Dial-a-Ride and Bus Transit Services: A Mode-Choice Analysis

MARCIA C. WILDS and WAYNE K. TALLEY

ABSTRACT

Because of the anticipated reduction in federal assistance funds, mass transit carriers in some localities are considering replacing or supplementing mass transit services with less costly paratransit services. In planning the addition of paratransit services, transit planners should be aware of those factors that affect an individual's choice of mass transit or paratransit services. A logit analysis of the factors that affect individuals' choice of bus transit or dial-a-ride paratransit services is presented. It is concluded that passenger perception of the reliability of dial-a-ride and bus transit and the accessibility of bus transit are primary factors that affect this decision.

Government assistance funds to the U.S. mass transit industry have, in recent years, allowed the industry to reverse the postwar trend of declining ridership. Federal transit assistance funds, however, are scheduled to be drastically cut by the Reagan administration. Federal transit capital assistance funds in 1982-1985, for example, are expected to be $4 billion less than what was recommended by the Carter administration, and federal transit operating assistance funds are expected to be reduced substantially until they are finally eliminated after the 1985 fiscal year (1,p.7). Transit carriers suggest that these budget cuts are "the rebirth of the vicious cycle that put private transit operators out of business twenty-five years ago--where you raise your fares and cut your services to lower costs and then end up carrying fewer riders" (2,p.6).

With cutbacks in government assistance funds, mass transit carriers will be forced to increase fares to maintain service. In addition, some mass transit carriers are considering replacing their mass transit services on marginal routes with less costly paratransit services. Mass transit service is a fixed-route, scheduled, passenger service as provided by bus, heavy rail, and light rail systems. Paratransit services may be nonscheduled or variable-route passenger services (3,p.319).

A paratransit service that has been proposed as a replacement for mass transit service in relatively low-density areas and as a feeder service to mass transit's fixed-route systems is dial-a-ride (4-6). Dial-a-ride paratransit includes shared-ride taxi and demand-responsive bus services. The customary method of hailing this service is by telephone. Dial-a-ride service may be provided on immediate request, or passengers may be required to make requests at least a few hours before their desired trip time. The dispatcher of a dial-a-ride system then dispatches vehicles to collect and distribute passengers from and to their requested origin-destination points. Door-to-door service is provided (i.e., passengers are picked up at their homes and delivered to the door of their final destinations). For shared-ride taxi service, the trend has been for a publicly owned mass transit carrier to contract with a local taxicab operator to provide the service. The publicly owned mass transit carriers, in turn, are eligible for federal capital and operating assistance funds.

In planning whether to replace mass transit service with dial-a-ride service, transit planners should be aware of the factors that affect the likelihood of passengers switching from mass transit to dial-a-ride services. The purpose of this paper is to investigate such factors. Specifically, those factors that affect individuals' choice of fixed-route bus transit or dial-a-ride services will be investigated. Previous mode-choice studies have been concerned primarily with automobile and mass transit services (7-10); hence, little attention has been devoted to mode choice between mass transit and paratransit services. One exception is a study by Gordon, Williams, and Theobald (11), which concluded that dial-a-ride had a chance of being implemented in East Los Angeles, because it offered greater comfort and security than do conventional mass transit services.

THE MODEL

Assume the utility function U_{dj} of the jth individual using dial-a-ride transit service for a given trip may be expressed as

$$U_{dj} = \alpha_0 + \beta_1 P_{dj} + \beta_2 T_{dj} + \beta_3 C_{dj} + \beta_5 R_{dj} \qquad (1)$$

where

- P_{dj} = price of a given dial-a-ride trip for the jth individual,
- T_{dj} = travel time of a given dial-a-ride trip for the jth individual,
- C_{dj} = perception of the noncrowdedness of a given dial-a-ride trip for the jth individual, and
- R_{dj} = perception of the reliability of a given dial-a-ride trip for the jth individual.

Similarly, assume the utility function U_{bj} of the jth individual using fixed-route bus transit service for a given trip may be expressed as

$$U_{bj} = \gamma_0 + \beta_1 P_{bj} + \beta_2 T_{bj} + \beta_4 C_{bj} + \beta_6 R_{bj} + \beta_7 A_{bj} \qquad (2)$$

where

- P_{bj} = price of a given bus transit trip for the jth individual;
- T_{bj} = travel time of a given bus transit trip for the jth individual;
- C_{bj} = perception of the noncrowdedness of a given bus transit trip for the jth individual;

R_{bj} = perception of the reliability of a given bus transit trip for the jth individual; and
A_{bj} = bus transit accessibility, or distance from home to the nearest bus stop, for the jth individual.

Further, assume that the relative probability (P_j/1-P_j) that the jth individual will choose dial-a-ride rather than bus transit for a given trip may be expressed as

$$P_j/1-P_j = e^{U_{dj}}/e^{U_{bj}} \quad (3)$$

where

P_j = probability that the jth individual will choose dial-a-ride rather than bus transit service for a given trip and
1-P_j = probability that the jth individual will choose bus transit rather than dial-a-ride service for a given trip.

Taking the natural log of Equation 3 and rewriting give

$$\ln (P_j/1-P_j) = U_{dj} - U_{bj} \quad (4a)$$

or

$$\ln (P_j/1-P_j) = \beta_0 + \beta_1(P_{dj}-P_{bj}) + \beta_2(T_{dj}-T_{bj}) + \beta_3C_{dj} - \beta_4C_{bj} + \beta_5R_{dj} - \beta_6R_{bj} - \beta_7A_{bj} \quad (4b)$$

where $\beta_0 = \alpha_0 - \gamma_0$.

Equation 4b is an example of a logit statistical model whose parameters will be estimated to investigate passenger choice of dial-a-ride or fixed-route bus transit services. The dependent variable, ln(P_j/1-P_j), has been referred to in the literature as the logit variable and for Equation 4b may be interpreted as the log of the odds ratio that the jth individual will choose dial-a-ride rather than bus transit for a given trip. The signs of the $P_{dj} - P_{bj}$ and $T_{dj} - T_{bj}$ coefficients in Equation 4b are expected to be negative, because increases in the price and travel time of dial-a-ride relative to those of bus transit are expected to decrease the odds of an individual choosing dial-a-ride rather than bus transit. The expected sign of the C_{dj} coefficient is positive, because an improvement in dial-a-ride noncrowdedness is expected to increase the odds of an individual choosing dial-a-ride. Conversely, the sign of the C_{bj} coefficient (i.e., $-\beta_4$) is expected to be negative, because an improvement in bus transit noncrowdedness is expected to decrease the odds of an individual choosing dial-a-ride rather than bus transit. Similarly, the signs of the dial-a-ride reliability coefficient (β_5) and the bus transit reliability coefficient ($-\beta_6$) are expected to be positive and negative, respectively. Finally, the expected sign of the A_{bj} coefficient (i.e., $-\beta_7$) is positive, because, as distance from home to the bus stop increases, the odds of selecting dial-a-ride increase.

EMPIRICAL RESULTS

The data for this study were extracted from the 1977 TELTRAN Impact Study (12) conducted by the Institute for Social Research of the University of Michigan and the Ann Arbor Transportation Authority. The data contain information on the travel behavior of Ann Arbor residents and their perceptions and evaluations of the available transit alternatives including dial-a-ride and bus transit.

The travel time variable (T_j) measures the total travel time (i.e., it may include in-transit, waiting, walking, and transfer times for a given trip). Because the total or aggregated travel time only was available in the data set, individual time components could not be considered in the following mode-choice analysis. If an observation for the T_j variable was missing, an estimate was made by calculating the average mile-per-hour by bus and dial-a-ride using the harmonic mean. The use of the harmonic mean is appropriate for measures involving speed (13). A travel time estimate was then computed by dividing the passenger's distance from home to work (or home to shopping area) by the average mile-per-hour for the given transportation service. Travel time is measured in minutes. Furthermore, because the price of bus transit and dial-a-ride for a given passenger trip is the same in the data set, the price variable (P_j) will always be zero and therefore will not be considered in these estimations. The C_{bj} and C_{dj} variables are dummy variables that consider the relative noncrowdedness of bus and dial-a-ride trips, respectively, for the jth individual. Individuals in the data set were asked to indicate their perception of the noncrowdedness of a bus or dial-a-ride vehicle by using a rating scale from zero to five (i.e., a zero was to be assigned if the bus or dial-a-ride vehicle was never crowded and a five if it was always crowded). This rating scale was transferred to a dummy-variable format by assigning a one to C_{bj} or C_{dj}, denoting noncrowdedness, if the rating was between zero and two and assigning a zero to C_{bj} or C_{dj}, denoting crowdedness, if the rating was between three and five. This transformation format was used to give equal weight to the response categories of the rating scale (i.e., the response categories from zero to two are three in number and the response categories from three to five are three in number).

The R_{bj} and R_{dj} variables are dummy variables that consider the relative reliability of bus and dial-a-ride services. Individuals in the data set were asked to indicate their perception of the reliability of bus and dial-a-ride services by using a rating scale from zero to five (i.e., a zero was to be assigned if the bus or dial-a-ride service was perceived to be reliable and a five if it was perceived to be unreliable). This rating scale was transferred to a dummy-variable format by assigning a one to R_{bj} or R_{dj}, denoting reliability, if the rating was between zero and two and assigning a zero to R_{bj} or R_{dj}, denoting unreliability, if the rating was between three and five. Bus accessibility (A_{bj}) is the distance (measured in miles) from the home of the jth individual to the nearest bus stop. An accessibility variable for dial-a-ride service was not considered, because this service is perfectly accessible (i.e., dial-a-ride vehicles pick up passengers at their homes).

Estimations of two forms of logit Equation 4b, based on a sample of 28 work trips (using dial-a-ride and bus transit services), are given in Table 1. (The shorter form of Equation 4b is $\ln(P_j/1-P_j) = \beta_5R_{dj} - \beta_6R_{bj} - \beta_7A_{bj}$.) A sample of 28 work trips was constructed from the data set by deleting all work trips where observations on the explanatory variables (except the travel time variable) were missing. The computer package SHAZAM (14) was used to obtain the logit estimates. As stated previously, the variable P_j is deleted, because the price of bus and dial-a-ride services for a given trip is identical. For Equation 4b in Table 1, the variables R_{dj} and A_{bj} are significant (based on one-tailed tests) at the 0.10 level; the variables T_j, C_{dj}, and

TABLE 1 Logit Estimation for Work Trips

Explanatory Variable	Logit Coefficient	
	Equation 4b	Shorter Form
Constant	-6.75 (-1.55)	-2.02 (-1.81)
T_j	-.098 (-1.13)	
C_{bj}	2.94 (.737)	
C_{dj}	4.83 (1.15)	
R_{bj}	-6.98 (-1.31)	-2.78 (-1.83)
R_{dj}	3.63 (1.49)	2.58 (1.69)
A_{bj}	.186 (1.67)	.085 (2.07)
LRS	14.85	9.69
AOP	89%	86%

Note: t-coefficients are shown in parentheses, LRS = likelihood ratio statistic, and AOP = accuracy of prediction.

R_{bj} are significant at the 0.20 level. All coefficients of Equation 4b, except that of the variable C_{bj}, have the expected sign; however, C_{bj} is insignificant at the 0.20 level of significance. The sign of the T_j coefficient indicates that as travel time of dial-a-ride increases relative to that of bus transit, the odds of an individual choosing dial-a-ride (relative to bus transit) decrease. The positive sign of the C_{dj} coefficient indicates that the odds of an individual selecting dial-a-ride increase as dial-a-ride noncrowdedness improves. The negative sign of the R_{bj} coefficient indicates that as bus reliability increases, the odds of choosing dial-a-ride decrease. Conversely, when the reliability of dial-a-ride increases, the odds of choosing dial-a-ride increase, because the R_{dj} coefficient is positive. Finally, the positive sign of the A_{bj} coefficient indicates, as expected, that as the distance from home to bus stop increases, the odds of selecting dial-a-ride increase. Based on the likelihood ratio test (7,p.123), Equation 4b is significant at the 0.025 level. Furthermore, this equation correctly predicted 89 percent of the choices (i.e., dial-a-ride and bus transit choices) actually made by the sample.

Although the T_j variable is significant at a rather low level, the size of its coefficient is reasonable compared to similarly estimated coefficients of other studies. For example, Train (15, p.12) in a logit estimation (considering automobile, bus, and carpool as alternatives) found coefficients of -0.064, -0.026, -0.069, and -0.054 for automobile on-vehicle time, transit on-vehicle time, walk time, and transfer wait time, respectively (time was measured in minutes). In a logit estimation in a later study, Train (16,p.7), in considering automobile, bus, heavy rail, and carpool as alternatives, found coefficients of -0.047, -0.019, -0.086, and -0.048 for automobile on-vehicle time, transit on-vehicle time, walk time, and transfer wait time, respectively (time was measured in minutes).

One plausible explanation of why the travel time variable was not significant at a relatively low level of significance is the lack of sufficient variation in the data set between the travel times of dial-a-ride and bus transit services for given passenger trips. This is reasonable because the justification offered by transit management for replacing bus transit service with dial-a-ride service is often that cost is reduced rather than that travel time of passenger service is reduced. For example, dial-a-ride service is often provided with nonunion labor, which is less costly than the labor used to provide bus transit service.

In addition to the specification of Equation 4b, other specifications (i.e., considering various combinations of explanatory variables) of the logit model for work trips were considered. The specification that gave the best results in terms of improved levels of significance is the specification represented by the second equation in Table 1. All coefficients of this equation have the expected signs. The R_{dj} variable is significant at the 0.10 level of significance; the R_{bj} variable is significant at the 0.05 level of significance; and the A_{bj} variable is significant at the 0.025 level of significance. Based on the likelihood ratio test, the second equation is significant at the 0.025 level. Also, the equation correctly predicted 86 percent of the choices actually made by the sample.

In addition to work trips, dial-a-ride and bus shopping trips were considered. A logit estimation using a sample of 54 shopping trips in which all explanatory variables are significant at 0.30 or lower is given in Table 2. All coefficients have the expected sign. The variables A_{bj} and R_{bj} are significant at the 0.10 level; R_{dj} is significant at the 0.20 level; and T_j is significant only at the 0.30 level of significance. Based on the likelihood ratio test, the logit equation is significant at the 0.20 level. The equation correctly predicted 76 percent of the dial-a-ride and bus transit choices actually made by the sample.

TABLE 2 Logit Estimation for Shopping Trips

Explanatory Variables	Logit Coefficients
Constant	-1.20 (-1.59)
T_j	-.0113 (-.623)
R_{bj}	-1.03 (-1.43)
R_{dj}	.751 (1.07)
A_{bj}	.034 (1.59)
LRS	6.29
AOP	76%

Note: t-coefficients are shown in parentheses, LRS = likelihood ratio statistic, and AOP = accuracy of prediction.

POLICY IMPLICATIONS

Because cutbacks in federal assistance funds to the U.S. mass transit industry are anticipated, some mass transit carriers are considering replacing mass transit services on marginal routes with less costly paratransit services. The paratransit service, dial-a-ride in particular, is being considered as a replacement for or a supplemental service to mass transit services in relatively low-density areas. Based on empirical results, transit planners should be especially concerned with passenger perception of the reliability of dial-a-ride and bus transit services and the accessibility of bus transit in developing dial-a-ride and bus transit services. Of the number of explanatory variables considered in explaining choice of dial-a-ride or bus transit services, these variables were consistently significant at relatively low levels of significance for both work and shopping trips. Specifically, the results indicate that improvement in passenger perception of the reliability of dial-a-ride service will increase the odds of an individual choosing dial-a-ride. Alternatively, it may be stated that individuals will be more likely to switch to dial-a-ride from bus transit service as their perception of the reliability of dial-a-ride service improves. This result is particularly important, because one concern in replacing bus transit service in a particular area with dial-a-ride service in whether former mass transit riders will be willing to switch to dial-a-ride. If bus transit and dial-a-ride are allowed to compete in a particular area (i.e., both services are available), these results indicate that improvements in the reliability and accessibility of bus service will decrease the odds of an individual choosing dial-a-ride.

REFERENCES

1. A.E. Weise. Reaganomics: Spelling Trouble for Transit. Mass Transit, Vol. 8, No. 10, 1981, pp. 6-9, 32.
2. A.E. Weise. New Federalism: Transit on Its Own. Mass Transit, Vol. 9, No. 3, 1982, pp. 6-8, 11, 16, 45, 47, 49.
3. W.K. Talley. Introduction to Transportation. South-Western Publishing Co., Cincinnati, Ohio, 1983.
4. R.E. Furness. The Westport, Connecticut, Integrated Transit System. U.S. Government Printing Office, Washington, D.C., 1979.
5. R.H. Menard, M. Flusberg, and L.S. Englisher. Modeling Demand-Responsive Feeder Systems in the UTPS Framework. U.S. Government Printing Office, Washington, D.C., 1978.
6. L.A. Newmann, J.A. Wojno, and R.D. Juster. Integrated Dial-a-Ride and Fixed Route Transit in Ann Arbor, Michigan. U.S. Government Printing Office, Washington, D.C., 1977.
7. T.A. Domenich and D. McFadden. Urban Travel Demand: A Behavioral Analysis. North Holland Publishing Co., Amsterdam, The Netherlands, 1975.
8. C.A. Lave. A Behavioral Approach to Modal Split Forecasting. Transportation Research, Vol. 3, No. 4, 1969, pp. 463-480.
9. D.A. Quarmby. Choice of Travel Mode for the Journey to Work. Journal of Transport Economics and Policy, Vol. 1, No. 3, 1967, pp. 273-313.
10. R.B. Weston and D.W. Gillen. Parking Location and Transit Demand. Journal of Econometrics, Vol. 8, No. 1, 1978, pp. 75-101.
11. P. Gordon, C.S. Williams, and P.M. Theobald. Intrametropolitan Travel Demand Forecasting Using an Abstract Mode Approach. Transportation Research, Vol. 13A, No. 1, 1977, pp. 39-59.
12. 1977 TELTRAN Impact Study. Institute for Social Research, University of Michigan, and Ann Arbor Transportation Authority, Ann Arbor, Mich., 1977.
13. H.E. McAllister. Elements of Business and Economics Statistics. Wiley, New York, 1975.
14. K.J. White. A General Computer Program for Econometric Methods--SHAZAM. Econometrica, Vol. 46, No. 1, 1978, pp. 239-240.
15. K.E. Train. A Comparison of the Predictive Ability of Mode Choice Models with Various Levels of Complexity. Transportation Research, Vol. 13A, 1979, pp. 11-16.
16. K.E. Train. A Structured Logit Model of Auto Ownership and Mode Choice. Review of Economic Studies, Vol. 47, No. 147, 1980, pp. 357-370.

Publication of this paper sponsored by Committee on Application of Economic Analysis to Transportation Problems.

Export Transportation Issues

PETER L. SHAW

ABSTRACT

The U.S. seaport industry is sensitive to the ways economic forces are reflected in government policy at all levels. Possible changes in exports and the balance of trade, demographic shifts, and implications of government policy all present challenges to the seaport industry. Planning to meet the challenges in both the short and the long term is discussed, and the ways the ports of Long Beach and Los Angeles, California, are facing these challenges are described in detail.

U.S. seaports have been widely recognized as the pivotal point in the land-sea export process. Some current strategic issues that affect U.S. ports and two major southern California ports are discussed. The President in the State of the Union address noted:

> One out of every five jobs in our country depends on trade. . . . So, I will propose a broader strategy in the field of international trade--one that increases the openness of our trading system and is fairer to America's farmers and workers in the world marketplace. . . . We must strengthen the