | 0.146 |
| 1981                     | --         | --          | --                 | 0.089  | --            | 0.089 |
| 1990                     | --         | --          | --                 | 0.075  | --            | 0.075 |
| % Diff. 65-90            | --         | --          | --                 | -49%   | --            | -49%  |
| <b>Walk</b>              |            |             |                    |        |               |       |
| 1965                     | 0.090      | 0.286       | 0.177              | 0.514  | 0.281         | 1.348 |
| 1981                     | 0.076      | 0.188       | 0.143              | 0.285  | 0.303         | 0.995 |
| 1990                     | 0.061      | 0.151       | 0.089              | 0.160  | 0.287         | 0.748 |
| % Diff. 65-90            | -32%       | -47%        | -50%               | -69%   | 2%            | -45%  |
| <b>Other</b>             |            |             |                    |        |               |       |
| 1965                     | 0.031      | 0.053       | 0.057              | 0.057  | 0.065         | 0.263 |
| 1981                     | 0.050      | 0.037       | 0.063              | 0.065  | 0.042         | 0.257 |
| 1990                     | 0.029      | 0.020       | 0.029              | 0.032  | 0.027         | 0.137 |
| % Diff. 65-90            | -6%        | -62%        | -49%               | -44%   | -58%          | -48%  |
| <b>Total</b>             |            |             |                    |        |               |       |
| 1965                     | 1.858      | 2.732       | 1.184              | 1.097  | 1.906         | 8.777 |
| 1981                     | 1.890      | 2.274       | 1.262              | 0.952  | 2.335         | 8.713 |
| 1990                     | 1.991      | 1.891       | 0.827              | 0.744  | 2.100         | 7.553 |
| % Diff. 65-90            | 7%         | -31%        | -30%               | -32%   | 10%           | -14%  |

All three home-based non-work trip purposes show steady declines in the number of trips per household over the three Bay Area household travel surveys. The number of home-based social/recreation trips per household increased slightly between 1965 and 1981, only to show a precipitous drop of 34.5 percent (1.26 to 0.83 trips per household) between 1981 and 1990. This might mean that Bay Area residents are not having fun any more or that household members are trading off out-of-home social/recreation activities for in-home (or weekend) social/recreation activities. The Bay Area travel surveys do not indicate what people are doing at home—whether they are asleep, working or telecommuting, playing, eating, socializing, or watching television. Thus, it is impossible with current survey data to understand the true nature of the trade-off between in-home activities and out-of-home activities.

The number of non-home-based trips per household increased substantially between 1965 and 1981 (1.91 to 2.34 trips per household) only to fall back to a level moderately higher than the 1965 trip rate (2.10 trips per household).

The total number of transit trips per household decreased slightly between 1981 and 1990, from 0.56 to 0.48 trips per household. The

number of school bus trips per household also showed a slight decrease between 1981 and 1990. In-vehicle person trips showed the most significant absolute decline between 1981 and 1990, dropping from 6.81 to 6.12 trips per household. The total number of vehicle trips per household (not shown in Table 9) decreased from 5.23 trips per household in 1981 to 4.86 vehicle trips per household by 1990. A steady decline in the number of walk trips per household can be shown between the three household travel surveys, dropping from 1.35 walk trips per household in 1965 to 1.00 trips per household by 1981 and then leveling off at 0.75 walk trips per household by 1990.

## CONCLUSIONS

Results from the 1990 San Francisco Bay Area household travel survey provides major challenges to Bay Area transportation planners. An apparent decline in trip frequency per household and per person is offset by an increase in average trip duration, yielding an apparent stability in the average travel time expended per household and per person. Findings from this study are generally consistent

with the travel time budget studies of the 1970s and early 1980s. Findings may also rekindle interest in travel time budget analyses and alternative travel demand forecasting models based on activity analysis, time use studies, and travel time budgets.

Comparison of model-simulated trips with 1990 survey trips shows an excellent match for home-based work trips, yet a moderate overprediction of non-work trips with respect to 1990 survey person trips. The non-work trip generation and trip distribution models in use in the Bay Area are not structured to account for this inverse relationship between trip frequency and trip duration. Trip generation models are typically built to provide ever-increasing non-work trips per household on the basis of assumptions of real income growth and growth in automobile ownership per household. New and improved non-work trip generation models may need to incorporate some direct linkage with work trip distribution models (e.g., total work trip duration).

There is a significant potential for underreported trips in the 1990 survey, especially for non-work trips, and for vehicle driver, vehicle passenger, walking and bicycling trips. There is probably a minor (5 percent) underreporting of transit trips in the 1990 household travel survey. As a part of a cross-validation project, MTC will assign the raw, expanded survey trip records to regional highway and transit networks for analysis of screenline loadings and for analysis of vehicle miles and person miles of travel. This project would also allow for the editing and correction of survey outliers (e.g., trips with absurdly low or absurdly high travel speeds).

There is a relatively stable share of mobile persons and households for the three Bay Area household travel surveys. This means that the share of persons falsely claiming no travel is not a major problem with the three household surveys.

The 1990 survey was conducted in less than ideal situations. Survey response rates declined between 1981 and 1990. In 1981 69 percent of eligible households contacted completed the survey; in 1990 49 percent completed the survey. The survey consultant reported problems owing to interviewer fatigue as well as interviewee fatigue and a reported a higher degree of interviewer turnover than expected. It is also unclear what impact that the October 1989 Loma Prieta earthquake had on moderating travel patterns, the impact of the economic recession in the United States on moderating out-of-home travel, the nature and extent of the in-home substitution for out-of-home activities, and the nature and extent of weekend travel substitution for weekday travel.

The most challenging aspect of this future research could be the integration of travel time expenditure concepts into a disaggregate travel demand model system for use by regional transportation planners. The findings of this aggregate analysis should be used to inform a more detailed and rigorous disaggregate travel behavior analysis.

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## DISCUSSION

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This interesting and provocative paper uses data from a 1990 travel survey to update the well-known previous comparison of results from the 1965 and 1981 surveys in the San Francisco Bay Area (1). In particular Purvis is to be congratulated for extending the analysis to include daily travel time.

Understanding how people use their time, both in activity participation and in traveling to and from those activities, is critical to the understanding and modeling of travel behavior, and one can identify considerable recent interest in time use research among travel demand researchers (2-4). The traditional approach to travel forecasting does not incorporate activity participation and the related concept of time use; however, the past 15 years has seen the development of the activity-based approach to travel analysis [for a recent review, see the paper by Axhausen and Garling (5)]. This approach has yielded considerable insight regarding travel behavior, and it serves as the basis for emerging travel modeling frameworks (6,7).

Although I am reluctant to enter the constant travel time budget debate (8-11), I do feel compelled to make some general observations about interpreting data and inferring relationships from the data and to make some observations that pertain specifically to the results reported in this paper. In making these observations, I cannot avoid expressing concern about the constant travel time budget theory. Each of us has only 24 hr each day in which to accomplish our wants and needs, and we therefore all do have a time budget. Thus, if we spend more time in one activity on a given day we have no alternative but to spend less time in another activity on that day, and vice versa. But this does not mean, for example, that if we make fewer trips (for whatever reason) we will necessarily choose to make them longer in duration to maintain a constant daily travel time budget, and vice versa. Certainly, the data presented in this paper do not provide evidence to support a constant travel time budget theory.

Perhaps the most important general point to be made is that it is dangerous to infer behavioral regularities from very aggregate data, because the apparent regularities could arise for multiple reasons. It seems clear that in the case reported in this paper changes over time at the disaggregate level interact with changes in the population distribution to provide apparent temporal stability at the aggregate level. The results reported in Table 7 show that there was substantial change over the period from 1965 to 1990 when one looks at the data segmented by household size, whereas the aggregate data show a great deal of stability over time in the case of daily travel time per household. Specifically, the results reported in Table 7 show that over the period from 1965 to 1990 daily travel time per household increased for each household size segment, with the increases ranging from 4 to 21 percent, whereas the average daily travel time per household remained essentially the same over this period.

The stability of the average daily travel time per household, in the face of substantial changes in travel time per household in the different household size segments, can be very readily explained by the fact that the average household size in the San Francisco Bay Area declined from 3.12 to 2.61 in this period. The increase in the relative proportion of households in the smaller household size categories, which have lower daily travel time expenditures, acted as a counterbalance to the increase in travel time per household per day in each household size category, and the overall average daily travel time per household remained essentially constant. Clearly, had there not been a decline in average household size, Purvis would have found a substantial increase in daily travel time per household over the period of the analysis.

Although the decline in average household size caused daily travel time per household to appear to be stable, the same result did not occur in the case of daily travel time per person because daily travel time per person is greater in those household size segments that increased in proportion in the time period under consideration. On the other hand, even if the daily travel time per household in each household size segment had not changed at all over the period from 1965 to 1990, Purvis would have found a decline in the average daily travel time per household solely due to the decline in average household size over the analysis period.

To determine whether there is any behavioral regularity in travel time expenditure, I would want to examine this question using panel data—that is, to see whether persons or households maintain a constant travel time budget in the face of transportation system and other changes. My hypothesis is that one would not find stability in daily travel time (either per person or per household) from such an analysis, certainly over an extended period of time in which transportation and land-use system changes and/or sociodemographic changes take place. Analyses based on panel data generally show considerable changes over time in time use for various activities (3).

In summary the results reported in this paper do not justify the conclusion that we should consider using the travel time budget concept as the basis of a new system of disaggregate travel demand models. In particular I am very uncomfortable with the suggestion that we should use observed stability in aggregate daily travel time as the basis of a new disaggregate model system. Although studying time use and activity participation is vital to the understanding and modeling of travel, I do not think that the concept of a constant travel time budget is a meaningful one, and this paper does not provide evidence that makes me change my mind. However, I do hope that this paper will draw attention to the need to examine time use and activity participation in trying to understand and model travel behavior.

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