of course, could be a coincidence. Nevertheless, it provides a plausible explanation to the initial car-pool underprediction that is not based on a downwardly biased travel-time coefficient, as suggested by Brand.

The coefficient of the car-pool-promotion-and-awareness dummy variable in the modal-choice model was estimated by using data taken from a home-interview survey of the Metropolitan Washington Council of Governments in 1968. These data are less than ideal, but they are among the best available. In particular, this dummy variable was defined on a basis of the limited car-pooling promotion and matching available at that time to employees in the large federal office buildings.

4. Uniform cross elasticities: Brand's final comment is directed to the logit model's property of uniform cross elasticities. Car-pooling incentives will cause the choice probabilities of all other modes to decrease by the same proportion. However, this property is valid only for disaggregate predictions. It is not valid for aggregate predictions, as the results reported in the paper demonstrate. [The difference between disaggregate and aggregate elasticities has been shown by Ben-Akiva (8).] It is an unreasonable property for aggregate predictions, but there is no empirical evidence to reject it, if the model is otherwise well specified, for the disaggregate predictions.

Thus, given the successful before-and-after tests of the modal-choice model, there is no apparent reason to suspect the validity of the predicted diversions from transit to car pools. The only way to avoid a shift from transit to car pools is to accompany car-pooling incentives with transit-service improvements in areas having heavily used transit services.

REFERENCES


8. M. Ben-Akiva. Structure of Passenger Travel Demand Models. Department of Civil Engineering, MIT, Cambridge, PhD dissertation, 1973.
9. H. P. Brown. Attitudinal Measures in Models of Mode Choice. Paper presented at the 3rd Australian Transport Research Forum, Melbourne, 1977.
10. C. Chamberlain. A Preliminary Model of Automobile Choice by Class of Automobile: Aggregate State Data. Transportation Systems Center, U.S. Department of Transportation, Cambridge, Mass., Discussion Paper, 1974.
11. T. F. Golob, A. D. Horowitz, and M. Wachs. Attitudinal-Behavior Relationships in Travel Demand Modeling. Resource paper prepared for the 3rd International Conference on Behavioral Travel Modeling, Tanunda, South Australia, 1977.
12. C. Lave and K. Train. A Behavioral Disaggregate Model of Automobile-Type Choice. Univ. of California, Irvine; Energy Research and Development Agency, 1977.
13. S. R. Lerman. A Disaggregate Behavioral Model of Urban Mobility Decisions. Department of Civil Engineering, MIT, Cambridge, PhD dissertation, 1975.


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# Analysis and Prediction of Nonwork Travel Patterns of the Elderly and Handicapped


David T. Hartgen, Planning Research Unit, New York State Department of Transportation
Stephen M. Howe,* North-Central Texas Council of Governments
Mark Pasko,* Lancaster County Planning Commission


**This paper summarizes a recent survey of 165 randomly selected elderly and handicapped persons in the Albany, New York, standard metropolitan statistical area. The respondents were administered a 6-min questionnaire on nonwork travel habits, perceived barriers to travel, and intended travel if barriers were removed. Four disaggregate models were constructed relating total travel and modal choice to system, demographic, mode availability, and physical handicap factors. The results show that, contrary to present thinking, the elderly and handicapped vary widely in mobility problems and travel patterns and there is no homogeneity within each group; travel mobility is primarily a function of physical disability, availability of an automobile, and the individual's ability to use it; specific bus-service improvements will not materially affect transit demand, but will ease the travel burden; and improvements concentrating on service availability and direct pickup appear to be the most promising.**

In recent years, public transportation systems have been encouraged (and mandated) to give special attention to the services provided to the elderly and handicapped. Off-peak transit fares for these persons are now required as a condition for federal transit-operating assistance under section 5 of the Urban Mass Transportation Act of 1974; federal regulations also require full consideration of these persons in transit system design and operation. The unified work programs prepared annually by metropolitan planning organizations also include similar requirements. These activities are generally consistent with the attitudes of the citizens of New York, 85 percent of whom support reduced fares and special services for the elderly and handicapped (1).

The study discussed here was undertaken in the Albany, New York, standard metropolitan statistical area (SMSA) to determine the factors influencing nonwork travel demand by the elderly and handicapped and to develop a method of estimating their nonwork travel demand. Further results are given by Hartgen and others (2).

## DATA

Numerous studies, as well as common sense, suggest that nonwork travel by the elderly and handicapped will probably depend on a number of basic factors. It is hypothesized that, in addition to the traditional socioeconomic factors, such as income and automobile ownership, travel by these special groups (both the number of trips and the mode chosen), is affected by the characteristics of the individual's disability, the characteristics of buildings and other potential destinations, and features of the various means of transportation (e.g., barriers).

In this study, cost and time considerations dictated a small-sample daytime telephone survey. Because some handicapped and elderly persons work, such a sample will not include many of these. Hence the study is essentially limited to the nonwork travel patterns of those elderly and handicapped who do not work. Two groups were studied:

1. The transportation handicapped (self definition), which includes some elderly persons, and
2. The elderly (age ≥ 65) who are not handicapped.

To calibrate disaggregate models for these groups, sample sizes of at least 30 to 50 individuals are required. The handicapped are the rarer group: about 4.7 percent of all persons in the large metropolitan areas of New York State have a physical handicap that inhibits travel (1). Therefore, this group controlled the sample design: About 150 to 200 households would be needed to yield 30 to 50 households with a handicapped person and 120 to 150 households with one or more elderly persons.

The sample was drawn in March and April 1976 from Albany, Schenectady, Rensselaer, and a part of Saratoga counties by using the Albany and Rensselaer Metropolitan Telephone Book (1976). A systematic sampling strategy with a random starting point was used. Of 743 residences contacted, 578 had neither an elderly nor a handicapped person. The remaining 165 residences constitute the sample and are distributed as shown below.

| | Number of Respondents | | | Percentage |
|---|---|---|---|---|
| Category | Control Group | Modeling Group | Total | of Contacts |
| Handicapped (includes some elderly) | 6 | 29 | 35 | 4.7 |
| Elderly (not handicapped) | 15 | 115 | 130 | 17.5 |
| Total | 21 | 144 | 165 | – |

A 6-min questionnaire (2) was administered to these respondents about their travel patterns, perceptions of barriers, and travel characteristics.

## TRAVEL CHARACTERISTICS

This section describes the travel habits and patterns of the elderly and handicapped respondents of the survey. The analysis also shows comparison statistics from other major studies, where possible. The major source of comparison statistics is the National Health Survey (NHS) (3). However, such comparisons can only be rough, because the NHS report summarizes only chronically disabled persons and uses slightly different question formats.

Table 1 shows the demographic data of the handicapped sample. The results show that the handicapped population is about equally divided into elderly and nonelderly groups and between those who require aid and those who do not. The sample also agrees well with the NHS data. Their physical problems are reflected directly in the mobility levels of the handicapped: Seventy-seven percent of the sample has at least some difficulty in getting about outside the home. Physical handicaps clearly imply special problems in transportation mobility as well. But at the same time, the handicapped as a group are not homogeneous; there exist wide differences in disability and extent of mobility within the group, which leads to quite different transportation problems and hence (probably) different solutions.

The sample screening procedure is such that persons interviewed as elderly are not also handicapped. Table 2 summarizes the demographic data of the elderly nonhandicapped and handicapped persons. The sample overestimates the younger elderly (65 to 70 years) and women. These discrepancies are probably due to the daytime telephone-interviewing procedure. However, the sample is generally consistent with the conventional wisdom in that women make up a higher proportion of the elderly than do men and that the incidence of physical handicaps generally increases with age. Table 3 summarizes the family sizes of the elderly and handicapped and the automobile-ownership characteristics of these families. The sample clearly demonstrates a smaller than average family size for the elderly and handicapped than for the general population. But, while the elderly and handicapped have mobility problems related to their physical situations, apparently they nevertheless have automobiles available through other members of their families.

As expected, travel by the elderly and handicapped is primarily nonwork oriented. Table 4 shows the frequency of travel for nonwork purposes. The elderly and handicapped make about 7.0 and 5.3 nonwork trips/week respectively. Work trips account for an additional 17 percent of their trips (Table 5). Only 11 percent of the respondents use transit for nonwork travel; however, transit-use rates range from 1 to 11 trips/week. Reliance on the automobile is heavy. However, as shown below, the handicapped are far more reliant on automobiles driven by others than are the elderly: Two-thirds of all nonwork trips by the handicapped are as automobile passengers, but only one-third of such trips by the elderly are as automobile passengers.

| | Percentage of Trips | |
|---|---|---|
| Mode Used | Elderly | Handicapped |
| Automobile driver | 60 | 30 |
| Automobile passenger | 26 | 52 |
| Bus | 12 | 15 |
| Taxi, walk, or other | 2 | 3 |

Further, as Table 6 shows, the private automobile is generally available to the elderly and handicapped, and most individuals can either drive or be driven in automobiles. For transit services, however, the picture is uneven. Regular bus service is generally perceived to be available, but special (e.g., client-agency) bus service is not. The limited awareness of special bus service also reduces its effectiveness.

The survey also asked respondents to identify any problems or barriers encountered in using bus service. Table 7 summarizes the responses and shows that many respondents were unable to identify any particular problem of a typical bus trip. These low numbers reflect the voluntary nature of the response: In most barrier studies, respondents are given a list of barriers and are asked to respond, so that their responses include yea-and-nay effects. While the handicapped generally perceive more barriers and view them as more severe, both groups generally stress the same items: climbing bus steps, lack of handrails, crossing streets and curbs, and seat comfort. The picture, then, is one of a wide range of perceptions of transportation barriers, with only a few such barriers being perceived as important by the group as a whole. Thus, specific improvements to the transportation system will probably not significantly reduce barriers for most travelers, and their effect on travel demand will probably be small. Further analysis shows that, if all transportation barriers were removed, the percentage of the elderly and handicapped who use the bus for at least 1 trip/week would increase from 11 to 21 if regular bus service were improved and to 27 if special bus service were improved. However, this is a noncommitment response; experience shows that actual increases would be only one-half to one-third as much.

## MODELS OF TRAVEL

Four linear disaggregate models to estimate total nonwork trips and transit use were constructed from the data base. These were

1. Handicapped: total nonwork trips per week,
2. Handicapped: percentage of nonwork trips via transit,
3. Elderly: total nonwork trips per week, and
4. Elderly: percentage of nonwork trips via transit.

**Table 1. Comparative data for the handicapped.**

| Descriptor | Percentage of Sample | Percentage of NHS Survey | Descriptor | Percentage of Sample | Percentage of NHS Survey |
|---|---|---|---|---|---|
| Sex | | | Age, years | | |
| Female | 59 | 56 | ≥65 (elderly) | 49 | 54 |
| Male | 41 | 44 | 45 to 64 | 33 | 32 |
| Special aid | | | 17 to 44 | 18 | 11 |
| Needed | 49 | 51 | ≤17 | 0 | 3 |
| Not needed[a] | 51 | 49 | | | |

[a] Includes those confined to house.

**Table 2. Comparative data for the elderly.**

| Descriptor | Sample: Nonhandicapped | Sample: Handicapped No. | Sample: Handicapped % | Sample: Total | % of Total Sample | Albany SMSA (1970) No. | Albany SMSA (1970) % | % Handicapped in NHS Survey (1972) |
|---|---|---|---|---|---|---|---|---|
| Sex | | | | | | | | |
| Female | 89 | 11 | 11 | 100 | 68 | 48 497 | 60 | 18.5 |
| Male | 39 | 8 | 17 | 47 | 32 | 32 389 | 40 | 16.2 |
| Age, years | | | | | | | | |
| 65 to 70 | 59 | 5 | 8 | 64 | 44 | 26 502 | 33 | – |
| 71 to 75 | 35 | 5 | 13 | 40 | 27 | 22 058 | 27 | – |
| 76 to 80 | 13 | 5 | 28 | 18 | 12 | 16 119 | 20 | – |
| >80 | 21 | 4 | 16 | 25 | 17 | 16 207 | 20 | – |
| Total | 128 | 19 | 147 | 13 | 100 | 80 886 | 100 | 17.6 |

**Table 3. Size and automobile-ownership characteristics of families having elderly and handicapped members.**

| Descriptor | Sample No. | Sample % | Albany SMSA (1970) No. | Albany SMSA (1970) % | Descriptor | Sample No. | Sample % | Albany SMSA (1970) No. | Albany SMSA (1970) % |
|---|---|---|---|---|---|---|---|---|---|
| Family size | | | | | Automobile ownership | | | | |
| 1 | 43 | 27 | 45 120 | 20 | 0 | 38 | 24 | 41 392 | 18 |
| 2 | 59 | 37 | 67 504 | 29 | 1 | 80 | 50 | 123 389 | 54 |
| 3 | 25 | 16 | 39 113 | 17 | 2 | 33 | 20 | 57 336 | 25 |
| 4 | 17 | 11 | 33 852 | 15 | ≥3 | 9 | | 8 377 | 4 |
| ≥5 | 15 | 9 | 44 895 | 19 | | | | | |
| Total | 159 | 100 | 230 484 | 100 | Total | 160 | 100 | 230 484 | 100 |

Note: The following mean values were obtained: for the sample population—family size of elderly = 2.49, family size of handicapped = 2.75, and automobile ownership = 1.08/family; for the Albany SMSA population—family size = 3.22 and automobile ownership = 1.14/family.

**Table 4. Nonwork trip frequency.**

| Category | Nonwork Trips n | Nonwork Trips Average Trip Rate | Nonwork Trips S.D. | Transit Use n | Transit Use Average (%) | Transit Use S.D. |
|---|---|---|---|---|---|---|
| Handicapped | 29 | 5.34 | 4.21 | 27 | 0.145 | 0.34 |
| Elderly (nonhandicapped) | | | | | | |
| Urban | 60 | 6.73 | 4.12 | – | 0.21 | – |
| Suburban | 41 | 7.29 | 5.60 | – | 0.03 | – |
| Rural | 14 | 7.00 | 5.07 | – | 0 | – |
| Total | 115 | 6.96 | 4.79 | 110 | 0.13 | 0.32 |
| Total complete samples | 144 | 6.63 | – | 137 | 0.13 | – |
| Total sample | 165 | 5.80 | – | – | – | – |

The data for these models were analyzed separately by using stepwise linear regression methods and assuming the following general structures:

$$T_i = b_0 + b_1x_1 + b_2x_2 + \ldots \quad (1)$$

$$\% Tr_i = c_0 + c_1x_1 + c_2x_2 + \ldots \quad (2)$$

where

$T_i$ = trips per week (nonwork for person i),
$\%Tr_i$ = percentage of trips via transit for person i,
$x_1, x_2, \ldots, x_n$ = independent variables,
$b_1, b_2, \ldots, b_n$ = coefficients, and
$c_1, c_2, \ldots, c_n$ = coefficients.

Nonlinear (e.g., logit) models were not attempted, but are a possibility for later analysis. Table 8 shows the variables available for input to each model.

The results of this analysis are shown in Table 9 and the statistical indexes of the values developed are shown in Table 10. Although numerous variables were available

**Table 5. Detailed travel data.**

| Item | For Work (%) | For Nonwork (%) |
|---|---|---|
| No. of one-way trips per week | | |
| 0 | 88 | 9 |
| 1 to 3 | 1 | 18 |
| 4 to 7 | 2 | 43 |
| 8 to 11 | 8 | 17 |
| 12 to 15 | 1 | 12 |
| ≥16 | 0 | 1 |
| Mean | 1.06 | 5.80 |
| Mode used | | |
| Automobile driver | 79 | 53 |
| Automobile passenger | 11 | 32 |
| Bus | 5 | 11 |
| Taxi, walk, or other | 5 | 4 |
| Frequency of bus use, trips per week | | |
| 0 | 90 | 83 |
| 1 to 3 | 5 | 6 |
| 4 to 7 | 5 | 9 |
| 8 to 11 | 0 | 2 |

**Table 6. Availability to elderly and handicapped of modes.**

| Item | No. | % |
|---|---|---|
| Availability of automobile | | |
| Always | 112 | 71 |
| Most of the time | 15 | 10 |
| Occasionally | 11 | 7 |
| Never | 19 | 12 |
| Total | 157 | 100 |
| Ability to use automobile | | |
| Drive with no difficulty | 85 | 55 |
| Drive with some difficulty | 6 | 4 |
| Ride only, but no difficulty | 46 | 30 |
| Ride only, with some difficulty | 11 | 7 |
| Ride only and need help | 5 | 3 |
| Total | 153 | 100 |
| Availability of regular bus service | | |
| Nearby and frequent | 77 | 48 |
| Nearby but infrequent | 25 | 16 |
| None nearby | 50 | 31 |
| Don't know | 7 | 4 |
| Total | 159 | 100 |
| Availability of special bus service | | |
| Yes | 16 | 10 |
| No | 62 | 39 |
| Don't know | 81 | 51 |
| Total | 159 | 100 |

**Table 7. Barriers to using bus service.**

| | Handicapped | | | Nonhandicapped Elderly | | |
|---|---|---|---|---|---|---|
| Barrier | Percentage Per Perceiving[a] | Avg Barrier Level[b] | Barrier Index[c] | Percentage Per Perceiving[a] | Avg Barrier Level[b] | Barrier Index[c] |
| Transportation | | | | | | |
| Reading schedules | 18.5 | 1.4 | 25.9 | 1.9 | 1.0 | 1.9 |
| Reading maps | 22.2 | 1.5 | 33.3 | 2.8 | 1.0 | 2.8 |
| Getting information over telephone | 18.5 | 1.4 | 25.9 | 4.7 | 1.0 | 4.7 |
| Uneven ground and slopes | 40.7 | 1.27 | 51.7 | 8.5 | 1.11 | 9.4 |
| Street crossings and curbs | 40.7 | 1.18 | 48.0 | 8.5 | 1.0 | 8.5 |
| Bad weather | 33.3 | 1.44 | 48.0 | 14.2 | 1.07 | 15.2 |
| Fear of crime | 14.8 | 1.25 | 18.5 | 3.8 | 1.0 | 3.8 |
| Distance to vehicle | 29.6 | 1.25 | 33.0 | 6.6 | 1.43 | 9.4 |
| No shelter | 7.4 | 1.50 | 11.1 | 3.8 | 1.25 | 47 |
| Wait too long | 25.9 | 1.29 | 33.4 | 4.7 | 1.2 | 56 |
| Climbing steps | 59.3 | 1.31 | 77.7 | 17.0 | 1.11 | 18.9 |
| No handrails | 40.7 | 1.27 | 51.7 | 9.4 | 1.10 | 10.3 |
| Crowding or rushing | 29.4 | 1.25 | 36.8 | 4.7 | 1.0 | 4.7 |
| Handling change or tokens | 14.8 | 1.25 | 18.5 | 0.9 | 1.0 | 0.9 |
| Cost | 7.4 | 1.00 | 7.4 | 0.9 | 1.0 | 0.9 |
| Not enough time to sit down | 37.0 | 1.20 | 44.4 | 6.6 | 1.14 | 0.75 |
| Getting to seat near back | 14.8 | 1.25 | 18.5 | 1.9 | 1.0 | 0.19 |
| No space for wheelchair, crutches, or such | 20.2 | 1.40 | 28.3 | 0 | 0 | — |
| Seats not right | 18.5 | 1.0 | 18.5 | 7.3 | 1.38 | 1.01 |
| Lack of comfort | 18.5 | 1.0 | 18.5 | 1.9 | 1.00 | 0.19 |
| Swaying and lurching | 7.4 | 1.0 | 7.4 | 4.5 | 1.67 | 0.75 |
| Travel time too long | 11.1 | 1.0 | 11.1 | 6.4 | 1.14 | 0.73 |
| Pull cord | 19.2 | 1.0 | 19.2 | 1.9 | 1.0 | 0.19 |
| Pushing door open | 23.1 | 1.0 | 23.1 | 4.7 | 1.0 | 0.47 |
| Place | | | | | | |
| Uneven ground and slopes | 26.9 | 1.29 | 34.7 | 6.6 | 1.0 | 0.66 |
| Street crossings and curbs | 30.8 | 1.13 | 34.8 | 6.6 | 1.0 | 0.66 |
| Climbing steps | 50.0 | 1.38 | 69.0 | 14.8 | 1.13 | 1.67 |
| Opening doors | 30.8 | 1.13 | 34.8 | 3.6 | 1.0 | 0.36 |
| Unfamiliar areas | 11.5 | 1.00 | 11.5 | 1.8 | 1.0 | 0.18 |
| Cannot go very far or fast | 38.5 | 1.20 | 46.2 | 9.4 | 1.1 | 1.03 |

[a] Percentage of respondents mentioning a given barrier.
[b] Average severity level (1 = some problem and 2 = severe problem) for those perceiving this barrier.
[c] Percentage perceiving times average level.

Table 8. Variables used in model building.

| Variable | Form | Variable | Form |
|---|---|---|---|
| Personal | | Trip | |
| Age | In years | Mode | Transit or other |
| Sex | M or F | Travel time | Minutes perceived |
| Disability | Type of ailment (1 to 9 scale)[a] | Trip length | Miles perceived |
| | | Automobile availability | 1 to 4 scale[a] |
| Aid | Type of aid used (1 to 6 scale)[a] | Ability to use automobile | 1 to 6 scale[a] |
| Extent of disability | Degree of disabledness (1 to 5 scale)[a] | Regular bus availability | 1 to 3 scale[a] |
| Family size | 1, 2, ... | Special bus availability | 1 to 3 scale[a] |
| Automobiles owned by family | 0, 1, 2, ... | Barriers listed in Table 7 | 0 to 2 scale[a] |

[a] Increasing severity.

Table 9. Summary of travel-demand models.

| | Handicapped | | | | Nonhandicapped Elderly | | | |
|---|---|---|---|---|---|---|---|---|
| | Trip Generation | | Modal Split | | Trip Generation | | Modal Split | |
| Variable | Value | t-Statistic | Value | t-Statistic | Value | t-Statistic | Value | t-Statistic |
| Constant | 5.07 | — | 0.15 | — | 10.11 | — | -0.06 | — |
| Family size | 1.42 | 14.54 | — | — | +0.56 | 4.83 | — | — |
| Physical-aid index | — | — | -0.11 | 5.84 | — | — | — | — |
| Ability to use automobile | -1.45 | 7.86 | — | — | — | — | — | — |
| Automobile unavailability | — | — | +0.15 | 6.82 | -0.97 | 5.53 | +0.21 | 106.17 |
| Bus unavailability | — | — | — | — | -1.24 | 8.36 | -0.079 | 12.83 |
| Bus-steps barrier | — | — | — | — | -3.41 | 13.6 | — | — |

Table 10. Statistical indexes of models.

| | Handicapped | | | | Nonhandicapped Elderly | | | |
|---|---|---|---|---|---|---|---|---|
| | Trip Generation | | Modal Split | | Trip Generation | | Modal Split | |
| Variable | Value | t-Statistic | Value | t-Statistic | Value | t-Statistic | Value | t-Statistic |
| Statistical index | | | | | | | | |
| $R^2$ | 0.45 | — | 0.39 | — | 0.21 | — | 0.57 | — |
| Standard error of estimate | 3.32 | — | 0.28 | — | 4.33 | — | 0.21 | — |
| F-ratio | 10.71 | — | 7.61 | — | 7.44 | — | 70.26 | — |
| n | 29 | — | 27 | — | 115 | — | 110 | — |
| Means | | | | | | | | |
| Constant | 5.34 | 4.21 | 0.145 | 0.34 | 6.96 | 4.79 | 0.13 | 0.32 |
| Family size | 2.75 | 1.64 | — | — | 2.49 | 1.62 | — | — |
| Physical-aid index | — | — | 2.07 | 1.20 | — | — | — | — |
| Ability to use automobile | 2.51 | 1.18 | — | — | — | — | — | — |
| Automobile unavailability | — | — | 1.46 | 0.94 | 1.60 | 1.02 | 1.59 | 1.01 |
| Bus unavailability | — | — | — | — | 1.87 | 0.97 | 1.84 | 0.95 |
| Bus-step barrier | — | — | — | — | 0.20 | 0.44 | — | — |

Table 11. Elasticities.

| | Handicapped | | Nonhandicapped Elderly | |
|---|---|---|---|---|
| Variable | Trip Generation | Modal Split | Trip Generation | Modal Split |
| Family size | 0.72 | — | 0.56 | — |
| Physical-aid index | — | -1.56 | — | — |
| Ability to use automobile | -0.68 | — | — | — |
| Automobile unavailability | — | 1.53 | -0.22 | 2.56 |
| Bus unavailability | — | — | -0.33 | -1.12 |
| Bus-steps barrier | — | — | -0.43 | — |

Note: Calculated at the mean.

for entry into the models, only a few did so. These were primarily automobile and bus unavailability, ability to use an automobile, physical disability (reflected in the aid index), and family size. With one exception (elderly modal choice), barriers did not enter the models. The influence of automobile availability is clear: increasing levels of automobile availability increase total nonwork travel, but decrease the propensity to use transit. For the elderly, increasing levels of transit availability influence both total travel and modal choice. The effect of family size is to increase total travel by the elderly and handicapped by providing other household members as chauffeurs and increasing family ties for the elderly or handicapped individual. The absence of barriers in these models suggests that, generally, travel patterns of the elderly and handicapped depend primarily on the availability of transportation service and not on the degree to which such service, when available, is barrier free. These findings confirm the conclusions of other studies [e.g., the Institute for Public Administration Planning Handbook (4) and Knighton and Hartgen (5)], which emphasize service rather than vehicle in transit system design. The high modal-split elasticities for service availability (Table 11) underscore these results.

## DISCUSSION AND SUMMARY

This report describes a recent study in the Albany-Schenectady-Troy SMSA of nonwork travel habits of the elderly and handicapped. The study was based on a sample of 165 elderly and handicapped persons, who were telephoned at random. The significant results of the study are that

1. The elderly and handicapped are not a homogeneous group, either separately or together: There are wide variations in travel behavior and mobility problems within each group;
2. The elderly and handicapped average about 7.0 and 5.3 one-way nonwork trips/week respectively;
3. Automobile availability to the elderly and handicapped is not signficantly less than that to the general population;
4. Travel of these groups is primarily by automobile, either as a passenger or a driver with bus travel constituting only about 13 percent of their nonwork trips;
5. For the handicapped, travel mobility is primarily a function of personal disability and the ability of the individual to use an automobile: Bus service improvements would appear to change this picture only slightly;
6. Specific barriers on the public bus system do not materially affect either total nonwork travel or modal split, but the availability of bus transportation affects both;
7. Bus systems that emphasize availability (coverage and frequency) as well as direct pickup appear to be the most promising for increasing the mobility of the elderly and handicapped; and
8. The widely divergent needs of these individuals imply that very specialized solutions will probably be required to solve their transportation problems.

A set of small-sample disaggregate models was developed to enable prediction of elderly and handicapped nonwork travel and modal choice. The models are generally sensitive to automobile and bus availability, family size, and the level of disability of the individual.

REFERENCES

1. E. P. Donnelly and others. Statewide Public-Opinion Survey on Transit Operating Assistance: Technical Report. Planning Research Unit, New York State Department of Transportation, Preliminary Res. Rept. No. 80, 1975.
2. D. T. Hartgen, M. Pasko, and S. M. Howe. Forecasting Nonwork Travel Demand for the Elderly and Handicapped. Planning Research Unit, New York State Department of Transportation, Preliminary Res. Rept. No. 108, 1976.
3. C. S. Wilder. Limitation of Activity and Mobility Due to Chronic Conditions, U.S. 1972. National Center for Health Statistics, Rockville, Rept. 10:96, Nov. 1974.
4. Planning Handbook: Transportation Services for the Elderly. Institute for Public Administration, Administration on Aging, Nov. 1975.
5. R. G. Knighton and D. T. Hartgen. Incorporating Barrier Effects in Elderly and Handicapped Demand Forecasts. New York State Department of Transportation, Draft Rept., Oct. 26, 1976.

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**Dr. Howe and Mr. Pasko were with the New York State Department of Transportation when this research was performed.*

# Policy-Contingent Travel Forecasting With Market Segmentation

Frederick C. Dunbar, Charles River Associates, Cambridge, Massachusetts

**Market segmentation of travel data gives a data base that is easy to use and interpret. This paper develops methods for tabulating travel data so that disaggregate travel-demand models can be applied to market segments. These methods result in improved accuracy of travel forecasts because aggregation bias is reduced. The approach also allows nearly immediate computation of demand elasticities. These procedures can be applied to most urban travel-data files by using cross-tabulation software. To demonstrate the methods and their accuracy, the work-trip modal split is simulated on Nationwide Personal Transportation Survey data by using a disaggregate logit model. Travel demand is forecast under a variety of transportation policies that involve automobile controls and transit level-of-service improvements.**

An approach to the use of market segments with existing disaggregate demand models has been developed. The advantages of such an approach include accurate travel-demand forecasts with minimal data and computational resources. In the present case, the effects of a policy scenario can be calculated by most programmable calculators or within a few hours by hand.

The use of market segments is not a new technique. Usually, market segments are defined by the characteristics of the trip maker rather than by those of the trip. However, travel data are sometimes cross tabulated by distance and time as well as the socioeconomic characteristics of the trip makers. This format has been useful in segmenting the travel market so that the impact of policies on particular socioeconomic groups can be emphasized (1). Market segmentation has the additional advantage of reducing aggregation error when such data are analyzed with disaggregate logit models.

The application of multinomial logit models to market segments is actually an extension of the early development of logit analysis. Models of binary choice were originally developed from the application of statistical tools to contingency tables (2). These models gave the probability that a response to a stimulus would occur within a specified range. For a simple univariate model, a table giving the proportions of the sample that will respond at each level of stimulus will have sufficient information for the estimation of the model. Similarly, given a model such as an estimated logit equation, the proportion of a sample that will respond to stimuli within given ranges can be predicted.

This approach can be generalized to the common specification of disaggregate modal-split models. If only two modes are considered, then the response will be the proportion of trips by a given mode, for example, automobile. The approach becomes computationally more complex as the number of different types of stimuli (independent variables such as modal attributes) in-