Modeling Waterborne Passenger Transportation User Characteristics

CARL BERKOWITZ

This research was conducted on Staten Island, New York, and provides an analytical tool to evaluate the viability of implementing new waterborne passenger transportation systems. The analysis of passenger travel characteristics and ridership potential is conducted using a logit-based demand model. The model and data collection techniques are discussed, including the essential elements of time, cost, comfort, convenience, special enjoyment, and validation. Special emphasis is given to the analysis of passenger travel characteristics and mode potential using demand modeling. The model is used to estimate the effects of policy decisions on travel behavior. The effects of these changes are represented in terms of overall patronage estimates by varying the values of one or two variables. This study area is served by passenger ferry, express bus, and automobile operating in direct competition with each other. This relationship makes the model suitable for transfer to other locations with similar geographical configurations.

Staten Island, New York, was selected as the study area because it is the home base for the Staten Island Ferry. As an island suburb of New York City it is linked to the central business district (CBD) via ferry, express bus, and automobile operating in direct competition with each other.

To obtain data for the model, three representative census tracts were selected using the following criteria: they must be (a) served by at least two competing modes, (b) have travelers destined for the Manhattan CBD, (c) have household income distributed from low to high, (d) have at least 700 households, (e) have different housing types and be representative of old and new communities (Table 1).

SURVEY

A mail-back survey was chosen for data collection based on the author's experience with this method. (A 1975 Staten Island mail-back survey conducted by the author had a 29 percent return.) The survey was designed for the work trip with four separate information sections: user travel data, comfort and convenience evaluation, demographic data, and modal comparison.

The form was designed to be completed in less than 30 min. A 100 percent sampling was conducted of the 5,118 residential households in the selected area. A survey return of 22 percent (1,123) was obtained; of these, 76 percent were traveling to the Manhattan CBD and 89 percent of the responses were considered usable.

Schools of Engineering and Education, The City College, Steinmon Hall, Convent Ave. and 139th St., New York, N.Y. 10031.

To overcome the potential problem of respondents overestimating travel time, the survey used a graphic form designed to improve travel time information accuracy. Travelers were asked to specify the travel time components that form the total work trip (access times, wait times, mode times, destination times, and so on). This information did not always agree with the response to a control question that requested: Usual time it takes to go from your home to your place of work (min). Field travel time studies were conducted to verify the accuracy of the graphic form travel time. The field reported travel time was found to be within 10 percent of the reported travel time.

Information questions on comfort, convenience, and special enjoyment were asked. Responses provided insight into factors that might influence the mode choice decision (Table 2). Respondents were asked to select four areas that were most important in the comfort, convenience, and special enjoyment categories, and to rank them, from most important to least important, in terms of personal travel needs. This was accomplished by having the respondent circle the four characteristics considered most important and check the appropriate box to indicate order of importance. These questions quantified the relative importance of these characteristics in terms of the respondents' mode choice and assisted in determining the characteristics that affect the traveler's decision-making process.

To obtain a respondent profile, a series of demographic questions were asked (Table 3). Several conclusions were drawn from this analysis. Female respondents had a strong preference for the express bus. Express-bus and ferry passengers have similar income distributions; automobile drivers and passengers have a greater number with incomes in the $50,000 plus range. The ferry has the highest percentage of low-income passengers. Commuters live in private homes and own at least one automobile.

The survey also collected information on travel characteristics. Travelers were asked to evaluate the ferry, the express bus, and the automobile for the work trip. This evaluation was important because it was based on the concept that an individual will choose a mode on personal perceptions—correct or incorrect—and the mode selection is based on a series of behavioral characteristics. The respondent was asked to give an opinion on how satisfied or dissatisfied they were with the ferry, the express bus, and the automobile. The respondent was then asked to make a mode comparison, even if the particular form of transportation had never been used, by indicating how satisfied or dissatisfied they might be. Satisfaction was divided into five categories from very dissatisfied to very satisfied (Table 4).

CALIBRATION

A general model was then developed from these survey data. First, the total data set was randomly divided into a two-third and a one-third sample. The two-third sample was used for calibration, reserving the one-third sample for later validation. The UTPS/U-Model program was used to develop the required calibration files for input into the UTPS/U-Logit computer model package.

Fifty-five different variables were evaluated by the program and screened for their ability to predict mode choice. More than 100 models were formulated, tested, and evaluated using different variable combinations (Table 5). Variables that had poor statistical tests, or that did not affect the model split, or did not represent the present transportation conditions, were eliminated from consideration.

MODEL

The resulting U-LOGIT model had the following form:

$$p(i) = \frac{e^{-du(i)}}{\sum_{i=1}^{3} e^{-du(i)}}$$

where

Mode 1 = ferry
$du(1) = C11(\text{PRTRF}) + C12(\text{ATIME}F) + C13(\text{COST1}F) + C14(\text{COMCO}F)$
Mode 2 = express bus
$du(2) = C21(\text{COST1}B) + C22(\text{COMCO}B)$
Mode 3 = automobile
$du(3) = C31(\text{TIME}A) + C32(\text{COST1}A) + C33(\text{COMCO}A)$

and

Cij = coefficient of calibration for Mode i and Variable j

PRTRF = principal mode travel time (ferry)
ATIMEF = access time (ferry)
COST1F = cost of trip/income index (ferry)
COMCOF = comfort and convenience factor (ferry)
COST1B = cost of trip/income index (express bus)
COMCOB = comfort and convenience factor (express bus)
TIMEA = total travel time (automobile)
COST1A = cost of trip/income index (automobile)
COMCOA = comfort and convenience factor (automobile)

Access Time Versus Principal Mode Travel Time

To better understand the factors that affect mode choice, an evaluation of access time and principal model travel time was undertaken (Table 6).

The average travel time for ferry and express bus users was 90 min; this time is 30 min greater than the automobile travel time. The ferry access time is equal to the express bus in-vehicle time and the ferry in-vehicle time is equal to the express bus access time.

TABLE 1 CENSUS TRACT STATISTICS

CENSUS TRACT	INCOME RATING	MEDIAN AGE	MEDIAN NO. PERSONS/ HOUSEHOLD	HOUSEHOLDS
1	D	44	3.2	727
	C	48	3.1	794
2	E	46	3.3	165
	E	49	3.7	871
3	B	39	3.7	2734
	A	42	3.7	964

NOTE: A - Highest, E - Lowest

Source: Cole Directory, Staten Island, 1980.

TABLE 2 KEY TRAVEL CHARACTERISTICS

TRAVEL CHARACTERISTIC	DESCRIPTION	FIRST CHOICE RANKING FERRY	EXBUS	AUTO
COMFORT	Safety from crime	1	3	1
	Availability of seating	2	6	6
	Cleanliness of vehicle	3	5	5
	Safety from injury	4	4	4
	Heat/air conditioning	5	2	2
	Comfortable seating	6	1	3
CONVENIENCE	Reliability of schedule	1	1	2
	Cost of trip	2	2	4
	Travel time	3	3	1
	Reliability of vehicle	4	4	3
	Waiting time	5	5	5
SPECIAL ENJOYMENT	Quality of ride	1	1	1
	Relaxing	2	2	2
	Enjoyment of ride	3	3	3
	Freedom of movement	4	5	4
	Attractiveness of vehicle	5	4	5

TABLE 3 KEY USER DEMOGRAPHICS (percent)

CHARACTERISTIC	FERRY	EXPRESS BUS	AUTO
GENDER			
Male	72.6	58.8	86.9
Female	27.4	41.2	13.6
AGE			
18-24	10.1	7.7	-
25-34	30.0	33.5	45.9
35-44	26.0	34.8	29.5
45-54	20.5	15.8	14.8
55-64	11.7	7.2	9.8
65+	1.7	0.9	-
PRIVATE HOMES	87.7	95.0	95.0
OCCUPATION			
Clerical	25.8	22.5	-
Craftsman/foreman	6.9	10.6	11.5
Civil servant	10.7	5.0	31.1
Sales	2.5	4.1	8.2
Manager	21.0	27.1	21.3
Student	2.5	0.9	-
Professional	15.5	20.6	19.7
Other	15.1	9.2	8.2
DRIVERS LICENSE	89.7	91.9	96.7
AUTOS IN HOUSEHOLD			
One	52.0	61.3	30.0
Two or more	44.6	36.4	70.0
AUTO AVAILABILITY			
Always	52.2	47.1	83.3
Sometimes	22.3	23.1	11.7
FAMILY INCOME			
Under $14,999	9.7	4.0	1.7
15,000-19,999	8.9	7.5	-
20,000-24,999	15.1	15.0	15.5
25,000-29,999	20.2	20.5	17.2
30,000-39,000	26.2	29.5	31.0
40,000-49,000	12.2	12.5	12.1
over 50,000	7.6	11.0	22.4

TABLE 4 EVALUATION OF TRAVEL CHARACTERISTICS

CHARACTERISTIC	MODE	MODE USER: FERRY USER (PERCENT)					EXBUS USER (PERCENT)					AUTO USER (PERCENT)				
		VD	SD	NN	SS	VS	VD	SD	NN	SS	VS	VD	SD	NN	SS	VS
TRAVEL TIME	FERRY	9	19	14	38	20	13	15	50	17	5	15	21	33	23	8
	EXBUS	32	23	33	11	1	36	30	10	21	3	40	25	20	12	3
	AUTO	19	21	41	12	7	16	11	47	16	10	12	28	9	20	31
AVAILABLE SEAT	FERRY	10	18	15	31	26	6	10	53	18	13	16	25	21	28	10
	EXBUS	33	20	34	8	5	36	26	8	17	13	33	30	16	16	5
	AUTO	2	1	47	3	47	1	1	46	4	48	2	3	13	3	79
COMFORT (RIDE QUALITY)	FERRY	3	8	16	32	41	5	8	54	20	13	3	13	32	26	26
	EXBUS	25	22	38	12	3	31	31	12	25	1	28	34	20	15	3
	AUTO	2	6	47	13	32	2	2	46	6	44	7	3	14	15	61
COST OF TRIP	FERRY	6	2	12	19	61	4	4	48	15	29	5	5	26	16	48
	EXBUS	47	20	31	1	1	54	23	18	4	1	31	36	23	8	2
	AUTO	42	11	41	3	3	32	16	44	4	4	36	15	13	15	21
SAFE FROM CRIME	FERRY	6	18	21	36	19	15	17	47	15	6	15	26	23	21	15
	EXBUS	2	5	40	26	27	2	4	15	30	49	3	7	26	30	34
	AUTO	1	2	42	7	48	1	0	41	5	53	3	3	10	5	79

VD - VERY DISSATISFIED; SD - SOMEWHAT DISSATISFIED; NN - NEITHER SATISFIED NOR DISSATISFIED; SS - SOMEWHAT SATISFIED; VS - VERY SATISFIED

TABLE 5 VARIABLES TESTED

CATEGORY	DESCRIPTION	
TIME	1. USUAL TRAVEL TIME DOOR TO DOOR	
	2. WALK TIME TO ACCESS MODE	
	3. TIME WAITING FOR ACCESS MODE	
	4. TRAVEL TIME ON ACCESS MODE	
	5. TIME ON PRINCIPAL MODE	
	6. TIME WAITING FOR PRINCIPAL MODE	
	7. MODE LINKING PRINCIPAL MODE TO DESTINATION	
	8. TIME TO PARK AUTO USED AS PRINCIPAL MODE	
	9. TIME TO WALK TO DESTINATION	
	10. FINAL WALK TIME TO FINISH TRIP	
	11. TOTAL TRAVEL TIME FOR ENTIRE TRIP	
COST	1. ONE WAY COST	2. TOLLS
	3. TRANSIT FARES	4. PARKING COST
	5. CARPOOL COST (OW)	6. AUTO TRIP LENGTH (OW)
COMFORT	1. SAFETY FROM CRIME	2. CLEANLINESS OF VEHICLE
	3. SAFETY FROM INJURY	4. FREEDOM FROM ANNOYANCE
	5. WEATHER PROTECTION	6. COMFORTABLE SEATING
	7. HEAT AND AIR CONDITIONING COMFORT	
CONVENIENCE	1. COST OF TRIP	2. RELIABLITY OF SCHEDULE
	3. TRAVEL TIME	4. RELIABILITY OF VEHICLE
	5. WAITING TIME	6. EASE OF TRANSFER
	7. CONTINUOUS RIDE	8. AVAILABILITY OF INFO
	9. PROXIMITY OF SERVICE TO ORIGIN AND DESTINATION	
SPECIAL ENJOYMENT	1. ENJOYMENT OF RIDE	2. ATTRACTIVENESS OF RIDE
	3. QUALITY OF RIDE	4. SCENIC RIDE
	5. NOSTALGIA	6. RELAXING QUALITIES
	7. FREEDOM OF MOVEMENT	8. OPPORTUNITY TO BUY FOOD
	9. SOCIAL ENVIRONMENT	10. OTHER
DEMOGRAPHIC	1. MALE OR FEMALE	2. MARRIED OR SINGLE
	3. AGE GROUPINGS	4. HOUSING TYPE
	5. DRIVERS LICENSE	6. # OF AUTOS IN HOUSEHOLD
	7. AUTO AVAILABILITY	8. INCOME GROUPINGS
	9. LICENSED DRIVERS IN HOUSEHOLD	

TABLE 6 COMPARISON OF AVERAGE ACCESS TIME AND PRINCIPAL MODE TRAVEL TIME (minutes)

MODE	ACCESS TIME	PRINCIPAL MODE TIME	TRAVEL TIME
FERRY	64.91	25.00	89.91
EXPRESS BUS	23.15	66.49	89.64
AUTOMOBILE	13.75	46.13	59.88

This time relationship partially explains the results obtained from the survey question, "I do not use the Staten Island Ferry to commute to work because. . . " answered by express bus users. Sixty-six percent of the survey respondents selected inconvenience, whereas 23 percent selected slower travel time as their answer. Although the travel times for ferry and express bus users are comparable, the need to use at least two modes to complete a ferry trip gives the potential user an incorrect perception.

Final Variable Selection

On evaluation of the different variables, it was determined that most of the variables did not contribute to the model's ability to predict. The final analysis identified principal mode in-vehicle travel time; total access time; total travel time; and total trip cost, comfort, and convenience as the most important variables.

Variable Selection for Express Bus Model

In the process of selecting the variables for inclusion in the express bus part of the model, total travel time, access time, waiting time, and principal mode time were tested. When the travel time variables were included and the model was calibrated, the resulting variable coefficients assumed negative or zero values. The resultant statistical test was below acceptable standards established in the literature.

This result was not expected and an investigation was conducted to determine the possible reasons. A series of conditions were developed to help explain the lack of impact exhibited by the express bus travel time variable.

Express bus service on Staten Island was established in 1966. In the first year of operation, the system transported 18,000 passengers. In 1981, the system reached its peak, transporting 7,400,000 passengers. At the time of this research, the annual ridership was approximately 6,500,000. In-house studies conducted by the New York City Department of Transportation and other agencies indicate that the express bus system may have reached its capacity on Staten Island.

The first express bus users were diverted from the Staten Island Ferry. This modal shift was attributed to the express buses' improved travel time, levels of comfort and convenience, and pricing structure. Based on the system's initial success, the service was expanded with additional equipment and routes. The expanded system attracted ferry users and new residents. In recent years a new trend has emerged in which passengers who might have used the express bus have instead selected the ferry. This trend can be attributed to the express bus losing its competitive edge in travel time, trip cost, comfort, and convenience. The cost for an express bus trip at the time of the study was $3.00; today it is $3.50, and in January 1990 it increased to $4.00.

Annual ferry ridership declined from 18,000,000 in 1975 to 14,000,000 in 1979, increased to 21,000,000 in 1983, and remained constant through 1989. The increase in ferry users is attributed to the population explosion on Staten Island, increases in express bus fares, express bus system capacity restraints, and reductions in the general quality of express bus service. This service decline has spawned van pooling, minibuses, and community charter buses. This latter development has resulted in the leveling off of ferry ridership growth. Improvements to the express bus system, including special bus lanes and traffic control modifications, have not significantly improved the system's operating characteristics.

Attempts to mitigate the negative attributes have been unsuccessful. One possibility that has not been investigated is a combined ferry-express bus system. This system would combine the positive attributes of both services. This service offers an opportunity to reduce ferry access time. One scenario being investigated is a guided bus system used in conjunction with an abandoned railroad right-of-way that conveniently accesses the Staten Island Ferry Terminal.

FINDINGS

Survey respondents were asked to comment on their perceptions of satisfaction or dissatisfaction about trip cost and travel time. The majority of express bus users indicated their dissatisfaction with trip cost and travel time. When asked to evaluate the ferry, they were neither satisfied or dissatisfied with trip time and indicated their satisfaction with ferry trip cost (Table 7).

Total Trip Cost/Income

Dividing cost by income allows for the testing of the concept that travelers with different incomes value travel costs differently.

One-Way Automobile Operating Cost

To obtain the one-way automobile operating cost, the total cost of parking and tolls was divided by two and added to the total operating cost. The total operating cost, including maintenance, fuel, depreciation, insurance, and other direct costs was established at 35 cents/mile.

Comfort and Convenience Index

To establish comfort and convenience indexes, scaling techniques were used to weigh the relative importance of each characteristic for each mode as determined by the respondents (Table 8). The comfort and convenience index formulations are made up of five characteristics: travel time, trip cost, comfortable seat, available seat, and safety from crime. The weighing factors were based on the relative importance given by the respondents to each factor. Respondents were asked to evaluate a series of comfort and convenience characteristics and give their perceptions even if the mode was never used.

TABLE 7 PERCEPTIONS COMPARED FOR TRAVEL TIME (TT) AND TRIP COST (TC)

PRINCIPAL MODE	MODE	SATISFIED (PERCENT) TT	SATISFIED (PERCENT) TC	DISSATISFIED (PERCENT) TT	DISSATISFIED (PERCENT) TC
FERRY	FERRY	58	80	28	8
	EXBUS	12	2	55	67
	AUTO	19	6	40	53
EXPRESS BUS	FERRY	22	44	28	8
	EXBUS	24	5	66	77
	AUTO	26	8	27	48
AUTOMOBILE	FERRY	31	64	36	10
	EXBUS	15	10	65	67
	AUTO	51	36	40	51

TABLE 8 COMFORT AND CONVENIENCE INDEX VARIABLES

		MODE CHOICE		
		FERRY	EXPRESS BUS	AUTOMOBILE
GROUP	VARIABLE	RESPONDENT FIRST CHOICE GROUP (PERCENT)	RESPONDENT FIRST CHOICE GROUP (PERCENT)	RESPONDENT FIRST CHOICE GROUP (PERCENT)
COMFORT	AVAILABILITY OF SEATING	15.75 (40)	19.40 (46)	14.63 (35)
	COMFORTABLE SEATING	6.01 (15)	10.13 (24)	9.35 (23)
	SAFETY FROM CRIME	17.56 (45)	13.00 (30)	17.47 (42)
CONVEN-	TRAVEL TIME	14.80 (46)	16.53 (58)	18.56 (63)
IENCE	COST OF TRIP	17.30 (54)	11.73 (42)	10.98 (37)

This evaluation was then correlated with the ranking of the characteristics in the order of subjective importance.

Statistical Summary

The UTPS/U-LOGIT statistics package is designed to help determine whether the model is acceptable. This, however, is not the only criterion. The most important consideration is whether the model is consistent with subjective experience of the travel behavior being investigated. In developing the model, care was taken not to include highly correlated variables in the same utility expression. The statistical summary of the selected independent variables is presented in Table 9.

Table 10 indicates the correlation matrix of independent variables used to determine whether or not the selected variables show any degree of independence. Explanatory variables do not have high levels of correlation one to another. Because it is impossible to obtain a set of variables that do not correlate at all, the matrix helps select appropriate variables. Independent variables highly correlated with other independent variables were not included in the same utility expression. The variables selected have intercorrelation values ranging from 0.0002 to 0.3117. This is considerably below the unacceptable range of 0.6 to 1.0, as indicated in the literature.

Final Model Coefficient Values

The final coefficient values and the results of the model calibration are presented in Table 11. The values are the reverse

TABLE 9 STATISTICAL SUMMARY OF INDEPENDENT VARIABLES

VARIABLE	MEAN	STANDARD DEVIATION	LARGEST VALUE	SMALLEST VALUE	UNITS
PRTRF	25.00	0.00	25.00	25.00	MIN.
ATIMEF	64.91	18.99	155.00	9.00	MIN.
COSTIF	4.87	5.14	56.00	1.20	----
COMCOF	30.09	8.10	44.50	8.90	----
COST1B	7.92	5.61	81.80	1.50	----
COMCOB	16.99	4.72	34.60	6.60	----
TIMEA	59.88	11.16	110.00	32.00	MIN.
COSTIA	28.20	24.60	163.70	2.00	----
COMCOA	24.01	4.66	35.00	10.60	----

TABLE 10 CORRELATION MATRIX OF INDEPENDENT VARIABLES

	1	2	3	4	5	6	7	8
2	0.0002							
3	-0.0046	0.1667						
4	-0.0105	-0.0945	-0.0730					
5	-0.0196	0.0163	0.2283	-0.0274				
6	-0.0115	0.0046	0.0594	0.1444	0.0179			
7	0.0003	0.2762	0.0568	-0.0321	-0.1208	0.0019		
8	-0.0142	-0.0415	0.2266	0.0404	0.3117	0.1112	0.1367	
9	-0.0099	0.0233	-0.0341	0.0345	-0.1165	0.0633	-0.0642	-0.1600

TABLE 11 FINAL COEFFICIENT VALUES

COEFFICIENT	FINAL VALUE	STANDARD ERROR	T RATIO
C11	0.2917	0.0480	6.07
C12	0.0219	0.0089	2.45
C13	0.1557	0.0340	4.58
C14	-0.5108	0.0477	-10.70
C21	0.3890	0.0637	6.10
C22	-0.3681	0.0443	-8.30
C31	0.0881	0.0193	4.55
C32	0.6840	0.1033	6.62
C33	-0.5205	0.0591	-8.81

of how they are actually applied in the logit form. In the actual logit form, the disutility has a negative sign; thus the signs are reversed. Therefore a negative sign means that a disutility has become a utility.

The signs of all the coefficients were checked for consistency with expected behavioral attitudes and whether they displayed reasonable trends. It was found that when travel time and cost increased, ridership declined; when comfort and convenience offered greater satisfaction, ridership increased.

The final model equations are

Ferry Mode:

$$du(1) = 0.2917\text{PRTR}F + 0.0219\text{ATIME}F + 0.1557\text{COST1}F - 0.5108\text{COMCO}F$$

Express bus mode:

$$du(2) = 0.3890\text{COST1}B - 0.3681\text{COMCO}B$$

Automobile mode:

$$du(3) = 0.0881\text{ATIME}A + 0.6840\text{COST1}A - 0.5205\text{COMCO}A$$

Statistical Tests

The UTPS/U-LOGIT program produced a series of statistical tests that aid in the evaluation of the quality of the model: standard error, T-ratio, equal and alternate dependent probability hypothesis, and pseudo R-square (Table 12).

Observed Versus Correctly Predicted Modal Split

This analysis tests the goodness of fit, measured as a percentage of correctly predicted trips. This percentage refers to the proportion of observations in which the mode of highest probability is also the mode of choice. This statistic provides a direct mode-by-mode indication of the ability of the model to simulate the individual choice process. The model correctly predicted 93 percent of the ferry passengers, 84 percent of the bus passengers, and 77 percent of the automobile users. These results for a small sample are excellent.

McFadden Success Predictions (MSP)

To further validate the model, the McFadden Success Predictions Method was used to calculate the probability of successful prediction for each of the three modes, using the 1/3 data set reserved for validation.

TABLE 12 STATISTICAL TESTS

TEST	ACCEPTABLE	ACTUAL	EXPLANATION
T-TEST	> 1.96	> 2.45	Final coefficient values are significantly different from zero
EQUAL PROBABILITY HYPOTHESIS	>16.92	950.2	Calibrated model is better than an equal share model (Chi-square)
ALTERNATE DEPENDENT PROBABILITY HYPOTHESIS	>16.92	704	Calibrated model is better than a model chosen in proportion to the number of passengers observed selecting the mode (Chi-square)
PSEUDO R-SQUARE LIKELIHOOD RATIO INDEX	.12 -.63	.75	How well the model fits the data

The MSP examines the proportion of successful predictions on an overall basis or by alternatives and gives a success index, which is obtained by normalizing the predicted success proportion by the samples' observed share. A success index of 1.0 indicates that the model predictions are no better than chance; values greater than one indicate greater predictive success. The indexes ranged from 1.76 for the ferry, 2.44 for the express bus, to 6.43 for the automobile (Table 13).

Conclusion

Based on the final results of the statistical test, it can be concluded that the model does an excellent job in predicting modal split for CBD-bound ferry, express bus, and automobile users. All tests exceeded minimum levels of acceptance, as established in the literature available.

DECISION ANALYSIS

The developed model estimated the effects of policy decisions on travel behavior of overall patronage caused by changes in time, cost, comfort, and convenience. This analysis consisted of estimating the modal split by changing the values of one or two independent variables. The results were estimates of the number of trips for the incremental change in the variable.

Ferry Time Variables

By varying travel time, the impact of introducing a faster ferry was considered. Speed was increased by reducing travel time by 20 percent; the higher speed attracted 16 percent more users, with 80 percent of the new users diverted from the express bus. A 50 percent reduction in travel time resulted in attracting 35 percent more users with a 78 percent diversion from the express bus.

Ferry access time was found to have a small impact on ridership. For example: a 75 percent reduction in ferry access time resulted in a 12 percent increase in ferry users, with 82 percent of the passengers diverted from the express bus. A 75 percent reduction in ferry travel time resulted in a 46 percent increase in ferry users, with 75 percent of the passengers diverted from the express bus. It should also be noted that a 75 percent reduction in the average ferry access time of 69 min was reduced by 49 min to 16 min, whereas for a 75 percent reduction in ferry travel time, the average in-vehicle time was reduced by 19 min to 6 min. It can be concluded that in-vehicle travel time was more important than access time. This was a big plus for high-speed ferry service.

Total Ferry User Trip Cost Indexed By Income

To evaluate the impact of increased total trip cost, the indexed cost of the ferry trip was varied. A 50 percent increase in total trip cost resulted in a 4 percent decline in the number of ferry users, with 87 percent of the users diverted to the express bus and 13 percent to the automobile. Every 55 percent increase in total trip cost resulted in an aproximate 4 percent decline in ferry ridership.

Ferry Comfort and Convenience Index

Improvements in the comfort and convenience index showed the greatest impact on ferry users. A 20 percent improvement in this index resulted in a 26 percent increase in the number of passengers attracted; conversely, a 20 percent decline in the index resulted in a 36 percent decline in the number of passengers using the mode. When the improvement in the index was 50 percent, a 44 percent increase in the number of passengers using the ferry mode resulted; conversely, a 50 percent decline in the index resulted in a 91 percent reduction in ferry users. It is noted that the express bus received the largest share of the passenger diversion.

The components that made up the comfort and convenience index include the subjective psychological characteristics of travel time, trip cost, safety from crime, seat comfort, and availability. The subjective characteristic that offers the greatest opportunity for improvement is travel time. Most passengers have an available seat, although in the peak rush hours a proportion of passengers are required to stand. The seats

TABLE 13 McFADDEN SUCCESS PREDICTION TABLE

	FERRY	EXPRESS BUS	AUTOMOBILE	OBSERVED COUNT	OBSERVED SHARE
FERRY	86	4	0	90	0.489
EXPRESS BUS	10	56	2	68	0.370
AUTOMOBILE	4	2	20	26	0.141
PREDICTED COUNT	100	62	22	184	1.000
PREDICTED SHARE	0.54	0.34	0.12	1.00	
PROPORTION SUCCESSFULLY PREDICTED	0.86	0.90	0.91	0.88	
SUCCESS INDEX	1.76	2.44	6.43	--	

in the ferry are either hardwood or formed plastic. In general, there is little or no crime except for violations such as smoking and loud radio playing. The cost of the ferry ride is minimal.

The index could be affected by an increase in the perceived travel cost, travel time, and in the crime rate. These would result in an index decline, which in turn would produce user losses.

Ferry Travel Time and Ferry User Total Trip Cost

The impact of varying both the principal mode time and the total trip cost indexed by income was evaluated. Ferry travel time was reduced by 5 min to determine its effect on ridership when total travel cost was increased. It was found that when ferry travel time was reduced by 5 min, total travel cost could be increased by 200 percent without a significant change in ridership. When the ferry travel time was reduced by 50 percent and a 300 percent increase in total cost was instituted, there was still a gain in ridership. This also reflects the trade-off between reduced travel time and increased trip cost, indicating the value of time in terms of the fare charged.

The joint effect of travel time and total trip cost on users indicates that ferry riders are not as sensitive to cost increases as other mode travelers. This can be attributed to the fact that a significant percentage of ferry users are captive riders, a lesser percent having the opportunity to divert to competitive modes. This is definitely not the case with express bus and automobile users, who are more sensitive to changes in cost. The express bus user was found to have minimum sensitivity to time.

PRACTICAL APPLICATION

The policy analysis results were used to determine a required fare level required to break even on the Staten Island Ferry operating expenses. The ferry currently has a 25 cent two-way fare. This fare generates $2,625,000 in revenue from 21,000,000 annual passengers. The operating budget for this analysis is approximately $29,000,000. The Staten Island Ferry earned approximately $3,000,000 from concessions and other nonfare sources; this left $26,000,000 to be recovered from the fare box. To meet the total operating cost based on this analysis, it was necessary to charge a one-way fare of $1.37. This fare takes into consideration the loss of users resulting from the fare increase.

The analysis indicates that ferry passengers are affected less by increases in the fare structure than they are by ferry travel time. A 50 percent increase in ferry travel time reduces ridership by 38 percent, whereas a 50 percent increase in the fare charged results in only a 4 percent decrease in ridership.

SUMMARY AND CONCLUSION

The model can be used to estimate the effects of policy decisions on travel behavior. The effects of these changes can be represented by changes in ridership. Because the study area is served by ferry, express bus, and automobile operating in direct competition with each other, the model is suitable for transfer to other locations with similar geographical configurations.

Publication of this paper sponsored by Committee on Ports and Waterways.