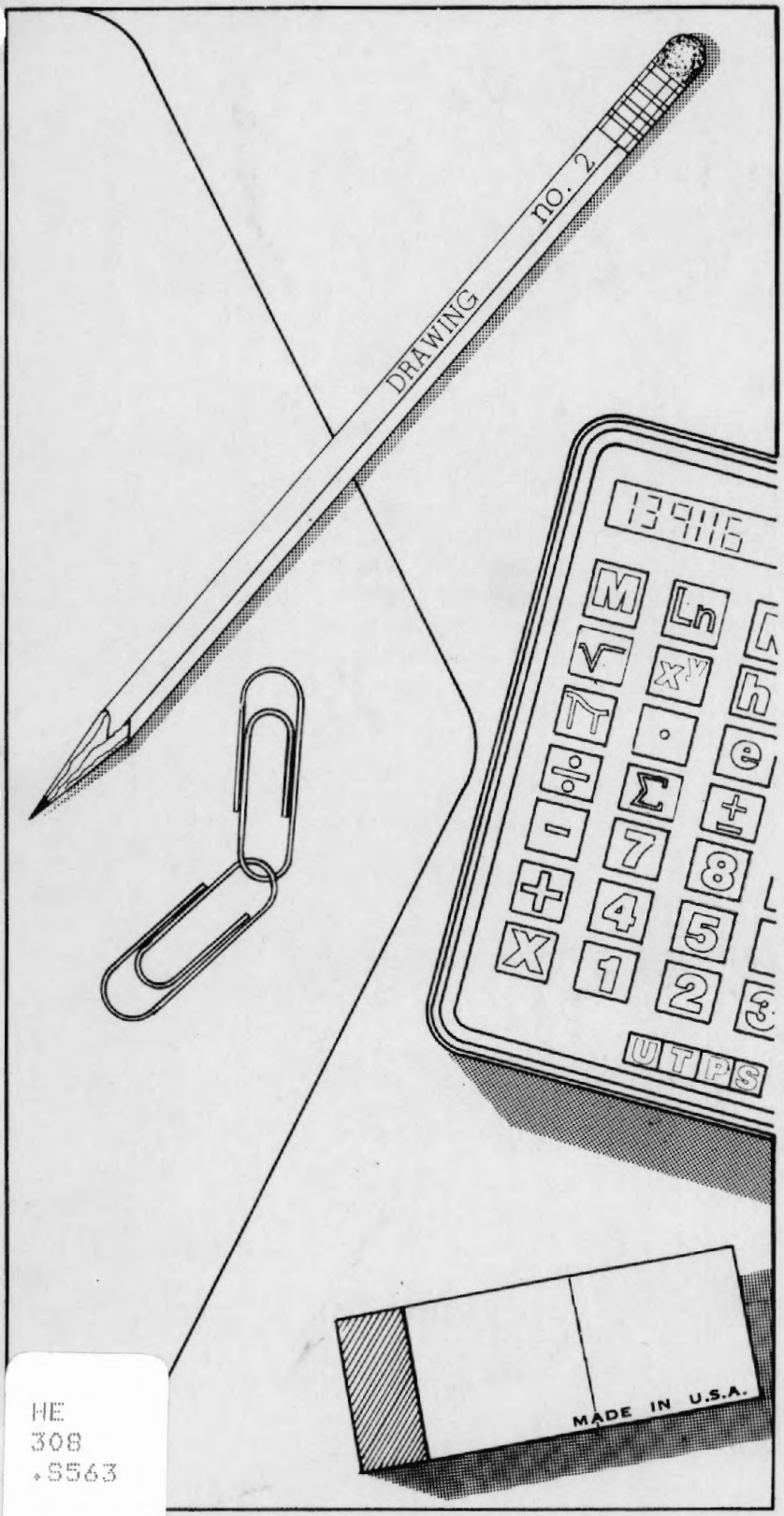

simplified aids for transportation analysis

estimating ridership and cost

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16. Abstract

In this report, an analytical aid is presented which provided a simple method for estimating the annual ridership and operating expenses of fixed-route bus system alternatives in urban areas with populations of less than 300,000. The method is based on regression equations generated principally from 1974 operating data for 55 U.S. fixed-route bus systems. These equations can be used to develop preliminary estimates of the annual ridership and public financial operating assistance required for such systems in small urban areas. The equations can be solved using a hand calculator and readily available data inputs.

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SIMPLIFIED AIDS FOR TRANSPORTATION ANALYSIS

Estimating Annual Ridership and Operating Expense for Fixed Route Bus Systems in Small Urban Areas

Prepared by
Peat, Marwick, Mitchell & Co.
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Based on Original Work Submitted by
John Collura

January 1979
Prepared for
U.S. Department of Transportation
Urban Mass Transportion Administration
Office of Planning Methods and Support

FOREWORD

Today's transportation planner confronts ever-changing issues within a variety of work environments. To assist him, UMTA's Planning Methods and Support Program researches, develops and distributes planning aids, including novel planning studies, and new design and forecasting techniques.

This is one of a series of six reports describing simplified aids to improve transportation decisions without resorting to computers or extensive data collection. The series, titled Simplified Aids for Transportation Analysis, presently includes the following titles:

1. Annotated Bibliography (UMTA-IT-06-9020-79-1)

2. Forecasting Auto Availability and Travel (UMTA-IT-06-9020-79-2)

3. Estimating Ridership and Cost (UMTA-IT-06-9020-79-3)

4. Transit Route Evaluation (UMTA-IT-06-9020-79-4)

5. Estimating Parking Accumulation (UMTA-IT-06-9020-79-5)

6. Fringe Parking Site Requirements (UMTA-IT-06-9020-79-6)

All are the work of recognized experts. They clearly present usable planning concepts, and add to the growing set of manual and computerized techniques comprising the UMTA/FHWA Urban Transportation Planning System (UTPS).

More important than the production and dissemination of new tools is the experience and opinion of their user. Local issues change. Better methods evolve. Or, realistically errors may appear in the final product. We depend on you, the transportation planner, to alert us to any of the above. We need your comments and your ideas. Please let us hear them, so we can continually improve our products.

You may obtain copies of any of the above reports from the National Technical Information Service (NTIS), Springfield, VA, 22161. On your request, please include the reference number in parenthesis.

Robert B. Dial, Director
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and Support (UPM-20)
Department of Transportation
Washington, DC 20590

ABSTRACT

In January 1976, the U.S. Department of Transportation issued a Technical Notice (DOT-1-76) requesting transportation planners, engineers, and transit operators to submit useful but not widely known manual techniques that could be developed and distributed as simplified aids for transportation analysis. Over 70 analytical aids were submitted in response to this request.

Based on an evaluation process conducted to determine the most useful, easily applied, and generally applicable techniques, several of these analytical aids have been selected and documented in sufficient detail to permit their immediate use. In addition to these techniques, three additional analytical aids were developed as part of the Short Range Transportation Planning project, and an annotated bibliography of each analytical aid reviewed was prepared. These individual analytical aids and the annotated bibliography have been prepared as separate reports and have been brought together in this manual of simplified aids for transportation analysis.

In this report, an analytical aid is presented which provides a simple method for estimating the annual ridership and operating expenses of fixed-route bus system alternatives in urban areas with populations of less than 300,000. The method is based on regression equations generated principally from 1974 operating data for 55 U.S. fixed-route bus systems. These equations can be used to develop preliminary estimates of the annual ridership and public financial operating assistance required for such systems in small urban areas. The equations can be solved using a hand calculator and readily available data inputs.

SOURCE

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REFERENCE

Considering Transportation Alternatives in Urban Areas in North Carolina: An Examination of the Ridership and Costs of Fixed Route Bus Systems, a research report prepared for the North Carolina Department of Transportation, Division of Mass Transportation, March 1976.

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I. INTRODUCTION

This report describes one of a collection of useful but not widely known manual techniques employed by local transportation planners, engineers, or transit operators. The technique presented in this report provides equations useful for determining order of magnitude estimates of the annual ridership and operating expenses of fixed-route bus systems in small urban areas. Sufficient information is provided to permit the immediate use of this analytical aid; this information is presented in three sections:

- I. Introduction. This section describes the analytical aid, its applicability as a simplified aid for transportation analysis, the data and information required to use the aid, and the analysis output.

- II. The Estimation Equations. This section describes the equations used to estimate annual ridership and operating expense for fixed-route bus systems.

- III. Using the Equations. This section presents an application example to illustrate the use of the estimating equations presented in Section I.

- IV. Shortcomings and Limitations. This section describes the shortcomings and limitations of this analytical aid to make the user aware of the limits of its applicability.

The technique reported here is oriented to the practical planner who requires a specific analytical technique but who has limited data and time to perform an in-depth analysis. The soundness of the method described in this report, however, must be considered independently by the potential user for each specific application. The section on shortcomings and limitations is provided to assist the potential user in making this assessment. Modifications, embellishments, and improvements to this technique are encouraged should local data or past analyses suggest a more appropriate procedure.

DESCRIPTION AND APPLICABILITY

In a research project for the the North Carolina Department of Transportation (NCDOT), an analysis was conducted of the ridership and operating expenses of fixed-route bus systems in 55 small urban areas (those with populations between 100,000 and 300,000). From this analysis, estimating relations were developed for calculating the annual ridership and annual operating expense of any similar system.

To conduct this analysis, 1974 operating data were collected from bus system operators through a nationwide telephone survey. The data were combined with secondary source data obtained primarily from the 1972 County and City Data Book, published by the U.S. Bureau of the Census. Statistical regression techniques were then used to determine what effects a variety of socioeconomic, transportation, and transportation-related characteristics had on the annual ridership and operating expenses of the systems analyzed. The resulting regression equations can be used to develop preliminary ridership estimates and thus to project requirements for public financial operating assistance for other fixed-route bus systems in similar environments.

NCDOT found the equations to be particularly useful in determining order of magnitude estimates of the ridership and operating expense that would result from proposed changes in existing systems throughout the state. These estimates permitted NCDOT to evaluate both the possible benefits for riders and the public financial commitment that would be required given each of a variety of level-of-service scenarios. They were also found to be useful, when assumptions were developed regarding the value of certain independent variables, in evaluating the advantages and disadvantages of new fixed-route alternatives.

DATA AND INFORMATION NEEDED

The data inputs needed for applying this analytical aid are defined in this subsection. The range of data used in the analysis and the use of these data for estimating annual ridership or annual operating expense are illustrated in Table 1 and Figure 1, respectively.

The input data and information requirements are as follows:

- Automobile Availability - measured as the percent of households in the city that have no automobile.

- Service Area Population - measured as the sum of the city population and the product of route miles extending beyond the city limits multiplied by the density of the population outside the city limits. This measurement approach assumes the following:

  - The density of population in the service area and outside the city limits is uniformly distributed.

  - The service area band around the transit route is one mile wide.

TABLE 1

SUMMARY OF INPUT DATA CHARACTERISTICS

VARIABLE	INPUT TO RELATIONSHIP FOR:		RANGE OF VARIABLES[1]	TYPICAL DATA SOURCE
	Annual Ridership	Annual Operating Expense		
Automobile Availability	X		5% to 35%	*County and City Data Book*
Service Area Population	X		90,000 to 280,000	*Data Book* or planning agency
Annual Revenue-Miles of Service	X	X	730,000 to 3,200,000	Transit operator
Average Fare	X		$0.10 to $0.45	Transit operator
System Improvement Index	X		−1 and +1	Transit operator
System Ownership Index		X	−1 and +1	Transit operator
Driver Wage Rate		X	$2.60 to $5.50	Transit operator

[1]Used in developing the estimating equations.

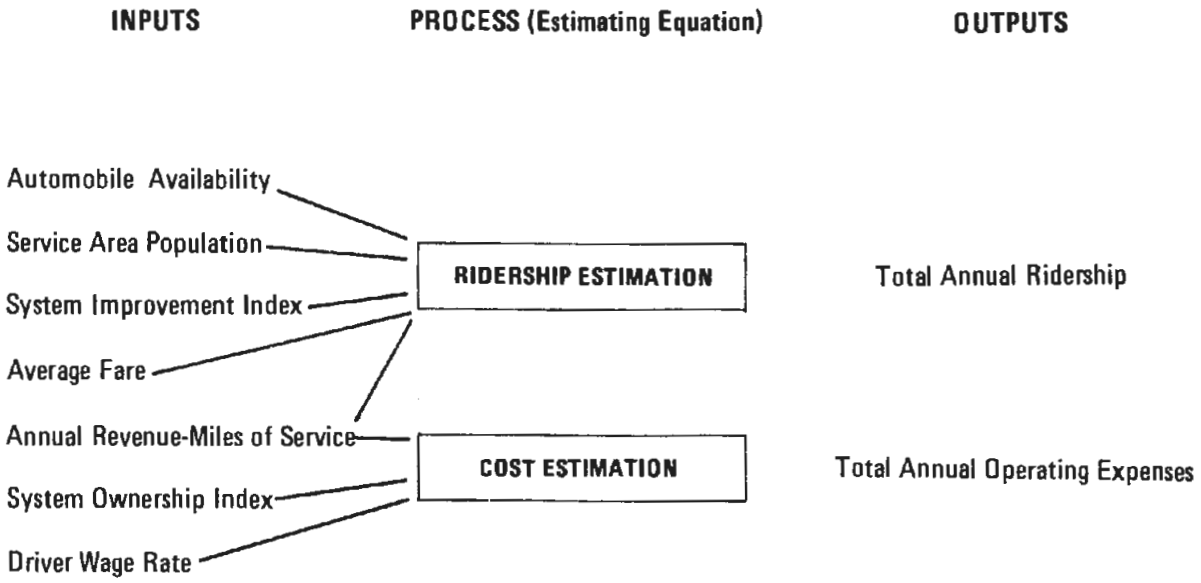

FIGURE 1: USE OF DATA INPUTS IN ESTIMATING EQUATIONS

- Annual Revenue Miles of Bus Service - measured for the entire system, but excluding deadhead mileage as well as charter, school, and other special operating mileage.

- Average Fare - measured as the ratio of total annual revenue to total annual ridership.

- System Improvement Index - a class variable for which each transit system is assigned a value: +1 for those systems which had implemented a capital improvement program prior to 1974 and -1 for those which had not. For the transit systems considered in this analysis, 38.2 percent were assigned a value of -1 and 61.8 percent were assigned a +1.

- System Ownership Index - a class variable for which each transit system is assigned a value: +1 indicates public ownership of the system and -1 indicates private ownership. For the transit systems considered in this analysis, 16.7 percent were assigned a value of -1 and 83.3 percent were assigned a +1.

- Driver Wage Rate - measured as the average hourly wage for drivers, excluding fringe benefits.

ANALYSIS OUTPUT

The primary purpose of this analytical aid is to produce two data items:

- Total Annual Ridership - measured as the total number of person-trips made on a regularly scheduled, fixed-route bus system in one year (a trip requiring one or more transfers is still considered a single trip). Charter, school, and other special bus operations are excluded. The range of annual ridership for the transit systems considered in this analysis was 674,606 to 10,991,945.

- Total Annual Operating Expense - measured as the cost of wages for drivers and other workers, taxes, fuel, tires, and other operating supplies. Expenses such as capital depreciation and capital costs for purchasing buses, bus shelters, and other related facilities and equipment are excluded. The range of annual operating expense for the transit operators considered in this analysis was $340,878 to $4,244,700.

Using these two basic data items, it is possible to derive several other statistics useful in planning and evaluating fixed-route bus systems. For example, an estimate of the annual operating revenue generated by the system can be determined by multiplying the estimate of total annual ridership by the average fare. Total annual revenue can be derived by adding this annual operating revenue estimate to the revenue from other operations such as charter and school service (available from other sources). If this total annual revenue estimate is deducted from the basic annual operating expense data item, the result is an estimate of the annual operating deficit or surplus.

It is this last measure that permits the community to assess the level of annual public financial assistance necessary to support the operation of the fixed-route system. The estimate of needed assistance can be combined with other system performance measures or with specific community characteristics to produce further statistics useful for planning and policy analysis of fixed-route system alternatives, such as:

- annual deficit per bus mile;
- annual deficit per passenger; and
- annual deficit per capita.

II. THE ESTIMATION EQUATIONS

In this section, two equations are presented, one for estimating the annual transit ridership and one for estimating the annual operating expense of fixed-route bus systems.[1]

ESTIMATING TRANSIT RIDERSHIP

The analysis of the data collected for this study indicated five variables to be statistically related to annual transit ridership. These variables included service area population, the percent of households with no automobile, total annual revenue-miles of service, average fare, and the quality of system improvements. Using statistical regression techniques, the relation between these five variables and annual transit ridership on a fixed-route bus system was estimated. The values of R^2 and n for this regression analysis were .80 and 47, respectively. The standard error of estimate of ln (ANRD) was 0.308 and the mean of ln (ANRD) was 14.7401. The resulting equation was:

$$ANRD = \frac{(SVOP)^{.66} \quad (HNCAR)^{.84} \quad (ANRTMI)^{.74} \quad (UCON)}{29.13(AFAR)^{.81}}$$

where:

ANRD = annual transit ridership (in millions)

SVPOP = service area population

HNCAR = percent of households with no car

ANRTMI = annual revenue miles of bus service

AFAR = average fare (in cents)

UCON = converted system improvement index

$= e^{.11U}$, where

e = base of natural logarithm = 2.71828

U = system improvement index

---

[1] A brief description of the analyses conducted to determine these equations is summarized in the Appendix.

Therefore, UCON = 1.11628 if U is +1

= 0.89583 if U is -1

ESTIMATING TRANSIT OPERATING EXPENSE

The analysis of the data collected for this study indicated that four variables were statistically related to annual transit operating expense. These variables included total annual revenue-miles of bus service, average driver wage rate, type of system ownership, and service area population density. Due to the gross measurement used to estimate service area population density, however, this variable was dropped from consideration in the regression analysis.

Using statistical regression techniques, the relation between the remaining three independent variables and annual operating expense was estimated. The values of R^2 and n for this analysis were .78 and 37, respectively. The standard error of estimate was 413,205.88 and the mean of ANXP was 1,502,793.32. The resulting equation was:

ANXP = -1,142,794.13 + .83(ANRTMI) + 3605.61(DRWAGE) + 183667.81(M1)

where: ANXP = annual operating expense

ANRTMI = annual revenue miles of bus service

DRWAGE = average driver wage rate

M1 = type of ownership (+1 or -1)

III. USING THE EQUATIONS

In this section, an application example is presented to illustrate the use of the equations described in Section II.

Given the following conditions, calculate (1) the preliminary annual ridership estimate, (2) a preliminary annual operating expense estimate, and (3) the approximate annual public financial operating assistance requirement:

- service area population (SVPOP) = (sum of city population and the product of route miles extending beyond the city limits multiplied by the population density outside the city limits) = 200,000;
- percent of households with no car (HNCAR) - 11 percent;
- annual revenue-miles of bus service (ANRTMI) - 1,300,000;
- average fare (AFAR) = 20 (cents);
- system improvement index (U) = +1 (capital improvement program had been implemented prior to 1974);
- type of system ownership (M1) = +1 (public ownership); and
- average driver wage (DRWAGE) = 425 (cents/hour).

Annual Ridership Estimate

$$UCON = e^{.11(U)} = 1.11628$$

$$ANRD = \frac{(SVPOP)^{.66} \quad (HNCAR)^{.84} \quad (ANRTMI)^{.74} \quad (UCON)}{29.13 \ (AFAR)^{.81}}$$

$$= \frac{(200,000)^{.66} \quad (11)^{.84} \quad (1,300,000)^{.74} \quad (1.11628)}{29.13 \ (20)^{.81}}$$

= 2.7 million passengers per year

Annual Expense Estimate

$$ANXP = -1,142,794 + .83 \ (ANRTMI) + 3605.61 \ (DRWAGE) + 183,667 \ (M1)$$

$$= -1,142,794 + .83 \ (1,300,000) + 3605.61 \ (425) + 183,667 \ (1)$$

= $1,652,000 per year

Annual Public Operating Assistance Estimate

Annual Operating Revenue (ANREV)[1] = (ANRD) (AFAR)

= (2,700,000) (20)

= 54,000,000 cents

= $540,000

Annual Public Operating Assistance Estimate

= ANXP - ANREV

= 1,652,000 - 540,000

= 1,112,000

Annual Public Operating Assistance Estimate Per Capita

$$= \frac{\text{ANXP - ANREV}}{\text{SVPOP}}$$

$$= \frac{1,652,000 - 540,000}{200,000}$$

= $5.56 per person

[1]Assuming no other revenue.

IV. SHORTCOMINGS AND LIMITATIONS

When deciding if the methods described here for estimating annual ridership and operating expense for fixed-route bus systems are applicable in a particular situation, the user should be aware of the limitations of the techniques. These limitations fall in the following areas:

- level of detail of the estimates;
- validity of calibration data;
- area variations and transferability; and
- logic of estimating equations.

LEVEL OF ESTIMATE DETAIL

The estimates derived from both the ridership and expense equations are intended for use only in a preliminary or first-cut analysis of alternative bus systems. They are systemwide estimates with minimal sensitivity to route locations, service frequencies, hours of service, and transit travel times. As such, they cannot be substituted for the detailed ridership or cost estimates required for system design, or for the route-specific estimates required for evaluating proposed service improvements.

VALIDITY OF CALIBRATION DATA

The collection of the calibration data used in this analytical aid was extensive. It is difficult, however, to obtain valid and consistent technical data for a wide variety of transit systems from a telephone survey. There is no assurance, therefore, that the data reported is in fact valid and consistent. Furthermore, the data were collected for 1974. No analysis was conducted to determine whether the relationships continue to be valid over time. If current year data is used in the cost estimating relationships, however, at least a portion of the effects of time will be incorporated by the driver wage rate input. No further adjustment is necessary as long as the estimates are used for preliminary or first-cut estimates.

AREA VARIATIONS AND TRANSFERABILITY

Because the data were collected from transit systems throughout the United States, the calibrations performed should be representative of

national averages for ridership and operating expenses. However, due to variations in social, economic, and geographic conditions and in specific transportation characteristics among cities throughout the country, the relationships may not be representative for a given area. They are nevertheless suitable for preliminary analyses in any location.

LOGIC OF ESTIMATING EQUATIONS

The two final estimating equations were derived as a result of several successive model formulation trials. The regression statistics indicate that the relationships are statistically valid and the two equations generally describe logical relationships betwen the inputs and outputs. The value of the constant in the annual operating expense equation does, however, warrant caution because of its large negative value relative to the observed mean of annual operating expense. This indicates that relatively low values of estimated annual operating expense are influenced more by the large negative constant rather than by the independent variables which should have the greater causal effect.

APPENDIX

DESCRIPTION OF ANALYSES CONDUCTED TO DETERMINE ESTIMATING EQUATIONS

APPENDIX

DESCRIPTION OF ANALYSES CONDUCTED TO DETERMINE ESTIMATING EQUATIONS

The principal source for the data used to conduct the analysis of annual transit ridership and operating expense was a telephone survey of transit operators across the United States. The 55 transit operators that responded to this survey are listed in Table A-1. The data obtained in this survey was combined with selected secondary source data to conduct a series of regression analyses.

For the analysis of annual transit ridership, 19 independent variables were considered in the original specification of the estimating equation. Using this set of variables, three successive regression analyses were conducted to determine the best relation for estimating the annual ridership of fixed-route bus systems. The results of the final analysis are shown in Table A-2.

Similarly, for the analysis of annual transit operating expenses, seven independent variables were originally considered, and two successive regression analyses were conducted. The final results of this analysis are shown in Table A-3.

The variables used in the analysis, both dependent and independent, are described below. The full title of each variable is followed by its acronym and a detailed definition.

DEPENDENT VARIABLES

Total Annual Ridership (ANRD) - This variable is measured as the total number of person trips made on a regularly scheduled, fixed-route bus system in one year (a trip requiring one or more transfers between buses is still considered a single trip). Charter, school, and other special bus operations are excluded. The data for this variable were collected through the telephone survey.

Total Annual Operating Expense (ANXP) - This variable is measured as the cost of wages for drivers and other workers, taxes, fuel, tires, and other operating supplies. Expenses such as capital depreciation and capital costs for purchasing buses, bus shelters, and other related facilities and equipment are excluded. The data were collected through the telephone survey.

TABLE A-1

TRANSIT OPERATORS RESPONDING TO TELEPHONE SURVEY

Mobile, Alabama	Lansing, Michigan
Bakersfield, California	Saginaw, Michigan
Fresno, California	Duluth/Superior, Minnesota
Santa Barbara, California	Jackson, Mississippi
Stockton, California	Springfield, Missouri
Pueblo, Colorado	Albuquerque, New Mexico
New London, Connecticut	Trenton, New Jersey
Waterbury, Connecticut	Charlotte, North Carolina
Pensacola, Florida	Greensboro, North Carolina
Columbus, Georgia	Winston-Salem, North Carolina
Savannah, Georgia	Canton, Ohio
Champaign/Urbana, Illinois	Lorain-Elyria, Ohio
Peoria, Illinois	Eugene, Oregon
Rockford, Illinois	Erie, Pennsylvania
Evansville, Indiana	Harrisburg, Pennsylvania
Fort Wayne, Indiana	Lancaster, Pennsylvania
South Bend, Indiana	Reading, Pennsylvania
Cedar Rapids, Iowa	Charleston, South Carolina
Des Moines, Iowa	Columbia, South Carolina
Topeka, Kansas	Chattanooga, Tennessee
Lexington, Kentucky	Knoxville, Tennessee
Baton Rouge, Louisiana	Amarillo, Texas
Shreveport, Louisiana	Austin, Texas
Brockton, Massachusetts	Corpus Christi, Texas
Lowell, Massachusetts	Lubbock, Texas
New Bedford, Massachusetts	Waco, Texas
Worcester, Massachusetts	Spokane, Washington
Ann Arbor, Michigan	Madison, Wisconsin
Kalamazoo, Michigan	

TABLE A-2

FINAL REGRESSION ANALYSIS OF ANNUAL RIDERSHIP AND SELECTED INDEPENDENT VARIABLES

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F	R-SQUARE	C.V.
REGRESSION	5	18.36772017	3.67354403	33.77108	0.0001	0.80462739	2.23753 %
ERROR	41	4.45988980	0.10877780				
						STD DEV	LANRD MEAN
CORRECTED TOTAL	46	22.82760997				0.32981480	14.74010

SOURCE	DF	SEQUENTIAL SS	F VALUE	PROB>F	PARTIAL SS	F VALUE	PROB>F
LSVPOP	1	11.56750565	106.34068	0.0001	0.80586212	7.40833	0.0095
LHNCAR	1	2.20243602	20.24711	0.0001	2.06414374	18.97578	0.0001
LANRTMI	1	2.46732581	22.68226	0.0001	2.68859785	24.71642	0.0001
U	1	0.02812171	0.25852	0.6139	0.40363964	3.71068	0.0610
LAFAR	1	2.10233099	19.32684	0.0001	2.10233099	19.32684	0.0001

SOURCE	B VALUES	T FOR HO: B=0	PROB>|T|	STD ERR B	STD B VALUES
INTERCEPT	–3.37192793	–1.75064	0.0875	1.92611476	0.0
LSVPOP	0.65788552	2.72183	0.0095	0.24170748	0.29852605
LHNCAR	0.83586556	4.35612	0.0001	0.19188304	0.36675037
LANRTMI	0.74380842	4.97156	0.0001	0.14961265	0.56756690
DUMMY001	0.10552883	1.92631	0.0610	0.05478281	0.14551476
LAFAR	–0.80555359	–4.39623	0.0001	0.18323736	–0.37214893

NOTE: Variable names beginning with L indicate natural logarithm of variable indicated; e.g., LSVPOP = ln(SVPOP).

TABLE A-3

FINAL REGRESSION ANALYSIS OF ANNUAL OPERATING EXPENSE AND SELECTED INDEPENDENT VARIABLES

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F	R-SQUARE	C.V.
REGRESSION	3	2.22018873237D 13	7.40062910788D 12	38.65875	0.0001	0.77848820	29.11462 %
ERROR	33	6.31734679700D 12	1.91434751424D 11				
						STD DEV	ANXP MEAN
CORRECTED TOTAL	36	2.85192341207D 13				437532.57184391	1502793.32432

SOURCE	DF	SEQUENTIAL SS	F VALUE	PROB>F	PARTIAL SS	F VALUE	PROB F
ANRTMI	1	1.91995675498D 13	100.29301	0.0001	1.360832912700 13	71.08599	0.0001
DRWAGE	1	2.33443228235D 12	12.19440	0.0014	2.18457032688D 12	11.41157	0.0019
MI	1	6.67887491491D 11	3.48885	0.0707	6.67887491491D 11	3.48885	0.0707

SOURCE	B VALUES	T FOR HO:B=0	PROB>|T|	STD ERR B	STD B VALUES
INTERCEPT	−1142794.13374528	−2.57847	0.0146	443206.00822892	0.0
ANRTMI	0.83350099	8.43125	0.0001	0.09885852	0.72255652
DRWAGE	3605.61220574	3.37810	0.0019	1067.34885721	0.28881985
DUMMY001	183667.81276761	1.86785	0.0707	98331.30175341	0.15422321

INDEPENDENT VARIABLES

These variables are divided into three types: (1) the site specific characteristics of the service area, (2) related automobile/highway system characteristics, and (3) bus system service characteristics.

Site Specific Characteristics of the Service Area

Region of the Country (REG) - This characteristic was measured using a three-level class variable. Level 1 includes urban areas in Federal Standard Regions I, II, III, and V. Level 2 is Region IV. Level 3 comprises Regions VI, VII, VIII, IX, and X.

Age of Individuals in the Service Area (EAGE and PYAGE) - Two interval variables were used for this measurement: (1) the percent of the total city population that is 65 years of age or older, for EAGE; and (2) the percent of the total population that is less than 18 years old, for PYAGE. The data were obtained from the 1972 County and City Data Book, published by the U. S. Bureau of the Census.

University Community (PCOLLS) - This was defined as the percent of the city population composed of college students. The data were obtained from the 1972 County and City Data Book, published by the U. S. Bureau of the Census.

Income (PFMP and MDINC) - This was measured using two interval variables: (1) the percent of families in the city earning less than 125 percent of the poverty level, for PFMP; and (2) the median family income, for MDINC. The data were taken from the 1972 County and City Data Book, published by the U. S. Bureau of the Census.

Employment (IEMP, GEMP, and WCEMP) - This was defined using three interval variables: (1) the percent of people in the city employed in industry, for IEMP; (2) the percent of people employed in government, for GEMP; and (3) the percent of employees who were white-collar workers, for WCEMP. The data for these variables were obtained from the 1972 County and City Data Book, published by the U. S. Bureau of the Census.

College Education (COLLED) - This variable was measured as the percent of the population with four or more years of college education. The data source was the 1972 City and County Data Book, published by the U. S. Bureau of the Census.

Automobile/Highway System Characteristics

Automobile Availability (HNCAR) - This was measured as the percent of households in the city with no automobile, using data from the 1972 County and City Data Book, published by the U.S. Bureau of the Census.

Amount of Roads in the Community (RDMIC) - This variable was measured using the miles of roads per capita. The data were obtained from the 1967 National Highway Classification Study, published by the U.S. Department of Transportation.

Bus System Service Characteristics

Service Area Population (SVOP) - This variable was measured as the sum of the city population and the product of route miles extending beyond the city limits times the density of the population outside the city limits.

Size of Area Served (AREA) - This variable was measured using the total square miles of the approximate service area. The data were obtained from both the telephone questionnaire and the 1972 County and City Data Book.

Population Density (POPDEN) - This variable was calculated by dividing the service area population (SVPOP) by the size of the area served (AREA).

Frequency of Bus Service (H) - This was measured using a four-level class variable. Level 1 includes systems with 15-minute peak headways and 30-minute or greater off-peak headways. Level 2 includes systems with 20- to 30-minute peak headways and 30- to 45-minute off-peak headways. Level 3 covers systems with 30-minute peak headways and 45-minute off-peak headways. Level 4 includes systems with both peak and off-peak headways of 45 minutes or more. The data were collected in the telephone survey.

Amount of Bus Service (ANRTMI) - This variable was measured using the total annual revenue-miles of bus service. Deadhead, charter, school, and other special bus operations were excluded. The data were obtained from the telephone questionnaire.

Fare Policy (FARE, AFAR, D, P) - This was described using both interval and class variables. The interval variables were: (1) the regular adult cash fare in cents (FARE), and (2) the average fare

in cents calculated by dividing total annual revenue by total annual ridership (AFAR). The first class variable, D, described the reduced fare program for the elderly, the handicapped, and the young. For this variable, Level 0 included systems with no reduced fare programs, Level 1 included systems with a reduced fare program for one of these groups, and Level 2 covered systems with a program for at least two of the groups. The second class variable, P, described special fares offered to the general public through weekly, monthly, or yearly passes. Level 0 was for systems which did not offer such passes, while Level 1 included those which did. The data describing each bus system's fare policy were collected through the telephone survey.

Index of System Improvement Quality (U) - This was described using a two-level class variable. Level 1 included bus systems which had not implemented a capital improvement program prior to 1974, while Level 2 included those which had done so. A capital improvement could include new buses and possible new bus shelters, bus stop signs, and maintenance garages. Information on these programs was obtained through the telephone survey and from the list of "Capital Grant Approvals" maintained by the Urban Mass Transit Administration of the U. S. Department of Transportation.

Type of Ownership and Operation (M and M1) - This was described using two class variables. One of these, M, had three levels: Level 1 for bus systems under private ownership and operation; Level 2 for systems under public ownership, but private operation; and Level 3 for systems under public ownership and operation. The two levels for the other class variable, M1, were: Level 1 for bus systems under private ownership and Level 2 for publicly owned systems. The data were collected through the telephone survey.

Driver Wage Rate (DRWAGE) - This variable was measured using the average hourly wage for drivers in each bus system in 1974 (excluding fringe benefits). These data were obtained through the telephone survey.

Daily Hours of Service (HRPDA) - This variable was measured as the average number of hours per weekday that service was provided by a system. The data for this variable, reported as 12, 16, 18, or 24 hours per day, were collected through the telephone survey.

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