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Analysis of Rapid Transit Access Mode Choice

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The application of the logit modeling methodology to the development of rapid transit access-mode-choice models that are transferable among different stations in a system is described. Rapid transit stations are classified into groups by using discriminant analysis to test for common behavior at sites within groups and to verify differences in behavior among groups. Eighteen variables are used to define the physical nature and accessibility of the terminal and the socioeconomic structure of the surrounding area. Five station groups are identified: (a) central city; (b) dense residential; (c) predominantly residential, some commercial; (d) predominantly commercial, some residential; and (e) sparse residential and undeveloped land. Multinomial logit access-mode-choice models are described for the different station groups in the Bay Area Rapid Transit system. The modes considered are drive alone, kiss-and-ride, bus, carpool, and walk. An areawide model is compared with the station group models. The results show that models for classified station groups have coefficients that differ from each other and from a model calibrated with the data for all stations in all groups. These models, however, do not offer sufficient uniqueness to justify recommendations. More precise, detailed calibration data are needed to establish transferable models.

This paper reports on the results of the application of the Urban Transportation Planning System (UTPS) ULOGIT calibration program in the analysis of rapid transit access-mode-choice behavior. The choice of mode of arrival at the line-haul rapid transit station for the journey to work was the principal focus of the study.

In spite of the extensive research on and appli-

cation of travel demand models, few instances have been reported in which the principal focus was on the choice of access mode (1). This is the case because the access-mode-choice scenario is much more complex than the primary-mode-choice situation. For example, a basic problem associated with the use of a model based on a single station in a given area is that parameters are biased by the characteristics of the particular location, environment, station design, and interconnecting modes. On the other hand, a model calibrated with a cross section of data from all of the stations in a system may be representative of no particular station.

The fundamental hypothesis underlying this modeling method is that logit models of access mode choice must consider all viable alternatives and should be constructed in a manner that allows them to be transferred among different areas. The access modes considered in this study are drive alone, kiss-and-ride, bus, carpool, and walk. The data set did not permit consideration of the bicycle and motorcycle as rapid transit access modes. Station location characteristics, together with socioeconomic variables, are used to classify a station in a way that permits logit models to be compared for differences among station types.

STATION INFLUENCE AREA

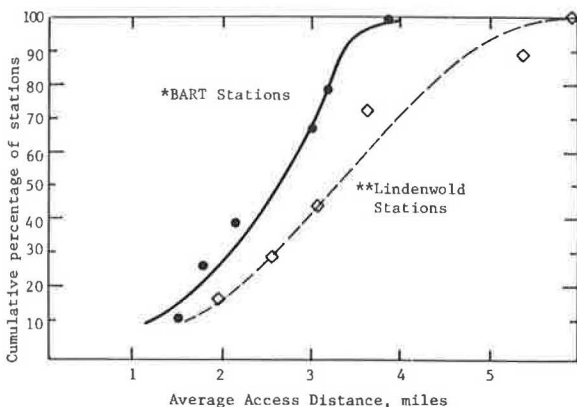
The average distance of all trips to and from a particular transit station is an indication of the size of the area that the station services. Figure 1 (2) shows the distribution of average distances traveled in accessing eight Bay Area Rapid Transit (BART) stations and seven stations on the Lindenwold High-Speed Line. The average access travel distances ranged from 2.4 to 6.1 km (1.5–3.8 miles) and 3.1 to 9.1 km (1.9–5.6 miles), respectively, for these two systems. Figure 2 shows the distribution of travel distances for specific access modes.

These data show that the range of access distance differs between systems and among modes. The observed patterns are a result of complex interrelations that complicate the development of a prediction methodology.

An analysis of the data from the BART system and the Lindenwold Line reveals little increase in transit-station trip production when the market area goes beyond 6.5 km (4 miles). Therefore, for the purpose of this study, a distance of 6.5 km from the station is used to define the influence area, the distance from which trips are considered to be attracted to the station.

The station area is defined as the area within

Figure 1. Cumulative distribution of average access distance for BART system and Lindenwold Line.



*8 BART Stations: Concord, Pleasant Hill, Rockridge, El Cerrito Del Norte, N. Berkeley, Ashby, Union City, and Bay Fair

**7 Lindenwold HSL Stations: Lindenwold, Ashland, Haddonfield, Westmont, Collingswood, Ferry Ave., and Broadway

Figure 2. Cumulative percentage of trips by mode versus access distance in miles for eight BART stations.

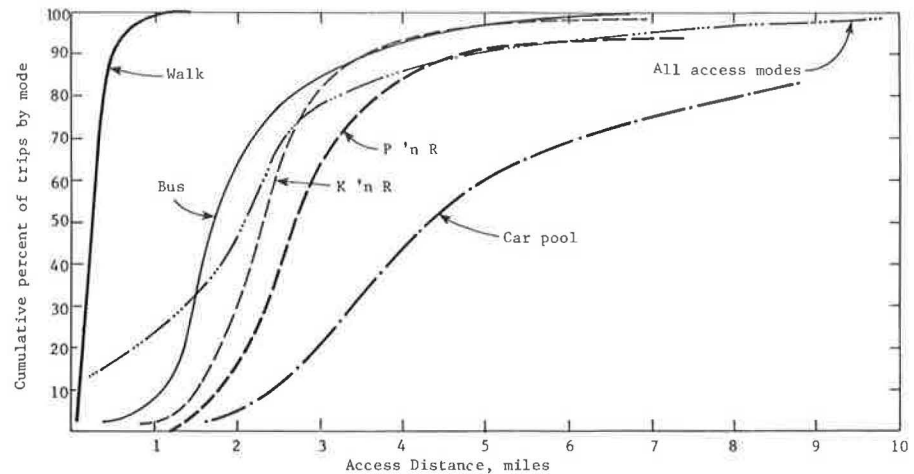


Table 1. Criteria for transit station classification.

Criterion	Analysis Variable ^a	Measurement	Classification
Station type	STTYPE	-	Aerial, surface, subway
Line situation	STSIT	-	Through, transfer, terminal
Station function	STFUNC	A = access trips/peak hour, E = egress trips/peak hour	Attractor (E > 1.1A), generator (A < 1.1E), balanced (0.9E ≤ A ≤ 1.1E)
Station volume	STVOLM	T = daily trips/station	High volume (T > 25 000), medium volume (10 000 < T ≤ 25 000), low volume (T ≤ 10 000)
Parking capacity and use	STPARK	P = occupied spaces/total spaces available	Available (P < 0.75), difficult to find (0.75 < P < 1.0), unavailable (no space provided)
Automobile accessibility	AUTOAC	AC = accessibility index	Good accessibility (AC > 2), fair accessibility (0 < AC ≤ 2), poor accessibility (AC ≤ 0)
Pedestrian accessibility	WALKAC	AC = accessibility index	Good accessibility (AC > 2), fair accessibility (0 < AC ≤ 2), poor accessibility (AC ≤ 0)
Bus accessibility	BUSAC	N = buses/peak hour	Poor service (N < 25), fair service (25 < N ≤ 100), good service (N > 100)
Family income	INCOME	I = mean family income	Low income (I ≤ 10 000), middle (10 000 < I ≤ 15 000), upper-middle (I > 15 000)
Uniformity of income	INCUNI	$U = \sqrt{\frac{3}{\sum_{i=1}^3 (P_i - 33)^2}}$	Nonuniform (U > 10), uniform (U ≤ 10)
Gross population density of station area	GPOPDEN	GD = residents/gross station area	Dense (GD > 10 000), intermediate (5000 < GD ≤ 10 000), sparse (GD ≤ 5000)
Net population density of station area	NPOPDEN	ND = residents/residential station area	Dense (ND > 20 000), intermediate (10 000 < ND ≤ 20 000), sparse (ND ≤ 10 000)
Racial and ethnic characteristics	RACETH	W% or B% or A% + M% > 90% 70% < W% or B% or A% + M% ≤ 90% W% and B% and A% + M% ≤ 70%	Exclusively white, black, Asian, and Mexican Predominantly white, black, Asian, and Mexican Mixed
Rapid transit service	SRVLEV	H = departures/peak hour	Good service (H > 12), fair service (6 < H ≤ 12), poor service (H ≤ 6)
Land development in station area	LNDUSE	Total land use per category exceeds 40%	Industrial, service, residential, composite, other
Gross population density of influence area	GINFL	GP = residents/gross influence area	Dense (GP > 10 000), intermediate (5000 < GP ≤ 10 000), sparse (GP ≤ 5000)
Net population density of influence area	NINFL	NP = residents/residential influence area	Dense (NP > 20 000), intermediate (10 000 < NP ≤ 20 000), sparse (NP ≤ 10 000)
Land use development in influence area	LUINFL	Category based on percentage land use	Basic industrial, service, residential, composite, others, all > 40 percent

^aVariable names used during computer analysis.

0.8 km (0.5 mile) of the station and is used to characterize the area within walking distance of the station (2).

STATION CLASSIFICATION METHODOLOGY

The parameters given in Table 1 vary among transit stations and are used to initiate comparative analyses of rapid transit access-mode-choice behavior. These variables include socioeconomic data for each jurisdictional area, aerial photographs, land use data for 440 traffic zones in the Bay Area, BART system data, and access trip data for each station (3,4). The majority of these measures were cited in the BART Residential Impact Study (5).

These data were then evaluated with regard to the

criteria given in Table 1 and translated into ordinal values for analysis purposes (2). These ordinal values for each variable served as input to statistical routines used to establish station classes.

Although no two rapid transit stations are identical, all stations exhibit common transit-related characteristics and some stations share a sufficient number of these characteristics to be considered equivalent for the purpose of access-mode analysis. Furthermore, the inclusion of sufficient station characteristics to clearly define a classification for a station permits the identification of station types independent of geographic location, a premise essential to the solution of the transferability issue.

Data related to the characteristics that appear

Table 2. BART station groups by type.

Type	Category	Station No.	Station Name	No. of Observations	No. of Home-Based Work Trips
1	Highly urbanized	11	Berkeley	330	133
		21	Lake Merritt	329	126
		23	19th Street	329	88
		24	12th Street	328	79
		30	Mission and 16th Street	330	145
2	Predominantly single-family dwellings	31	Civic Center	327	104
		32	Powell Street	328	92
		1	Concord	330	229
		6	Rockridge	326	173
		7	Richmond	330	200
		9	El Cerrito Plaza	330	201
		10	North Berkeley	330	181
		12	Ashby	329	161
		15	South Hayward	329	217
		22	MacArthur	327	157
		26	Dale City	329	225
		27	Balboa Park	330	193
		28	Glen Park	330	223
		29	24th Street and Mission	329	160
3	Single-family dwellings with some commercial property	2	Pleasant Hill	330	235
		3	Walnut Creek	329	236
		4	Lafayette	330	234
		8	El Cerrito del Norte	326	224
		16	Hayward	329	177
4	Commercial property with some single-family dwellings	17	Bayfair	329	222
		18	San Leandro	330	184
		19	Coliseum	330	147
		20	Fruitvale	330	184
		25	Oakland West	330	164
5	Sparse residential development with undeveloped land	5	Orinda	329	205
		13	Fremont	328	205
		14	Union City	330	233

to distinguish the 34 BART stations were compiled. Of the 18 distinguishable variables described in Table 1, as few as 10 can be used to identify well-defined station classes. The relative importance of these variables was established during the analysis and is given below:

Rank	Variable	F-Ratio
1	NINFL	17.162 56
2	STFUNC	8.933 39
3	STTYPE	5.707 35
4	BUSAC	5.344 24
5	GPOPDEN	4.713 57
6	GINFL	1.997 36
7	STPARK	3.481 48
8	INCOME	3.295 65
9	AUTOAC	3.247 46
10	LUINFL	3.160 75
11	STSIT	2.285 29
12	INCUNI	1.941 81
13	SRVLEV	2.291 08
14	NPOPDEN	1.428 90
15	RACETH	3.243 15
16	STVOLM	0.598 62
17	WALKAC	0.402 91
18	LNDUSE	0.183 76

An initial hypothesis as to the most practical number of groups and their respective memberships was formulated by inspection of aerial photographs of the stations (3). Five groups were selected based on the subjective criteria: (a) central city; (b) dense residential; (c) predominantly residential, some commercial; (d) predominantly commercial, some residential; and (e) sparse residential and undeveloped land. This hypothesis was then tested by using the discriminant analysis program contained in the Statistical Package for the Social Sciences (6). Visually, some of the stations exhibited characteristics of two groups, and proper initial classification was difficult to determine. The analysis results were examined, and the hypothesis was modified until visual and numerical data

strongly supported the classification hypothesis. The groups are given in Table 2.

MODEL DEVELOPMENT

Model Description

With the stations grouped into five classes, it was further hypothesized that access-mode-choice models for each of these classes would be significantly different from all other class models. In addition, the performance of these five models should exceed that of a model developed without regard to station class. This aspect of the classification hypothesis was also explored.

Although a comprehensive access-mode-choice model design would explore the significance of the many potentially relevant variables, this modeling effort was limited to the variables available from the 1975 BART Passenger Profile Survey. That survey provided the following:

1. Trip-maker variables--Age, sex, race, education, income, and automobile availability;
2. Trip-related variables--Purpose, origin, origin time, number of traveling companions, and destination;
3. Automobile-related variables--Trip time and vehicle occupancy; and
4. Transit-related variable--Access travel time.

Not all of these variables proved useful during the calibration trials, nor did all of the variables used prove significant for every station type. For comparative purposes, however, the same model structure was applied to each station type and to the entire BART system. The model structure (i.e., the disutility expressions) is as follows:

$$\text{LOCAL BUS} = D \text{ COEF2} * \text{ACCESS DISTANCE}$$

$$+ T \text{ COEF2} * \text{ACCESS TIME}$$

$$+ \text{AUTO COEF} * \text{AUTO AVAILABLE}$$

(1)

$$\begin{aligned} \text{DRIVE ALONE} = & D \text{ COEF1} * \text{ACCESS DISTANCE} \\ & + T \text{ COEF1} * \text{ACCESS TIME} \\ & + \text{AGE COEF} * \text{MIDDLE-AGED} \end{aligned} \quad (2)$$

$$\begin{aligned} \text{CARPOOL} = & T \text{ COEF3} * \text{ACCESS TIME} \\ & + \text{AGE COEF} * \text{MIDDLE-AGED} \end{aligned} \quad (3)$$

$$\begin{aligned} \text{KISS-AND-RIDE} = & D \text{ COEF1} * \text{ACCESS DISTANCE} \\ & + T \text{ COEF1} * \text{ACCESS TIME} \\ & + \text{RACE COEF} * \text{NONWHITE RACE} \\ & + \text{INCM COEF} * \text{LOW INCOME} \\ & + \text{AGE COEF} * \text{MIDDLE-AGED} \end{aligned} \quad (4)$$

$$\begin{aligned} \text{WALK} = & D \text{ COEF3} * \text{ACCESS DISTANCE} \\ & + \text{AUTO COEF} * \text{AUTO AVAILABLE} \end{aligned} \quad (5)$$

where

LOCAL BUS = local transit to rapid transit station;
 ACCESS DISTANCE = calculated distance;
 ACCESS TIME = perceived access time (min);
 AUTO AVAILABLE = 0 if none available, 1 if available;
 DRIVE ALONE = driver parks automobile at rapid transit station;
 MIDDLE-AGED = 0 if not, 1 if over 17 and under 65;
 CARPOOL = member of group that parks automobile at station;
 KISS N RIDE = rider dropped at transit station;
 NONWHITE RACE = 0 if white, 1 if race other than white;
 LOW INCOME = 0 if not, 1 if income less than or equal to \$7000/year; and
 WALK = patron walks to rapid transit station.

The access-distance variable was derived from the perceived access-time variables and an estimated speed for each mode. Automobile availability is a perceived variable (i.e., yes or no) and is not a calculated value associated with the number of vehicles owned and number of licensed drivers in the household. The age variable used stratified the population into two groups: those relatively independent in their movement (middle-aged) and those possibly dependent on others for transportation (young and elderly). The income variable chosen (low income) divided the population into those earning more and less than \$7000/year. The racial variable (nonwhite race) separated whites from nonwhites.

Model Structure

Models using level-of-service variables--access time and access distance--were developed by using each variable independently (2). The model form was first optimized by using access distance, and then the same model form was used for the access-time-only model by substituting access time for access distance. The model form that uses both access time and access distance was also optimized. For this combined model, unique coefficients for access distance were applied to those modes where the speed used during distance development was appropriate for only that mode. The drive-alone and kiss-and-ride modes share coefficients for both the distance and the time variables in all models, since these modes are identical in these two level-of-service variables. If access cost or driver time was to be used as a calibration variable, it could be argued that

drive alone and kiss-and-ride are characterized by different levels of service. However, this argument has been weakened by the realization that many career families drop some household members at the rapid transit station and others continue on to employment destinations. This type of trip compares more favorably with the drive-alone mode than with the kiss-and-ride mode. Speed for the carpool mode is difficult to estimate, since these journeys are a combination of low-speed rider pickup and high-speed line-haul to the station. For this reason, the combined model used access time in the carpool mode and both access time and distance were used in the drive-alone and kiss-and-ride modes. Conversely, for the walk mode, access distance proved to be a much more significant variable than access time.

The local bus and walk modes are the only access modes that do not require an automobile; for these, the automobile-availability variable is a negative influence. The sign of the automobile-availability coefficient should be the same as those of the time and distance coefficients. Similarly, the age variable--middle-aged--could be placed with the local bus and walk modes to exhibit a negative influence; however, it is equally valid to place it in the other three mode expressions as a positive influence. The age coefficient should carry a sign opposite to that of the automobile coefficient.

The race and income variables were both placed in the local bus mode expression of the access-distance and the access-time models. In the combined level-of-service model, these variables performed better in the kiss-and-ride expression. This placement of the race and income variables is difficult to rationalize, although a negative influence by the variables might be expected. The consistently small t-scores exhibited by the variable sex indicated that it was of little value, so it was excluded from the combined model form.

The Models

The results of testing the three proposed model forms by using the station type 2 data are given in Table 3. The following additional measures are provided for comparison:

Model	Percentage		
	Correct	Pseudo R ²	χ ²
Distance	68.9	0.279	9537
Time	55.4	0.110	8877
Time and distance	94.5	0.638	2125

The access-distance model form acts as a poor predictor for the local bus, carpool, and kiss-and-ride modes. The access-time model predicts poorly the local bus, carpool, kiss-and-ride, and walk modes. The combined model form is an excellent predictor for all modes except kiss-and-ride. Accordingly, the combined form was chosen for the rest of the study.

Applying the calibration procedure to the files for each of the five station types and to a calibration file for all of the BART stations taken as one group yields the coefficients given in Table 4. It can be seen from this table that type 1 coefficients differ greatly from the model coefficients of the other station types, whereas for the other models the differences in coefficients are not so readily apparent. As can be seen from the t-statistics, the importance of a given variable can vary greatly from one station-type model to another. The t-statistics for the socioeconomic variables are generally lower than those for the level-of-service variables. The signs of the coefficients are as expected, except for one of the distance coefficients and the age

coefficient of the model for station type 1. These two coefficients appear only in the automobile-related modes, which for type 1 (highly urbanized) are greatly underrepresented.

The model statistics for each calibration group are given in Table 5. For each model type and mode, the number of observations, the number correctly identified, and the sum of the probabilities are shown. The following additional measures are provided for comparison:

Station Type	Percentage Correct	Pseudo R^2	χ^2
1	85.9	0.504	1041.1
2	94.5	0.638	2124.9
3	95.5	0.549	1717.6
4	90.6	0.567	780.4
5	92.9	0.533	856.0
All	94.4	0.628	5499.6

All models performed well except for the type 1 model's inability to correctly predict the automobile modes. The kiss-and-ride mode was poorly

predicted in every case, which indicated that the calibration data lacked variables sensitive to this mode.

The six models described in Tables 4 and 5 differ significantly and support the hypothesis that station-type classifications provide a basis for developing models that can be transferred to comparable geographic and socioeconomic areas. Because the quality of a logit model is difficult to define, models cannot be readily compared. One of the basic questions to be considered is whether or not the model calibrated by using data from all stations differs significantly from the individual station-type models. This question can be answered by using the likelihood ratio test, which is applied to the null hypothesis that there is no difference between the all-stations model and each of the station type models. The results given in Table 6 indicate that a significant difference does exist. Another basic question to be considered is whether or not the all-stations model is as good a forecasting model as the model designed specifically for the station type. This question is much more difficult to answer due to the variability in the criteria for comparing logit models. One straightforward approach is to review the results of applying the all-stations model to each station-type group as given in Table 6. The following measures are provided for comparison (the critical χ^2 value is 16.9 at 0.05 level of significance with 9 degrees of freedom):

Table 3. Comparisons of performance of time, distance, and time-distance models.

Mode	No. Observed	No. Estimated		
		Distance Model	Time Model	Time and Distance Model
Local bus	265	132	105	263
Drive alone	727	670	703	727
Carpool	156	75	67	156
Kiss-and-ride	345	123	112	239
Walk	576	426	159	573
Total	2069	1426	1146	1958

Station Type	Percentage Correct	Pseudo R^2	χ^2	Likelihood Ratio Test
1	94.6	0.723	472.3	485.0
2	94.5	0.641	2114.1	18.6
3	96.0	0.595	1552.4	179.2
4	91.2	0.608	717.8	80.0
5	93.4	0.563	828.9	57.2

Table 4. Coefficients for access-mode-choice model by station type.

Variable	1		2		3		4		5		All	
	C	t	C	t	C	t	C	t	C	t	C	t
Access distance												
D COEF1	-0.1776	1.40	2.6989	15.40	2.5519	11.66	2.2355	8.02	2.5883	8.72	2.8632	23.04
D COEF2	0.7125	5.03	5.2282	22.80	4.4968	16.73	4.3925	12.14	4.6910	12.21	5.4986	34.97
D COEF3	2.0632	10.28	8.1549	28.32	5.7975	18.46	5.6596	12.81	5.4963	12.50	8.3385	42.50
Access time												
T COEF1	0.3440	11.63	0.9975	20.23	0.6733	13.33	0.7461	9.09	0.6816	8.46	1.0010	31.71
T COEF2	0.1303	6.44	0.3423	14.96	0.1492	6.12	0.1048	2.96	0.0769	2.21	0.3192	20.43
T COEF3	0.3473	8.95	2.1331	24.83	1.7348	18.01	1.7360	12.44	1.8161	12.57	2.2028	38.18
Automobile availability	0.4938	2.44	0.8033	3.89	0.8477	3.14	1.3188	3.56	0.5764	1.44	0.9211	6.73
AUTO COEF												
Age (middle)	0.9022	4.49	-0.2270	0.97	-0.8143	2.73	-0.6691	1.65	-1.4595	3.32	-0.2679	1.73
AGE COEF												
Income (low)	0.2524	0.83	0.7330	3.51	0.6774	2.27	0.5269	1.52	0.3105	0.92	0.5959	4.55
INCM COEF												
Race (nonwhite)	-0.2416	1.13	0.3939	2.99	0.4868	2.37	0.6122	3.27	0.8930	3.67	0.4580	5.53
RACE COEF												

Note: C = coefficient, and t = t-statistic.

Table 5. Calibration statistics for access-mode-choice model by station type.

Mode	1		2		3		4		5		All	
	N/N	P	N/N	P	N/N	P	N/N	P	N/N	P	N/N	P
Local bus	266/266	260.9	265/263	336.5	109/105	131.8	103/99	108.1	45/43	53.6	788/783	880.6
Drive alone	91/45	90.9	729/729	549.4	642/642	430.3	302/302	218.3	346/346	243.5	2110/2110	1537.3
Carpool	16/0	56.1	156/156	208.4	82/82	130.6	34/34	50.7	36/36	55.3	324/324	463.0
Kiss-and-ride	86/51	94.7	346/239	469.7	237/189	392.6	110/59	171.8	129/92	204.0	908/628	1333.4
Walk	231/231	187.4	577/573	508.6	140/138	124.5	56/54	56.0	37/34	36.3	1041/1034	954.7
Total	690/593		2073/1960		1210/1156		605/548		593/551		5171/4879	

Note: N/N = number of observations/number correctly predicted, and P = probability sums.

Table 6. Performance of general model for each station type.

Mode	1		2		3		4		5	
	N/N	P	N/N	P	N/N	P	N/N	P	N/N	P
Local bus	266/266	244.2	265/262	340.8	109/108	137.9	103/103	98.8	45/44	59.3
Drive alone	91/91	107.4	729/729	557.3	642/642	427.9	302/302	213.6	346/346	231.4
Carpool	16/16	24.7	156/156	206.7	82/82	118.0	34/34	53.0	36/36	60.9
Kiss-and-ride	86/49	86.6	346/239	475.4	237/189	393.5	110/59	175.2	129/92	203.1
Walk	231/231	227.1	577/573	492.5	140/140	132.6	56/54	64.4	37/36	38.3
Total	690/653		2073/1959		1210/1161		605/552		593/554	

Notes: N/N = number of observations/number correctly predicted, and P = probability sums.

The values for pseudo R^2 and total percentage correct are generally higher in Table 6 for the type models than in Table 5. The χ^2 values for the all-stations model were lower than those for all other models, as was anticipated. The probability sums of Table 6 were neither consistently better nor consistently worse than those of the type models. These results make it difficult to determine whether the station-type model is the best in each case.

CONCLUSIONS

Adequate planning for rapid-transit-station facilities is enhanced by the use of access-mode-choice models. The development of an access-mode-choice model for a new site is impractical because the calibration is dependent on unverifiable, subjective data. The apparent solution to this problem is the use of a model developed and verified for an existing station in an area that exhibits characteristics similar to those of the proposed site for the new station. Proper characterization of the proposed station market area is the necessary first step in an effective model transfer. In this study, as few as 10 identifying variables were found to provide the basis for market area classification and the concomitant model selection.

The models developed in this study, although significantly different from each other and from the all-stations model, do not offer sufficient uniqueness to justify their recommendation. All models performed well, and the all-stations model predicted access mode choice for the station groups as well as or better than the individual group models. However, this is similar to the experience concerning aggregate and disaggregate trip-generation models in the forecasting mode (7). Transferable access-mode-choice models will be available only when they can be based on precise, detailed travel and system data. Such was not the case for this study because existing data were used. A more comprehensive set of modeling variables collected by using a questionnaire similar to the one suggested by Korf, Demetsky, and Hoel (2) should provide the desired model uniqueness.

This paper provides a systematic methodology for analyzing and predicting rapid transit access-mode-choice travel behavior (2). It is expected that the methods developed will become refined as further applications of the tools described are implemented.

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Discussion

Gregory P. Benz

At the National Conference on Planning and Development of Public Transportation Terminals in Silver Spring, Maryland, in September 1981, access to transportation terminals attracted the most attention and discussion. The virtues of fully integrated bus-rail networks, as seen in Washington, D.C., and Atlanta, were described, and the priority given to various modes of access to stations was argued and debated. Given this interest, the paper by Korf and Demetsky is indeed timely.

The examination of rapid-transit-station access mode choice is an important part of the transportation planning process for several reasons.

The first is capital cost. Acquiring land for and building parking facilities are a substantial part of the total cost of a station. The demand for these facilities needs to be estimated carefully. The consequences of underestimating parking demand in the planning stage and trying to provide parking facilities later can be quite severe.

Another reason is operating cost. Feeder bus lines cost money to operate. Financially strapped transit properties cannot afford to run underused or poorly planned services.

Poor transit and pedestrian access to stations could discourage system ridership, as could inadequate park-and-ride and kiss-and-ride facilities.

And, finally, there are environmental concerns. Those environmental concerns that have local community impacts and are related to station access modes, such as air quality, noise, and traffic congestion, need to be estimated creditably, particularly since more citizens are actively participating in the station-planning process.

Modal-choice models for rapid-transit-station access would bring the planning of this important part of the transit system up to a level of sophistication comparable to the planning for other parts of the system. Such models should relate to and make use of data available from the system planning modal-choice models. Station access models should allow an examination of various supply and demand scenarios and policies, including concerns such as parking availability and cost, feeder transit fares, and frequency of service. Finally, the models should be sensitive to varying supply and demand characteristics of the station environment. Supply refers to the availability of transit service or parking, for instance, and demand refers to the socioeconomic characteristics of the population around the station.

The paper by Korf and Demetsky describes their attempt to develop a rapid transit access-mode-choice model that is sensitive to the geographic and socioeconomic characteristics of the station environment. The authors conclude at the end of their paper that the models they developed do not offer sufficient uniqueness to justify recommending the models. They state that transferable access models will be available only when they can be based on precise, detailed travel and system data. Although I concur with their conclusion, let us look at some features of the models presented by the authors as means of offering some suggestions for future investigations.

STATION INFLUENCE AREA

The study by Korf and Demetsky uses a distance of 6.5 km (4 miles) from the station to define the area from which trips are considered to be attracted to the station. The influence areas of stations vary as a function of station spacing. Stations in highly urbanized areas, such as a central business district, would generally have an influence area of 0.8 km (0.5 mile) or less, whereas the influence areas of stations in suburban areas may approach the 6.5-km distance used in this paper. The effect that different station influence areas have on access mode choice, particularly for the walk mode, needs to be considered.

STATION CLASSIFICATION METHODOLOGY

The authors use a set of criteria for classifying transit stations into groups: highly urbanized, predominantly single-family dwellings, etc. Although many of the criteria used can be applied to existing stations, they may require forecasting a tremendous amount of data for new stations. Station classification criteria that can be readily applied to new stations must be developed. A misclassified station would result in the wrong model being applied and incorrect modal-split estimations.

MODEL DEVELOPMENT

The authors' main purpose was to develop a model for

each of the five classes of stations. They use data available from the 1975 BART Passenger Profile Survey. The socioeconomic factors used as independent variables are age, automobile availability, income, and race. The income variable used divides the population into low income and non-low income. The racial variable separates whites from nonwhites. I would think that, historically, nonwhite trip-making behavior has been influenced more by income level than by race. In some geographic areas, I would also think that the low-income and nonwhite variables may be highly correlated. A similar relation may exist between income and automobile availability. The relation of variables such as these should be investigated carefully before they are included in the models.

The level-of-service variables are access time and access distance. Access distance was derived from the perceived access time and an estimated speed for each mode. Although it is not discussed in the paper, the estimated modal speed should vary according to station type. Generally, the more built-up the area, the lower the speed will be. Using a more accurate means of estimating access distance and other variables should, as the authors conclude, improve the models. Including other factors, such as transit fares, walk time to the access mode, and parking cost for automobile modes, would allow planners to test various policies and scenarios.

The authors use a model structure that contains both access time and access distance (which is derived from access time). They state that the superior performance of the combination of these variables in the models outweighs the undesirability of including two highly correlated level-of-service variables. Since distance is calculated from perceived time for each mode, it is conceivable that the coefficients for the time variable should be able to account for the distance variable.

APPLICATION

Since the purpose of developing rapid transit access-mode-choice models is to apply them to the planning process, the planner must be able to forecast the input variables with some degree of certainty. Perceived automobile availability or perceived access time, as used in the paper, would be difficult to forecast. The station access-mode-choice model should try to use the same input that would be used for the system mode-choice analysis.

CONCLUSIONS

The authors conclude that the models they developed do not offer sufficient uniqueness to justify recommending them. Transferable access models will be available only when they can be based on precise, detailed travel and system data. I agree that the major problem with the models is the data base from which they were derived. However, given an improved data base, the methodology used by Korf and Demetsky can be followed to develop rapid transit access-mode-choice models. Improved data, including cost data, should lead to transferable access-mode-choice models that can assist transit station planners.

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