this tendency to overestimate is still being investigated; preliminary observations indicate that more accurate determination of the frequency distribution of distance to bus in large zones that have scant transit service will correct this tendency of the model. Another possible reason is the lack of socioeconomic variables (e.g., income or automobile ownership) in this calibration. More detailed analysis of the model estimates for the developed portions of the region indicate satisfactory performance, even for small areas.

CONCLUSIONS

The paper describes a methodology for mode-split analysis that possesses a number of highly desirable attributes: (a) it is compatible with the conventional transportation planning process, (b) it permits the application of disaggregate mode-choice models, and (c) it permits a detailed description of the access and egress transit service and a realistic account of its effect on transit ridership. The method for describing the service is flexible enough to support analyses of nonstandard services, such as dial-a-ride.

The model is fully operational and has been proven applicable for analysis of large-scale regional problems as well as for small-scale, subregional projects, including transportation system management strategies. The resources required for data preparation and analysis are reasonable.

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Abridgment

Second Role of the Work Trip–Visiting Nonwork Destinations

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On a typical weekday in a major California urban area, about one-third of the households in which the head is employed visit one or more nonwork destinations as part of a trip to or from the workplace. Many transportation analysts find this number surprisingly high because conventional models of urban travel behavior make the assumption that the sole function of the work trip is to get the worker to and from the workplace. In fact, the analysis presented in this paper found that intermediate stops during trips to and from the workplace are an important means of visiting nonwork destinations and account for about 17 percent of nonwork destinations visited per household per weekday.

These figures are based on an analysis of home-interview origin-destination data collected in 1971 as part of the Fresno-Clovis area transportation study. An initial reaction to these numbers is to ask why Fresno is so at variance with the conventional wisdom. Fresno may be an unusual case; however, the use of complex patterns of travel found in Fresno is consistent with studies by Ginn and Horowitz of complex travel patterns in other cities (1, 2).

More likely, the conventional wisdom is no longer consistent with actual travel behavior. Cross-sectional evidence presented later in this paper implies that, if current demographic trends continue, the use of workplace-related trips to visit nonwork destinations will increase from the already substantial levels found in 1971. The conventional wisdom may be based on earlier data, collected when these types of trips were less important than they are now.

CHARACTERISTICS OF THE DATA

Before turning to the results of the analysis, briefly consider the strengths and weaknesses of the data on which they are based. The Fresno survey was used because the data were collected and organized in a disaggregated manner that permitted the analysis of complex travel patterns. These data reflect travel behavior before the oil emargo and subsequent increases in the price of gasoline. The data refer only to trips made by vehicle by persons age 5 and older. Thus, walking trips were excluded. Trips by vehicle include trips made by

automobile, pickup truck, and public transit. Public transit, however, was relatively unimportant in Fresno; it accounted for only about 1 percent of trips to work.

The data were recorded in terms of person trips rather than vehicle trips. If a second person rode along on a trip made by another person, the trips were recorded as two separate trips.

Some additional restrictions were placed on the data used for this analysis. Only weekday travel was included because the character of weekend trips to the workplace might be substantially different. Destinations visited for related business purposes, such as a salesperson's call on customers, were excluded because these trips were considered to be an attribute of the person's job rather than a dimension of travel over which a person had much daily choice. Because the focus is on workplace-related trips to visit nonwork destinations and because the data were collected during July and August, when a relatively high incidence of vacation travel behavior could be expected, only the travel of household members when the head of the household made a work trip on the travel day was included. Only household members who had one or more automobiles (or pickup trucks) available were included. Finally, destinations refer only to nonwork destinations.

SAVINGS IN TRAVEL RESOURCES

A reasonable assumption is that a principal incentive for visiting a nonwork destination during a workplace-related trip (a trip from home to work, a trip from work to home, or a trip that originates and terminates at the workplace) is to obtain a savings in the time and money cost of travel, thereby lowering the total costs of the goods and services obtained via travel. The savings realized from making an intermediate stop during a workplace-related trip rather than making a separate single-destination trip from the home to accomplish the same purpose can be substantial.

To get an estimate of the order of magnitude of these savings, assume that, instead of visiting nonwork destinations via workplace-related trips, the household member visits different destinations for the same purposes via single-destination trips from the home. Further assume that the travel time and travel distance for these single-destination trips are the same as the average for all single-destination trips made for the same purposes by members of other households living in the same census tract. These assumptions represent the situation where close substitutes for the goods obtained via workplace-related trips are available at many locations throughout the urban area.

Under these assumptions, each time a household member visits a nonwork destination via a workplace-related trip an estimated 3.9 person-km (2.4 person miles) and 4.8 person-min of travel resources are saved. Recall that each weekday about one-third of the household members visit one or more nonwork destinations in this manner. Without such use of these trips, household members would use about 5 percent more travel resources per weekday.

If the destinations visited via workplace-related trips offer highly specialized goods or services not widely available, then an alternative method for calculating the travel savings would be to assume that the household member would visit the same destinations via single-destination trips. The savings calculated under this assumption are substantially higher. Each destination visited via workplace-related trips results in a savings of 6.3 person-km (3.9 person miles) and 6.6 person-min. Without such trips, household members would use about 7.6 percent more travel resources. This method is reasonable for some destinations but, in general, it almost surely overstates the savings from workplace-related trips and can be regarded as an upper bound.

VARIATIONS IN HOUSEHOLDS' USE OF WORKPLACE-RELATED TRIPS

If the use of workplace-related trips to visit nonwork destinations did not vary greatly among households, then we might argue that the omission from transportation analysis of consideration of this function of these trips is not serious. If, however, this use of workplace-related trips does vary systematically with differences in the characteristics of households, then ignoring this use may introduce systematic error into urban transportation analysis.

The analytical tool used to examine the relations between the characteristics of the household members and their use of workplace-related trips is ordinary least-squares multiple-regression analysis by using the daily travel of each household as the unit of observation. A linear additive functional form is used in all cases. If all of the household's characteristics are included in each equation, then the estimated effects are the separate effects of each individual characteristic, holding all other characteristics constant. The dependent variables measure the number of nonwork destinations visited during workplace-related trips and not the number of workplace-related trips themselves.

Table 1 contains the significant coefficients from the regression equations that describe the effects of differences in household characteristics on the total number of nonwork destinations per household per weekday, the number of these destinations, the fraction of these destinations, and the probability of visiting one or more of these destinations via workplace-related trips.

In addition to the independent variables presented in Table 1, the equations also contained variables for the number of household members less than five years of age, accessibility indices for the residence, the workplace of the head of the household, the workplace of a second worker, and dummy variables for the availability of a second or third automobile (or pickup truck). None of these variables had a significant impact on any of the dependent variables.

Household Income

Household income is total annual income for all household members measured in hundreds of 1971 dollars. As might be expected, an increase in household income increases the total number of nonwork destinations. We can presume that members of higher-income households have more goods and services in their consumption bundle and thus visit more destinations to obtain these goods and services. The effect of a $1000 increase in household income is not large; total nonwork destinations per household per weekday increase by 0.06 for an income elasticity of 0.17.

In addition to visiting more nonwork destinations, members of higher-income households place greater reliance on workplace-related trips to visit these destinations. Not only does the number of nonwork destinations visited via workplace-related trips increase with an increase in income, but the fraction of total nonwork destinations visited via such trips increases as well. A $1000 increase increases the number of destinations by 0.03, for an income elasticity of 0.51 and the fraction by 0.01 for an elasticity of 0.38.

The use of workplace-related trips has been seen to offer a savings in travel time and distance over the use of single-destination trips to visit nonwork destinations.

Table 1. Principal effects on the use of workplace-related trips.

Household Characteristics	Total Nonwork Destinations	Nonwork Destinations via Workplace-Related Trips	Fraction of Nonwork Destinations via Workplace-Related Trips	Probability of at Least One Nonwork Destination via Workplace-Related Trips
Annual household income				
$1000 increase	0.06	0.03	0.01	0.01
t-statistic	3.59	5.18	3.99	4.82
Elasticity	0.17	0.51	0.38	0.34
Household size age 16+				
One-person increase	3.34	0.08	-0.11	-0.15
t-statistic	25.9	1.79	-7.68	-7.64
Elasticity	1.65	0.24	-1.15	-0.88
Household size ages 5-15				
One-person increase	0.43	-0.06	-0.03	-0.04
t-statistic	6.73	-2.78	-5.47	-5.17
Elasticity	0.11	-0.10	-0.19	-0.13
Presence of second worker				
Second worker	-1.84	0.57	0.24	0.38
t-statistic	-2.56	2.25	3.49	4.02
Elasticity	-0.13	0.23	0.34	0.31
Total destinations				
One-destination increase	-*	-*	0.01	0.04
t-statistic			3.17	12.5
Elasticity			0.15	0.47

*Total destinations was not used as an independent variable in this equation.

The observed greater reliance on workplace-related trips by members of higher-income households suggests that the higher value of time usually associated with higher income increases the incentive to economize on the use of travel time and has an important impact on the composition of travel.

Household Size and Structure

The variables that characterize household size and structure are the number of household members age 16 and older and the number ages 5-15. Household members age 16 and older are eligible to have a driver's license and, if an automobile is available, have the potential for independent automobile travel.

An increase in household members age 16 and older (holding the number of workers constant) increases total nonwork destinations per household per weekday by 3.34. Only 0.08 of this increase comes via workplace-related trips so that the fraction via such trips declines by 0.11.

An increase in household members ages 5-15 increases total nonwork destinations per household per weekday by 0.43, but the number visited via workplace-related trips actually declines by 0.06 so that the fraction via such trips declines by 0.03.

An increase in household size increases the total number of nonwork destinations visited, in part because members of larger households are likely to have more goods and services in their consumption bundle and in part because there are more people to go places. Neither of these reasons provides an incentive for the household members to make a large change in the number of nonwork destinations visited via workplace-related trips.

Two-Worker Households

The presence of a second worker in the household (recall that all households in the sample have at least one worker) decreases the total number of nonwork destinations per household per weekday by 1.84 in spite of increasing the number of nonwork destinations visited via workplace-related trips by 0.57.

Because of the additional time spent at work, a two-worker household has less time available for travel than an otherwise identical one-worker household. As a result, the time savings realized from using workplace-related trips are more valuable and the incentive to make more use of such trips is greater. In addition, there are more opportunities to make such trips.

IMPLICATIONS FOR FUTURE TRAVEL PATTERNS

The systematic variation of household members' use of workplace-related trips with differences in household characteristics suggests that, as the demographic characteristics of the population change, the aggregate travel patterns of the population may also change. By projecting recent trends in changing demographic characteristics and using the elasticities of the coefficients presented in Table 1, changes in future aggregate travel patterns can be predicted.

If recent trends continue (3), over a five-year period household income would increase 10.4 percent, household size age 16 and older would decrease by 2.9 percent, household size ages 5-15 would decrease by 14.6 percent, and the fraction of households that have two workers would increase 8.8 percent. As a result, total nonwork destinations per household per weekday would decrease by 5.7 percent in spite of an increase in nonwork destinations visited via workplace-related trips of 8.2 percent. The fraction of nonwork destinations visited via workplace-related trips would increase 12.7 percent over a five-year period. The probability of visiting one or more nonwork destinations via a workplace-related trip, which in the aggregate can be interpreted as the fraction of households who would visit at least one such destination on a typical weekday, would increase 9.7 percent.

The magnitudes of these changes are subject to a great deal of uncertainty; however, the direction of change is clear. Workplace-related trips, already a frequently used means of visiting nonwork destinations in 1971, are likely to become increasingly more important if current demographic trends continue.

IMPLICATIONS FOR TRANSPORTATION PLANNING

The systematic variation in the use of workplace-related trips to visit nonwork destinations suggests that household members have more mechanisms by which they can adjust their travel behavior in response to changes in household characteristics than conventional transportation analysis recognizes. Household members would

use these same adjustment mechanisms to respond to changes in the price of travel or changes in transportation policy. If so, then transportation analysis, which fails to account for these mechanisms, may have difficulty predicting the magnitude or even the direction of changes in travel patterns in response to these price or policy changes.

Empirical evidence suggests that household members used such mechanisms during the gasoline shortages of 1973-1974. A study by Peskin, Schofer, and Stopher of travel patterns of households in the suburbs north of Chicago found that the combining of nonwork destinations with work trips increased sharply during the shortage, as did the combining of single-destination trips into multiple-destination tours (4).

The analysis of transportation policies intended to divert commuters from the private automobile to other modes to help achieve air pollution or energy conservation goals must recognize the advantages of the private automobile in visiting nonwork destinations as part of workplace-related trips and the increasing importance of such use of these trips for many households. Incentive schemes that subsidize transit or penalize private automobile may not be as effective in diverting commuters as conventional, generalized cost analysis would imply.

The assumption that the sole function of the work trip is to get people to and from the workplace may have once been reasonable. However, as demographics change and emphasis on using transportation policy to help achieve air pollution goals and energy conservation goals increases, this assumption is becoming increasingly untenable (5). An understanding of the extent to which and the reasons why household members use workplace-related trips to visit nonwork destinations seems essential for effective transportation planning.

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Generalized Attributes and Shopping Trip Behavior

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Attitudinal data obtained from an impact travel survey of the San Francisco area was analyzed to determine the composition of generalized attributes that identify an individual's cognitive structure of shopping behavior. Once it was determined (by employing two measures of factorability) that factor analysis was an appropriate analytical tool, the data (stratified by residence and trip destination) were factor analyzed. The results indicate that each population's cognitive structure is unique, although in all cases a common set of generalized attributes was found to be important. For the respective populations, an index of satisfaction was developed for each of the generalized attributes. The index was used to investigate the relation between a population's cognitive structure and its socioeconomic profile. Based on tests of independence and gamma measures of association, the following attributes were significantly related to a population's satisfaction relative to alternative attributes of the shopping excursion: travel, mode, length of residence at current address, and age distribution. Among the implications of the analysis is that a set of attributes exists, independent of residence or trip destination, that should be incorporated into travel-demand models if shopping travel behavior is to be forecast accurately. Moreover, the extent of travel incurred in a shopping journey appears to significantly affect an individual's attitude structure of shopping activities.

Recent emphasis in transportation research has focused on the development of travel-demand models that seek to explain and subsequently predict, as accurately as possible, individual travel behavior (1-4). Concomitant with the shift toward disaggregate modeling has been the recognition that individual attitudes are important inputs into the decision process (5-11). As a result of its explanatory and predictive potential for travel behavior, therefore, attitudinal modeling and its associated analytical techniques are of widespread interest to transportation analysts.

In general, attitudinal modeling serves the travel forecaster in two ways:

1. Univariate or multivariate psychometric scaling techniques can be applied to define multifaceted transportation attributes, such as comfort and convenience,