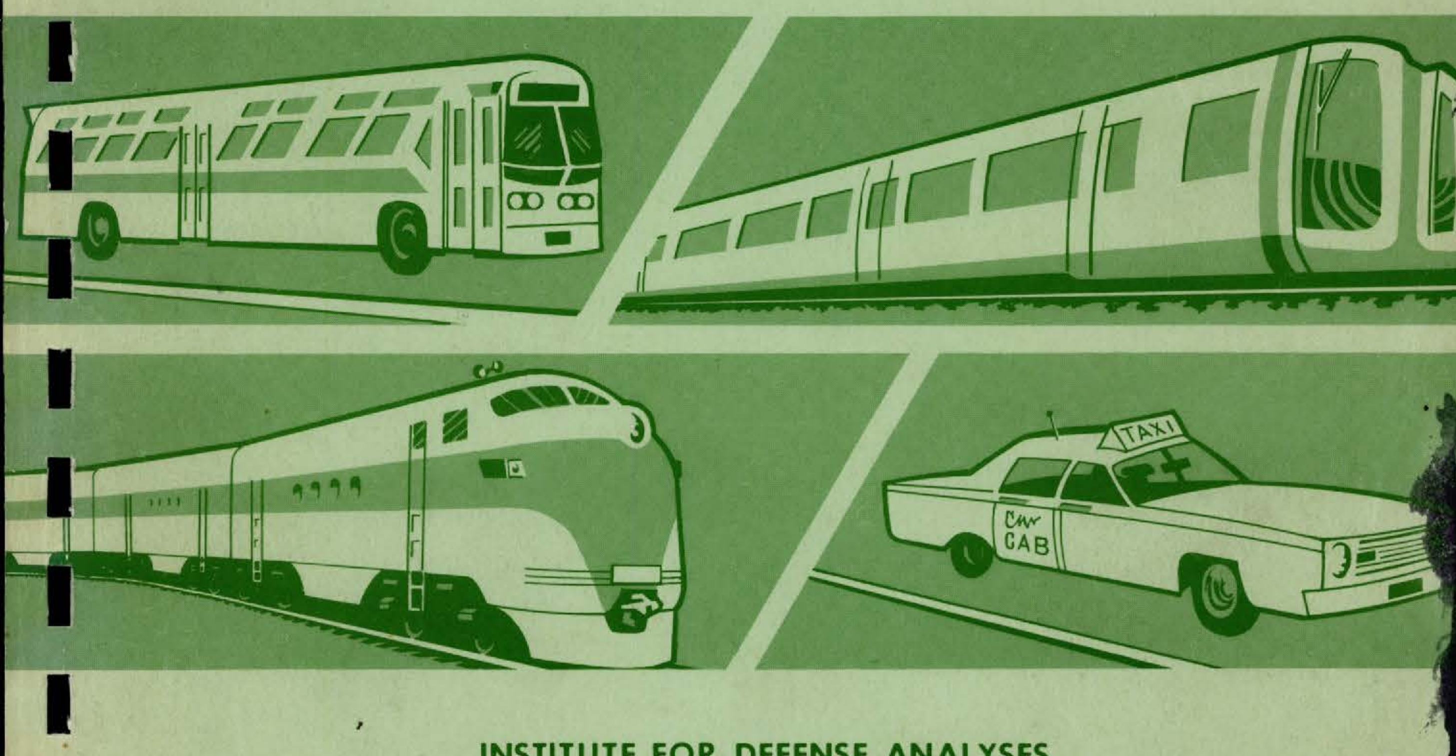
ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY



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ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY

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FOREWORD

Since September 1970, the Institute for Defense Analyses has been under contract with the Department of Transportation to perform a general study of the economic behavior of the urban public transit industry.[1] The project comprised two complementary tasks. The first was to develop a computerized data bank of economic information on the operations of bus transit, rail rapid transit, commuter rail transit, and taxicab firms. The second was to analyze and interpret this information to determine the economic characteristics of the industry. The papers in this study present the results of the latter task.

In reading these papers, it is important that the reader be aware that virtually all of the information collected comes from secondary sources. The bus and rail rapid transit data were provided by the American Transit Association (ATA). This was supplemented by information from individual companies, but the format and definitions were the same as those of the ATA. The information on commuter rail operations came from the ATA, individual companies, and the Interstate Commerce Commission. The taxicab information was provided by the International Taxicab Association. Most of the data are annual aggregates, not daily operational data; therefore, the orientation of the analyses must be rather general, and very few inferences can be drawn with respect to individual company operations.

By design, the papers are empirically oriented. The objective is to indicate what appear to be the emerging patterns of economic behavior and to document this behavior so that others may also

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1. The contract is under the cognizance of the Office of Systems Analysis and Information in the Office of the Assistant Secretary for Policy and International Affairs.

speculate on the implications. We have avoided purely theoretical discussions except where they are essential to the understanding of the analytical methodology.

The reader will find an imbalance in the treatment of the various transit modes because many more data were available for bus transit operations than the other modes; consequently, more time was spent in analysis of bus transit operations. We hope this imbalance will be corrected in the future.

We wish to take this opportunity to thank Mr. Edward Weiner of the Office of Systems Analysis and Information who served as the project monitor for this contract. Mr. Weiner's positive attitude regarding the project and his willingness to take the necessary time to provide frank and thorough evaluations of the effort are greatly appreciated.

In addition, this project could not have been completed without the assistance of many individuals within the American Transit Association, the International Taxicab Association, and the officials of various transit systems in the United States and Canada. Their interest in this project demonstrates their keen desire to obtain more information about urban public transit as an industry. We thank them for their cooperation and hope that the papers will help to fill some of the gaps in the understanding of the industry's behavior patterns.

Special thanks are due to Mrs. Rebecca McMorrow, the Project Secretary, who has spent long hours typing, proofreading, and generally keeping things organized throughout the project.

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PART ONE

INTRODUCTION AND OVERVIEW

CHAPTER I

INTRODUCTION

A. URBAN PUBLIC TRANSIT, A DECADE OF DECLINE

Over the last decade and generally since the end of World War II, the urban public transit industry in the United States has suffered economic decline.[1] Even though fares have more than kept pace with the Consumer Price Index (see Table 1.1), patronage of public transit has declined or has not grown rapidly enough to offset increases in operating costs. As a result, more and more systems have experienced operating deficits and many privately owned systems have either ceased to operate entirely or have sold their depleted operations to the municipalities they served. For temporary relief, other systems have cut back service, increased fares, or both. Still others obtained relief through local operating subsidies or capital grants, but the pressure of decline seems relentless, regardless of the nature and degree of aid that has been provided.

1. PRIMARY CAUSE OF THE DECLINE

The deficiency in demand can be traced to several interdependent causes. A basic cause is the rapid growth of urban population outside the central cities in which most public transit systems are located (see Table 1.2). From 1960 to 1970, the population outside central cities increased by 33.5 percent as against 1.5 percent in central cities. In the latter year, population outside central cities actually exceeded that in central cities by about 14 million persons.

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1. The term "public" in public transit refers to the right of any person to ride the vehicle upon payment of the proper fare. It does not refer to the ownership of the system. There are both publicly and privately owned "public" transit systems.

Table 1.1

INDEXES OF PUBLIC TRANSIT FARES
ANNUAL AVERAGE 1964-1970

Year	Basic Indexes[1]			Converted to 1965 = 100			
	All Public Transit[2] 1957-59 = 100	Local Transit[3] 1957-59 = 100	Taxicabs Dec. 1963 = 100	All Public Transit	Local Transit	Taxicab	Consumer Price Index
1964	119.0	122.8	101.9	98.0	97.9	97.5	98.3
1965	121.4	125.4	104.5	100.0	100.0	100.0	100.0
1966	125.8	130.9	109.9	103.6	104.4	105.2	102.9
1967	132.1	140.2	116.7	108.8	111.8	111.7	105.8
1968	138.2	148.2	121.7	113.8	118.2	116.5	110.3
1969	148.9	160.4	126.7	122.7	127.9	121.2	116.2
1970	169.5	188.6	134.2	139.6	150.4	128.4	123.1

Source: 1. U.S. Department of Labor, Bureau of Labor Statistics, Handbook of Labor Statistics, 1968, Table 108, p. 250, and February issues of Monthly Labor Review, 1969, 1970, 1971.

2. Includes airline, Intercity rail, Intercity bus, as well as urban transit.

3. Bus and rail rapid transit.

Table 1.2

POPULATION SHIFTS IN THE UNITED STATES
1960 TO 1970

(Population in Millions)

Area	1960	1970	Change	
			Number	Percent
United States	178.7	202.5	23.8	13.4
Metropolitan Areas	112.4	131.5	19.1	17.0
Inside Central Cities	57.8	58.6	0.8	1.5
Outside Central Cities	54.6	72.9	18.3	33.5
Nonmetropolitan Areas	66.3	71.0	4.7	7.1

Source: U.S. Department of Commerce, Bureau of the Census, Social and Economic Characteristics of the Population in Metropolitan and Nonmetropolitan Areas: 1970 and 1960. (Current Population Reports, Series P 23, No. 37, June 24, 1971.)

Suburban living in the United States is, of course, automobile-oriented. Housing and population densities are low, and for those who work in the central city, distances from home to work are long. In suburbia there are many places to go and things to do, and parking space is usually available. Moreover, because of the low population densities and large number of origins and destinations, conventional public transit normally cannot operate profitably, and therefore is usually not available to the suburbanite even if he wants it. Thus, the typical American family's dream of having its own house in the suburbs, along with car(s), dog(s), etc. is being fulfilled, but evidently to the disadvantage of urban public transit.[1]

2. CHANGES IN AUTOMOBILE OWNERSHIP

The increasing dependence and desire for the automobile is shown clearly in Table 1.3. Both per-capita and per-household ownership increased from 1960 to 1970. Moreover, the percent of households having two or more cars has increased markedly. This has important consequences for public transit, for one of the cars of a multi-car family is usually used by the wage earner for transportation to work and back. These home-to-work and return auto trips are impinging on a key revenue-generating source of public transit.

Table 1.3 also shows that the percentage of households with no automobile, another source of demand for public transit, has declined. However, in 1970, 20 percent of the households were still in this category. The highest concentrations of no-car households are in the low-income brackets, the older age groups, the urbanized Northeast region, and in central cities (see Table 1.4).

Table 1.5 supports the point that there are greater concentrations of no-car families in the Northeast cities. Highest concentrations appear in the New York, Philadelphia, Boston, Pittsburgh,

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1. This dream, of course, could not be fulfilled without a general rise in real family income. Moreover, there are many other economic and sociological reasons for the movement to the suburbs.

Table 1.3

AUTOMOBILE OWNERSHIP, 1960 AND 1970

Item	1960	1970
Automobiles in Use		
Per Capita	0.32	0.39
Per Household	1.09	1.27
Percent of Households Owning Automobiles	75.5	79.6
One Automobile Only	62.1	50.3
Two or More Automobiles	13.4	29.3
Percent of Households With No Automobile	24.5	20.4

Source: Automobile Manufacturers Association, Inc., Automobile Facts and Figures, 1968 and 1971. Data estimated by the Association from Census information

Table 1.4

HIGHEST AND LOWEST CONCENTRATIONS OF NO-CAR HOUSEHOLDS, 1970

Characteristics	Percent of Households With No Car
ALL HOUSEHOLDS	20.4
HOUSEHOLD INCOME:	
Under $3,000	57.5
$15,000 and over	3.8
AGE OF HOUSEHOLD HEAD:	
65 and over	44.8
35 to 44	11.6
REGIONS:	
Northeast	27.5
West	14.9
RESIDENCE:	
Metropolitan	
In Central Cities	34.0
Outside Central Cities	12.2
Nonmetropolitan	
Nonfarm	17.5
Farm	12.8

Source: Automobile Manufacturers Association, Inc., Automobile Facts and Figures, 1968 and 1971. Data estimated by the Association from Census information.

Table 1.5

OWNERSHIP OF CARS IN SELECTED METROPOLITAN AREAS, 1970

Standard Metropolitan Statistical Area	Percent of Households Owning		
	No Car	One Car	Two or More Cars
New York	41.2	40.4	18.4
Los Angeles-Long Beach	17.2	45.1	37.7
Chicago	28.3	50.0	21.7
Philadelphia	27.0	45.3	27.7
Detroit	15.5	48.3	36.2
San Francisco-Oakland	19.9	47.3	32.8
Boston	28.6	47.7	23.7
Pittsburgh	29.1	51.4	19.5
St. Louis	24.7	47.8	27.5
Washington, D. C.	24.5	44.6	30.9
Cleveland	19.0	47.9	33.1
Minneapolis-St. Paul	12.8	46.6	40.6
All Households	20.4	50.3	29.2

Source: Automobile Manufacturers Association, Inc., Automobile Facts and Figures, 1968 and 1971. Data estimated by the Association from census information.

and Washington, D. C., standard metropolitan statistical areas. Chicago and St. Louis also have higher-than-average concentrations. Many of the midwestern and Western cities have well-below-average concentrations. What is perhaps most surprising about the figures in Table 1.5 is that the percentages of no-car families is very low even in the Northeast cities. Except for New York, every metropolitan area has a car ownership ratio exceeding 70 percent!

Thus, it appears that public transit industry is not providing an acceptable alternative to the automobile, especially in suburban areas. Moreover, as will be shown in subsequent sections, the problem has been compounded by increasing fares and (to a lesser extent) reduced service, two factors that make the automobile alternative even more attractive. Accordingly, an unfortunate cycle has developed which, unless checked, will lead to the demise of many transit systems.

B. THE FOCUS OF THIS STUDY

The general problems of the urban public transit industry described above are well known to students of urban transportation. What are not as well known are the specifics of the economic condition of the individual firms or classes of firms that comprise the industry. Is the decline in ridership general throughout the industry, or is it concentrated in specific sectors or geographic areas? Is the cost structure similar for all firms? Are there scale economies in bus transit operations? Are privately owned operations more efficient than publicly owned operations? What has been happening with respect to service levels and resource inputs? What is the effect of regulation on system operations? These are the questions that must be answered before solutions to the general problems can be found and the questions that are addressed in this study.

The study is organized into five parts. Part One contains this introduction and a general overview of the findings. Because this latter section is designed to be a self-contained, nontechnical presentation of the economic characteristics of the industry, the reader will find some repetition of the tabular material in subsequent sections. The next three Parts contain individual papers, each dealing with economic aspects of a particular mode of urban public transit. The three papers in Part Two are concerned with urban bus transit. The two papers in Part Three analyze rail rapid transit and commuter operations, respectively. Taxicab operations are examined in Part Four. Finally, the single paper in Part Five presents an analysis of three of the external costs of public transit, the air pollution, noise pollution, and accident costs.

Most of the papers are empirical. Emphasis is on the analysis and interpretation of statistical information on a large number of individual companies obtained from the American Transit Association, the International Taxicab Association, agencies of the U. S. and Canadian Governments, and individual companies. Perhaps the main contribution of the study is that, for the first time, a large data bank of economic statistics on the industry has been collected, computerized, and an attempt made to uncover the industry's economic intricacies.

CHAPTER II

ECONOMIC CONDITIONS IN THE URBAN PUBLIC TRANSIT INDUSTRY: AN OVERVIEW

A. GENERAL INDUSTRY COMPOSITION

It is important at the outset to note the relative sizes of the various components of the urban public transit industry and their distinguishing characteristics. There are five major modes of urban transit, four of which (bus, rail, trolley coach, and commuter rail) are regarded as "mass" transit; the other (taxicab) is considered to be "personalized" transit. The difference between mass transit and personalized transit is primarily in the passenger capacity of the vehicle and whether or not the operations are scheduled. Buses and rail cars are designed to haul large numbers of persons on a regular basis; however, some nonscheduled operations, e.g., additional vehicles to handle the peak hour rush, are included in the mass-transit concept. Taxicab transit is personalized and the trip is usually generated on demand, i.e., either by hailing a cruising cab, or by telephoning or prearranging cab service. There are, of course, some activities that have the character of both mass transit and personalized transit, e.g., charter and airport limousine services.

In 1970, taxicabs hauled more passengers than the combined total of the rail, trolley coach, and commuter rail, and more than one-half as many as the bus mode. (See Table 2.1.) Revenues for the taxicab mode were larger than the combined total of the mass transit modes. There are, of course, far more individual taxicab companies than mass transit companies and the former are dominated by small operations. In 1970 there were over 7,200 taxicab fleet operations, all privately owned, serving about 3,300 communities or "jurisdictions" that regulate taxicab operations. In many communities, taxicabs are the only form of public transportation available.

Table 2.1

SELECTED URBAN TRANSPORTATION ANNUAL STATISTICS, 1970

	All Modes	Taxicab	Bus, Rail, and Trolley Coach				Commuter Rail[b]
			Total	Bus	Rail[a]	Trolley Coach	
Revenue Passengers (Millions)	8,557	2,378	5,932	4,058	1,746	128	247
Percent of all-mode total	100.0	27.8	69.3	47.4	20.4	1.5	2.9
Passenger Revenue (Millions of Dollars)	4,065	2,221	1,639	1,194	415	30	205
Percent of all-mode total	100.0	54.6	40.3	29.4	10.2	0.7	5.0
Revenue miles traveled (Millions)	-	3,417	1,884	1,409	441	33	d
Number of vehicles (Thousands)	-	170	62	50	11	1	d
Average employment level (Thousands)[c]	-	111	138	d	d	d	d

[a] Includes elevated and subway rail rapid transit, grade-separated surface rail, and streetcar operations.

[b] Urban passenger rail service provided by railroad companies.

[c] Taxicab employment believed to be underestimated.

[d] Not available.

Source: For bus, rail, and trolley coach data: American Transit Association, 1970-71 Transit Fact Book.

For taxicab data: International Taxicab Association, American Automobile Association, Bureau of Labor Statistics, Employment and Earnings, United States 1909-70 (Bulletin 1312-7). Employment figures are believed to be understated.

For commuter rail: Interstate Commerce Commission, commuter railroad companies and several independent studies.

Compared to taxicab fleet operations, there are far fewer bus, rail, and trolley coach transit systems, and public ownership plays a more important role, especially in the larger cities (see Table 2.2). Although only 141 (13 percent) of the 1,079 mass transit systems existing in 1970 were publicly owned, these 14 systems accounted for at least 80 percent of all passengers, revenues, and employees. Rail rapid operations are almost 100 percent publicly owned. Private ownership is more prevalent in the smaller bus operations.

Private ownership of bus, rail, and trolley coach systems has been declining over the last decade as has the total number of systems (see Table 2.3). According to the American Transit Association, there were 146 fewer systems on December 31, 1970 than on the same date in 1959; however, there were 235 fewer private systems. This is because many of the private systems were taken over by the local municipalities. The result was a net increase of 89 publicly owned systems.

To sum up, movement of passengers by public transit vehicles in urban areas is accomplished by both mass transit and personalized transit operations. The latter form of transit cannot be ignored, because passenger movement by this means is about equivalent to that of the larger mass-transit operations. Private ownership of public transit dominates the industry in terms of number of systems, but the large-scale operations in big cities are mostly publicly owned and haul over 80 percent of the bus, rail, and trolley coach passengers. This information on the relative size and ownership of companies within the industry should be kept in mind when the summaries presented in subsequent sections are evaluated.

Table 2.2

PUBLIC OWNERSHIP IN THE BUS, RAIL, AND TROLLEY COACH TRANSIT INDUSTRIES, 1970

Item	Total	Publicly Owned	Publicly Owned as Percent of Total
Number of Systems	1,079	141	13
Annual Revenue Passengers (Billions)	5.9	4.8	81
Annual Operating Revenue ($ Billions)	1.7	1.4	80
Annual Vehicle Miles (Billions)	1.9	1.3	68
Number of Employees (Thousands)	138.0	113.2	82
Passenger Vehicles Owned (Thousands)	61.4	40.8	66
Motor buses	49.7	29.3	59
Subway and elevated rail cars	9.3	9.3	100[a]
Surface railway cars	1.3	1.2	93
Trolley coaches	1.1	0.9	88

[a]Thirty cars are privately owned.

Source: American Transit Association Supplement to the 1970-71 Transit Fact Book.

Table 2.3

OWNERSHIP OF BUS, RAIL, AND TROLLEY COACH SYSTEMS, December 31, 1959 through December 31, 1970

Year	Total	Private	Public
Number			
1959	1,225	1,173	52
1964	1,152	1,073	79
1967	1,138	1,040	98
1968	1,094	980	114
1969	1,086	955	131
1960	1,079	938	141
Change			
1959-64 (Average per Year)	-15	-20	+5
1965-57 (Average per Year)	-4	-11	+6
1968	-44	-60	+16
1969	-8	-25	+17
1970	-7	-17	+10
Total Change 1959 through 1970	-146	-235	+89

Source: American Transit Association Supplement to the 1970-71 Transit Fact Book.

B. URBAN BUS TRANSIT

1. THE PROFIT "SQUEEZE"

Over the last decade, urban bus transit firms have been experiencing a profit "squeeze" that has forced many to go out of business or to turn their operations over to their respective municipalities. Table 2.4 shows the situation for samples of firms that were in existence in both 1960 and 1969.[1] Median revenue actually declined by 3 percent, but median operating expenses increased by 22 percent. Drivers' wages increased faster than the other major components. Drastic declines occurred in the number of passengers--undoubtedly the main cause for the decline in revenue.[2] Service levels, on the other hand, did not decline as rapidly as the number of passengers, for route and line miles remained about the same, the number of buses declined only slightly, and bus miles decreased about 10 percent. Reductions in the number of employees also occurred.

This profit squeeze seems to typify the industry, but small properties (companies) appear to be worse off than larger properties.[3] In both 1960 and 1969 a much larger percentage of small properties (those with annual revenues under $1 million) were not able to cover operating costs with revenues (see Table 2.5). When depreciation

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1. Medians were used to minimize the effects of extreme values.

2. Fare changes were not examined on a comparable basis but Table 2.7 indicates that revenue per passenger increased by about 50 percent.

3. Because some systems are publicly owned, the terms "company" or "firms" may be misnomers. To avoid confusion, the industry uses the term "property" to signify individual systems. These three terms will be used interchangeably from this point on.

Table 2.4

MEDIAN PERCENT CHANGE FOR SELECTED BUS COMPANY OPERATING STATISTICS, 1960 TO 1969

Variable	Median Percent Change
Total Operating Revenue	-3
Passenger Revenue	-5
Charter Revenue	+133
Total Operating Expenses	+22
Maintenance Expenses	+18
Transportation	+28
Driver's Wages	+31
Administrative and General	+19
Line Miles	0
Route Miles	0
Number of Buses	-2
Number of Employees	-14
Bus Miles	-10
Number of Passengers	-32

Table 2.5

FINANCIAL CONDITION OF BUS PROPERTIES, 1960 AND 1969

Item	1960	1969
Number of Properties in the Sample	78	52
Percentage of Properties Where Revenues Did Not Cover Total Operating Costs, Including Depreciation		
All Properties	22%	54%
Properties with Revenues Less than $1 Million	34%	70%
Percentage of Properties Where Revenues Did Not Cover Total Operating Costs (Less Depreciation)		
All Properties	7%	33%
Properties with Revenues Less than $1 Million	12%	48%

is included in the operating cost concept, 54 percent of the properties had deficit positions as compared to 70 percent for the small properties. When depreciation is excluded from cost, the relative situation is about the same.[1]

2. DESCRIPTION OF 1960 AND 1969 SAMPLES

The information in Table 2.5 was obtained from two separate samples of properties selected for the years 1960 and 1969. It will be helpful at this point to examine the characteristics of these samples (see Table 2.6).

First, the properties in the samples were selected on the basis of data availability; they are not random samples. Second, the 1969 sample includes some, but not all, of the properties in the 1960 sample; therefore, direct comparisons are not possible, and the samples should be regarded as two separate cross-sections of the industry for the two years. Finally, the properties in the sample were classified according to their annual revenue so that the effects of size can be examined. Note in Table 2.6 that there is a strong correlation between other indicators of firm size such as buses owned, number of employees, number of passengers, and annual revenue, so that these indicators can be used interchangeably to indicate size.[2] Annual revenue was selected for convenience.

3. REVENUE AND COST RATIOS

The figures in Table 2.7 verify the fact that small firms (firms with revenues under $1 million) tend to be worse off than large firms. In both 1969 and 1960, the ratio of operating costs to revenues (the so-called "operating ratio") was considerably larger

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1. Depreciation procedures vary considerably within the industry.

2. All correlation coefficients exceed .9. City population is also highly correlated with these variables.

Table 2.6

GROUP MEDIANS OF SELECTED ANNUAL OPERATING STATISTICS, BY REVENUE SIZE GROUP, 1960 AND 1969

Variable	All Properties	Annual Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1969					
Number of Properties in Sample	52	23	18	7	4
Operating Revenue ($ thousands)	1,199	454	1,842	6,879	16,806
Operating Cost[a] ($ thousands)	1,171	502	1,998	6,265	17,430
Passengers (thousands)	4,308	2,304	6,947	2,905	88,211
Bus Miles (thousands)	2,024	931	2,835	8,454	23,357
Buses Owned	72	40	110	276	647
Employees	129	56	190	577	1,319
Line Miles	111	59	162	290	538
Route Miles	248	134	314	712	2,015
1960					
Number of properties in Sample	78	41	29	5	3
Operating Revenue ($ thousands)	898	365	1,699	6,112	36,202
Operating Costs[a] ($ thousands)	809	291	1,505	5,282	32,872
Passengers (millions)	5,167	2,005	9,571	4,046	257,612
Bus Miles (millions)	1,904	801	2,873	10,034	28,989
Buses Owned	57	26	99	309	1,127
Employees	108	47	188	671	3,359
Line Miles	84	46	131	235	349
Route Miles	172	96	267	493	894

[a] Excludes depreciation.

Table 2.7

GROUP MEDIANS OF REVENUE AND COST RATIOS, BY REVENUE SIZE GROUP, 1960 AND 1969

Ratio	All Firms	Annual Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1969					
Properties in sample	52	23	18	7	4
Operating cost[a]/operating revenue (percent)	94.5	98.9	92.6	90.7	93.9
Revenue per passenger (cents)	23.9	22.6	24.9	26.3	22.2
Cost per passenger (cents)	23.5	23.5	24.2	26.0	20.8
Revenue per bus-mile (cents)	64.6	54.4	66.9	79.8	84.8
Cost per bus-mile (cents)	63.3	57.8	64.6	75.7	79.5
1960					
Properties in sample	78	41	29	5	3
Operating cost[a]/operating revenue (percent)	91.2	93.8	89.2	85.5	90.0
Revenue per passenger(cents)	16.8	15.0	18.3	16.9	14.8
Cost per passenger (cents)	15.1	14.1	16.1	14.4	13.0
Revenue per bus-mile (cents)	50.3	44.9	56.7	68.4	71.9
Cost per bus-mile (cents)	46.6	41.2	51.7	59.7	63.1

[a]Excludes depreciation and amortization.

for small firms. Note also that the operating ratio was lowest for the properties in the $5 to $10 million revenue bracket.

The reason for the relatively poor profit performance of the small properties is not the high cost of supplying service. In both 1969 and 1960, cost per bus-mile was lower for the smaller firms.[1] Rather, it appears that the problem is in the smaller firm's relative inability to attract passengers. In both 1960 and 1969, cost per passenger for the small firms was higher than for the largest firms,[2] whereas revenue per passenger (weighted average of fares) was at about the same level for both small and large firms. Note also that differences in revenue per bus-mile are greater than differences in cost per bus-mile.

4. PASSENGER DENSITY AND PRODUCTIVITY

Table 2.8 confirms the demand deficiency of the smaller properties. All of the passenger density and productivity figures are lower for the smaller operations. The table also shows that all passenger density and productivity ratios have declined over the 10-year period, and that this is true regardless of the size of firm. Note that the number of passengers per bus has declined drastically, despite the fact that the average size of bus has increased. Evidently, the industry has not tailored vehicle size to passenger density. Whether or not it should, of course, is a complex issue that was not examined as part of this study.

5. SYSTEM SERVICE LEVELS AND PRODUCTIVITY

Service levels involve several aspects: frequency of service, time in transit, accessibility to bus stops, length of scheduled

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1. Wage rates tend to be lower in smaller cities than in larger cities; therefore, they tend to be lower for smaller firms.

2. The fact that the cost per passenger for the small firms is equal to the median is due to rounding.

Table 2.8

GROUP MEDIANS OF SELECTED BUS PASSENGER DENSITY AND PRODUCTIVITY INDICATORS, BY REVENUE SIZE GROUP, 1960 AND 1969

Ratio	All Properties	Annual Revenue ($ Millions)			
		Under 1	1 and Under 5	5 and Under 10	10 and Over
Properties in sample					
1960	78	41	29	5	3
1969	52	23	18	7	4
Passengers per line-mile (000)					
1960	74.2	57.9	79.6	202.9	324.9
1969	50.0	32.4	38.8	79.3	123.0
Passengers per route mile (000)					
1960	34.6	29.5	34.9	101.2	98.1
1969	18.2	16.2	21.7	31.2	44.8
Passenger per bus-mile					
1960	3.07	2.95	3.17	4.14	4.87
1969	2.58	2.58	2.44	2.89	4.23
Passengers per bus-hour[a]					
1960	36.76	32.45	37.76	40.84	50.84
1969	29.90	26.71	30.27	34.21	49.60
Passengers per employee (000)					
1960	47.7	47.4	47.1	50.3	60.5
1969	41.3	39.6	41.4	41.9	53.9
Passengers per bus (000)					
1960	96.1	80.2	100.6	130.4	144.0
1969	67.2	61.0	70.2	97.1	129.4
Seats per bus					
1960	37.1	35.0	40.0	44.8	44.6
1969	44.2	40.5	44.3	50.8	48.8

[a] Based on reduced sample.

Note: Line miles refer to the one-way street mileage over which the buses run, regardless of the number of routes. Route miles refer to the round-trip mileage of each bus route. Route miles would be twice line miles if there were no multiple routes on the streets.

operation, comfort of ride, and other qualitative aspects of the bus trip. Unfortunately, the available statistics could provide only rough indications of changes in these variables. Buses per line- or route-mile give an indication of frequency of service. Table 2.9 shows that, for all properties in the sample, median buses per line-mile declined slightly, and buses per route-mile remained about the same. The medians for the properties in the individual revenue-size groups all appear to have declined, especially in the larger operations.[1]

One measure of time-in-transit is the reciprocal of average bus-miles per hour for the property over a given period.[2] Bus-miles per hour are given in Table 2.10 for a reduced sample of properties. Evidently, there has been a slight increase over the decade for all revenue size groups, and the differences between the groups are slight.

Returning again to Table 2.9, note that the annual number of miles per bus (a measure of bus use) has changed only slightly. Smaller firms appear to have lower bus utilization than larger firms, and the differences appear larger in 1969. Note further that the number of employees per bus has declined. This is undoubtedly a reflection of a decline in nondriver personnel. The reductions appear to be greater for the smaller firms. Finally, the average age of the bus fleets has increased in all size groups.

To sum up, all of the statistics appear to be consistent with what would be expected for a declining industry. Largely as a result of declining demand (caused by competition from the automobile), the revenue-generating capability of bus properties has declined. Costs have increased at a faster rate than revenue, primarily

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1. However, the sample sizes for the two larger groups are very small and may yield deceptive results in year-to-year comparisons.

2. Both bus-miles and bus-hours include all miles and hours during which the bus is out of the garage. This includes mileage and time when the bus is not on its route and waiting time at route terminals. The ratio, therefore, cannot be regarded as a direct measure of time in transit.

Table 2.9

GROUP MEDIANS OF SELECTED BUS SERVICE AND PRODUCTIVITY INDICATORS, BY REVENUE SIZE GROUP, 1960 AND 1969

Ratio	All Properties	Annual Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
Properties in sample					
1960	78	41	29	5	3
1969	52	23	18	7	4
Buses per line-mile					
1960	.76	.60	.76	1.63	2.26
1969	.71	.55	.66	.99	1.13
Buses per route-mile					
1960	.34	.30	.35	.77	.68
1969	.34	.28	.34	.44	.35
Bus-miles per bus (000)					
1960	29.6	28.9	30.8	32.2	29.6
1969	29.4	24.1	29.4	30.5	36.1
Bus-miles per employee (000)					
1960	14.9	16.0	14.8	12.5	12.4
1969	15.9	16.2	16.1	14.0	14.7
Average age of bus fleet					
1960	9.6	10.1	10.0	6.7	7.4
1969	10.9	11.3	12.1	7.1	8.5
Employees per bus					
1960	1.97	1.80	2.05	2.37	2.45
1969	1.72	1.55	1.83	2.21	2.40

Table 2.10

GROUP MEDIANS OF BUS MILES AND PASSENGERS PER BUS HOUR, BY REVENUE SIZE GROUP, 1960 AND 1969

Ratio	All Properties	Annual Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
Properties in sample					
1960	51	20	24	4	3
1969	45	21	14	6	4
Vehicle miles per vehicle hour					
1960	10.98	10.95	11.08	10.43	10.45
1969	12.00	11.68	11.95	11.13	12.04
Passengers per vehicle hour					
1960	36.76	32.45	37.76	40.84	50.84
1969	29.90	26.71	30.27	34.21	49.60

because properties have maintained about the same service levels even in the face of declining demand. Such cutbacks in resource inputs as have been made have not been great enough to counter the demand deficiency.

6. CHARACTERISTICS OF DEMAND AND SUPPLY

The econometric model developed as part of this study has yielded some interesting results based upon a sample of 51 bus properties, each of which is the only mass transit operation in the city, i.e., there are no competing bus or rail rapid transit operations. This "selective" sample makes it possible to observe the demand and supply effects on bus transit when the competition comes only from taxicabs and private automobiles.

a. Demand Characteristics

With respect to demand (defined as the number of bus passengers), the analysis yielded the following results for 1968:[1]

(1) At a given fare level, properties that provided higher bus-miles per capita experienced higher patronage. This suggests that improved service levels will, indeed, attract riders.

(2) The number of passengers does, in fact, decrease with increases in fare, and the elasticity (percentage change in demand relative to a percentage change in fare) at the average fare of 22 cents in 1968 was about -.67. This means that, at an original fare of 22 cents, a 10 percent increase in fare can be expected to yield a 6.7 percent decline in passengers. The industry's rule-of-thumb is a decline of 3 percent in passengers for an increase of 10 percent in fares, a figure which apparently underestimates the fare impact.

(3) Bus patronage is higher in cities where the proportion of persons in the 19 to 64 age group is higher. This reflects the likelihood that the chief use of mass transit is for work trips and the primary beneficiaries of bus transit are members of the labor force.

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1. The year 1968, rather than 1969, was used to provide information required by the Department of Transportation for 1968.

(4) Bus patronage is lower in cities where the proportion of households in the low-income range (under $3,000) is higher and the proportion of households in the high-income range ($10,000 and above) is higher. Some of the reasons for the lower ridership by the poor may be: (a) unemployment in this group is higher, (b) they lack funds to ride, (c) they tend to live within walking distance of their work place, (d) transit service is not accessible.

The lower ridership by persons in high-income households is undoubtedly linked to their greater use of the automobile for transit.

b. Supply Characteristics

The analysis of the supply side yielded the following results for 1968:

(1) The firms that experienced the highest ratio of total cost to total passenger revenue were private firms owned by power companies and public firms operated by cities.[1] Private firms regulated by local municipalities, state-regulated firms, and firms operated by transit authorities had lower ratios.

An important factor in high ratios of cost to revenue is the ability to subsidize transit operations. Power companies presumably subsidize bus operations with revenue from other operations, while city governments are able to subsidize operations from other sources. There is no evidence that firms with high ratios also have high unit costs.

(2) In systems where such subsidization occurs, the firm may encourage ridership either by constraining fares or promoting service levels. Supply estimates reveal that firms with high cost-to-revenue ratios tend to operate with lower fares but not significantly higher levels of service.

(3) There do not appear to be economies or diseconomies of scale in bus transit. The major differences in unit

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1. Total costs here include operating costs plus plant and equipment investment recovery costs plus a normal return on investment. They do not include so-called "social overhead" costs.

costs that are observed between small and large operations are explained by differences in wage rates.

(4) Unit costs of publicly owned firms are not higher than privately owned firms and, in fact, tend to be lower.

7. EFFECTS OF REGULATION

Privately owned transit companies are regulated by various state and local agencies, and very often the same principles of regulation developed by such agencies are applied to publicly owned companies. Basically, regulators attempt to control the levels of fare and service rendered, and they act to limit competition in urban transit markets.

Fares are often based on a fixed rate of return to the company. Sometimes fares are based on a fixed operating ratio. Service is regulated through controls on the alteration, expansion, and abandonment of routes and the frequency of service. Competition is restrained by controlling the issuance of certificates of public convenience and necessity, which convey the legal right to supply transit services.

Theoretical analysis indicates that fare and service regulation of a monopolistic transit supplier can bring about higher levels of ridership and/or service than without such regulation. However, given an operating ratio constraint, it is generally impossible to maximize both ridership and level of service. At some point the regulatory authority is forced to trade off higher fares, fewer riders, and more extensive and frequent service against lower fares, increased ridership, and lower service levels.

An inflexible regulatory framework with respect to service levels and entry may limit the transit system's ability to respond to changes in population patterns and the nature of demand for public transportation. It is also possible that a regulatory constraint on maximum earnings will seriously weaken management incentives to produce given levels and qualities of service at least cost.

C. URBAN RAIL RAPID TRANSIT

Rail rapid transit systems are defined in this study as rail facilities operating within urban areas on exclusive rights-of-way, whether below ground or on the surface. Included are surface systems such as the "high-speed trolleys" which usually have their own rights-of-way, but which operate, to some extent, on regular streets or cross roads at grade level. Rail rapid transit systems generally use vehicles that are lighter and capable of higher acceleration than the conventional railroad equipment used by commuter rail systems. The latter are usually operated by regular interstate railroad corporations as part of their overall railroad activities; whereas the former are normally operated by municipalities, either separately or as part of an overall system devoted exclusively to people movement in urban areas.

The following 10 systems in the United States conform to this definition.

- New York City Transit Authority
- Chicago Transit Authority
- Massachusetts Bay Transit Authority (MBTA)
- Southeastern Pennsylvania Transportation Authority (SEPTA)
- Port Authority Trans Hudson Corporation (PATH)
- Port Authority Transit Corporation of Pennsylvania and New Jersey (Lindenwold Line)
- Cleveland Transit System
- Shaker Heights Department of Transportation (in Cleveland)
- Public Service Coordinated Transport, Newark
- Staten Island Rapid Transit Railway Company

The analysis covers the first nine of these systems--data were not available for the Staten Island system--and two Canadian systems, Toronto Transit Commission and Montreal Urban Community Transit Commission.

1. RELATIVE SIZE OF THE SYSTEMS

Regardless of the size indicator used, New York is by far the largest system (see Table 2.11). In 1970, it accounted for well over 75 percent of the revenue, revenue passengers, and passenger car-miles of the nine U.S. systems studied. The Chicago system is about one-eighth as large and occupies an intermediate position between New York and a group of three properties (Massachusetts Bay Transit Authority, Southeastern Pennsylvania Transportation Authority, and Port Authority Trans Hudson Corporation), which are about the same size. The Toronto and Montreal systems are also in the size range of the latter three U.S. systems. Cleveland and Lindenwold are about the same size, and Shaker Heights and Newark are the smallest operations. In any case, there is a wide spectrum of sizes of operations, and these relationships (especially New York's dominance) should be kept in mind whenever "industry" aggregates are examined.

2. TRENDS IN U.S. OPERATIONS 1960-1970

The trends in rail rapid transit are almost identical to those of bus transit, although the economic decline is perhaps not as severe. Table 2.12 shows that the industry has also had a revenue-cost squeeze. Revenues have not increased as rapidly as costs. As a result, the aggregate operating deficit for eight properties has increased from \$.4 million in 1960 to \$80.2 million in 1970 (New York accounted for \$56 million of the 1970 deficit).[1] The number

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1. The Lindenwold Line began operations in 1969. Operating profits equal operating revenues-operating costs (excluding depreciation). This concept measures the ability of the system to (cont'd)

Table 2.11

PERCENT DISTRIBUTION OF SELECTED OPERATING STATISTICS FOR U. S. RAIL RAPID TRANSIT PROPERTIES, 1970

Property	Total Revenue	Revenue Passengers	Passenger Car-Miles	Active Passenger Cars	Total Miles of Single Track
Total U. S.	100.0	100.0	100.0	100.0	100.0
New York	76.1	78.7	78.4	69.9	58.2
Chicago	9.6	6.6	11.2	12.6	16.8
MBTA	6.1	6.3	2.9	7.2	10.5
SEPTA	3.9	3.9	3.3	4.9	4.0
PATH	2.3	2.4	2.0	2.5	2.4
Cleveland	0.6	0.9	1.0	1.2	3.0
Lindenwold	0.8	0.5	0.8	0.8	2.4
Shaker Heights	0.4	0.3	0.3	0.6	2.1
Newark	0.2	0.2	0.1	0.3	0.6

Note: Figures may not total 100 due to rounding.

Table 2.12

CHANGES IN TOTAL U.S. RAIL RAPID TRANSIT OPERATIONS, 1960-1970
(Excludes Lindenwold Line)

Operating Characteristics	1960	1970	Actual Change	Percent Change
Revenue Passengers (millions)	1,713.9	1,588.4	-125.5	-7.3
Total Revenue ($ millions)	292.4	510.9	218.5	74.7
Operating Expenses ($ millions)[a]	292.8	591.1	298.3	101.9
Gross Profit (Deficit)($millions)	(0.4)	(80.2)	-79.8	
Passenger Car-Miles (millions)	395.4	455.5	60.1	15.2
Active Passenger Cars	9,300	9,833	533	5.7
Total Miles of Single Track	1,374	1,411	37	2.7

[a]Excluding capital depletion allowances and interest on debt.

of passengers has declined by about seven percent, but the physical capacity (active passenger cars and miles of single track) and number of passenger car-miles have increased slightly.

With respect to the individual systems (see Table 2.13), six of the eight U.S. systems that existed in 1960 suffered passenger declines (on the average) over the eleven-year period. Seven of the eight properties experienced the revenue cost squeeze, i.e., higher rates of growth in costs than in revenues. The Toronto system, on the other hand, experienced passenger increases, and rates of increase in costs were lower than for revenues.

The pattern of changes in physical capacity and car-miles is mixed (see Table 2.14). Most of the U.S. properties had slight increases in capacity, but five of the eight systems had average declines in passenger car-miles. Toronto had high positive growth rates for all three variables.

The net effect of the changes in the demand and operating variables is a general deterioration in operating profits or increases in operating deficits. Table 2.15 presents the "operating ratio" (operating costs/operating revenues) for all the properties over the full 1960 to 1970 period. Almost all systems experienced a general increase in the ratio. Some, e.g., New York and Chicago, have nearly always operated at a ratio of 1.0 or greater, but the ratios have generally become larger, especially in recent years. This means that the systems will require additional financial assistance in some form if they are to continue operating at the same levels; otherwise they will have to revise their operations. The former implies operating subsidies or increased fares (which will probably lead to a further decline in passengers), or, perhaps both. The latter suggests reorganization to obtain efficiencies in operation or to stimulate demand, or both. Usually, it means curtailing or eliminating service on unprofitable runs.

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operate "out of the fare box." If capital depletion allowances and interest on debt are added to operating costs, the profit picture becomes even worse.

Table 2.13

AVERAGE RATES OF CHANGE PER YEAR IN REVENUE PASSENGERS, TOTAL REVENUE AND OPERATING EXPENSES, 1960-1970 (PERCENT)

Property	Revenue Passengers	Total Revenue	Operating Expenses
New York	-0.29	2.07	2.88
Chicago	-0.18	2.00	2.11
MBTA	-0.37	1.76	2.42
SEPTA	-0.53	1.41	1.63
PATH	0.98	1.90	4.24
Cleveland	-0.75	1.36	2.91
Shaker Heights	-0.98	1.18	1.70
Newark[a]	0.27	2.93	1.88
Toronto	5.72	8.11	7.23

[a] For the 10 years 1961-1970.

Note: Rates of change should be interpreted as compounded rates; i.e., they are estimates of the parameter, b, in the equation

$$Y = a \cdot x^b$$

where Y is the variable, x (=1, 2, ... n) denotes the order of years.

Table 2.14

AVERAGE RATES OF CHANGE PER YEAR IN PASSENGER CAR-MILES, ACTIVE PASSENGER CARS, AND MILES OF SINGLE TRACK, 1960-1970 (PERCENT)

Property	Passenger Car-Miles	Active Passenger Cars	Miles of Single Track
New York	0.69	0.38	0.03
Chicago	0.39	-0.03	0.70
MBTA	-0.46	0.17	-0.19
SEPTA	-0.71	-0.35	-0.41
PATH	2.50	0.80	2.77
Cleveland	-0.17	1.26	1.11
Shaker Heights	-0.15	0.00	0.00
Newark[a]	-0.37	-0.34	0.00
Toronto	6.15	4.78	8.36

[a]For the 10 years 1961 through 1970.

Table 2.15

OPERATING RATIOS OF RAIL RAPID TRANSIT PROPERTIES, 1960 THROUGH 1970

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	1.01	1.03	1.04	1.11	1.13	1.10	1.16	1.11	1.24	1.28	1.14
Chicago	1.00	1.02	.99	1.00	1.00	1.03	1.03	1.00	.99	.98	1.11
MBTA	1.04	1.01	.93	.95	.96	.98	.99	.95	1.01	1.06	1.32
Toronto	.86	.91	.94	1.00	.90	.90	.96	.84	.81	.73	.76
SEPTA	.92	.88	.92	.93	.89	.88	.88	.90	.91	.92	1.02
Montreal							.57	.62	.84	.82	.84
PATH	.98	.98	1.10	1.25	1.39	1.66	1.65	1.61	1.59	1.53	1.57
Cleveland	.87	.87	.94	1.05	1.12	1.10	1.16	1.11	1.13	1.15	1.34
Lindenwold										1.29	1.04
Shaker Heights	.86	.89	.89	.91	.95	.97	.98	.99	.98	.93	.98
Newark		1.08	1.13	1.13	1.16	1.06	.99	.98	1.00	.94	.92

3. COMPARISONS AMONG RAIL SYSTEMS

The statistics on individual rail rapid transit operations presented in this study are not detailed enough to allow valid comparisons; however, there are clear indications that the various operations have quite different operational profiles, suggesting that general policies designed to correct the systems' difficulties must be flexible enough to accommodate these differences.

As an illustration of these differences, consider Table 2.16. Note that the Chicago system's revenue per passenger (in effect an average of fares) is the second highest of all the U.S. systems, and its cost per passenger is the highest. Yet, the system's adjusted cost per car-mile (a gross measure of efficiency) is the lowest of the U.S. systems and compares with the New York system. Apparently, the reason for Chicago's high revenue and cost per passenger is its low passenger density. As Table 2.16 shows, the system's passengers per car-mile and per car are the lowest of all the systems.

In contrast, the Massachusetts Bay Transit Authority (MBTA) system has relatively low fare and cost per passenger, but it is able to achieve these low per-passenger values only because of very high passenger density. Note that its cost per car-mile is nearly three times that of Chicago.

Clearly, remedies for Chicago's problems should focus on the demand side while those for Boston's problems should focus on the cost side.

On the other hand, the New York, PATH, and Cleveland systems seem to have low fares relative to their respective passenger densities and car-mile costs. Upward adjustments in fares, however, can have a negative effect on patronage, and few systems can afford further declines in passengers. In any event, these examples support the point made above that general policies with respect to rail rapid transit systems should be flexible.

Finally, it would be a serious error of omission to ignore the relative performance of the two Canadian systems which seem to have everything in the right proportions. They appear to be highly

Table 2.16

SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, BY PROPERTY, 1970

Property	Revenue per Passenger (dollars)	Cost per Passenger (dollars)	Revenue Passengers		Adjusted[a] Cost per Car-Mile (dollars)	Car-Miles per Car (thousands)
			per Car-Mile (number)	per Car (thousands)		
New York	.31	.36	3.49	181.6	1.24	52.0
Chicago	.47	.52	2.05	84.6	1.23	41.3
MBTA	.31	.41	7.39	140.5	3.59	21.0
SEPTA	.32	.33	4.24	127.0	1.75	30.2
PATH	.31	.49	4.21	154.6	2.04	36.7
Cleveland	.24	.32	3.09	120.6	1.37	39.0
Lindenwold	.48	.50	2.36	115.4	1.49	48.9
Shaker Heights	.40	.39	3.94	87.8	2.13	22.2
Newark	.29	.27	6.10	141.9	1.98	23.3
Toronto	.25	.19	4.34	294.9	1.12	68.0
Montreal	.28	.23	3.59	178.5	1.17	49.8

[a]Operating costs adjusted for wage rate differentials among the properties.

efficient systems (low cost per car-mile, high car utilization). They have high passenger density per car-mile and per car, and all of this is reflected in low revenue per passenger (fares) and even lower cost per passenger, resulting in operating profits rather than deficits. These are, of course, newer systems. Toronto increased its track mileage and passenger cars substantially in 1966. Montreal began its operations in 1966 and had the advantage of "Expo" traffic in 1967. However, they serve as excellent examples of low-fare systems that are still able to operate "out of the fare box." It will be interesting to see whether the new San Francisco (Bay Area Rapid Transit) and Washington, D. C. Metro systems perform as well.

D. COMMUTER RAILROAD OPERATIONS

Commuter railroads are railroads that have daily passenger service designed to haul passengers between cities, towns, and villages outside metropolitan areas and points within the latter areas. Such operations differ from rail rapid transit in several respects. First, the trip length is somewhat longer (averaging about 22 miles). Second, the passenger cars used are usually heavier than those used by rapid transit. Third, the operations are run by railroad companies as part of their overall passenger and freight service. In terms of management, they are not regarded as part of the metropolitan rapid transit systems.

1. FINANCIAL STATUS IN 1970

Because the commuter operations are intermixed with other railroad operations, trends in the financial status of the commuter sector are difficult to measure. However, it has been possible to obtain for the year 1970 what appear to be reasonably consistent data on 14 of the 16 commuter railroads in the United States.

a. Net Income

Table 2.17 shows that when all sources of revenue and expense are taken into consideration, commutation passenger service in 1970 was generally a money-losing operation. The aggregate deficit for 14 of the 16 commuter railroad operations in the United States amounted to about $35.7 million and only 2 of the 14 registered a net profit.[1] The table also shows, however, that there was a great

1. Data for Penn Central and Pennsylvania-Reading Seashore Lines were not complete and are excluded from the analysis.

Table 2.17

SUMMARY OF COMMUTER RAILROAD OPERATIONS, BY RAILROAD, 1970
(All Figures in Thousands)

Railroad	Income				Expenses				Net Income	Commuter Passengers	Commuter Passenger Miles
	Total	Commuter Passenger Revenue	Revenue From State & Local Government	Other Income	Total	Operating Expenses	Interest on Equipment Obligations	Depreciation			
Boston and Maine	9,373	5,260	4,113	0	9,353	8,747	16	590	20	5,556	91,951
Burlington Northern	6,275	6,227	0	48	7,005	5,872	162	971	-730	9,726	173,654
Central of New Jersey	8,675	4,166	4,409	100	9,291	8,392	648	251	-616	6,516	123,758
Chicago, Milwaukee, St. Paul, and Pacific	4,968	4,956	0	12	5,955	5,194	218	543	-987	5,954	134,261
Chicago Northwestern	21,149	21,036	0	113	19,237	15,196	1,280	2,761	1,912	25,046	523,966
Chicago, Rock Island, and Pacific	4,289	4,264	0	25	5,824	5,132	283	409	-1,535	6,197	99,697
Chicago, South Shore, and South Bend	3,441	3,442	0	-1	5,238	5,092	0	146	-1,797	2,682	81,058
Erie Lackawanna	16,572	10,872	5,000	700	19,025	19,025	0	[a]	-2,453	15,839	325,217
Illinois Central	11,025	11,006	0	19	11,315	10,870	0	445	-290	18,785	310,241
Long Island	85,189	85,189	0	0	108,523	103,250	0	5,273	-23,334	70,069	1,760,614
Pittsburgh and Lake Erie	97	55	0	42	626	599	0	27	-529	69	1,497
Reading Company	13,716	9,016	4,700	0	16,473	15,183	717	573	-2,757	13,699	195,405
Southern Pacific	4,124	4,001	0	123	6,777	5,767	156	854	-2,653	5,826	144,429
Staten Island Rapid Transit	3,640	1,077	2,549	14	3,640	3,504	45	91	0	4,657	39,022
Total, 14 Railroads	192,533	170,567	20,771	1,195	228,282	211,823	3,525	12,934	-35,749	190,621	4,004,770

[a] Equipment is being retired and replaced by the State of New Jersey.

Source: Association of American Railroads.

deal of variation in nonoperating revenue and in interest and depreciation charges.

b. Net Operating Revenue

A better measure of the financial results of actual operations appears in Table 2.18. Here, operating expenses (which exclude depreciation and interest on equipment obligations) have been subtracted from revenue generated from commuter passengers. This yields net operating revenue. In addition, the "operating ratio" has been calculated by dividing operating expenses by commuter passenger revenue. Note that only three railroads--all of them serving the Chicago area--yielded a net operating profit in 1970. Moreover, the operating deficit for all 14 railroads was over $41 million.

c. Revenue and Cost Ratios

The relative performance of the railroads in terms of revenue and cost ratios is compared in Table 2.19. The first two columns indicate that there is considerable variation in passenger revenue per passenger (average fare) and even more variation in operating cost per passenger. These variations can be caused by differences in trip length, fare structure, relative efficiency, passenger load factor, and other aspects of the operation. Adjustment for trip length can be made by placing revenue and costs in terms of passenger-miles as shown in the last two columns of Table 2.19. Here it becomes clear that passenger revenue per passenger-mile is much more uniform than operating cost per passenger-mile. The former ranges from $.0275 to $.0572, with an average of $.0425. The range of the latter is $.0290 to $.4001 with an average of $.0528. Even without the Pittsburgh and Lake Erie Railroad, the range of cost per passenger-mile is much greater.

The two columns also indicate that the various railroads incur operating deficits or profits for different reasons. To give some illustrations: The Boston and Maine had the highest passenger revenue per passenger-mile ($.0572); however, the railroad's

Table 2.18

NET OPERATING REVENUE AND OPERATING RATIO, BY RAILROAD, 1970
(Dollar Figures in Thousands)

Railroad	Commuter Passenger Revenue	Operating Expenses[a]	Net Operating Revenue	Operating Ratio
Boston and Maine	5,260	8,747	-3,487	1.66
Burlington Northern	6,227	5,872	355	.94
Central of New Jersey	4,166	8,392	-4,226	2.01
Chicago, Milwaukee, St. Paul, and Pacific	4,956	5,194	-238	1.04
Chicago Northwestern	21,036	15,196	5,840	.72
Chicago, Rock Island, and Pacific	4,264	5,132	-868	1.20
Chicago, South Shore, and South Bend	3,442	5,092	-1,650	1.47
Erie Lackawanna	10,872	19,025	-8,153	1.74
Illinois Central	11,006	10,870	136	.98
Long Island	85,189	103,250	-18,061	1.21
Pittsburgh and Lake Erie	55	599	-544	10.89
Reading Company	9,016	15,183	-6,167	1.68
Southern Pacific	4,001	5,767	-1,766	1.44
Staten Island Rapid Transit	1,077	3,504	-2,427	3.25
Total, 14 Railroads	170,567	211,823	-41,256	1.24

[a] Excludes Depreciation and Interest on Equipment Obligations.

Table 2.19

SELECTED REVENUE AND COST RATIOS, BY RAILROAD, 1970
(All Figures in Dollars)

Railroad	Passenger Revenue Per Passenger	Operating Cost Per Passenger	Passenger Revenue Per Passenger-Mile	Operating Cost Per Passenger-Mile
Boston and Maine	.95	1.57	.0572	.0951
Burlington Northern	.64	.60	.0358	.0338
Central of New Jersey	.64	1.29	.0336	.0678
Chicago, Milwaukee, St.Paul, and Pacific	.83	.87	.0369	.0386
Chicago Northwestern	.84	.61	.0401	.0290
Chicago, Rock Island, and Pacific	.69	.83	.0427	.0514
Chicago, South Shore, and South Bend	1.28	1.90	.0424	.0628
Erie Lackawanna	.68	1.20	.0334	.0584
Illinois Central	.59	.58	.0354	.0350
Long Island	1.22	1.47	.0483	.0586
Pittsburgh and Lake Erie	.80	8.68	.0367	.4001
Reading Company	.66	1.11	.0461	.0777
Southern Pacific	.69	.99	.0277	.0399
Staten Island Rapid Transit	.23	.75	.0275	.0897
Average for 14 railroads	.89	1.11	.0425	.0528

operating cost was next to the highest ($.0951). At $.0358, the Burlington Northern had below average revenue per passenger-mile, but it managed to keep its cost per passenger-mile even lower ($.0338) and was able to make a profit. The key to the Chicago Northwestern's success was obviously its low cost per passenger-mile ($.0290); for its revenue per passenger-mile ($.0401) was somewhat below the average for the group. Finally, the Southern Pacific had below average cost per passenger-mile ($.0399), but its revenue per passenger-mile ($.0277) was next to the lowest of the group and was not large enough to cover costs.

The illustrations imply that the remedies to the financial condition of the railroads are probably specific to the railroad. Some may require reductions in operating cost; while others may require stimulation on the revenue side. Still others may require improvements in both the revenue and cost side of the operation.

d. Distribution of Operating Expenses

Tables 2.20 and 2.21 present the dollar and percentage distribution, respectively, of operating expenses according to certain expense categories. Transportation Expense refers to all expenses having to do with the actual movement of people and equipment. Traffic Expense refers to expenses associated with setting fares, scheduling, ticketing, advertising, etc. The other categories are self-explanatory.

Table 2.21 shows that, in 1970, Transportation Expense for the 14 railroads represented over 52 percent of Total Operating Expenses. Maintenance of Equipment and Maintenance of Way represent about 21 percent and 11 percent, respectively. There is considerable variation in the percentages for these three categories, and there does not appear to be a specific pattern associated with failure or success in obtaining operating profits. The three railroads that had operating profits for 1970--Burlington Northern, Chicago Northwestern, and Illinois-Central--have somewhat different distributions. Moreover, other railroads that had deficits have a variety of distributions, some of which are similar to the successful railroads.

Table 2.20

BREAKDOWN OF OPERATING EXPENSES, BY EXPENSE CATEGORY AND BY RAILROAD, 1970

(Thousands of Dollars)

Railroad	Total Operating Expenses	Trans-portation	Maintenance of Way	Maintenance of Equipment	Traffic	Non-Income Tax Payments	Other
Boston and Maine	8,747	5,076	435	1,961	34	1,071	170
Burlington Northern	5,872	3,295	575	950	114	581	357
Central of New Jersey	8,392	5,134	817	1,104	56	771	510
Chicago, Milwaukee, St. Paul, and Pacific	5,194	2,635	214	592	24	207	1,522
Chicago Northwestern	15,196	8,382	1,216	2,913	254	1,434	997
Chicago, Rock Island, and Pacific	5,132	2,799	299	1,188	36	491	319
Chicago, South Shore, and South Bend	5,092	2,140	672	737	60	409	1,074
Erie Lackawanna	19,025	9,010	3,090	5,205	62	[a]	1,658
Illinois Central	10,870	5,673	1,248	1,686	122	1,447	694
Long Island	103,250	52,578	13,230	24,420	338	6,022	6,662
Pittsburgh and Lake Erie	599	412	38	41	2	65	41
Reading Company	15,183	8,368	1,436	2,658	352	1,440	929
Southern Pacific	5,767	3,607	310	1,248	43	488	71
Staten Island Rapid Transit	3,504	1,634	282	584	11	748	245
Total, 14 Railroads	211,823	110,743	23,862	45,287	1,508	15,174	15,249

[a] Included in other categories.

Source: Association of American Railroads.

Table 2.21

PERCENTAGE DISTRIBUTION OF OPERATING EXPENSES, BY EXPENSE CATEGORY AND BY RAILROAD, 1970

Railroad	Total Operating Expenses	Transportation	Maintenance of Way	Maintenance of Equipment	Traffic	Non-Income Tax Payments	Other
Boston and Maine	100.0	58.0	5.0	22.4	0.4	12.2	1.9
Burlington Northern	100.0	56.1	9.8	16.2	1.9	9.9	6.1
Central of New Jersey	100.0	61.2	9.7	13.2	0.7	9.2	6.1
Chicago, Milwaukee, St. Paul, and Pacific	100.0	50.7	4.1	11.4	0.5	4.0	29.3
Chicago Northwestern	100.0	55.2	8.0	19.2	1.7	9.4	6.6
Chicago, Rock Island, and Pacific	100.0	54.5	5.8	23.1	0.7	9.6	6.2
Chicago, South Shore, and South Bend	100.0	42.0	13.2	14.5	1.2	8.0	21.1
Erie Lackawanna	100.0	47.4	16.2	27.4	0.3	[a]	8.7
Illinois Central	100.0	52.2	11.5	15.5	1.1	13.3	6.4
Long Island	100.0	50.9	12.8	23.7	0.3	5.8	6.4
Pittsburgh and Lake Erie	100.0	68.8	6.3	6.8	0.3	10.9	6.8
Reading Company	100.0	55.1	9.5	17.5	2.3	9.5	6.1
Southern Pacific	100.0	62.5	5.4	21.6	0.7	8.5	1.2
Staten Island Rapid Transit	100.0	46.6	8.0	16.7	0.3	21.3	7.0
Total, 14 Railroads	100.0	52.3	11.3	21.4	0.7	7.2	7.2

[a] Included in other categories.

2. TRENDS IN PATRONAGE

Table 2.22 provides "best estimates" of the 1960-1970 commuter railroad patronage for railroads serving the five major cities with important levels of service. Note that total passengers dipped from a level of 248 million in 1960 to 233 million in 1965. Then the figure returned to the 248 million level by 1968 and remained at about that level in 1969 and 1970. There were some differences among the cities, however. New York dropped from 142 million in 1960 to about 125 million in 1965 and then seemed to stablize at the 126- to 127-million level. Ridership in Chicago and Philadelphia increased over the period, but Boston and San Francisco remained at about the same levels. In general, however, the picture appears to be relatively stable with respect to passengers.

Table 2.22

COMMUTER RAIL PASSENGERS BY CITY
(Passengers in Millions, Annually)

City	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	142	140	134	131	128	125	125	126	127	126	127
Chicago	62	62	60	60	61	62	64	67	70	72	67
Philadelphia	24	24	24	26	27	28	29	31	33	33	36
Boston	13	11	11	13	12	11	12	11	11	11	11
San Francisco	7	7	7	7	7	7	7	7	7	7	6
TOTAL	248	244	236	237	235	233	237	242	248	249	247

3. OPERATING TRENDS 1964-1970

Additional operating trends for 14 commuter railroads appear in Table 2.23. It should be pointed out first that the differences in the revenue passenger levels reported in this table and those in the previous table are primarily due to definition. Again, the patronage picture is one of relative stability, with a slight upward drift since 1964. Average trip length has been about 21.6 miles and has increased the last two years to 22.3 miles. Revenue per passenger and per passenger-mile has increased as a result of fare increases.

Table 2.23

AGGREGATE COMMUTER RAIL OPERATING STATISTICS
FOR FOURTEEN OPERATORS, 1964-1970

Item	1964	1965	1966	1967	1968	1969	1970
Revenue Passengers (millions)	192.8	190.9	193.7	198.1	201.9	206.6	204.6
Passenger Revenue ($ millions)	132.4	135.2	138.4	142.9	152.2	160.7	170.8
Revenue Passenger-miles (millions)	4,178.8	4,091.0	4,161.0	4,264.7	4,350.4	4,515.2	4,558.8
Average Trip Length (miles)	21.7	21.4	21.5	21.6	21.6	21.9	22.3
Revenue per Passenger	.69	.71	.71	.72	.75	.78	.83
Revenue per Passenger-Mile	.032	.033	.033	.033	.035	.036	.037

Source: Interstate Commerce Commission.

E. URBAN TAXICAB TRANSIT

In any discussion of overall movement of passengers in urban areas by public transit vehicles, movement by taxicab transit should be given equal consideration with mass transit. In some communities, taxicabs are the only form of public transit available and, as indicated earlier, more people ride taxicabs than rail rapid transit. However, taxicabs are not designed for mass transit; they are a form of personalized transit that is summoned either by telephone-radio dispatch, by prearrangement, or by being hailed on the street or at cab stands. Taxicabs, like the private automobile, provide virtually door-to-door service. Moreover, they are not driven or parked by the passenger. This feature, in the opinion of some, makes the taxicab the best form of public transportation available.

1. TRENDS IN THE TAXICAB INDUSTRY

Time-series data on the economic status of the taxicab industry are rather sparse. The employment series presented in Table 2.24 indicates that, since 1963, the average employment level has been quite stable. The number of taxicabs in fleets has apparently increased. These two series suggest that the demand for taxicab services has been relatively stable. This is in line with statements by industry spokesmen.

The reader will note that there appear to be fewer employees than taxicabs. Actually, there has been a shortage of drivers throughout the period. The cab utilization figure used by the industry is about 80 percent. The figures in Table 2.24 indicate a somewhat lower utilization rate. However, the employment levels estimated by the United States Bureau of Labor Statistics are

Table 2.24

TAXICAB EMPLOYMENT, 1960 to 1970 AND NUMBER OF TAXICABS IN FLEETS, 1966-1970

(All Figures in Thousands)

Year	Annual Average Employment Level	Number of Taxicabs in Fleets
1960	121	
1961	114	
1962	112	
1963	111	
1964	110	
1965	110	
1966	109	142
1967	111	146
1968	111	163
1969	111	169
1970	111	175[1]

[1]Estimated from trend line.

believed to be understated. Moreover, employment turnover rates are high in the industry. It has been estimated that over 600,000 persons are employed in the industry during the year. Finally, there is a seasonal variation in driver employment in many parts of the country. Although publishable data were not available at this writing, preliminary indications are that costs have risen faster than revenues, so that taxicab operations are suffering a profit squeeze. A financial survey of 50 cab fleets (5,425 cabs) in New York concluded that, in 1970, total expenses, including interest and depreciation, exceeded fare income by 4.5 percent. This and other evidence was the basis for a recent fare increase in New York.

There is an obvious need to expand the historical information base on the industry, and future work along these lines is contemplated. It is possible, however, to present a general profile of the industry, the subject matter of the remaining paragraphs in this section.

2. CHARACTERISTICS OF TAXICAB RIDERS

Relatively few major studies have been made of taxicab rider characteristics, but those that have been made yielded similar conclusions.[1] First, rider characteristics differ according to whether the trip destinations are in the central city or outside the central city. The 1956 Chicago Area Study indicated that housewives are major users of taxicabs, regardless of the point of destination (see Table 2.25). Housewives accounted for about one-third of the trips to the central area and over one-half of the trips to the noncentral area.[2] Aside from housewives, the dominant users are in the white-collar occupations. This is true in both the central and noncentral areas, but the percentage of riders in the blue-collar occupations, especially service workers, is greater in the noncentral areas. Presumably, this is associated with the requirements of suburban living.

With respect to personal characteristics, taxicab ridership is highest among the above-average-income, white population. In the noncentral areas, the largest percentage of the riders are females who do not drive. In the central areas, riders are about evenly divided among males and females. The largest proportion (about two-thirds) of riders are in the working-age groups (age 25 to 64), but this indicates that a large proportion of the riders are youths or senior citizens. It is well known that taxicabs are major

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1. The results of three studies are discussed here: the Tri-State (New York Area) Transportation Commission Study of 1969, the Chicago Area Study of 1956, and the Pittsburgh Area Study of 1963.

2. The Pittsburgh Area Study also showed high ridership by housewives.

Table 2.25

PERCENTAGE DISTRIBUTION, TAXICAB PERSON TRIPS IN THE CHICAGO AREA, BY OCCUPATIONAL GROUPS

Occupational	Trip Destination: Central Area	Non-Central Area	All Areas	Exclusive of Housewives and Farmers
Total	100.0	100.0	100.0	100.0
Professional and Technical	20.7	11.8	15.6	28.2
Farmers	0.0	0.0	0.0	a
Managers, etc.	17.6	6.4	11.1	20.2
Clerical	9.0	8.5	8.8	15.8
Sales workers	12.5	4.7	7.9	14.4
Operatives	2.7	3.4	3.1	5.7
Private household workers	0.2	1.6	1.0	1.8
Craftsmen, foremen	2.2	1.7	1.9	3.5
Service workers	2.4	6.7	4.9	9.0
Laborers	0.4	1.0	0.7	1.3
Housewives	32.4	54.2	45.0	a

[a]Not included in the percentages.

Note: Figures may not total 100 due to rounding.

transporters of the aged, infirm, and other persons who cannot drive or do not have access to an automobile or other forms of public transit.

3. THE SUPPLY OF TAXICABS

The taxicab industry is dominated by small fleet or individual operations that are conducted under franchise in communities or jurisdictions that usually regulate fares, the number of licenses, and other matters pertaining to the operations. Table 2.26 shows that, for a sample of 741 communities or "jurisdictions," the median number of licenses is 26 and the third quartile is only 56; the range is from 1 to 11,754 (New York). Although the number of

Table 2.26

DISTRIBUTION OF LICENSES, POPULATION, AND LICENSES PER 1,000 POPULATION FOR A SAMPLE OF 741 COMMUNITIES

	First Quartile	Median	Third Quartile	Range
Licenses	13	26	56	1 - 11,754
Population Served (000)	30	47	88	2 - 7,867
Licenses per 1,000 population	.364	.568	.900	.03 - 11.13

Note: Total Licenses in Sample 77,064
Total Population in Sample (000)[a] 83,130
Licenses per 1,000 population .927

[a]Includes some overlapping of jurisdictions, therefore the mean licenses per 1,000 is overstated.

licenses issued is not necessarily equivalent to the number of taxicabs, it is clear that the industry consists of a very large number of small operations and few very large operations.[1]

One measure of taxicab supply is the number of licenses per 1,000 population. Although the range is considerable (.03 for a small western community to 11.13 for Washington, D. C.), 50 percent of the communities are within the values .364 to .900, and the median is .568. There is a correlation, however, between the size of city and licenses per 1,000. Table 2.27 indicates that most of the large cities have values well over the median. Those that were well below the median are located in the more automobile-oriented west or southwest.[2]

1. The large operations tend to dominate the statistics. This is the reason that medians are used to describe the average situation.

2. As with mass transit, the private automobile is the main competition faced by taxicabs. Rental automobiles (another form of personalized public transit) also give taxicabs stiff competition.

Table 2.27

LICENSES PER 1,000 POPULATION IN CITIES WITH 1970 POPULATIONS OF 500,000 OR MORE

City	State	Population Served (000)	Licenses	Licenses per 1,000 Population
New York	N. Y.	7,867	11,754	1.49
Chicago	Ill.	3,366	4,600	1.37
Los Angeles	Calif.	2,816	1,024	.37
Philadelphia	Penn.	1,948	1,750	.90
Detroit	Mich.	1,511	1,358	.90
Houston	Texas	1,232	473	.38
Baltimore	Md.	905	1,151	1.27
Dallas	Texas	844	507	.60
Van Nuys [a]	Calif.	790	50	.06
Washington	D. C.	764	8,500	11.13
Cleveland	Ohio	750	560	.75
Indianapolis	Ind.	744	482	.65
San Francisco	Calif.	715	756	1.06
Milwaukee	Wisc.	713	423	.59
San Diego	Calif.	696	304	.44
San Antonio	Texas	654	518	.79
Boston	Mass.	641	1,575	2.46
Memphis	Tenn.	623	400	.64
St. Louis	Mo.	622	1,267	2.04
New Orleans	La.	593	1,500	2.53
Phoenix	Ariz.	581	95	.16
Columbus	Ohio	539	351	.65
Seattle	Wash.	530	316	.59
Jacksonville	Fla.	528	270	.51
San Gabriel	Calif.	525	52	.10
Pittsburgh	Penn.	520	550	1.06
Denver	Colo.	514	317	.62
Kansas City	Mo.	507	542	1.07

[a] Includes parts of surrounding communities.

The very large ratio for Washington, D. C. reflects the fact that the city allows virtually free entry into the taxicab business. However, many cabs are driven only a few hours per day, if at all. If all the ratios were converted to "full-time equivalents," Washington's figure would be more in line with the others.

4. PROFILE OF TAXICAB OPERATIONS

In most fleet operations, taxicab drivers are paid a percentage of their receipts. This gives the driver an incentive to try to maximize his paid mileage per man-hour, i.e., the miles driven with passengers in the cab during a given hour. Since short trips normally have a high revenue rate per mile, the ideal situation for the driver and the company would be to maximize the number of short paid trips per hour. In addition, because most cities allow an additional charge per passenger, the driver would normally prefer to maximize the number of passengers carried per trip.

Table 2.28 presents the medians of selected ratios for a sample of 27 taxicab fleet operations as of July 1970. The sample has wide geographical distribution. Note that the typical trip length for this sample was 5.85 miles, of which 2.95 (49.45 percent) were paid miles. The number of passengers per trip was 1.3 persons and the receipts per trip were $1.95.[1] Over 88 percent of the trips originated by phone order.

On an hourly basis, the typical cab driver takes in about $4.13 of which he receives $1.79 (43 percent) plus tips.[2] The balance goes to the company and from it the company must pay all of the investment and operating costs.[3]

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1. A sample of 194 communities indicates a median trip length of 4.7 miles and a median number of passengers per trip of 1.5.

2. He also receives social security and other benefits, depending on company policy.

3. There are a number of technical arrangements between the company and the drivers as to the distribution of receipts and costs. The foregoing is typical.

Table 2.28

MEDIANS OF SELECTED RATIOS FOR 27 TAXICAB FLEET OPERATIONS
MONTH OF JULY, 1970

Ratio	Median Value
Miles per trip	
Total	5.85
Paid	2.95
Percent paid miles	49.45
Passengers per trip	1.30
Cab receipts per trip	$1.95
Percent of trips from phone order	88.15
Trips per man-hour	2.15
Receipts per man-hour	
Total	$4.13
Driver commission	$1.79
Percent paid to driver	43.34
Receipts per mile	$ .30
Receipts per paid mile	$ .66
Cab mileage	
Per cab owned per day	106.70
Per man-hour	12.05
Per gallon of gas	11.45
Hours per shift	9.00
Receipts per shift	$39.29
Phone orders per shift	16.45

Unfortunately, directly comparable and complete figures are not available on costs; however, Table 2.29 gives some idea of the cost breakdown. Note that, in 1970, total costs for the 27 fleet operations ran about 28.2 cents per mile as against 31.7 cents per mile in receipts. The median values for these firms, which exclude New York, indicate a profit, but as mentioned earlier, a composite of 50 New York fleets indicated a deficit.

As with mass transit, the key to success in taxicab operations is to increase the proportion of paid miles and/or the number of passengers per trip. Radio dispatching has made an important impact along these lines, but it is recognized within the industry that further increases in efficiency cannot be expected from radio dispatching alone. High hopes are placed on computerized dispatching in combination with automatic vehicle location devices and radio communication. Such a system could be used to locate and dispatch the nearest available vehicle, thereby minimizing running costs and maximizing revenue per mile. The system can also be extended to group riding concepts wherein the computer would design a minimum time path route for a set of passengers with different origins and destinations.

Table 2.29

SELECTED COST ITEMS FOR 27 FLEET OPERATIONS, 1970

Revenue or Cost Classification	Median Value of Mile	Percent of Total Receipts	Percent of Total Expenses
Cab Receipts	.3172	100.0	
Total Expenses	.2821	88.9	100.0
Depreciation	.0166	5.2	5.9
Interest	b	b	b
Operating Expenses, Total	b	b	b
Driver cost	.1556	49.1	55.2
Vehicle operation	.0250[a]	7.9[a]	8.8[a]
Tires	.0029	0.9	1.0
Gasoline	.0221	7.0	7.8
Maintenance	.0197[a]	6.2[a]	7.0[a]
Labor	.0112	3.5	4.0
Parts	.0085	2.7	3.0
Garage	b	b	b
Public Liability (insurance)[1]	.0160	5.0	5.7
General and Administrative	b	b	b

[a]Assumed to be sum of two sub-items.

[b]Not available.

Note: The sample is composed of 27 individual companies covering a wide geographical distribution. New York companies are not included.

Source: International Taxicab Association, Cab Research Report: Composite Report on Operating Costs.

F. CONCLUDING REMARKS

The general theme that runs through all of the foregoing is that demand deficiency, especially for bus transit, is the main cause of the economic difficulties of urban public transit. Costs have increased more rapidly than revenues, but this is primarily because service levels have not declined as drastically as passenger levels. The industry is simply not filling buses and rail passenger cars the way it must to maintain a healthy economic posture.

Consumer preference for the private automobile is undoubtedly the main cause of the demand deficiency in public transit. The industry has not yet found a way to change this preference at an acceptable economic cost. How to do this is, of course, the main issue that needs investigation.

This section has only sketched certain economic aspects of the urban public transit industry. The papers which follow provide the details. The reader is reminded, however, that much more work must be done if the industry's economic behavior is to be thoroughly understood and documented. It is hoped that the papers presented in this study will provide a base for such future work.

PART TWO

URBAN BUS TRANSIT

CHAPTER III

ECONOMIC CHARACTERISTICS OF THE URBAN BUS TRANSIT INDUSTRY, 1960-1970

by

John D. Wells
Sharron Thomas

SUMMARY

This section examines the economic condition of urban bus transit firms in 1960 and 1969 to determine whether significant changes have taken place in the industry.[1] The focus is on trends and variations among firms rather than on specific operations within firms. For this reason, annual operating statistics are regarded as suitable for the analysis.

1. NATURE AND LIMITATIONS OF THE DATA

IDA has computerized data compiled by the American Transit Association for the ten-year period 1960 through 1969. However, only data for 1960 and 1969 have been used for this analysis. Data gaps have limited the sample sizes for each year; therefore, the results must be regarded as tentative. However, despite these statistical limitations, we believe that the analysis herein accurately describes the general economic profiles of the industry for the two years.

2. ANALYTICAL RESULTS

a. Revenue Versus Costs

The industry has generally experienced a revenue-cost squeeze. On the average, revenues of bus firms covered total costs in 1960

1. The term "firm" is used throughout this paper as being synonymous with what the industry calls a "property." The term applies to both publicly owned and privately owned "properties," and focuses specifically on the bus transit activity, i.e., other activities of the company are excluded.

but not in 1969; on the average, variable costs were covered in both years.[2] However, a breakdown of the firms indicates the following:

	1960	1969
Percent of firms that did not cover total costs	22	54
Percent of firms that did not cover variable costs	7	33
Percent of firms that did not cover variable costs minus operating taxes	4	27
Sample size	78	52

Clearly, the ability of firms to cover costs with revenues has deteriorated drastically. Note that in 1969, 27 percent of the firms would not have covered variable costs even if they were relieved of operating taxes.[3]

Small firms appear to be worse off than large firms. The following information applies to firms in the above samples with annual revenues less than $1 million:

	1960	1969
Percent that did not cover total costs	34	70
Percent that did not cover variable costs	12	48
Percent that did not cover variable costs minus operating taxes	10	43
Sample size	41	23

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2. The statistical concept of variable costs is defined herein as total operating costs minus depreciation and amortization chargeable to operations. It can be roughly regarded as the firm's out-of-pocket expenditures.

3. However, some operating taxes are probably unavoidable, e.g., social security taxes. Operating taxes include all federal, state, county, and municipal taxes other than income taxes.

b. Reasons for the Revenue-Cost Squeeze

In general terms, bus transit operations in 1969 were at about the same levels as 1960. Slight declines in the number of buses and bus-miles occurred, but the number of buses per line-mile and per route-mile tended to increase. The physical levels of cost-generating inputs, therefore, have remained at about the same or slightly lower levels. On the other hand, because of a drastic decline in passengers (median decline of 32 percent), the ability of firms to generate revenues has declined. The result is that, on the average, total revenue has declined by about three percent, whereas total cost has increased about 22 percent. Obviously, fare increases partially made up for the loss of passengers. If firms are operating at the same levels and the number of passengers has declined, the revenue-cost squeeze will occur even if fares increase at the same rate as costs.

c. Economic Consequences

In 1969, most bus transit firms (privately and publicly owned) were able to cover variable costs but not total costs. Under these conditions, the economic behavior of the firms can be predicted. The age of the firms' capital stock will increase because there is little incentive to invest in new plants and equipment. The capital stock will tend to deteriorate due to deferred maintenance. If allowed to do so, private firms that cover variable costs will tend to invest surplus funds in other, more lucrative enterprises. Or, they will consider selling the operation (to the community) or closing it down. Those firms that do not cover variable costs will minimize losses by closing down entirely. Public firms in the same situation will demand larger subsidies.

The evidence is strong that the bus transit industry is, indeed, behaving in this classical manner. The median age of the bus fleets increased from 9.6 years in 1960 to 10.9 years in 1969. All sizes of firms experienced this increase in age, but the increase appears larger among small firms. This is consistent with their relative economic situation. There is also evidence that maintenance costs have not increased as rapidly as other costs, which suggests deferred maintenance. However, more careful investigation of maintenance policies and the reasons for the increase in fleet age are needed before final conclusions can be reached.

Many private bus transit firms are no longer resisting public takeover. The results presented in this section appear to document some of the reasons for this change in attitude.

A. INTRODUCTION

This paper examines the economic characteristics of the urban bus transit industry in the two years 1960 and 1969 for the purpose of describing the similarities and differences in economic activity among the firms within the industry. Many firms have had economic difficulties, and some have shut down completely; others have been taken over by the communities they served. Still others are facing the prospect of having to shut down or become publicly owned operations. The basic questions investigated here are (1) whether these prospects are typical of all firms in the industry and (2) whether the causes of the difficulties are similar.

1. NATURE OF THE DATA

a. Sources

The American Transit Association (ATA) receives annual reports from its membership that contain various cost and operating statistics. The ATA reports this information each year, by individual firm, in the following publications:

- "Transit Operating Reports"

  Part I, System-Wide Totals
  Part II, Motor Bus Operations
  Part III, Railway Operations
  Part IV, Trolley Coach Operations

- "Classification of Motor Buses By Size, Make, and Manufacturer's Year."

All of the information in these reports has been stored on magnetic tapes, and any piece of information in the tape files can be extracted.

The specific information for this section was taken from the tape record of Part II. Section A of Part II contains the data for firms that report their operating data using the Interstate Commerce Commission system of accounts. Section B contains statistics for other firms that use the ATA system of accounts. Because of comparability problems with respect to the two systems, only the Section A firms that reported on the basis of the more widely used ICC system are analyzed.

b. Limitations

One of the problems encountered in analyzing the data in Section A of Part II was that some firms failed to report data on all the variables of interest. The reader will find, therefore, that the sample sizes used in the analysis vary. There is also a problem of reporting consistency. Wherever possible, consistency checks have been made, but whether all inconsistencies have been accounted for is not certain.

2. ANALYTICAL LIMITATIONS

The existence of data gaps made it virtually impossible to use random-sampling techniques, so we obtained the maximum number of observations available for the sets of variables being analyzed. This does not, of course, guarantee randomness and, technically, any inferences drawn from the sample cannot be evaluated in statistical terms. However, on a number of occasions the t-statistic has been used to test the significance of a sample value. This was done on the perhaps questionable assumptions that (1) the sample is random and large enough to assure approximate normality of sample statistics as predicted by the Central Limit Theorem, and (2) the error terms of the dependent variables are independent and normally distributed.

The reader is reminded that only two years of data are presented. It is possible that either one or both of these two years cannot be regarded as typical of the industry's performance. Ideally, each year during the decade should be analyzed separately using cross-sectional analysis, and those firms that existed over the full period should be analyzed using time-series analysis. In addition, the identification of the characteristics of firms that dropped out or merged with other firms would complement the statistical treatment.

Clearly, much remains to be done; for this reason the results presented here must be regarded as tentative.

3. OVERVIEW

The financial status of the urban bus transit firms during 1960 and 1969 is discussed first. The main concern is whether the revenues received by the firms have been enough to cover total and variable costs or both, as these terms are defined in this section. Changes in certain cost components are also examined.

Following the financial analysis, an analysis of the operating characteristics of the firms is taken up. This analysis shows, statistically, the apparent reasons for the changes in their financial posture.

B. REVENUE VERSUS COSTS

This section is devoted primarily to a discussion of the ability of urban bus transit firms to cover costs in the two years 1960 and 1969. It will be shown that the financial status of bus transit firms has deteriorated. This is especially true for small operations. Before presenting the statistical picture, however, it is necessary to discuss certain cost concepts and assumptions and their significance in explaining economic behavior.

1. COST CONCEPTS AND ASSUMPTIONS

Three cost concepts will be used in the subsequent analysis:

$$\text{Total Fixed Cost} = \text{Capital Consumption} + \text{Normal Profit (including interest)} \quad (1)$$

$$\text{Total Cost} = \text{Total Variable Cost} + \text{Total Fixed Cost} \quad (2)$$

$$\text{Average Total Cost} = \text{Average Variable Cost} + \text{Average Fixed Cost} \quad (3)$$

In Eq. 3 the averages are calculated by dividing their respective totals by the output levels that generated the costs. All of these costs are assumed at this point to be "short run" costs.[1]

It is important to be aware of the fact that the ATA cost concepts differ somewhat from the ideal that economists would prefer. Table 3.1 shows the ATA expense categories used for those firms employing the Interstate Commerce Commission (ICC) method of reporting. These categories can be aggregated as in Table 3.2. As the latter table indicates, variable cost can also be determined as follows:

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1. The "short run" is defined as a time so short that the firm is unable to vary quantities of some resources used.

Table 3.1

ATA EXPENSE CATEGORIES (ICC FORM)

Item No.	Item
4	Equipment, Maintenance, and Garage
7	Transportation
13	Station
14	Traffic, Advertising, etc.
15	Insurance and Safety
17	Administrative and General
18	Depreciation
19	Amortization Chargeable to Operations
20	Operating Taxes and Licenses
21	Operating Rents, Net
22	Total Operating Expense

Table 3.2

ATA AGGREGATE COST CONCEPTS

Item No.	Expense Item
4	Equipment, Maintenance and Garage
7	+ Transportation
13	+ Station
14	+ Traffic, Advertising, etc.
15	+ Insurance and Safety
17	+ Administrative and General
21	+ Operating Rents, Net
	Cost of Operations
20	+ Operating Taxes and Licenses
	Total Variable Cost
18	+ Depreciation
19	+ Amortization Chargeable to Operations
22	Total Operating Expenses

Total Variable Cost = Total Operating Expense Minus Depreciation and Amortization Chargeable to Operations. (4)

The latter variable-cost concept is probably reasonably close to the economist's definition; i.e., the costs are composed of those resources that can be varied by management over the short run, and they are a function of the levels of output. They are, primarily, "out-of-pocket" expenditures.

A major problem arises, however, when the ATA Total Operating Expense concept is compared with the theoretical Total Cost concept (see Eq. 2). Here there are two aspects to consider. First, the depreciation and amortization categories may not adequately reflect capital consumption. Depreciation and amortization are accounting concepts that may be dependent upon the tax posture of the private firms as well as other considerations. In any case, depreciation techniques used by the firms in the industry evidently have not been standardized, and there is considerable variation in this category. Second, there is no provision for normal profit in the ATA Total Operating Expense concept. Normal profits "...include a normal return to management services, as determined competitively in all industries; and a normal return to capital, as determined competitively everywhere by industries of equal riskiness...."[2] In regulated industries, such as urban public transit, these "normal" profits are usually not determined competitively but are based more on a discretionary "fair-rate-of-return" concept.

It is possible that the depreciation category may contain profits if there is widespread use of rapid write-off procedures and other devices to overstate capital consumption, but there is no way to be sure that profits are being under- or overstated relative to "normal" profits. Therefore, it is not possible to equate the ATA concept of total operating expenses with the theoretical total cost concept.

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2. Paul A. Samuelson, Economics: An Introductory Analysis, 7th ed. (New York: McGraw-Hill, 1967), p. 443.

On the other hand, the Total Operating Expenses minus Depreciation and Amortization concept is probably a reasonable approximation of the theoretical notion of total variable costs.

2. SIGNIFICANCE OF THE COST CONCEPTS

The foregoing cost concepts can be used to explain in rather simple terms the general economic behavior of the bus transit firms over the last decade. As will be demonstrated in later sections, the industry has followed a predictable behavior pattern, and it would be helpful at this point to discuss the nature of this expected behavior. Figure 3.1 presents hypothetical short-run average cost curves for a bus transit firm where the curves represent standard economic definitions. Vehicle-miles per year is used here as an

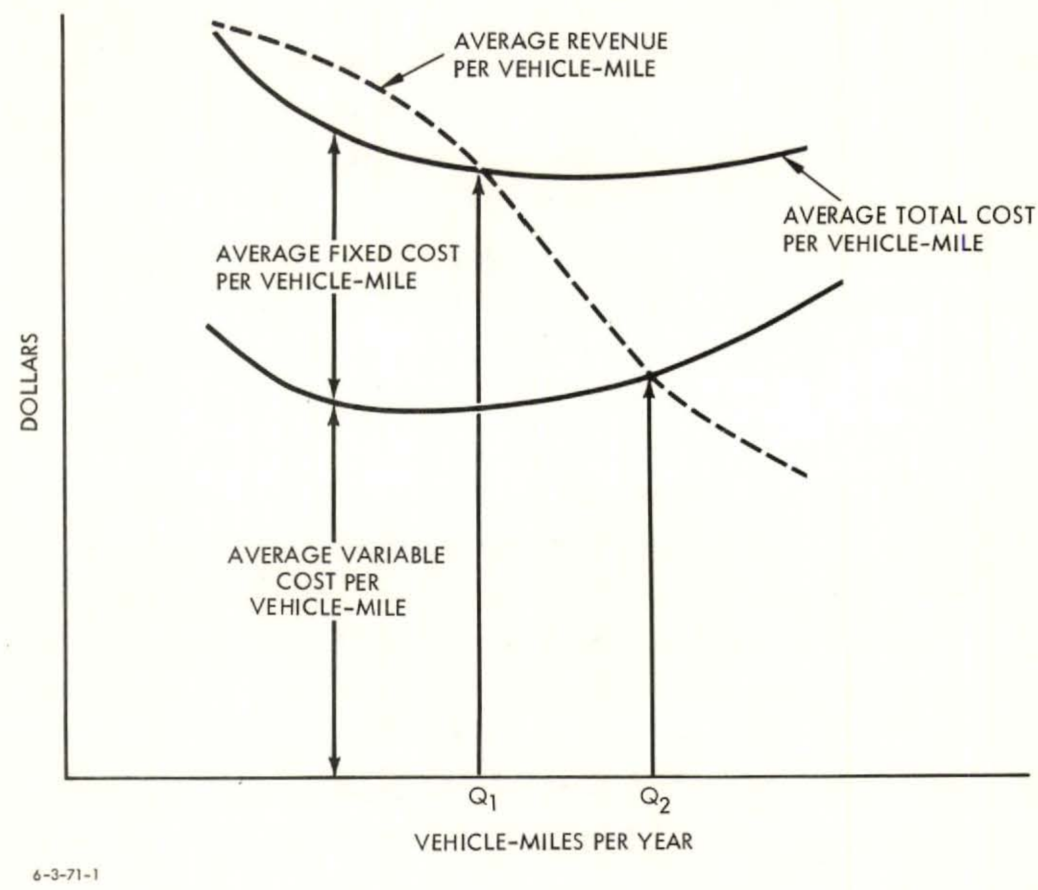

FIGURE 3.1 Hypothetical Bus Transit Short-Run Cost Curves

output measure merely as a convenience. Other output concepts, e.g., seats provided, seat-miles, passenger-miles, or passenger trips could have been used without loss of generality. As a matter of fact, all of these are highly correlated with one another.

It should be noted also that revenue is not necessarily generated by vehicle-miles. Revenue is primarily a function of fare and passengers. The shape of the average revenue per vehicle-mile curve assumes that a firm will first service areas with the highest passengers per vehicle-mile, and then expand service to the next highest ratios, etc. Average revenue, of course, cannot be zero or negative, so the curve is shown as approaching zero.

Now assume that the bus company is privately owned. The firm prefers to operate at a level of Q_1, or less. At that point, the firm's revenues are covering Total Operating Costs including a normal profit. As shown on the hypothethical diagram, the company would be receiving higher-than-normal profits if it operated at even lower levels.[3] At output level Q_2 and beyond, the firm would not be covering variable costs. To continue to operate would cause losses over and above fixed costs. If forced to operate at such levels by regulatory edict, the company would minimize losses by giving up its franchise and quitting entirely. Clearly, if the community desires this level of service, the company will need some sort of financial relief.

In the range of operations between Q_1 and Q_2, the firm is covering variable costs, but not total costs. The firm would not be receiving normal profits nor, perhaps, enough funds to replace worn-out capital stock. If the firm had other, more profitable, ventures, the propensity would be to use the cash flow generated by the bus system to invest in these other ventures. Regulation, of course, may prevent this. Under such circumstances, there is not much that the private firm can do but phase out the operation, search for ways

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3. More precisely, the firm would prefer to operate at the profit-maximizing position within this region, i.e., where marginal revenue equals marginal cost.

to generate more revenue, or reduce costs without investing new capital. Meanwhile, the age of the capital stock will increase, and the capital may deteriorate if normal maintenance schedules are relaxed in order to cut costs. As indicated earlier, if given the alternative, the firm would first attempt to reach a service level of Q_1 or less. However, this may be unacceptable to the community. If an impasse emerges, conditions are clearly ripe for public takeover or some sort of financial relief for the firm.

Obviously, the incentives for a publicly owned firm are different. Profit is not as important a factor. Moreover, the company can operate at any service level the community requires provided the latter is willing to supply the funds in some way. However, if the public firm is required to "operate out of the fare box," it faces the same kinds of problems as a private firm. Variable costs, at least, must be covered, and, ideally, enough funds should be obtained to cover capital consumption. If such costs cannot be covered, and if no financial relief is forthcoming, the capital stock will age and deteriorate, and the publicly owned firm will want to follow the same path as the privately owned firm, i.e., reduce service levels to operate at more favorable revenue-versus-cost levels.[4]

3. REVENUE AND COSTS OF BUS TRANSIT FIRMS

All of the foregoing has been presented to provide a context within which to evaluate the empirical findings. It will now be shown that, in 1969, bus companies generally did not cover total costs. Many of them did not even cover variable costs. In addition, small firms seemed to be worse off than large firms.

a. Sources of Revenue

Consider first the sources of bus transit company revenue. Table 3.3 shows that in 1960 about 95 percent of the revenue came

4. Assuming, of course, the average revenue curve is similar to that of Figure 3.1.

Table 3.3

PERCENTAGE DISTRIBUTION OF REVENUE, BY SOURCE, 1960 AND 1969

Source of Revenue	Percent of Total	
	1960	1969
Total Revenue	100.0	100.0
Passenger Revenue	94.9	92.8
Charter Revenue	4.0	5.7
Other	1.1	1.5
Number of Firms in Sample	107	76

from passengers using normal service, and 4 percent came from charter service. In 1969, the relative importance of charter service increased to about 6 percent.[5] The fact that the relative importance of charter revenue has changed from 1960 to 1969 is verified in Table 3.4. There it is shown that charter revenue increased about 133 percent, whereas passenger revenue declined by about 5 percent.[6]

5. It should be noted, however, that a separate sample of firms was taken for each year in order to maximize the number of observations. Therefore, some firms included in the 1960 sample are not included in the 1969 sample. This means that each sample must be interpreted separately, i.e., each sample is subject to a different level of variability.

6. Medians rather than arithmetic means were used because the former are not sensitive to extreme values. The arrays from which the medians were calculated appear in Appendix IIIA. Note that, in spite of the large percentage increase in charter revenue, its influence on total revenue is minor because of its relative size compared with passenger revenue. However, the additional revenue from charter sources becomes very important when a firm's survival is at stake.

Table 3.4

PERCENT CHANGE IN REVENUE SOURCES AND IN PASSENGERS, 1960 to 1969

Source of Revenue	Firms in Sample	Median Percent Change 1960 to 1969
Total Operating Revenue	51	- 3
Passenger Revenue	51	- 5
Charter Revenue	47	+133
Passengers	44	- 32

Note: See Appendix IIIA for more detail.

The results of Tables 3.3 and 3.4 are consistent, even though they are derived from different samples. In addition, there has been a decline in passengers of about 32 percent, which is consistent with the decline in passenger revenue.

b. Distribution of Revenue

Now consider the distribution of revenue for the same firms used in obtaining the source-of-revenue figures. Table 3.5 presents the percentage distribution of revenue according to the ATA expense categories. The upper section of the table shows how the revenue was spent in the two years.

The summary at the bottom of the table relates three total expense concepts to total revenue. This summary shows that, in 1960, the 107 firms in the sample, on the average, covered total operating expenses by a margin of about 5 percent; but in 1969, the 76 firms in the sample, on the average, did not cover total operating expenses. Expenses exceeded revenues by about 1.44 percent, so nonoperating revenue sources had to be tapped for this amount. The firms did,

Table 3.5

PERCENTAGE DISTRIBUTION OF REVENUE BY EXPENSE CATEGORY, 1960 AND 1969

Category Number	Category Name	Percent of Total 1960	Percent of Total 1969
	Total Revenue	100.00	100.00
4	Equipment, Maintenance, and Garage	18.27	16.61
7	Transportation	46.89	53.44
8	Drivers', Helpers' Wages, etc.	37.56	41.76
13	Station	.57	1.05
14	Traffic, Advertising, etc.	.85	1.31
15	Insurance and Safety	5.04	4.48
17	Administrative and General	9.55	11.09
18	Depreciation	5.65	6.65
19	Amortization Chargeable to Operations	.10	.43
20	Operating Taxes and Licenses	7.51	5.89
21	Operating Rents, Net	.45	.48
	Number of Firms in Sample	107	76
	Summary		
	Total Operating Expenses	94.88	101.44
	Total Operating Expenses Less Depreciation and Amortization	89.13	94.36
	Total Operating Expenses Less Depreciation, Amortization, and Operating Taxes	81.62	88.47

however, cover variable costs (Total Operating Expenses less Depreciation and Amortization).

Consider now the relative changes of the individual expense categories as shown in Table 3.6. Note first that the relative size of Equipment, Maintenance, and Garage expenses has declined. This suggests, but, of course, does not prove, deferred maintenance. The relative size of Transportation Expenses has increased, as has Administrative and General Expenses. Both of these categories have a high

Table 3.6

DISTRIBUTION OF OPERATING EXPENSES[a], BY EXPENSE CATEGORY

Category Number	Category Name	Percent of Total 1960	1969
	Total Operating Costs[a]	100.00	100.00
4	Equipment, Maintenance, and Garage	20.50	17.60
7	Transportation	52.61	56.64
8	Drivers', Helpers' Wages, etc.	42.14	44.25
13	Station	.64	1.11
14	Traffic, Advertising, etc.	.95	1.39
15	Insurance and Safety	5.65	4.75
17	Administrative and General	10.71	11.75
20	Operating Taxes and Licenses	8.43	6.24
21	Operating Rents, Net	.51	.51
	Number of Firms in Sample	107	76

[a]Excludes depreciation and amortization chargeable to operations.

labor component, and it is well known that wage rates have increased rapidly over the period.

As indicated earlier, the samples for the two years involve different companies; therefore, without additional evidence, it cannot be established definitely whether or not the shifts have taken place. Table 3.7, however, shows that the median rate of change in Equipment, Maintenance, and Garage expenses has been less than that for Total Operating Expenses; therefore, the relative size of this category has declined. In contrast, Transportation Expenses, including Drivers' Wages, has increased at a greater rate than Total Expenses; therefore, the relative size of these categories has increased. These two results are consistent with those in Table 3.6. However, an inconsistency arises in the Administrative and General Category.

Table 3.7

PERCENT CHANGES IN SELECTED EXPENSE CATEGORIES, 1960 TO 1969

Expense Category	Number of Firms in Sample	Median Percent Change 1960 to 1969
Total Operating Expenses	50	22
Equipment, Maintenance, and Garage	50	18
Transportation	50	28
Drivers' Wages	49	31
Administrative and General	49	19

Note: See Appendix IIIA for more detail.

Table 3.7 implies that its relative size should have declined, but Table 3.6 shows the opposite.

Up to this point, the discussion has focused on general tendencies for the industry in 1960 and 1969. The remainder of this section will be concerned with how the firms varied within the industry.

c. Distribution of Firms by Expense Ratio

Table 3.8 presents the distribution of the firms according to Expense Ratios, which are defined simply as the ratio of expense aggregates to Total Revenue expressed in percent.[7] The Total Expense

7. The term "operating ratio" has been avoided here because different concepts of expenses are involved. Note also that the sample sizes for 1960 and 1969 have diminished from 78 to 52, respectively. This is because the samples were maximized to analyze several more variables in addition to the expense items, and some firms were dropped for lack of data.

Table 3.8

DISTRIBUTION OF FIRMS BY EXPENSE RATIO[a], 1960 AND 1969

Expense Ratio	Total Expenses		Total Expenses Less Depreciation, and Amortization		Total Expenses Less Depreciation, Amortization, and Taxes	
	1960	1969	1960	1969	1960	1969
Number of Firms						
Under 70	-	-	-	-	1	-
70 and under 80	-	-	-	1	18	6
80 and under 90	1	2	29	6	49	25
90 and under 100	60	22	44	28	7	7
100 and under 110	14	15	3	6	2	6
110 and over	3	13	2	11	1	8
Total	78	52	78	52	78	52
Percentage of Firms						
Under 70	-	-	-	-	1	-
70 and under 80	-	-	-	2	23	12
80 and under 90	1	4	37	12	63	48
90 and under 100	77	42	56	54	9	13
100 and under 110	18	29	4	12	3	12
110 and over	4	25	3	21	1	15
Total	100	100	100	100	100	100

[a]Expenses as a percent of Total Revenue.

ratio is Total Operating Expenses divided by Total Revenue times 100. Again, Total Expenses less Depreciation and Amortization is a proxy for Variable Costs and is also expressed as a percent of Total Revenue. The third concept excludes Operating Taxes in addition to Depreciation and Amortization and is also expressed as a percent of Total Revenue.

The lower half of Table 3.8 shows the percentage of firms that were within certain classifications of expense ratios. The dashed lines across the table indicate the points at which expenses equal revenue. For example, in 1960, 18 percent of the firms in the sample had total expense ratios of 100 and under 110 percent, and 4 percent had ratios of 110 percent and over. In other words, 22 percent of the firms did not cover Total Operating Expenses. Compare this with the 1969 figure of 54 percent (29 + 25) that did not cover Total Operating Expenses, a considerable deterioration.[8]

The next two columns show the firms that did not cover variable costs in the two years. In 1960, about 7 percent did not cover variable costs; whereas in 1969, about 33 percent did not cover variable costs.

The last two columns indicate the effect of exempting firms entirely from operating taxes.[9] In spite of tax relief, 27 percent of the firms in 1969 would not have covered operating expenses.

d. Expense Ratios and Size of Firm[10]

The question naturally arises as to whether the size of firm has any bearing on the ability to cover costs. In Table 3.9 the firms have been classified according to annual revenue. In each class the percent of firms having expense ratios of 100 percent or more was determined. For example, in 1960, 34 percent of the firms with annual revenues under $1 million did not cover Total Operating Expenses. In 1969, 70 percent did not cover Total Operating Expenses.

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8. Note, however, that the size of sample is smaller in 1969; therefore, sampling variation is larger.

9. However, the largest proportion of operating taxes is social security taxes which as a practical matter may not be avoidable. Operating taxes include all federal, state, county, and municipal taxes other than income taxes.

10. Appendix IIIB presents detailed distributions by firm size.

Table 3.9

PERCENT OF FIRMS WITH EXPENSE RATIOS 100 PERCENT OR MORE, BY REVENUE SIZE CLASS, 1960 AND 1969

Annual Revenue (Millions)	Total Expenses		Total Expenses Less Depreciation, and Amortization		Total Expenses Less Depreciation, Amortization, and Taxes	
	1960	1969	1960	1969	1960	1969
Under 1	34	70	12	48	10	43
1 and under 5	7	39	-	22	-	11
5 and under 10	20	43	-	14	-	14
10 and over	-	50	-	25	-	25
All Firms	22	54	6	33	4	27

Note: See Appendix IIIB for more detailed breakdowns.

Table 3.9 should be studied carefully because it indicates that the smaller firms have suffered the greatest degree of deterioration with respect to their ability to cover costs. However, firms of all sizes have declined to some extent.[11] The most surprising figure is the large percentage of small firms (43 percent) that did not cover variable costs in 1969. These firms will not last under these conditions without some support.

e. Revenues and Cost Ratios

The revenue and cost ratios presented in Table 3.10 provide a general explanation for the plight of the small firms. In 1969, revenue per passenger for firms with annual revenues under $1 million were below the middle-sized firms and about the same level as the

11. The sample sizes are very small in the last two categories; therefore, the sizes of the percentages are highly unreliable (see Appendix IIIB). However, there is a clear indication that the larger firms have declined in their ability to cover costs.

Table 3.10

GROUP MEDIANS OF SELECTED REVENUE AND COST RATIOS, BY REVENUE SIZE GROUP, 1969

(All Ratios in Dollars)

Measure	Annual Revenue (Millions)				
	All Firms	Under 1	1 and Under 5	5 and Under 10	10 and Over
Number in Sample	52	23	18	7	4
Total Operating Revenue					
Per passenger	.239	.226	.249	.263	.222
Per vehicle mile	.646	.544	.669	.798	.848
Per seat-mile (cents)	1.44	1.38	1.45	1.67	1.69
Per employee (000)	10.091	8.167	10.279	11.339	12.404
Per bus (000)	17.758	13.381	19.127	24.934	26.966
Total Operating Cost[a]					
Per passenger	.235	.235	.242	.260	.208
Per vehicle mile	.633	.578	.646	.757	.795
Per seat-mile	1.46	1.44	1.40	1.60	1.63
Per employee (000)	10.000	9.011	10.001	10.869	11.675
Per bus (000)	17.996	14.374	18.568	22.799	27.042

[a]Less depreciation and amortization.

largest firms. This same inability to generate revenues is reflected in all of the other unit-revenue measures, and it will be shown in a later section that this is caused primarily by low passenger densities.

Unit costs are also lower for the smaller firms, but not low enough to be covered by revenues. Note that the very small firms have higher cost per passenger than the very large firms. This reflects the aforementioned differences in passenger density.

According to an analysis by Nelson, the higher unit costs for large operations is explained by higher wage rates in large cities.[12] It is not caused by diseconomies of scale. In fact, Nelson finds little evidence of diseconomies or economies of scale, i.e., the unit cost curves are relatively flat with respect to size of output when they are adjusted for wage rates and other variables that can account for the differences in capital and labor inputs.

Table 3.11 shows that approximately the same relationships held in 1960, except that median unit costs were below median unit revenues.

Costs, of course, reflect the various operating characteristics of the firms, and this is the subject matter of the remainder of this paper.

Table 3.11

GROUP MEDIANS OF SELECTED REVENUE AND COST RATIOS, BY REVENUE SIZE GROUP, 1960

(All Ratios in Dollars)

Measure	Annual Revenue (Millions)				
	All Firms	Under 1	1 and Under 5	5 and Under 10	10 and Over
Number in Sample	78	41	29	5	3
Total Operating Revenue					
Per passenger	.168	.150	.183	.169	.148
Per vehicle mile	.503	.449	.567	.684	.719
Per seat-mile (cents)	1.37	1.28	1.42	1.53	1.73
Per employee (000)	7.629	7.315	8.601	8.796	9.023
Per bus (000)	14.238	13.466	17.545	19.974	22.126
Total Operating Cost[a]					
Per passenger	.151	.141	.161	.144	.130
Per vehicle mile	.466	.412	.517	.597	.631
Per seat-mile	1.25	1.21	1.30	1.25	1.56
Per employee (000)	7.113	6.921	7.453	7.555	8.113
Per bus (000)	14.377	12.355	15.574	17.443	19.995

[a]Less depreciation and amortization.

12. Gary R. Nelson, "An Econometric Model of Urban Bus Transit Operations," Appendix IVA.

C. OPERATING CHARACTERISTICS

1. FLEET CHARACTERISTICS

a. Changes in the Number of Buses

In spite of apparent adverse economic conditions, a large proportion of the firms have increased their fleet sizes. Out of a sample of 49 firms that were in operation in 1960 and 1969, 23 increased the size of their fleets (see Table 3.12). Twenty-six firms decreased their fleets. The median percent change was -2 percent. Much of the funding for the increased fleets may have come from governmental capital grants or through other forms of subsidies--a matter not addressed in this paper. In any case, some investment in capital equipment has occurred.

Table 3.12

1969 INDEX NUMBERS OF NUMBER OF BUSES IN FLEET
(1960 = 100)

Index Number	Number of Firms
Under 60	2
60 and under 80	10
80 and under 100	14
100 and under 120	14
120 and under 140	7
140 and over	2
All Firms	49
Median Index	98

Note: See Appendix IIIA for more detail.

b. Average Age of Fleets

On the other hand, Table 3.13 shows that the median average age of bus company fleets has increased.[1] In 1960 the median for all firms in the sample was 9.6 years. This increased to 10.9 by 1969. Moreover, the median age appears to be increasing for all annual revenue size groups.

Table 3.14 verifies that the fleets are aging. In 1960, about 17 percent of the firms had fleets whose average age was greater than 12 years. In 1969, the figure was 38 percent. Again, the small firms dominate the figures. The 1960 and 1969 figures, for firms with annual revenues under $1 million, are 29 percent and 43 percent, respectively. Note also that the $1 million and under $5 million class had a substantially greater percentage of firms in the 12-year and over category in 1969 than in 1960.[2] Clearly, the small firms are behaving in a manner consistent with their financial postures.

Returning again to Table 3.13, observe that the median age of fleets appears to decline as the size of firm increases, where size is indicated by its total revenue. Again, this is consistent with the fact that large firms are not as bad off financially as the small firms. However, the sample may be somewhat misleading as to the degree of difference between small and large firms. A regression analysis of revenue versus fleet age (see Table 3.15) indicates that the higher the revenue level of the firm the lower the age, but the statistical relationship is very weak. Table 3.15 indicates that the negative regression coefficient was statistically significant at the .05 significance level in 1960 but not in 1969. Note, however, that the intercept terms indicate an upward shift in fleet age.[3]

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1. The average (arithmetic mean) age of the fleet was calculated for each firm, then the median was taken of these fleet averages. This is not the same as obtaining the median age of buses for all buses in the sample. Ten to 12 years is regarded by the industry as the average economic life of a bus.

2. Sample size problems enter into the picture here, but it seems safe to say that a substantial change has occurred.

3. There is a possibility of nonlinearity in this relationship.

Table 3.13

AVERAGE AGE OF BUS FLEET BY ANNUAL REVENUE SIZE GROUP, 1960 AND 1969

Average Age of Fleet (years)	All Firms	Annual Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
		1960			
0 and under 3	1	1	-	-	-
3 and under 6	4	3	-	1	-
6 and under 9	27	12	10	3	2
9 and under 12	33	13	18	1	1
12 and under 15	12	11	1	-	-
15 and under 18	1	1	-	-	-
Total Firms	78	41	29	5	3
Median	9.6	10.1	10.0	6.7	7.4
Range	2.0 to 17.1	2.0 to 17.1	7.7 to 13.4	3.8 to 9.3	7.1 to 10.5
		1969			
0 and under 3	2	2	-	-	-
3 and under 6	4	2		2	-
6 and under 9	12	5	2	2	3
9 and under 12	14	4	7	2	1
12 and under 15	8	2	5	1	-
15 and under 18	9	5	4	-	-
18 and under 21	3	3	-	-	-
Total Firms	52	23	18	7	4
Median	10.9	11.32	12.1	7.1	8.5
Range	0.0 to 19.9	0.0 to 19.9	7.3 to 17.8	3.5 to 12.0	7.3 to 10.9

Table 3.14

PERCENT OF FIRMS WITH AVERAGE FLEET AGE OF 12 YEARS OR MORE, BY REVENUE SIZE GROUP

Annual Revenue (Millions of Dollars)	Percent with Average Age 12 Years or Over	
	1960	1969
Under 1	29	43
1 and under 5	3	50
5 and under 10	-	14
10 and over	-	-
All Firms	17	38

Table 3.15

RELATIONSHIP BETWEEN TOTAL REVENUE AND AVERAGE AGE OF FLEET, 1960 and 1969

(Independent Variable: Revenue in Millions of Dollars)

Statistic	1960	1969
Intercept Term	9.98	11.00
Regression Coefficient	-.06	-.05
t-Value	-1.83	-1.63
R^2	.03	.03
Number of Observations	98	91

Note: t-value for .05 significance level is approximately 1.66.

There are a number of explanations that could be offered for the increase in bus age. The economic life of buses may be increasing as a result of equipment improvements. Some properties may find it more economical to purchase and recondition used equipment or simply to overhaul rather than replace their existing equipment. Clearly, this is an area that requires more detailed study before final conclusions can be reached.

c. Average Size of Bus in Fleet

As indicated earlier, some fleet replacement has been occurring in all firm size groups. This is evidenced by the fact that the average size of buses has increased in all groups (see Table 3.16). The median seats per bus increased by approximately 4 to 6 seats in every group. A comparison of the distributions for 1960 and 1969 reveals a substantial upward shift at all levels. This indicates that all firms tend to replace the smaller buses with larger buses.

2. PASSENGERS AND PASSENGER DENSITY

a. Changes in Number of Passengers

A sample of 44 firms that were in existence in 1960 and 1969 (and that reported their passenger figures) indicates, on the average, that the annual total of passengers for individual firms has declined substantially. Table 3.17 shows that the 1969 median index of total passengers (1960 = 100) was 68, a decline of 32 percent from 1960. The distribution of firms clearly leans toward negative percent changes, with only six firms showing increases in the number of passengers. If this sample can be regarded as representative, ridership has declined drastically and quite generally throughout the industry.[4]

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4. Better indicators are needed of change in ridership, e.g., growth rates over the 10-year period. There is a serious passenger reporting problem in the ATA data which accounts for the small sample.

Table 3.16

AVERAGE SEATS PER BUS, BY REVENUE SIZE GROUP, 1960 AND 1969

Average Seats Per Bus	All Firms	Annual Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
			1960		
Under 30	1	1	-	-	-
30 and under 35	21	19	2	-	-
35 and under 40	30	17	13	-	-
40 and under 45	19	3	11	3	2
45 and under 50	7	1	3	2	1
50 and under 55	-	-	-	-	-
Total Firms	78	41	29	5	3
Median	37.1	35.0	40.0	44.8	44.6
Range	29.9 to 46.2	29.9 to 45.0	34.4 to 48.0	41.8 to 46.2	42.9 to 45.9
			1969		
Under 30	1	1	-	-	-
30 and under 35	3	3	-	-	-
35 and under 40	8	6	2	-	-
40 and under 45	18	10	8	-	-
45 and under 50	16	3	7	3	3
50 and under 55	6	-	1	4	1
Total Firms	52	23	18	7	4
Median	44.2	40.5	44.3	50.8	48.8
Range	27.9 to 52.6	27.9 to 47.7	38.8 to 50.2	47.2 to 52.6	48.4 to 51.7

Table 3.17

1969 INDEXES OF TOTAL PASSENGERS

(1960 = 100)

Index Number	Number of Firms
Under 40	2
40 and under 60	15
60 and under 80	11
80 and under 100	10
100 and under 120	6
Total Firms	44
Median Index	68
Note: See Appendix IIIA for more detail.	

b. Passenger Density

The information in Table 3.18 and 3.19 should be studied carefully because it goes a long way toward explaining the general economic decline of the bus transit industry.[5] Consider first the two columns of Table 3.18 which show the situation for all firms in 1960 and 1969. The figures indicate that the number of passengers per line-mile and per route-mile has declined drastically as has the number of passengers per bus, per seat, and per vehicle mile.[6] The

5. The sample sizes are the same as those shown in Appendix IIIB.

6. Line miles are defined by the ATA as "the sum of the actual physical length (one-way) of all streets or highways traversed by motor bus." Route miles are defined as "the sum of the round-trip length of all bus routes operated, regardless of the number of times certain portions of the street or highway may be duplicated in the different routes."

Table 3.18

GROUP MEDIANS OF PASSENGER-DENSITY INDICATORS, BY REVENUE AND SIZE CLASS, 1960 AND 1969

Passenger-Density Indicator	All Firms		Annual Revenue ($ Millions)							
			Under 1		1 and Under 5		5 and Under 10		10 and Over	
	1960	1969	1960	1969	1960	1969	1960	1969	1960	1969
Passengers per Line-Mile (000)	74	50	58	32	80	39	203	79	325	123
Passengers per Route-Mile (000)	35	18	30	16	35	22	101	31	98	45
Passengers per Vehicle-Mile	3.1	2.6	3.0	2.6	3.2	2.4	4.1	2.9	4.8	4.2
Passengers per Bus (000)	96	67	80	61	101	70	130	97	144	129
Passengers per Seat	2482	1697	2445	1508	2375	1528	2912	1904	3136	2649
Passengers per Employee (000)	15	16	16	16	15	16	13	14	12	15

Source: Computer printouts of the arrays of the ratios.

Table 3.19

REGRESSION OF SELECTED ANNUAL PASSENGER-DENSITY INDICATORS ON ANNUAL REVENUE, 1960 AND 1969

(Independent Variable: Annual Revenue in Millions of Dollars)

Passenger-Density Indicator	Intercept Term	Regression Coefficient	t-Value	R^2	Number of Observations
Passengers per Line-Mile					
1960	78,863	7153	4.0	.16	87
1969	48,556	6463	10.0	.59	71
Passengers per Route-Mile					
1960	32,409	3899	7.3	.39	87
1969	34,060	2356	3.9	.18	72
Passengers per Vehicle-Mile					
1960	3.24	.07	3.0	.09	95
1969	2.81	.03	2.6	.07	90
Passengers per Bus					
1960	92,329	2010	4.0	.15	94
1969	74,267	1131	3.7	.14	88
Passengers per Seat					
1960	2,451	33	2.7	.07	91
1969	1,713	20	3.5	.13	85
Passengers per Employee					
1960	48,801	239	1.0[a]	.01	90
1969	41,890	169	1.4[a]	.03	81

[a] Not statistically significant at the .01 significance level (one-tailed test).

number of passengers per employee appear to have increased, a phenomenon that will be discussed in more detail in the next subsection.

These declines in passenger density explain why revenues have declined, even though fares are known to have increased. Moreover, most of the decline in these densities can be traced to declines in passengers; for, as will be shown later, the denominators of the ratios have not changed as rapidly over the period.

The second point that Table 3.18 brings out, and that is verified in Table 3.19, is the substantial difference in densities between the small and large firms. Clearly, the larger the firm the higher the density. This, of course, is explained by the differences in population and population densities served by the companies. In any case, the lower densities indicate the main reason why small firms are not doing as well, financially, as large firms.[7]

Note that all of the density indicators increased significantly--as indicated by the t-value--with an increase in revenue (except passengers per employee) and in every case the slopes were greater in 1960 than in 1969. This suggests that declines in the densities have been greater for the larger firms.

c. Passengers per Employee

Tables 3.18 and 3.19 give conflicting results as to whether the passengers-per-employee ratio (one measure of employee productivity) has increased. The former table shows that there has been a slight increase and the increase is greater in the larger firms. Moreover, the ratio seems higher for the smaller firms. In contrast, the regression equations in Table 3.19 indicate that there has been a modest downward shift in passengers per employee and that there is no statistically significant difference in the ratio when related to

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7. One wonders why, under these circumstances, small firms have increased the sizes of their buses. Larger buses cost more to buy and maintain. Although small firms may have purchased used buses at lower capital costs, the operating and maintenance costs still may be too high relative to passenger densities.

annual revenue. As further evidence that the ratio of passengers to employees has decreased, Table 3.20 shows that the 1960 to 1969 percent change in employees was -14 percent as against -32 percent for passengers.

More refined techniques may bring out whether there are significant changes or differences in passengers per employee, but apparently, the best hypotheses to accept are that (a) there has been a downward trend from 1960 to 1969, and (b) the size of firm has little or no bearing on the ratio.

Table 3.20

1969 INDEX NUMBERS OF EMPLOYEES
(1960 = 100)

Index Number	Number of Firms
Under 60	4
60 and under 80	12
80 and under 100	15
100 and under 120	11
120 and over	3
Total Firms	45
Median Index	86

Notes: Median Index for Passengers = 68 (see Table 3.17).
See Appendix IIIA for more detail.

3. SYSTEM OPERATIONS

The concept of service levels has always been elusive because there are so many ways to evaluate service. Clearly, the quality of the service as well as frequency, accessibility, speed, and other variables must all be considered. The term "system operations" has been used here to avoid the issue of whether service levels have actually changed.

Table 3.21 presents four variables that indicate the extent of system operations; line-miles, route-miles, buses, and bus-miles. As the table indicates, the median number of line-miles and route-miles in the samples did not change from 1960 to 1969. The median number of buses declined slightly, and the median number of bus-miles declined about 10 percent. Compare these figures with the changes in number of passengers described earlier, and it becomes clear that the latter is the driving force in the reduction in passenger densities.

Frequency of service is related to the number of buses per line-mile or per route-mile. More buses per line-mile or route-mile imply more frequent service (shorter headways). The data in Table 3.22 indicate that frequency of service seems to have increased slightly over the period.[8] However, note that the coefficient of variation in buses per route-mile increased by a factor of over two from 1960 to 1969 which implies that the changes in the ratios were not uniform throughout the industry.

Finally, Table 3.23 relates buses per line-mile and route-mile to the size of firm (using revenue as a measure of firm size). Notice here that although the intercept term for buses per route-mile indicates a slight upward shift, the slope has decreased. This implies that the frequency of service has not increased as rapidly for the larger firms. In fact, in 1960, buses per route-mile were positively related to size of firm, whereas in 1969 it cannot be accepted statistically that there is a positive relationship.

Table 3.23 also shows that the annual vehicle-miles per bus are about the same, regardless of the size of firm. There may have been a slight downward shift in bus utilization, but this cannot be verified statistically.

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8. The indexes in Table 3.21 imply a slight downward shift in frequency for those firms that operated in both years.

Table 3.21

SELECTED 1969 INDEXES OF SYSTEM OPERATIONS
(1960 = 100)

Index Number	Number of Firms			
	Line-Miles	Route-Miles	Buses	Bus-Miles
Under 60	2	6	2	4
60 and under 80	6	4	10	15
80 and under 100	8	8	14	12
100 and under 120	14	12	14	14
120 and under 140	2	3	7	2
140 and under 160	2	2	1	2
160 and under 180	3	1	-	1
180 and over	3	5	1	-
Total Firms	40	41	49	50
Median Index	100	100	98	90

Note: See Appendix IIIA for more detail.

Table 3.22

AVERAGES AND VARIATIONS OF BUSES PER LINE- AND ROUTE-MILE, 1960 AND 1969

Statistical Measure	Buses Per Line-Mile		Buses Per Route-Mile	
	1960	1969	1960	1969
Number of Observations	95	75	94	75
Arithmetic Mean	.865	.879	.408	.538
Standard Deviation	.648	.611	.249	.696
Coefficient of Variation[a]	75	70	61	129

[a]Standard deviation as a percent of the mean.

Table 3.23

REGRESSION OF SELECTED SYSTEM OPERATIONS INDICATORS ON ANNUAL REVENUE, 1960 AND 1969

(Independent Variable: Annual Revenue in Millions of Dollars)

System Operations Indicators	Intercept Term	Regression Coefficient	t-Value	R^2	Number of Observations
Buses per Line-Mile					
1960	.7854	.0306	3.39	.11	95
1969	.7173	.0312	7.82	.45	75
Buses per Route-Mile					
1960	.3623	.0160	5.43	.24	94
1969	.4896	.0094	1.56[a]	.03	75
Vehicle-Miles per Bus (000)					
1960	29.695	42.093	.32[a]	.001	103
1969	27.572	82.565	1.40[a]	.02	94

[a]Not significant at the .05 significance level.

4. SUMMARY

In 1969, bus transit firms were apparently operating at about the same levels as in 1960. The physical levels of the cost-generating inputs, therefore, have remained relatively stable, while the number of passengers has declined drastically, indicating that the ability to generate revenue has declined. This undoubtedly explains the revenue-cost squeeze described in Section B. It should also be noted that small firms have apparently maintained their services at levels as high, if not higher than large firms. Possibly this explains why the revenue-cost squeeze has been greater for the small firms.

With respect to investment, the industry appears to be behaving in the classical manner. The age of the fleet has increased, indicating that fleet replacement rate is not being maintained. What replacement has taken place has involved acquisition of larger (and presumably more costly) buses. This is true despite drastic reductions in passenger density at all firm size levels.

Appendix IIIA

INDEXES OF BUS TRANSIT OPERATIONS

Appendix IIIA

INDEXES OF BUS TRANSIT OPERATIONS

Table 3A-1 presents index numbers for selected variables for firms in existence in both 1960 and 1969. The sample sizes vary because availability of data varied. Note that each index has been arrayed from lowest to highest. This means that the order of firms has not been preserved; i.e., the indexes for a given row in the table involve different firms.

Table 3A-1

SELECTED 1969 INDEXES BY FIRM[a]

(1960 = 100)

(51) Total Operating Revenue	(51) Passenger Revenue	(47) Charter Revenue	(50) Total Operating Expenses	(50) Maintenance Expenses	(50) Transportation Expense	(49) Drivers Wages	(49) Administration & Central Expense	(40) Line-Miles	(41) Route-Miles	(49) Number of Buses	(45) Employees	(50) Bus-Miles	(44) Passengers
16	16	21	20	18	19	21	29	31	9	36	25	40	9
45	43	66	48	41	47	50	43	33	17	51	26	40	29
45	44	78	50	43	53	59	61	62	33	60	50	45	40
71	64	84	67	47	68	75	63	64	33	69	55	57	43
71	65	87	73	62	73	76	64	68	40	72	64	60	43
74	65	97	81	78	81	87	69	71	58	72	65	61	46
78	69	111	81	80	87	90	81	73	69	74	68	65	48
79	69	134	84	81	90	90	81	78	71	76	70	66	51
82	73	135	86	82	90	91	89	81	73	77	71	69	51
82	74	140	89	83	90	93	93	84	77	78	71	70	51
83	77	146	90	85	91	97	94	85	84	78	71	71	51
83	78	153	90	87	93	97	95	87	84	79	77	71	52
84	80	156	90	87	95	97	95	91	85	81	78	73	53
85	80	157	91	88	96	98	97	92	88	82	78	74	54
86	81	158	92	89	98	99	97	92	89	89	79	74	55
87	81	199	94	90	98	101	100	96	91	90	79	74	57
87	83	200	94	90	106	106	101	100	97	91	80	75	58
87	84	200	103	91	106	108	105	100	99	91	82	79	60
90	86	211	104	93	106	109	108	100	100	92	82	79	62
92	87	212	111	93	109	110	111	100	100	93	83	80	63
93	87	213	112	96	111	112	113	100[b]	100[b]	94	85	82	63
93	89	213	112	96	118	114	114	101	100	95	86	84	64
94	90	226	116	106	124	114	115	102	100	96	86[b]	87	68[b]
96	93	233[b]	118	109	126	115	117	103	104	97	88	89	70
97	94	245	122	114	127	131[b]	119[b]	107	106	98[b]	88	90[b]	71
97[b]	95[b]	254	122[b]	118[b]	128[b]	133	119	108	108	98	89	90	73
110	96	267	122	118	129	134	119	108	108	108	89	91	74
110	96	295	124	118	129	135	120	108	108	101	92	91	76
111	97	310	128	122	132	139	120	116	113	102	93	94	83
113	100	326	130	122	137	140	124	118	119	102	97	98	86
114	105	332	131	125	139	142	135	131	120	103	97	99	89
120	107	338	134	127	140	145	141	140	123	105	100	100	90
122	115	338	134	130	141	145	142	150	138	106	100	100	91
129	115	357	135	134	141	152	149	158	145	107	100	101	91
129	115	365	137	135	147	152	149	164	149	109	100	101	92
129	118	387	137	138	149	153	153	164	170	109	100	103	94
132	119	405	139	138	149	154	159	166	187	110	103	104	94
132	122	546	143	138	151	154	162	238	199	113	104	104	98
132	124	559	147	139	151	156	163	260	260	114	106	104	101
134	129	583	148	139	151	157	168	337	276	117	106	104	102
134	131	603	148	149	153	158	177		337	123	115	106	108
136	133	696	151	145	160	167	193			123	116	107	113
146	134	701	156	149	162	171	245			127	132	110	114
146	138	722	157	155	164	172	255			131	139	112	114
146	142	767	166	155	167	181	302			133	189	115	
147	144	1876	170	172	173	185	304			137		120	
148	144	2838	171	174	179	205	339			138		134	
164	146		189	186	188	229	348			147		142	
168	152		215	190	218	239	581			187		147	
218	158		232	231	225							165	
217	182												

[a]Numbers in parentheses indicate the number of firms in the array.

[b]Median.

Appendix IIIB

FREQUENCY DISTRIBUTIONS OF BUS TRANSIT OPERATIONS

Appendix IIIB

FREQUENCY DISTRIBUTIONS OF BUS TRANSIT OPERATIONS

This appendix presents more detailed frequency distributions of the various ratios discussed in the paper. Each ratio is classified according to annual revenue size groups. The medians were calculated from the individual arrays of the data, not from the standard frequency-distribution formula. A list of tables is provided on the next page for convenience in locating a particular table.

List of Tables

List of Tables (Cont'd)

Table 3B.1

TOTAL OPERATING EXPENSES[a] AS A PERCENT OF TOTAL REVENUE, BY REVENUE SIZE GROUP, 1960 AND 1969

Percent	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
85 and under 90	1		1		
90 and under 95	21	5	12	2	2
95 and under 100	39	22	14	2	1
100 and under 105	11	8	2	1	
105 and under 110	3	3			
110 and under 115	1	1			
115 and under 120	1	1			
120 and over	1	1	—	—	—
Total Firms	78	41	29	5	3
Median	96.6	97.6	95.2	95.2	94.0
1969					
80 and under 85	1	1			
85 and under 90	1		1		
90 and under 95	6	1	3	2	
95 and under 100	16	5	7	2	2
100 and under 105	13	6	5	1	1
105 and under 110	2	1		1	
110 and under 115	2	2			
115 and under 120	3	1	1	1	
120 and under 125	2	1			1
125 and over	6	5	1	—	—
Total Firms	52	23	18	7	4
Median	100.1	103.7	99.1	100.0	101.4

[a] Expenses based on Total Operating Expenses.

Table 3B.2

TOTAL EXPENSES LESS DEPRECIATION AND AMORTIZATION AS A PERCENT OF TOTAL REVENUE, BY REVENUE SIZE GROUP, 1960 AND 1969

Percent	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
80 and under 85	2	1	1		
85 and under 90	27	6	15	4	2
90 and under 95	31	17	12	1	1
95 and under 100	13	12	1		
100 and under 105	2	2			
105 and under 110	1	1			
110 and under 115	1	1			
115 and over	1	1	—	—	—
Total Firms	78	41	29	5	3
Median	91.2	93.8	89.2	85.5	90.0
1969					
75 and under 80	1		1		
80 and under 85	3	1		2	
85 and under 90	3		3		
90 and under 95	21	7	8	3	3
95 and under 100	7	4	2	1	
100 and under 105	5	3	2		
105 and under 110	1			1	
110 and under 115	3	3			
115 and under 120	2		1		1
120 and over,	6	5	1	—	—
Total Firms	52	23	18	7	4
Median	94.5	98.9	92.6	90.7	93.9

Table 3B.3

TOTAL EXPENSES LESS DEPRECIATION, AMORTIZATION, AND TAXES[a] AS A PERCENT OF TOTAL REVENUE, BY REVENUE SIZE GROUP, 1960 AND 1969

Percent	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
		1960			
65 and under 70	1	1			
70 and under 75	1	1			
75 and under 80	17	4	10	2	1
80 and under 85	31	11	16	3	1
85 and under 90	18	14	3		1
90 and under 95	6	6			
95 and under 100	1	1			
100 and over	3	3	—	—	—
Total Firms	78	41	29	5	3
Median	83.6	85.6	81.8	80.3	82.4
		1969			
70 and under 75	1	1			
75 and under 80	5		3	2	
80 and under 85	12	4	5	2	1
85 and under 90	13	6	5	1	1
90 and under 95	5	1	2	1	1
95 and under 100	2	1	1		
100 and under 105	5	4		1	
105 and under 110	1	1			
110 and under 115	2		1		1
115 and under 120	1	1			
120 and over	5	4	1	—	—
Total Firms	52	23	18	7	4
Median	87.8	91.2	85.8	84.1	89.3

[a]Operating taxes only.

Table 3B.4

REVENUE PER PASSENGER, BY REVENUE SIZE GROUP, 1960 AND 1969

Revenue per Passenger	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 10	2	1		1	
10 and under 15	27	20	5		2
15 and under 20	32	14	14	4	
20 and under 25	13	3	9		1
25 and under 30	1		1		
30 and under 35					
35 and under 40	1	1			
40 and under 45					
45 and under 50					
50 and over	2	2	—	—	—
Total Firms	78	41	29	5	3
Median	.1678	.1495	.1828	.1691	.1477
1969					
Under 10	1		1		
10 and under 15	1	1			
15 and under 20	13	8	2	1	2
20 and under 25	16	8	6	2	
25 and under 30	13	3	5	3	2
30 and under 35	3	1	1	1	
35 and under 40	2	1	1		
40 and under 45	1		1		
45 and under 50	1	1			
50 and over	1	—	1	—	—
Total Firms	52	23	18	7	4
Median	.2391	.2257	.2494	.2625	.2217

Table 3B.5

ANNUAL REVENUE PER VEHICLE-MILE, BY REVENUE SIZE GROUP, 1960 AND 1969

Revenue per Vehicle Mile	All Firms	Revenue ($ Millions)			
		Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under .30	1	1			
.30 and under .35	1	1			
.35 and under .40	8	8			
.40 and under .45	14	11	3		
.45 and under .50	13	11	2		
.50 and under .55	10	4	5	1	
.55 and under .60	11	3	7	1	
.60 and under .65	9		8		1
.65 and under .70	2		1	1	
.70 and over	9	2	3	2	2
Total Firms	78	41	29	5	3
Median	.5032	.4491	.5656	.6837	.7187
1969					
Under .30	2	2			
.30 and under .35	1	1			
.35 and under .40					
.40 and under .45	5	4	1		
.45 and under .50	4	3	1		
.50 and under .55	3	2	1		
.55 and under .60	8	5	3		
.60 and under .65	4	1	2		1
.65 and under .70	7	2	4	1	
.70 and under .75	7	2	3	2	
.75 and under .80	1			1	
.80 and over	10	1	3	3	3
Total Firms	52	23	18	7	4
Median	.6459	.5442	.6690	.7980	.8476

Table 3B.6

ANNUAL REVENUE PER SEAT-MILE, BY REVENUE SIZE GROUP, 1960 AND 1969

Revenue per Seat-Mile (Cents)	All Firms	Revenue Size Group			
		Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 1.0	2	2			
1.0 and under 1.2	13	7	6		
1.2 and under 1.4	30	21	7	2	
1.4 and under 1.6	21	7	10	2	2
1.6 and under 1.8	8	2	5	1	
1.8 and under 2.0	2	1	1		
2.0 and over	2	1	—	—	1
Total firms	78	41	29	5	3
Median	1.37	1.28	1.42	1.53	1.73
1969					
Under 1.0	5	4	1		
1.0 and under 1.2	4	2	2		
1.2 and under 1.4	10	6	3		1
1.4 and under 1.6	16	7	5	3	1
1.6 and under 1.8	9	4	2	1	2
2.0 and over	2	—	1	1	—
Total firms	52	23	18	7	4
Median	1.44	1.38	1.45	1.67	1.69

Table 3B.7

TOTAL REVENUE PER EMPLOYEE, BY REVENUE SIZE GROUP, 1960 AND 1969

Revenue per Employee ($ Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 4	1	1			
4 and under 5	2	1		1	
5 and under 6	4	3	1		
6 and under 7	12	10	2		
7 and under 8	26	16	10		
8 and under 9	14	5	5	3	1
9 and under 10	12	2	8	1	1
10 and under 11	5	2	2		1
11 and under 12					
12 and over	2	1	1	—	—
Total Firms	78	41	29	5	3
Median	7,629	7,315	8,601	8,796	9,023
1969					
Under 4					
4 and under 5	1	1			
5 and under 6	1	1			
6 and under 7	3	3			
7 and under 8	6	5	1		
8 and under 9	4	2	2		
9 and under 10	10	5	5		
10 and under 11	7	2	4		1
11 and under 12	12	2	3	6	1
12 and over	8	2	3	1	2
Total Firms	52	23	18	7	4
Median	10,091	8,167	10,279	11,339	12,404

Table 3B.8

TOTAL REVENUE PER BUS OWNED, BY REVENUE SIZE GROUP, 1960 AND 1969

Total Revenue per Bus ($ Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
5 and under 10	10	10			
10 and under 15	26	20	6		
15 and under 20	29	8	18	3	
20 and under 25	11	2	5	2	2
25 and under 30					
30 and over	2	1	—	—	1
Total Firms	78	41	29	5	3
Median	14,238	13,466	17,545	19,974	22,126
1969					
5 and under 10	6	6			
10 and under 15	12	9	3		
15 and under 20	14	5	8	1	
20 and under 25	13	3	5	3	2
25 and under 30	4		1	2	1
30 and over	3	—	1	1	1
Total Firms	52	23	18	7	4
Median	17,758	13,381	19,127	24,934	26,966

Table 3B.9

EXPENSES LESS DEPRECIATION AND AMORTIZATION PER PASSENGER, BY REVENUE SIZE GROUP, 1960 AND 1969

Expenses per Passenger (Dollars)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under .10	2	1		1	
.10 and under .15	36	22	10	2	2
.15 and under .20	33	13	17	2	1
.20 and under .25	4	2	2		
.25 and under .30					
.30 and under .35					
.35 and under .40	1	1			
.40 and over	2	2	—	—	—
Total Firms	78	41	29	5	3
Median	.1512	.1409	.1609	.1443	.1296
1969					
Under .10	1		1		
.10 and under .15	1				1
.15 and under .20	11	5	3	2	1
.20 and under .25	17	10	5	1	1
.25 and under .30	11	3	4	4	
.30 and under .35	4	1	2		1
.35 and under .40	4	2	2		
.40 and over	3	2	1	—	—
Total Firms	52	23	18	7	4
Median	.2350	.2350	.2419	.2603	.2082

Table 3B.10

EXPENSES LESS DEPRECIATION AND AMORTIZATION PER VEHICLE-MILE, BY REVENUE SIZE GROUP, 1960 AND 1969

Expenses per Vehicle Mile (Dollars)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under .30	1	1			
.30 and under .40	15	12	3		
.40 and under .50	30	20	9	1	
.50 and under .60	22	6	13	2	1
.60 and under .70	8	1	4	2	1
.70 and under .80					
.80 and under .90					
.90 and under 1.00					
1.00 and over	2	1	—	—	1
Total Firms	78	41	29	5	3
Median	.4656	.4117	.5173	.5969	.6310
1969					
Under .30					
.30 and under .40	2	2			
.40 and under .50	6	4	2		
.50 and under .60	11	6	5		
.60 and under .70	19	9	8	2	
.70 and under .80	8	1	2	3	2
.80 and under .90	4	1		1	2
.90 and under 1.00					
1.00 and over	2	—	1	1	—
Total Firms	52	23	18	7	4
Median	.6331	.5782	.6464	.7565	.7946

Table 3B.11

ANNUAL EXPENSES LESS DEPRECIATION AND AMORTIZATION
PER SEAT-MILE, BY REVENUE SIZE GROUP, 1960 AND 1969

Expenses per Seat-Mile (Cents)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
			1960		
Under 1.0	8	5	3		
1.0 and under 1.2	23	13	8	2	
1.2 and under 1.4	26	14	8	2	2
1.4 and under 1.6	16	6	9	1	
1.6 and under 1.8	3	2	1		
1.8 and under 2.0					
2.0 and over	2	1	—	—	1
Total Firms	78	41	29	5	3
Median	1.25	1.21	1.30	1.25	1.56
			1969		
Under 1.0	1	1			
1.0 and under 1.2	7	4	3		
1.2 and under 1.4	11	3	6	2	
1.4 and under 1.6	17	10	4	1	2
1.6 and under 1.8	12	3	4	3	2
1.8 and under 2.0	2	2			
2.0 and over	2	—	1	1	—
Total Firms	52	23	18	7	4
Median	1.46	1.44	1.40	1,60	1.63

Table 3B.12

EXPENSES LESS DEPRECIATION AND AMORTIZATION PER EMPLOYEE, BY REVENUE SIZE GROUP, 1960 AND 1969

Expenses per Employee ($ Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 5	2	1		1	
5 and under 6	8	5	3		
6 and under 7	25	17	8		
7 and under 8	22	11	8	2	1
8 and under 9	16	4	9	2	1
9 and under 10	3	2			1
10 and over	2	1	1	—	—
Total Firms	78	41	29	5	3
Median	7,113	6,921	7,453	7,555	8,113
1969					
Under 5					
5 and under 6	2	2			
6 and under 7	1	1			
7 and under 8	5	4	1		
8 and under 9	7	4	3		
9 and under 10	11	4	5	1	1
10 and under 11	13	3	5	4	1
11 and under 12	7	3	3	1	
12 and over	6	2	1	1	2
Total Firms	52	23	18	7	4
Median	10,000	9,011	10,001	10,869	11,675

Table 3B.13

EXPENSES LESS DEPRECIATION AND AMORTIZATION PER BUS OWNED, BY REVENUE SIZE GROUP, 1960 AND 1969

Expenses per Bus Owned ($ Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 8	4	4			
8 and under 10	7	7			
10 and under 12	8	6	2		
12 and under 14	16	13	3		
14 and under 16	20	7	12	1	
16 and under 18	13	2	8	3	
18 and under 20	5		3		2
20 and over	5	2	1	1	1
Total Firms	78	41	29	5	3
Median	14,377	12,355	15,574	17,443	19,895
1969					
Under 8	3	3			
8 and under 10	2	2			
10 and under 12	5	5			
12 and under 14	3	1	2		
14 and under 16	5	3	2		
16 and under 18	9	5	4		
18 and under 20	8	1	6	1	
20 and over	17	3	4	6	4
Total Firms	52	23	18	7	4
Median	17,996	14,374	18,568	22,799	27,042

Table 3B.14

ANNUAL PASSENGERS PER LINE-MILE, BY REVENUE SIZE GROUP, 1960 AND 1969

Passenger per Line Mile (Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 25	7	7			
25 and under 50	16	11	5		
50 and under 75	19	10	9		
75 and under 100	16	4	11		1
100 and under 125	7	5	1	1	
125 and under 150	5	2	2	1	
150 and under 175	2	1	1		
175 and under 200					
200 and under 225	2			2	
225 and over	4	1	—	1	2
Total Firms	78	41	29	5	3
Median	74.2	57,910	79,636	202,895	324,898
1969					
Under 25	10	6	4		
25 and under 50	16	10	6		
50 and under 75	12	5	5	2	
75 and under 100	5	1	1	2	1
100 and under 125	4	1	1	1	1
125 and under 150	1				1
150 and under 175					
175 and under 200					
200 and under 225	1		1		
225 and over	3	—	—	2	1
Total Firms	52	23	18	7	4
Median	50.0	32,485	38,849	79,251	122,963

Table 3B.15

ANNUAL PASSENGER PER ROUTE-MILE, BY REVENUE SIZE GROUP, 1960 AND 1969

Passengers per Route Mile (Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 10	6	5	1		
10 and under 20	15	10	5		
20 and under 30	8	6	2		
30 and under 40	18	9	9		
40 and under 50	11	3	7	1	
50 and under 60	7	4	1	1	1
60 and under 70	6	3	3		
70 and under 80	1		1		
80 and over	6	1	—	3	2
Total Firms	78	41	29	5	3
Median	34.6	29,488	34,915	101,158	98,124
1969					
Under 10	10	6	4		
10 and under 20	14	9	4		1
20 and under 30	11	5	4	2	
30 and under 40	7	1	3	2	1
40 and under 50	3	2	1		
50 and under 60	2			1	1
60 and under 70					
70 and under 80					
80 and over	5	—	2	2	1
Total Firms	52	23	18	7	4
Median	18.2	16,242	21,717	31,166	44,754

Table 3B.16

ANNUAL PASSENGERS PER VEHICLE-MILE, BY REVENUE SIZE GROUP, 1960 AND 1969

Passengers per Vehicle Mile	All Firms	Revenue ($ Millions)			
		Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 1	2	2			
1 and under 2	3	2	1		
2 and under 3	29	17	11		1
3 and under 4	29	15	13	1	
4 and under 5	12	4	4	3	1
5 and over	3	1	—	1	1
Total Firms	78	41	29	5	3
Median	3.07	2.9532	3.1709	4.1373	4.8672
1969					
Under 1	5	2	2		1
1 and under 2	5	3	2		
2 and under 3	29	14	11	4	
3 and under 4	8	4	1	2	1
4 and under 5	2		1		1
5 and over	3	—	1	1	1
Total Firms	52	23	18	7	4
Median	2.58	2.5759	2.4407	2.8944	4.2256

Table 3B.17

ANNUAL PASSENGER PER BUS OWNED, BY REVENUE SIZE GROUP, 1960 AND 1969

Passengers per Bus (Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
		1960			
Under 25	1	1			
25 and under 50	4	4			
50 and under 75	16	10	6		
75 and under 100	22	14	8		
100 and under 125	22	7	12	2	1
125 and under 150	9	3	3	2	1
150 and under 175	2	1		1	
175 and under 200					
200 and over	2	1	—	—	1
Total Firms	78	41	29	5	3
Median	96.1	80.2	100.6	130.4	144.0
		1969			
Under 25	2	1	1		
25 and under 50	9	6	3		
50 and under 75	20	12	7	1	
75 and under 100	12	2	5	4	1
100 and under 125	5	2	2	1	
125 and under 150	2				2
150 and under 175					
175 and under 200	1				1
200 and over	1	—	—	1	—
Total Firms	52	23	18	7	4
Median	67.2	61.0	70.2	97.1	129.4

Table 3B.18

ANNUAL PASSENGERS PER SEAT, BY REVENUE SIZE GROUP, 1960 AND 1969

Passengers per Seat	All Firms	Revenue ($ Millions)			
		Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 1,000	2	2			
1,000 and under 2,000	18	11	7		
2,000 and under 3,000	37	18	15	3	1
3,000 and under 4,000	17	8	7	1	1
4,000 and under 5,000	2	1		1	
5,000 and over	2	1	—	—	1
Total Firms	78	41	29	5	3
Median	2,482	2,445	2,375	2,912	3,136
1969					
Under 1,000	6	4	2		
1,000 and under 2,000	33	15	13	4	1
2,000 and under 3,000	11	4	3	2	2
3,000 and under 4,000	1				1
4,000 and under 5,000	1			1	
5,000 and over	—	—	—	—	—
Total Firms	52	23	18	7	4
Median	1,697	1,508	1,528	1,904	2,649

Table 3B.19

ANNUAL PASSENGERS PER EMPLOYEE, BY REVENUE SIZE GROUP, 1960 AND 1969

Passengers per Employee (Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
		1960			
Under 20	2	2			
20 and under 30	2	2			
30 and under 40	15	6	9		
40 and under 50	25	13	9	2	1
50 and under 60	20	9	9	2	
60 and over	14	9	2	1	2
Total Firms	78	41	29	5	3
Median	47.7	47.4	47.1	50.3	60.5
		1969			
Under 20	3	1	2		
20 and under 30	4	3	1		
30 and under 40	17	9	5	3	
40 and under 50	15	6	7	2	
50 and under 60	8	3	1	1	3
60 and over	5	1	2	1	1
Total Firms	52	23	18	7	4
Median	41.3	39.6	41.4	41.9	53.9

Table 3B.20

BUSES OWEND PER LINE-MILE, BY REVENUE SIZE GROUP, 1960 AND 1969

Buses Owned per Line Mile	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under .2	1	1	0		
.2 and under .4	10	7	3		
.4 and under .6	16	12	4		
.6 and under .8	15	5	10		
.8 and under 1.0	14	6	6	1	1
1.0 and under 1.2	6	3	2	1	
1.2 and under 1.4	8	5	3		
1.4 and under 1.6	1	0	1		
1.6 and under 1.8	3	1		2	
1.8 and under 2.0	0				
2.0 and over	4	1	—	1	2
Total	78	41	29	5	3
Median	.7612	.6022	.7557	1.6277	2.2556
1969					
Under .2					
.2 and under .4	6	4	2		
.4 and under .6	16	10	6		
.6 and under .8	11	4	5	1	1
.8 and under 1.0	7	2	2	3	
1.0 and under 1.2	4	1	1		2
1.2 and under 1.4	5	2	1	1	1
1.4 and under 1.6					
1.6 and under 1.8					
1.8 and under 2.0	1		1		
2.0 and over	2	—	—	2	—
Total	52	23	18	7	4
Median	.7113	.5529	.6634	.9878	1.1306

Table 3B.21

BUSES OWNED PER ROUTE-MILE, BY REVENUE SIZE GROUP
1960 AND 1969

Buses Owned per Route Mile	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under .1	1	1			
.1 and under .2	8	5	3		
.2 and under .3	22	13	9		
.3 and under .4	14	7	7		
.4 and under .5	12	6	3	2	1
.5 and under .6	5	3	2		
.6 and under .7	9	3	5		1
.7 and under .8	3	1		2	
.8 and under .9	2	1		1	
.9 and under 1.0					
1.0 and over	2	1	—	—	1
Total	78	41	29	5	3
Median	.3361	.3017	.3508	.7650	.6812
1969					
Under .1					
.1 and under .2	7	5	2		
.2 and under .3	15	7	6		2
.3 and under .4	11	4	4	3	
.4 and under .5	11	6	3	1	1
.5 and under .6	2	1		1	
.6 and under .7	1				1
.7 and under .8					
.8 and under .9					
.9 and under 1.0	1		1		
1.0 and over	4	—	2	2	—
Total	52	23	18	7	4
Median	.3438	.2765	.3400	.4402	.3469

Table 3B.22

ANNUAL VEHICLE MILES PER BUS OWNED, BY REVENUE SIZE GROUP, 1960 AND 1969

Vehicle Miles per Bus (Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 15					
15 and under 20	5	5			
20 and under 25	12	8	4		
25 and under 30	25	11	10	2	2
30 and under 35	21	10	8	3	
35 and under 40	11	5	5		1
40 and under 45	3	1	2		
45 and under 50					
50 and over	1	1	—	—	—
Total Firms	78	41	29	5	3
Median	29.6	28.9	30.8	32.2	29.6
1969					
Under 15	4	3	1		
15 and under 20	3	3			
20 and under 25	11	6	4	1	
25 and under 30	11	3	5	2	1
30 and under 35	14	5	6	3	
35 and under 40	7	2	1	1	3
40 and under 45	1	1			
45 and under 50	1		1		
50 and over	—	—	—	—	—
Total Firms	52	23	18	7	4
Median	29.4	24.1	29.4	30.5	36.1

Table 3B.23

EMPLOYEES PER BUS OWNED, BY REVENUE SIZE GROUP, 1960 AND 1969

Employees per Bus	All Firms	Revenue ($ Millions)			
		Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 1.0					
1.0 and under 1.5	11	11			
1.5 and under 2.0	29	16	13		
2.0 and under 2.5	29	13	11	3	2
2.5 and under 3.0	6		4	1	1
3.0 and over	3	1	1	1	—
Total Firms	78	41	29	5	3
Median	1.97	1.80	2.05	2.37	2.45
1969					
Under 1.0	4	3			1
1.0 and under 1.5	11	8	2	1	
1.5 and under 2.0	26	8	13	5	
2.0 and under 2.5	7	3	2	1	1
2.5 and under 3.0	3	1			2
3.0 and over	1	—	1	—	—
Total Firms	52	23	18	7	4
Median	1.72	1.55	1.83	2.21	2.40

Table 3B.24

ANNUAL VEHICLE MILES PER EMPLOYEE, BY REVENUE SIZE GROUP, 1960 AND 1969

Vehicle Miles per Employee (Thousands)	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 10	5	1	2	1	1
10 and under 12	3	1	2		
12 and under 14	20	7	9	3	1
14 and under 16	19	12	5	1	1
16 and under 18	18	10	8		
18 and under 20	7	5	2		
20 and under 22	5	5			
22 and over	1	—	1	—	—
Total Firms	78	41	29	5	3
Median	14.9	16.0	14.8	12.5	12.4
1969					
Under 10	1		1		
10 and under 12	3		1	1	1
12 and under 14	11	6	2	3	
14 and under 16	13	5	3	3	2
16 and under 18	12	4	8		
18 and under 20	4	3	1		
20 and under 22	5	2	2		1
22 and over	3	3	—	—	—
Total Firms	52	23	18	7	4
Median	15.9	16.2	16.1	14.0	14.7

Table 3B.25

VEHICLE MILES PER VEHICLE HOUR, BY REVENUE SIZE GROUP, 1960 AND 1969

Vehicle Miles per Vehicle Hour	All Firms	Revenue ($ Millions)			
		Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 8	2	1			1
8 and under 9	2	2			
9 and under 10	4	1	1	2	
10 and under 11	20	8	10	1	1
11 and under 12	12	5	7		
12 and under 13	10	3	5	1	1
13 and under 14	1		1		
14 and over	—	—	—	—	—
Total	51	20	24	4	3
Median	10.98	10.95	11.08	10.43	10.45
1969					
Under 8	1		1		
8 and under 9	4	2	1	1	
9 and under 10	6	5	1		
10 and under 11	5	2	1	1	1
11 and under 12	8	3	3	1	1
12 and under 13	12	3	5	3	1
13 and under 14	5	3	2		
14 and under 15	3	2			1
15 and over	1	1	—	—	—
Total	45	21	14	6	4
Median	12.00	11.68	11.95	11.13	12.04

Table 3B.26

PASSENGERS PER VEHICLE HOUR, BY REVENUE SIZE GROUP, 1960 AND 1969

Passengers per Vehicle Hour	All Firms	Revenue ($ Millions) Under 1	1 and Under 5	5 and Under 10	10 and Over
1960					
Under 20	1	1			
20 and under 30	6	3	3		
30 and under 40	28	11	16		1
40 and under 50	13	5	5	3	
50 and under 60	2			1	1
60 and over	1	—	—	—	1
Total	51	20	24	4	3
Median	36.76	32.45	37.76	40.84	50.84
1969					
Under 20	7	4	2		1
20 and under 30	16	11	3	2	
30 and under 40	14	4	8	2	
40 and under 50	2			1	1
50 and under 60	4	1	1		2
60 and over	2	1	—	1	—
Total	45	21	14	6	4
Median	29.90	26.71	30.27	34.21	49.60

CHAPTER IV

AN ECONOMETRIC MODEL OF URBAN BUS TRANSIT OPERATIONS

by

Gary R. Nelson

SUMMARY

The econometric model presented in this paper provides an analytical tool for the examination of the demand and supply aspects of urban bus transit. A demand function is formulated, the parameters of which are estimated from a cross-section of bus transit "markets," i.e., urban areas that have bus transit available. The variables in the demand function are level of service (bus-miles is used as a proxy), population, area, automobiles per capita, population per unit of highway capacity, and certain age and income classes. Supply is investigated in terms of the ratio of cost to revenue experienced by the transit firm and in terms of the average fare and the level of service established by the firm. Supply functions include as variables the type of regulation and ownership, the demand for transit, and the cost of providing transit service.

Samples of 44 firms in 1960 and 51 firms in 1968 are used to provide estimates of the model parameters. The samples were selected such that the firms were the only form of mass transit serving the city, i.e., there were no other bus or rail operations in the city. Two-stage least squares regression analysis is used in estimating the parameters of the model.

With respect to demand (defined as the number of bus passengers), the analysis yielded the following results for 1968:

(1) At a given fare level, properties that provided more bus-miles per capita experienced higher patronage. This suggests that improved service levels will, indeed, attract riders.

(2) The number of passengers does, in fact, decrease with increases in fare, and the elasticity (percentage change in demand relative to a percentage change in fare) at the average fare of 22 cents in 1968 was about -.67. This means that, at an original fare of

22 cents, a 10 percent increase in fare can be expected to yield a 6.7 percent decline in passengers. The industry's rule-of-thumb is a decline of 3 percent in passengers for an increase of 10 percent in fares, a figure which apparently underestimates the fare impact.

(3) Bus patronage is higher in cities where the proportion of persons in the 19 to 64 age group is highest. This reflects the likelihood that the chief use of mass transit is for work trips and the primary beneficiaries of bus transit are members of the labor force.

(4) Bus patronage is lower in cities where the proportion of households in the low-income range (under $3,000) is highest and the proportion of households in the high-income range ($10,000 and above) is highest. Some of the reasons for the lower ridership by the poor may be: (a) unemployment in this group is higher, (b) they lack funds to ride, (c) they tend to live within walking distance of their work place, (d) transit service is not accessible.

The lower ridership by persons in high-income households is undoubtedly linked to their greater use of the automobile for transit.

The analysis of the supply side yielded the following results for 1968:

(1) The firms that experienced the highest ratio of total cost to total passenger revenue were private firms owned by power companies and public firms operated by cities.[1] Private firms regulated by local municipalities, state-regulated firms, and firms operated by transit authorities had lower ratios.

An important factor in high ratios of cost to revenue is the ability to subsidize transit operations. Power companies presumably subsidize bus operations with revenue from other operations, while city governments are able to subsidize operations from other sources. There is no evidence that firms with high ratios also have high unit costs.

(2) In systems where such subsidization occurs, the firm may encourage ridership either by constraining fares or promoting service levels. Supply estimates reveal that firms with high cost-to-revenue ratios tend to operate with lower fares but not significantly higher levels of service.

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1. Total costs here include operating costs plus plant and equipment investment recovery costs plus a normal return on investment. They do not include so-called "social overhead" costs.

(3) There do not appear to be economies or diseconomies of scale in bus transit. The major differences in unit costs that are observed between small and large operations are explained by differences in wage rates.

(4) Unit costs of publicly owned firms are not higher than privately owned firms and, in fact, tend to be lower.

A. INTRODUCTION

This paper develops an econometric model of the urban bus transit market. Much of the previous economic and econometric research in urban transportation has been devoted to models for estimating demand for various modes of transportation.[1] There have also been extensive studies of costs and cost functions for urban transportation.[2] Demand and cost functions alone are not sufficient to determine fares, passengers, or service characteristics in a transit system. The transit firm, its regulator, and other institutions have a direct impact on setting fares and supplying transit service and, therefore, also affect transit ridership. This "supply behavior" has not been ignored in the literature on the theory of the regulated firm,[3] or in studies of urban transit regulation.[4] No previous

1. Significant methodological developments in urban transportation demand functions have resulted from studies of W. Oi and P. Shuldiner, An Analysis of Urban Travel Demands, Evanston, Ill., 1962, a number of studies of Charles River Associates, including T. Domencich and G. Kraft, Free Transit, Lexington, Mass., 1970. Although largely oriented to supply and cost questions, a general discussion of demand issues and results appears in J. Meyer, J. Kain, M. Wohl, The Urban Transportation Problem, Cambridge, Mass., 1966.

2. In the area of bus transit, the most extensive work has been done by D. Miller, Cost Functions in Urban Bus Transportation, PhD. dissertation, Northwestern Univ., 1967. An analysis of costs of various modes of urban transportation appears in Meyer, Kain, and Wohl, op. cit.

3. H. Averch and L. Johnson, "Behavior of the Firm Under Regulatory Constraint," American Economic Review, LII, December 1962, and E. Bailey and J. Malone, "Resource Allocation and the Regulated Firm," Bell Journal of Economics and Management Sciences, Vol. 1, Spring 1970, pp. 129-42.

4. R.L. Banks and Associates, Inc., "Study and Evaluation of Local Transit Regulation and Regulatory Bodies," DOT-UT-75, Washington, D.C., 1971.

econometric studies, however, have attempted to quantify transit regulation and the economic behavior of the transit firm and to measure their impact on transit service and transit use.

1. ECONOMIC CONCEPTS AND ISSUES

In focusing on the entire transit market rather than a specialized issue, such as demand or regulation, the model incorporates material from several areas of economics ranging from transportation economics to public utility economics to econometrics. A few of the more important concepts and topics considered in the development of the transit model are introduced here.

a. The Market

The parameters of the transit model are estimated from cross-section data on bus firms and transit markets. The transit market is defined geographically as an urbanized area--a central city plus surrounding nonrural environs. The sample of transit markets is restricted to those served by a single bus firm and in which no competing mode of mass transit exists.[5] The prevalence of bus transit throughout the United States makes it possible to perform a study of this type. It appears that mass transit in a majority of urban areas in the U.S. is represented by a single bus firm.

b. The Industry

The urban bus transit industry is almost universally characterized by regulated private monopolies or by publicly owned monopolies.[6] Despite their protected status, bus transit enterprises face

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5. The sample consits of 51 firms and markets in 1968 and 44 firms and markets in 1960. See Appendix IVC.

6. In the few markets with more than one urban bus firm, the market is carved up so that the various firms serve nonoverlapping routes. This type of market organization is known in the trade as "regulated competition."

level of transit service to the quantity of passenger trips demanded, the cost of producing transit service, and other variables. An important purpose of the econometric estimates of the supply parameters is to test alternative hypotheses of supply behavior.

2. ORGANIZATION OF THE PAPER

The remainder of the paper is organized into four sections. Section B discusses the aggregate demand for bus transit and formulates a demand function which can be estimated from a cross-section sample of bus transit markets. Section C develops transit supply functions based on several alternative hypotheses about supply objectives. Section D suggests how the institutional structure of the transit industry might affect the transit market. Section E presents and analyzes the statistical results of the study. Simultaneous-equation estimating techniques are used to estimate the parameters of the equations in the bus transit model. Appendix IVA contains an analysis of the private costs of producing transit service. Operating and capital costs are defined and discussed, and a cost function for bus transit is estimated from cross-section data.

severe competition from other modes of urban transportation, particularly the private automobile. The bus transit industry is marked by a considerable variety of institutions. Privately owned firms may be regulated by city governments, other local agencies, or the state government. Privately owned transit firms owned by power companies also comprise a special category. Publicly owned firms may either be an agency of the city government or an independent transit authority. In recent years there has been a strong trend toward public ownership of bus transit firms, due in large part to the increasing financial woes of transit firms.

c. Demand

For the individual user, the demand for bus transit may be assumed to depend on the fare and the characteristics of available bus service, the price and service characteristics of alternative modes, and the marginal value to the individual of additional trips. Such characteristics of bus service as the location of bus stops, the frequency of service, and the location of routes affect individual demand for bus transit. The demand function for the entire transit market relates the total number of passenger trips demanded to the average fare and the aggregate level of transit service (measured in bus-miles). The number of persons willing to ride bus transit, however, depends upon how a given number of bus-miles is allocated by the transit company in terms of routes, frequency of service, and hours of service. In this sense, the aggregate demand function can be influenced by the behavior of the transit firm. The transit model assumes that the firm allocates a given quantity of service to maximize passenger trips.

d. Supply

The supply side of the transit market is based on hypotheses concerned with the economic behavior of regulators and transit firms. One set of hypotheses is suggested by the recently developed economic theory of the regulated firm. From these and other hypotheses, supply functions are derived which relate the transit fare and the

B. THE DEMAND FOR BUS TRANSIT

This section develops a demand function for bus transit in which passengers per time period is a function of the fare, the level of transit service, the population and land area of the urbanized area, auto availability and highway capacity, the income distribution of households, and the age distribution of the population.

1. DEMAND AND TRANSIT SERVICE

The market demand for bus transit is the aggregate of individual demands. In classical economic theory, the demand for any service is a function of the price of that service, the prices of substitutes, the prices of complementary goods and services, and income. Competing modes of urban transportation are substitutes for bus transit. Goods and services which increase the demand for urban transportation are complements of bus transit. The full price of transit service can be viewed in terms of a number of components, including the fare and the cost of the various time components in transit use. One example of a division of total trip time is walking time, waiting time, and riding time. Although transit fares may be the same for everyone, the cost per unit of time will differ among individuals. It is also possible that the cost per unit of time is different for each component of the total trip time.

The components of total trip time for the individual depend not only on the type of trip and the average speed of transit vehicles but also on the location of transit stops, the frequency of service, and the location of routes. While a factor such as vehicle speed may be endemic to the bus mode, service characteristics will vary from individual to individual, depending on his point of departure, his destination, and his preferred time of arrival or departure. Improvement in these characteristics should be responsive to increases in transit service. The proliferation of routes and the addition of buses to existing routes serve to reduce the time cost of transit use. The improvement of service may constitute a de facto decrease in the fare. Consequently, if total service is increased, the demand for transit would be expected to increase.

The demand for transit in this cross-section study is the aggregate demand in a transit market.[1] Transit passengers trips are a function of the average fare and the total bus-miles of transit service.[2] The measurement of transit service by total bus-miles involves strong assumptions. In using bus-miles as a proxy for service, we are assuming that scheduling and route assignment practices are similar among firms and that demand for urban transportation in urbanized areas is similar in terms of the distribution of times and destinations for urban trips. Thus, in two cities of equal population and land area, a given number of bus-miles per year implies roughly similar service characteristics in the two transit markets. Among the more obvious shortcomings of bus-miles is the inclusion of "dead mileage" incurred when buses are not servicing routes. This shortcoming becomes relatively unimportant if the proportion of dead mileage to total mileage is relatively constant across systems. Other service characteristics, such as route miles and frequency of service, can be obtained, but these data are less reliable than bus-miles and are reported by fewer firms.[3]

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1. Formulations in other empirical studies include models of individual demand (S. Warner, Stochastic Choice of Mode in Urban Travel: A Study in Binary Choice, Evanston, Ill., 1962, and models of interzonal demand, T. Domencich and G. Kraft, Free Transit, Lexington, Mass., 1970.

2. Annual data are reported to the American Transit Association (ATA) by member firms and published in ATA Transit Operating Reports, Part II, "Motor Bus Operations."

3. A measure such as seat-miles of service was also rejected. At the relatively low passenger densities in the industry (three to four boardings per bus-mile), additional bus capacity may have little effect on service characteristics.

a. A Priori Considerations

The shape of the relationship assumed to exist between demand and bus-miles is based on several assumptions, as follows:

- The firm allocates service to maximize the number of transit riders. In so doing, bus trips are added first where the greatest net increment in ridership occurs; second, where the second greatest increment occurs; third, where the third greatest increment occurs.
- This method of allocating service implies diminishing marginal returns to additional units of service unless external effects are present. The incremental number of passengers from an additional bus-mile declines as total bus-miles increase. The absence of external effects implies that additional service at one time and along one route does not increase demand elsewhere in the system.[4]

b. A Specific Functional Form

The demand function used in this paper embodies most of these considerations. The function has a declining elasticity of demand with respect to additional bus-miles. Representing all other variables in the function by $f(\cdot)$, the demand function is

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4. Although some case for the existence of external effects has been made, it does not appear to be a phenomenon of overriding significance for aggregate demand.

In an unpublished paper on economies of scale in transit, H. Mohring has pointed out that additional service on a particular route may decrease the expected waiting time. These decreases in cost may lead to increasing increments in ridership as service becomes more frequent. Mohring's result depends on the randomness of bus service, or at least randomness from the viewpoint of the user. If increasing returns are large, there is a large payoff to efforts by the firm to publish schedules and to follow them. Furthermore, the Mohring result applies on a route-by-route basis. In allocating service one would expect the firm to concentrate on service routes to take advantage of these increasing returns. In so doing, aggregate demand may show little or no increasing returns.

$$D = \exp\left[-\alpha_1 \left(\frac{B}{S}\right)^{-\alpha'}\right] f(\cdot) \; . \tag{1}$$

D is demand, B is bus-miles, S is a measure of the size of the transit market, and $f(\cdot)$ is a function of the other variables discussed in Subsections 2 and 3. The size variable, S, may stand for either population, POP, or land area, AREA (square miles). A general definition of size which includes both population and land area is $S = POP^{\lambda}\ AREA^{1-\lambda}$, with λ between zero and one. Both parameters α_1 and α' are expected to be positive.

This exponential function exhibits a declining service-elasticity of demand as the quantity of bus-service increases relative to the size of the market. This elasticity is

$$\epsilon_B = \alpha_1\ \alpha' \left(\frac{B}{S}\right)^{-\alpha_1} \; . \tag{2}$$

The rate of decline in elasticity is controlled by the parameter α'. Figure 4.1 is a graph of demand as a function of bus service. Demand is an increasing function of the level of service but asymptotically approaches an upper bound. Although demand exhibits decreasing elasticity as service increases, there are increasing marginal returns in the dotted portion of the curve between the origin and B_o. Demand elasticity, although diminishing in this interval, is still larger than one; thus, the increasing returns.

Although a demand function can be specified which does satisfy _a priori_ considerations in every interval of B/S, the weakness in using a function which meets these considerations in an open-ended interval may not be too serious.[5] Furthermore, there is no obvious

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5. One such function is $D = \left[1 - \exp\left(-\alpha_1 \frac{B}{S}\right)\right]^{\alpha'} f(\cdot)$. A drawback to the use of this function is that it is not possible to get analytical solutions for supply behavior under certain objectives. Thus, since a primary focus of this paper is the behavior of the firm, use of this function is, in a sense, self-defeating. Another drawback is the necessity of using non-linear regression to estimate the parameters of the demand function.

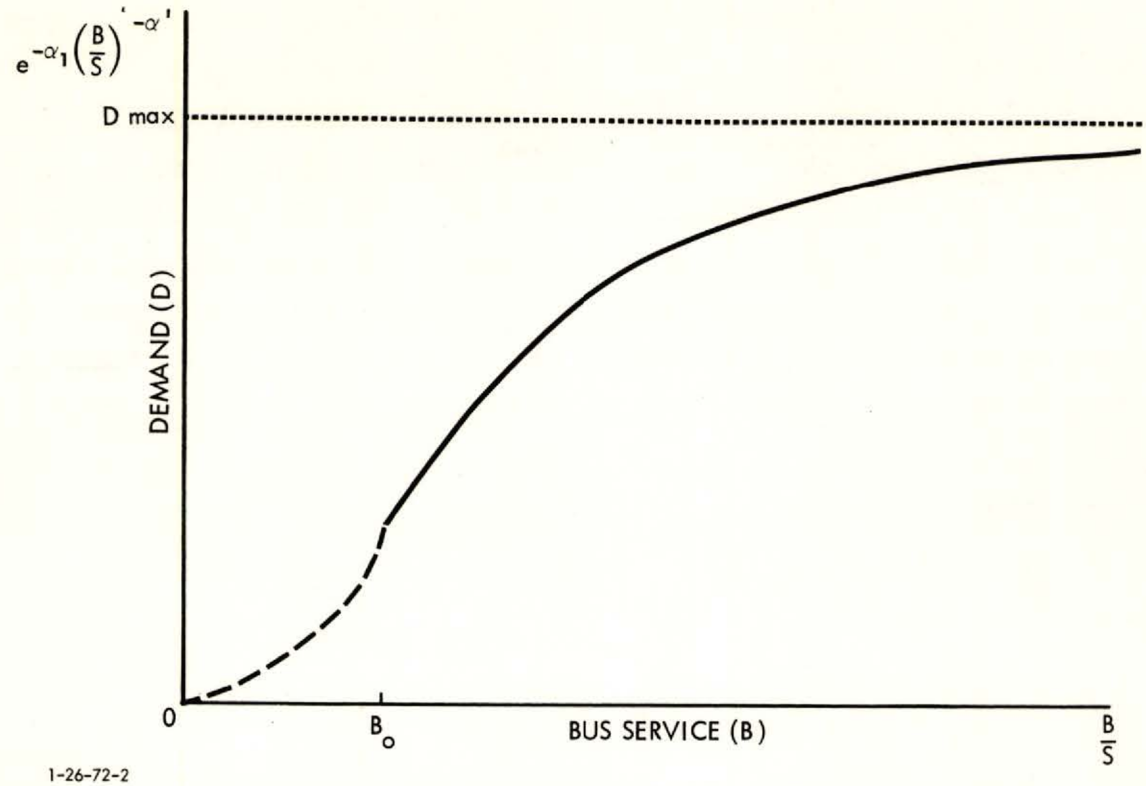

FIGURE 4.1. The Effect of Bus Service on the Demand for Transit

situation in which any transit firm would be willing to supply a level of service less than B_o. The compensating strengths of this exponential function are substantial. Briefly, use of this demand function leads to a simple and testable set of supply hypotheses. Also, most of the parameters of the function can be estimated using linear regression techniques.

2. DEMAND AND FARE

Higher fares reduce the demand for transit by making other modes of transportation more attractive and by reducing the total demand for urban transportation. Although most systems have a structure of fares which may depend on the length of the trip (inter-zonal charges), the time of travel (shopper's specials), or the age of the passenger (youth and senior citizen discounts), the fare referred to in this model is the average revenue per paying passenger.

Basic *a priori* considerations about the effect of fare on demand apply to total revenue. At very low fares we assume that total revenue increases as the fare increases. In effect, increases in fare outweigh decreases in ridership. Beyond some critical fare, however, additional fare increases are more than offset by declines in ridership, and total revenue decreases. At this critical fare, F^*, total revenue is a maximum. This assumption is equivalent to assuming that total revenue as a function of the fare is unimodal (see Figure 4.2). Another way to state this assumption is that the

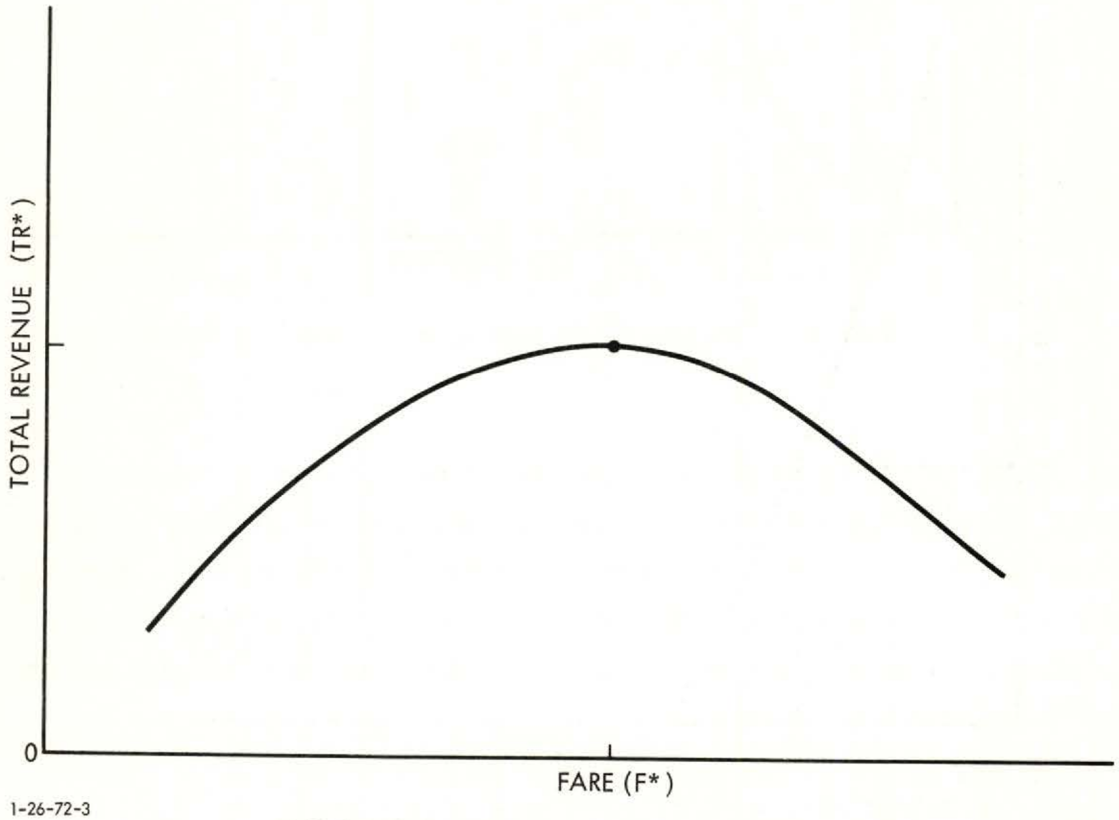

FIGURE 4.2. Unimodal Total Revenue Function

elasticity of demand with respect to the fare increases as the fare increases, and at some fare (F^*) the elasticity becomes greater than one. Total revenue is a maximum where the fare-elasticity of demand equals one.

Although a number of demand functions satisfy this condition,[6] a simple function that is easy to adapt to the model is the following:

$$D = e^{-\alpha_2 F} g(\cdot) \ . \tag{3}$$

F is fare, and $g(\cdot)$ is a function of bus-miles and the variables discussed in Subsection 3. The elasticity of demand is equal simply to $\alpha_2 F$, and this elasticity is unity where $F = \frac{1}{\alpha_2}$. In Figure 4.3, the rectangle represents maximum total revenue $F^* \cdot D^*$.

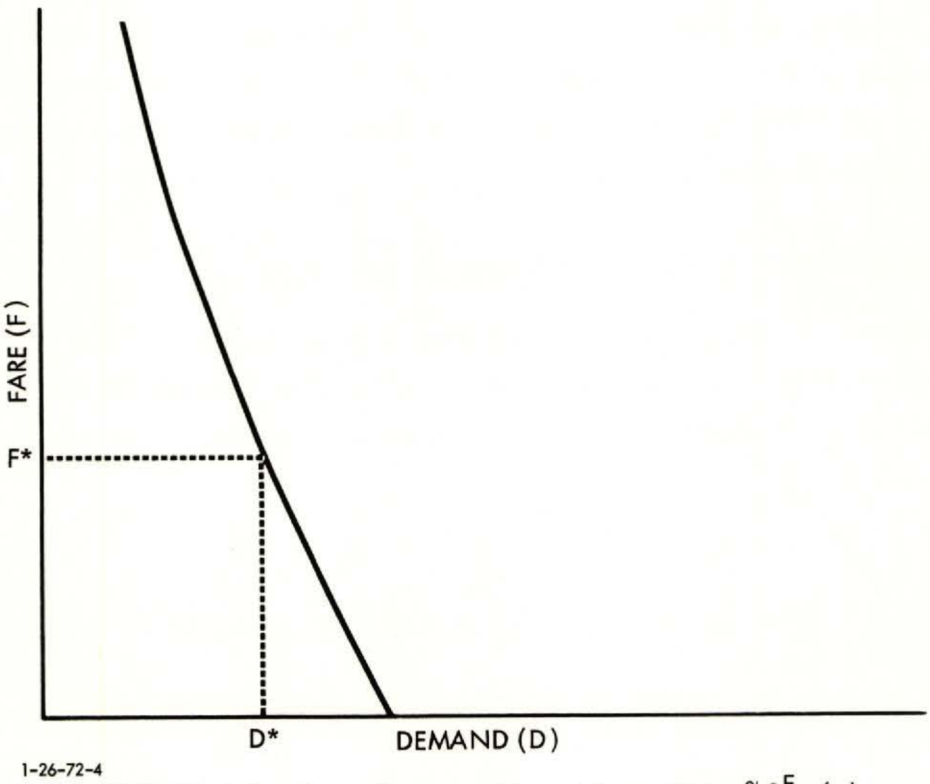

FIGURE 4.3. Demand as a Function of Fare: $D = e^{-\alpha_2 F} g(.)$

6. The most common demand function of this type is $D = (\alpha_1 - \alpha_2 F)g(\cdot)$. At a zero fare, demand equals α_1 and at a fare of α_1/α_2 no one is willing to use bus transit service. The drawback of this function is that it requires nonlinear estimation of the parameters and that it is difficult to use in the supply analysis of Section C.

The transit industry's rule-of-thumb is that the fare-elasticity of demand is 0.3. In light of the assumption that the elasticity varies with the fare, an elasticity of 0.3 applies only at one fare. A property of this demand function developed in this subsection is that elasticity is proportional to the fare. If the fare elasticity is 0.3 at a fare of 25 cents, then at a fare of 50 cents the elasticity is 0.6. The demand function of the form $D = \alpha_1 F^{\alpha_2}$ does have a constant fare-elasticity of α_2. If α_2 is less than one, the firm can always increase revenue by raising the fare, no matter how high the fare. If α_2 is greater than one, the firm can always increase revenue by lowering the fare. Where α_2 equals one, total revenue remains the same, regardless of the fare. The assumption that the elasticity of demand is a constant implies apparently unrealistic economic behavior.

3. THE LOGARITHMIC FORM OF THE DEMAND FUNCTION

Estimates of the parameters of the demand function are based on linear regression of a logarithmic form of the demand function. The complete demand function takes the following form:

$$\ell n\, D = \alpha_o - \alpha_1\left(\frac{B}{S}\right)^{-\alpha'} - \alpha_2 F + \alpha_3\, \ell n\, POP + \alpha_4\, \ell n\, AREA + \alpha_5\, \ell n\, AUTOS + \alpha_6\, \ell n\, HWAY + \alpha_7\, INC_3 + \alpha_7\, INC_{10} + \alpha_9\, AGE_{18} + \alpha_{10}\, AGE_{65} \quad (4)$$

where

POP = population of the urbanized area,

AREA = land area (square miles) of the urbanized area,

AUTOS = automobiles available per capita,

HWAY = population per unit of urban highway capacity,

INC_3 = proportion of households with income of less than \$3,000 per year (1960),

INC_{10} = proportion of households with income in excess of $10,000 per year (1960),

AGE_{18} = proportion of population 18 years of age or younger (1960),

AGE_{65} = proportion of population 65 years of age or older (1960),

ℓn = natural logarithm (to the base e = 2.71...).

In actual estimates of the demand function, the market size is always defined in terms of population. (Thus, for $S = POP^{\lambda} AREA^{1-\lambda}$, $\lambda = 1$.). Further discussion of the definitions and a listing of sources of data appear in Appendix IVB.

a. Population and Land Area (ℓn POP, ℓn AREA)

The coefficients of ℓn POP and ℓn AREA describe what happens to demand as population increases and population density changes.[7] Suppose all other variables remain constant, including bus-miles per capita (B/S). If population and land area both increase by one percent (i.e., density remains constant), demand increases by $\alpha_3 + \alpha_4$ percent. If only population increases, demand increases by α_3 percent.

b. Automobiles and Highway Capacity (ℓn AUTOS, ℓn HWAY)

Other things equal, an increase in the availability of automobiles should decrease the demand for bus transit. Increases in highway capacity, however, may decrease travel time for both autos and bus transit. Thus, while additional highway construction may increase the demand for urban transportation, the predicted effect on choice of mode is indeterminate.

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7. Since population and land area are highly correlated, it may appear that including both variables in the model introduces a problem of collinearity. ℓn POP and ℓn AREA are less highly correlated than POP and AREA. Collinearity does not create a problem in estimating the effect of market size in either demand or supply functions, because when population and land area both vary, the standard error of the effect is not large.

c. The Income Distribution of Households and the Age Distribution of the Population (INC_3, INC_{10}, AGE_{18}, AGE_{65})[8]

The demand for bus transit is a composite for the demand for urban transportation and the choice of mode. Factors which appear to make bus transit relatively more attractive than automobiles may actually lead to decreases in the demand for bus transit if the factor simultaneously reduces the demand for urban transportation. The old, the young, and the poor must rely on bus transit. Members of the labor force, most of whom do not fall in these categories, usually make at least two urban trips daily. Estimates of these effects of age distribution and income distribution provides a test of the relative strengths of these two factors.

On the basis of 1960 Census data, each transit market is given an age distribution of the population and an income distribution for households. The age groupings are 18 or younger, 19 to 64, and 65 or older. The income distribution groups are less than $3,000 per year, $3,000 to $10,000 per year, and more than $10,000. The proportion falling into the two extremes of each distribution are included as variables in the demand function.

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8. These variables do not appear as logarithms for two basic reasons. Suppose the effect of an increase in INC_3 is to increase the demand for bus transit. Thus $\alpha_7 > 0$. If INC_3 equals zero, the demand for transit is not necessarily zero as would be the case if INC_3 were $\ln INC_3$. ($\ln INC_3 = \ln 0 = -\infty$ implies that demand is zero if the coefficient of $\ln INC_3$ is positive.) On the other hand, if population were zero, one would expect the demand for transit to be zero. Thus, population appears as $\ln$ POP. The second reason is attributable to the variable given the proportion of households with income behavior $3,000 and $10,000. Since INC_3 and INC_{10} are not included as logarithms, the coefficient of the omitted variable INC_3 can be calculated as a weighted average of the coefficients of INC_3 and INC_{10}.

C. THE SUPPLY SIDE OF THE TRANSIT MARKET

The supply side of the transit market covers both the cost of producing transit service and the decisions affecting the fare and the quantity of transit service which are made by the bus firm and its regulators. Costs and cost functions are considered in Subsection 1. The focus of the supply study is the determinants of the fare and the quantity of transit service. The model developed in this paper includes a restriction on the relationship of total cost to total revenue which is similar to profit regulation. This restriction is discussed in Subsection 2. There is a locus of fares and levels of service that satisfy this regulation. Each point on the locus is associated with a different hypothesis about the supply behavior of the firm. In Subsection 3, a number of these hypotheses are examined.

1. THE COST OF BUS TRANSIT SERVICE

The concept of cost used here is the total cost of transit operations borne by the firm.[1] This definition includes depreciation and an interest charge on total capital, in addition to what is commonly called operating costs. If capital costs are partially paid for by a Department of Transportation capital grant, then this subsidy

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1. For purposes other than studying the behavior of the transit firm one may prefer a broader definition of transit cost. Some portion of the cost of building and maintaining freeways and roads should be attributed to transit buses. (However, road-use taxes should also be subtracted from transit costs.) The net contribution of transit operations to congestion and pollution is part of the real cost of transit operations. Many analysts argue that the net contribution is negative, in which case this constitutes an offset to transit costs. Another element of total social costs which is often ignored is the time cost to the user of transit service. In this study, time cost is at least implicitly recognized in the demand for transit.

reduces total costs[2] under this definition. Additional details of capital costs and operating costs, as well as estimates of a cost function for bus transit appear in Appendix IVA.

The average cost per bus-mile in any transit operation is assumed to be a constant. This assumption implies that total cost is proportional to the level of service with no economies of scale or inelasticities in the supply of capital or labor. The parameters of the cost function estimated in Appendix IVA show the elasticity of cost with respect to bus-miles to be 0.982 in 1968 and 1.013 in 1960. Neither estimate is significantly different from 1.0, the elasticity prevailing under constant returns to scale. Thus, increasing bus-miles by 100 percent would increase costs by approximately 100 percent. Although the results of this paper do not depend on a strict proportionality between cost and quantity of service, this simplifying assumption facilitates analysis.

The cost function for bus transit may more clearly resemble the cost function for a taxi fleet than the cost functions for other modes of mass transit such as rapid rail. The major elements of bus costs are roughly proportional to bus-miles of service.[3] Rail costs include costs of stations, track, and right-of-way. These costs are less than proportional to vehicle miles, resulting in economies of scale.

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2. The Department of Transportation through the Urban Mass Transportation Administration began a program of capital grants to urban transportation projects in February 1965. By the end of 1970, over $700 million in Federal funds were committed for 155 capital grant projects.

3. Bus costs are predominantly drivers' wages (40 percent); fuel (10 percent); maintenance (15 percent); insurance, advertising, and taxes (12 percent); administrative costs (11 percent); and vehicle costs (10 percent). Vehicle costs consist of depreciation (10 percent of estimated value) and interest or normal profit (77 percent of total estimated value). Station costs are only 1 percent. Vehicle cost items are discussed in detail in Appendix IVA. Other items of operating costs (reduced by 10 percent to reflect the inclusion of vehicle costs) are taken from J. D. Wells and Sharron Thomas, Economic Characteristics of the Urban Bus Transit Industry, 1971, IDA.

2. A COST-REVENUE RESTRICTION

The bus transit market is a model involving three variables--(bus-miles, average fare, and bus passenger trips). Cost per bus-mile, population, and other variables are constants in a given market. Three independent relationships are necessary to obtain a mathematical solution of the transit model. One such relationship is the demand function.

$$D = D\ (B,\ F). \qquad (5)$$

In this model, the remaining relationships are related to the behavior of transit firms and regulating agencies, referred to here as supply behavior. One possible hypothesis which, presumably, applies to nonregulated industries is that the firm sets the fare and the level of service to maximize profit. The formal regulation of privately owned firms and the nature of the ownership of publicly owned firms suggests that profit maximization is not an appropriate model for the bus transit industry.

It is likely that most firms in the bus transit industry operate under some constraints on surpluses or deficits. For privately owned firms, the binding constraint may be the maximum profit permitted by the regulation mechanism. Regulators usually control profit by limiting either the rate of return on capital or the operating ratio (operating costs divided by operating revenue). Informal aspects of the mechanism, such as the lag in permitting fare increases or service reduction, may also be very important determinants of the allowed profitability of transit operation. For publicly owned firms, a constraint may apply to the maximum loss which the public authority is willing or able to subsidize. Independent transit authorities may have no resources with which to subsidize transit operations or may have requirements imposed by bond underwriters to cover all operating costs. City-run firms may be able to tap the general revenues of the city to subsidize transit service.

These various constraints are summarized by the following requirement placed on transit firms:

$$k_o = \frac{cB}{FD} \quad (6)$$

k_o is the cost-revenue ratio; c is the cost per bus-mile. The cost-revenue ratio is distinct from the operating ratio in including interest and normal profit as well as depreciation. The requirement of this second relationship in the transit model is that the cost-revenue ratio, k, must equal some predetermined value, k_o. In the empirical hypothesis discussed in Section D and estimated in Section E, the value of k_o is determined by the types of institutions which regulate and own the bus firms.

Some discussion is in order to explain the relationship of the cost-revenue restriction to the maximum return on capital and the minimum operating ratio, which are more typically established by transit regulators. These three policies are identical if two special conditions hold: (1) if the firm operates at the maximum rate of return on capital or the minimum operating ratio (i.e., the constraint is satisfied as an equality), and (2) if capital and labor are not substitutable in the production function for bus transit. These conditions are easy to verify. If R is total revenue ($R = F^* \cdot D^*$), L is labor, K is capital, w is the wage rate, and r is "normal" profit per unit of capital, the three policies can be expressed as follows:

rate-of-return regulation --

$$\rho_o \leq \frac{R - wL}{K}, \quad (7)$$

operating-ratio regulation --

$$h_o \geq \frac{wL}{R}, \quad (8)$$

cost-revenue restriction--

$$k_o = \frac{rk + wL}{R}. \quad (9)$$

If the firm operates at the regulatory constraint ρ_o or the constraint h_o, the inequality becomes an equality. If capital and labor are not substitutable, capital and labor are applied in fixed proportions in the production process. Assume this proportion is $s = K/L$, or $K = sL$. It is simple to show that the cost-revenue restriction can be related to ρ_o and h_o using only the constraints r, w, and s. In particular,

$$\frac{w/s}{r + w/s} \cdot k_o = h_o \ , \tag{10}$$

and

$$\frac{r + w/s}{k_o} - w/s = \rho_o \ . \tag{11}$$

Thus, under these conditions, the rate of return on capital, the operating ratio, and the cost-revenue ratio can be made equivalent.

If capital and labor are substitutable, regulation either by rate of return or the operating ratio may lead to a different level of output or a different capital-labor ratio from that achieved by restricting the cost-revenue ratio.[4] The nature of the bus transportation technology in the United States during the past two decades suggests that the degree of substitutability between capital and labor may indeed be quite low. There is also some empirical evidence that tends to support this assumption.[5] In this case, the representation of other types of regulation with the cost-revenue ratio may be a very close approximation.

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4. A thorough analysis of this effect appears in E. Bailey and J. Malone, "Resource Allocation and the Regulated Firm" <u>Bell Journal of Economics and Management Science</u>, Vol. I (Spring 1970), pp. 129-42.

5. Although the bus transit technology in the U.S. may be described as one driver, one bus, substitution may involve nondriver personnel and nonbus capital. Furthermore, by varying the size of the bus or the number of shifts using the same bus, the capital-labor ratio can be varied. Some as yet unpublished IDA econometric work has yielded estimates of the elasticity of substitution (ES) in bus transit. If fixed proportions prevail, ES equals 0.0. If perfect (cont'd on next page)

3. ALTERNATIVE HYPOTHESES OF TRANSIT SUPPLY BEHAVIOR

a. Feasible Solutions in the Transit Market

There is a locus of average fares, total bus-miles, and total passenger trips which satisfies both the demand function and the cost-revenue ratio. At extremely low levels of service, the firm serves only those routes which yield very high passenger densities per bus-mile. Consequently, the firm may achieve some predetermined cost-revenue ratio at a relatively low fare. Within limits, the firm may increase both bus-miles and the fare without changing the cost-revenue ratio. Figure 4.4 shows the locus of possible outcomes

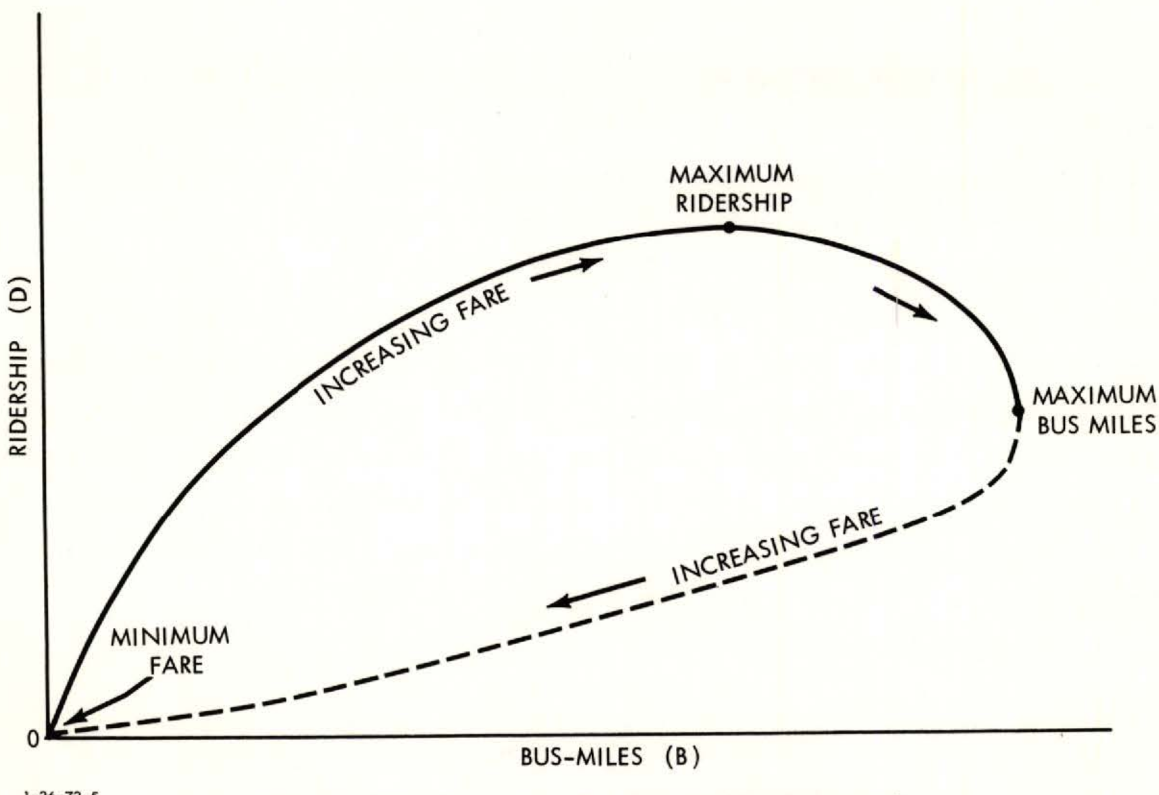

FIGURE 4.4. The Locus of Feasible Transit Solutions at k_o

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5. (continued)
substitutability exists, ES equals ∞. The estimate of ES for the bus transit industry is 0.27. At this value of ES, capital and labor are relatively insubstitutable.

in terms of passengers and bus-miles. The average fare is increasing in the clockwise direction, while the cost-revenue ratio is less inside the locus than on the outside. This subsection is concerned with how different supply objectives lead to different points on this supply locus.

b. Maximum Bus-Miles

In recent years there has been a substantial interest among economists in the theory of the firm under regulation. A typical assumption is that the regulator limits the earnings of the firm by specifying a maximum rate of return on capital or a minimum ratio of cost to revenue. Except for this constraint, the firm is free to pursue an objective such as profit maximization or revenue maximization.[6]

Subsection 2 has shown that the cost-revenue ratio, the operating ratio, and the rate of return on capital are equivalent regulations if capital and labor are not substitutes. In this case, the revenue maximizer always operates at maximum bus-miles, subject to the restriction on the cost-revenue ratio. The profit maximizer operates at maximum bus-miles if the cost-revenue ratio is less than or equal to one. At this ratio, the firm is covering all costs and earning at least a normal profit. Maximum profit occurs at maximum total revenue, or at maximum bus-miles.[7]

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6. In the pioneering study of the behavior of the firm under regulation, H. Averch and L. Johnson in "Behavior of the Firm Under Regulatory Constraint," American Economic Review, LII, December 1962, show that profit-maximizing firms operating under a maximum rate of return on capital may tend to overcapitalize and to expand the rate base by pursuing unprofitable ventures. More relevent to our model are the results of E. Bailey and J. Malone, op cit. If the regulator sets a minimum cost-revenue ratio, the profit-maximizing and revenue-maximizing firm "will want to operate where marginal revenue is zero, even if it means increasing costs by some arbitrary means" (p. 140).

7. If the cost-revenue ratio does not allow the firm to cover all costs and earn a normal profit, the firm maximizes profit (or minimizes losses) in the long run by halting operations completely.

Other factors may tend to support maximum service as the eventual, if not the optimal, outcome. Maximum bus-miles may yield maximum employment and thus be the preferred position of the transit union. Second, in a market where demand is declining relative to cost, if the adjustments occur chiefly through fare increases rather than service reductions, transit operations will inevitably arrive in a situation where no other fare increases are possible. The service provided at this point is the maximum attainable at the allowed ratio of cost to revenue.

Maximum bus-miles subject to the cost-revenue restriction is found by maximizing

$$B = \frac{k_o}{c} F \cdot D \tag{12}$$

$$\frac{\partial B}{\partial F} = \frac{k_o}{c} (D + F \frac{\partial D}{\partial F}) = 0. \tag{13}$$

$$\frac{\partial D}{\partial F} = -D \tag{14}$$

$$-\frac{F}{D} \frac{\partial D}{\partial F} = 1 = \epsilon_F. \tag{15}$$

As in the conventional model of a monopoly, the fare at which the fare-elasticity is equal to 1.0 also maximizes total revenue. As indicated previously, maximum bus-miles and maximum total revenue occur at the same fare and bus-miles.

c. Maximization of Passenger Trips

In many ways, maximizing passengers is a more desirable outcome than maximizing bus-miles. There is greater consumption of transit service. The fare for transit users is less than the fare at maximum bus-miles, although characteristics of service are not as good. Finally, the total cost of transit service is less if cost is measured in terms of inputs provided by the firm. There does not appear to be any economic incentive for the private firm to want to operate at this point unless this is preferred by the regulator or another influential agency. Thus, the realization of this outcome hinges on the ability and desire of the regulatory authorities and other public agencies to control the fare and the level of transit service.

A formulation for maximizing ridership using the Lagrangian multiplier λ is

$$\Lambda = D(B,F) - \lambda \left(k_o - \frac{cB}{F \cdot D(B,F)}\right) . \quad (16)$$

Differentiating Λ with respect to B,F, and λ and setting these partial derivatives to zero yields:

$$\frac{\partial\Lambda}{\partial F} = \frac{\partial D}{\partial F} + \lambda\frac{\partial}{\partial F}\left(\frac{cB}{F \cdot D}\right) = 0, \quad (17)$$

$$\frac{\partial\Lambda}{\partial B} = \frac{\partial D}{\partial B} + \lambda\frac{\partial}{\partial B}\left(\frac{cB}{F \cdot D}\right) = 0, \quad (18)$$

$$\frac{\partial\Lambda}{\partial\lambda} = k_o - \frac{cB}{F \cdot D} = 0. \quad (19)$$

If λ is eliminated from the first two expressions,

$$\frac{\frac{\partial D}{\partial F}}{\frac{\partial}{\partial F}\left(\frac{cB}{F \cdot D}\right)} = \frac{\frac{\partial D}{\partial B}}{\frac{\partial}{\partial B}\left(\frac{cB}{FD}\right)} . \quad (20)$$

Differentiating the denominators and using the third expression from above yields:

$$\frac{\frac{\partial D}{\partial F}}{-k_o\left(\frac{1}{F} + \frac{1}{D}\frac{\partial D}{\partial F}\right)} = \frac{\frac{\partial D}{\partial B}}{k_o\left(\frac{1}{B} - \frac{1}{D}\frac{\partial D}{\partial B}\right)} . \quad (21)$$

This yields

$$\frac{-\frac{F}{D}\frac{\partial D}{\partial F}}{\left(1+\frac{F}{D}\frac{\partial D}{\partial F}\right)} = \frac{\frac{B}{D}\frac{\partial D}{\partial B}}{\left(1-\frac{B}{D}\frac{\partial D}{\partial B}\right)} \quad . \tag{22}$$

The fare-elasticity is $-\frac{F}{D}\frac{\partial D}{\partial F}$, and the service-elasticity is $\frac{B}{D}\frac{\partial D}{\partial B}$. Therefore,

$$\frac{\epsilon_F}{1-\epsilon_F} = \frac{\epsilon_B}{1-\epsilon_B} \quad . \tag{23}$$

Or,

$$\epsilon_F = \epsilon_B \ . \tag{24}$$

Thus, for a given cost-revenue ratio, the maximum number of passengers in a bus transit system occurs where fare and bus-miles are set such that the elasticity of demand with respect to the fare is equal to the elasticity of demand with respect to bus-miles.[8]

d. Free Transit

Before adopting a more general formulation of the supply objective we will examine two additional special cases: free transit and unconstrained profit maximization. In both special cases we no longer assume a constraint on the cost-revenue ratio.

The cause of free transit has attracted a number of adherents in recent years.[9] The case for free transit is often built on the

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8. Second-order conditions for a maximum are satisfied if

$$B^2 \frac{\partial^2 D}{\partial B^2} + 2BF \frac{\partial^2 D}{\partial B \partial F} + F^2 \frac{\partial^2 D}{\partial F^2} > 0.$$

It is easy to show that this relatively weak condition is met by the demand function derived in Section B.

9. The best known study of free transit is the Charles River Associates study of Boston, op. cit.

argument that an increase in the number of passengers does not increase the costs of providing transit service. Thus, as the fare is lowered, there is a net increase in benefits to the users of transit service but no offsetting increase in the real costs of transit service unless capacity problems emerge. Suppose the fare is zero, and the subsidy provided by the government is S. Then a free transit system with bus-miles B = S/c can be created.

At the level of subsidy S which government is willing to provide, a free transit policy may not yield the maximum ridership. If the number of passengers lost by raising the fare from zero to one cent is less than the number of passengers that can be gained by spending this revenue on additional bus service, then greater ridership can be obtained by increasing the fare and providing additional transit service. In particular, this condition is:[10]

$$-\frac{\partial D}{\partial F} D > \frac{\partial D}{\partial B} c. \qquad (25)$$

e. Profit Maximization

Profit maximizing behavior is a norm against which other hypotheses about the behavior of the firm can be compared. It also permits a comparison of the bus-transit market with conventional economic markets. It is certainly rare today that a bus transit firm can operate without regulatory constraints. Perhaps it is less rare that regulated firms succeed in thwarting regulation or that the maximum attainable profit is less than the profit allowed under regulation.

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10. The general condition at a nonzero fare is that

$$\frac{-\frac{\partial D}{\partial F}}{D + F\frac{\partial D}{\partial F}} > \frac{\frac{\partial D}{\partial B}}{c - \frac{\partial D}{\partial B} F} .$$

This condition can be derived from the Lagrangian formulation:

$$V = D(B,F) + \lambda[S - F \cdot D(B, F) + cB].$$

The problem of profit maximization can be formally stated:

$$\underset{B,\,F}{\text{maximize}} \quad \pi = F \cdot D\,(B,F) - cB\,. \tag{26}$$

The firm sets the fare such that the marginal revenue from an additional increase in fare equals the marginal cost of that increase (which is zero). The firm sets the level of service such that the marginal revenue of an additional bus-mile is equal to the marginal cost of an additional bus-mile, c. These two conditions are:

$$-\frac{F}{D}\frac{\partial D}{\partial F} = \epsilon_F = 1 \tag{27}$$

and

$$F\frac{\partial D}{\partial B} = c. \tag{28}$$

Note that the former condition is the same as the condition for maximizing service.[11] It is simple to show that the profit maximizer provides a lower level of service than the service maximizer. If under maximum service the constraint is point $k_o = 1$, or total cost equals total revenue, then that constraint can be written:

$$F\frac{D}{B} = c. \tag{29}$$

In a market with diminishing marginal returns per bus-mile, $\frac{\partial D}{\partial B}$ will always be smaller than $\frac{D}{B}$. Thus, the profit maximizer, although he uses the same pricing principle, will establish a lower level of service.

f. A General Objective Function $D^{\theta}B^{1-\theta}$

Maximum bus-miles and maximum passengers are special cases of maximizing the "supply objective" $D^{\theta}B^{1-\theta}$. At $\theta = 0$, bus-miles are

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11. In a conventional market where demand is $Q = Q(P)$ and cost is $c \cdot Q$, the single marginal condition is that:

$$PQ'(P) = c.$$

maximized. At $\theta = 1$, passenger trips are maximized. It is highly probable that transit fares and levels of service are not determined by any of the simple patterns of behavior suggested previously. The welter of private firms, government agencies, labor unions, and consumer groups which may influence the operation of public transit introduces the possibility of economic behavior based on the interaction of these various groups. Rather than begin the fruitful but arduous task of modeling these interactions, economic behavior in the transit market is investigated with the aid of this general, but quite artificial, transit supply objective. As the parameter θ is varied, the maximum solution moves around the transit supply locus (Figure 4.5). This permits us to describe each interval on the supply locus in terms of maximizing some supply objective. The parameter θ is not restricted (on mathematical grounds) to the interval between zero and one. If $\theta > 1$, bus-miles are penalized. If $\theta < 0$, passenger trips are penalized, but bus-miles are rewarded.

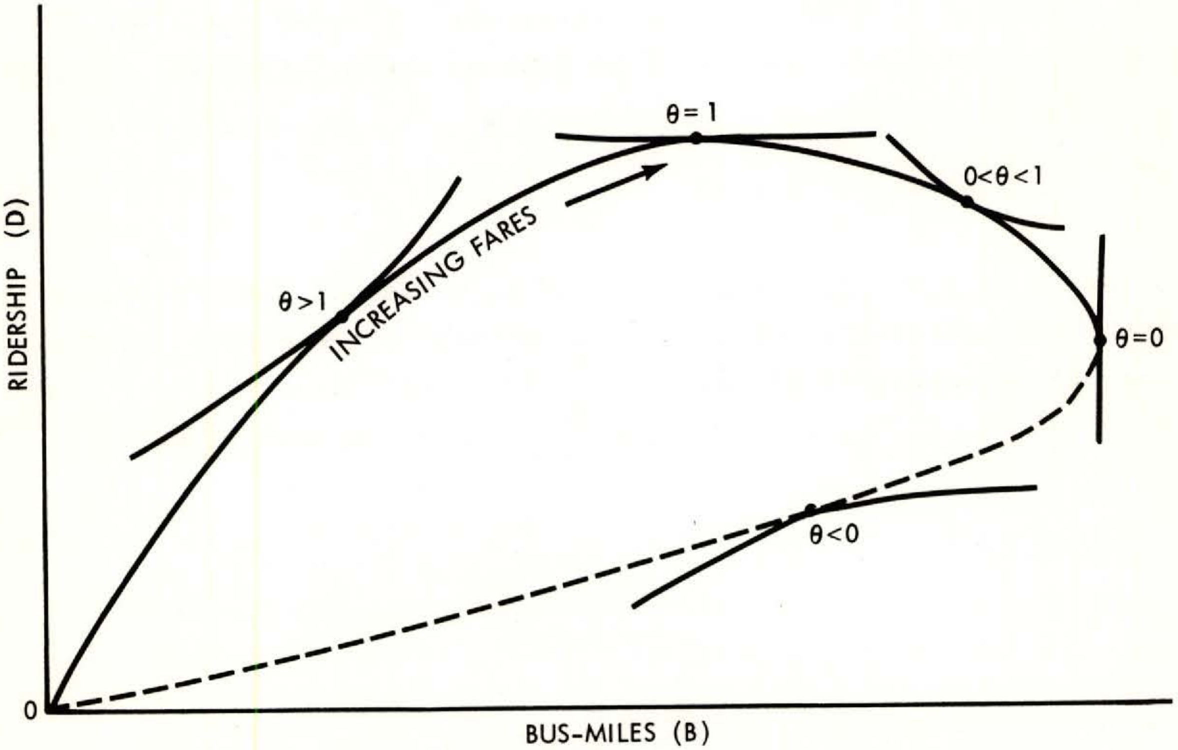

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FIGURE 4.5. A Comparison of Optimal Solutions Under Different Supply Objectives

Maximizing $D^{\theta}B^{1-\theta}$ occurs at the maximum of the Lagrangian expression

$$\Lambda = D^{\theta}B^{1-\theta} - \lambda \left(k_o - \frac{cB}{F \cdot D}\right). \tag{30}$$

Solution follows the lines of the solution in Subsection c to the problem of maximizing D subject to the cost-revenue constraint. The condition for a maximum involves the fare-elasticity, the service-elasticity and the parameter θ:

$$\epsilon_F = \theta \epsilon_B + (1 - \theta). \tag{31}$$

Note that for $\theta = 1$, $\epsilon_F = \epsilon_B$, and for $\theta = 0$, $\epsilon_F = 1$.

Variation of the value of θ is a useful way to demonstrate the relevance of different points on the transit supply locus. There are five possible ranges of values for θ: $\theta = 0$, $\theta = 1$, $0 < \theta < 1$, $\theta > 1$, and $\theta < 0$. For a value of θ in each of these intervals we will reach a maximum at some point on the locus.[12] Figure 4.5 shows the optimal outcome for a value of θ in each of these intervals. The condition for an optimum

$$\epsilon_F = \theta\epsilon_B + (1 - \theta) \tag{32}$$

enables us to solve also for the range in values of the fare-elasticity and the service-elasticity of demand in each of these five intervals. These values appear in Figure 4.6.

12. Except for very large or very small values of θ, which may approach a maximum in the neighborhood of the origin.

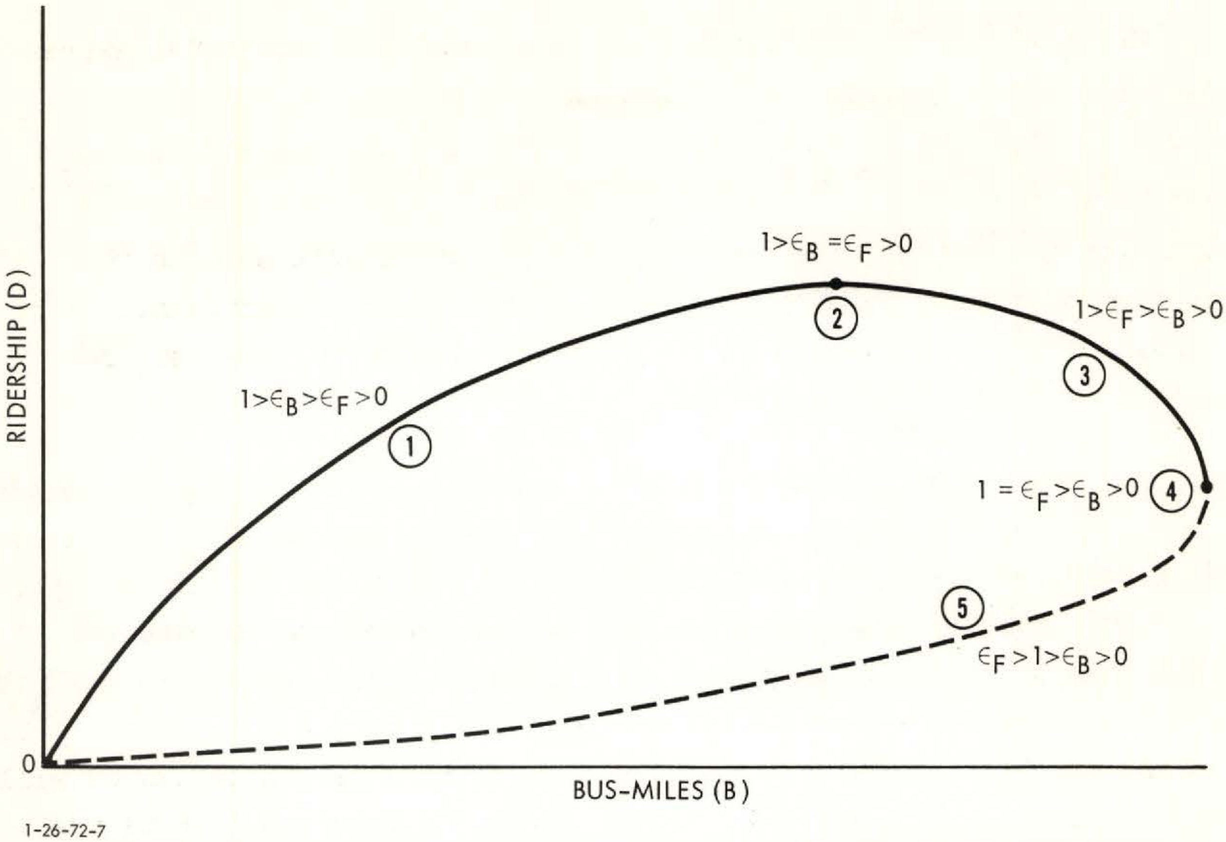

FIGURE 4.6 Relative Values of the Fare-Elasticity and the Service-Elasticity of Demand

(1) In the first interval, both demand and bus-miles are increasing. The effect of increases in the fare on passengers is more than outweighed by the effect of increases in bus-miles. Thus, the service-elasticity is greater than the fare-elasticity. Both lie between 0 and 1.0. The meaning of the parameter $\theta > 1$ is that the supply objective rewards ridership, D, but penalizes additional service, B. Hence the bias toward a solution with relatively low fares, but relatively low levels of service.

(2) This is the point of maximum ridership.

(3) This interval is the reverse of (1). The effect of increases in fare more than outweighs the increases in service. Consequently, demand is declining. A point on this interval may be optimal if the objective values bus service in its own right, independent of its effect on passengers.

(4) This is the point of maximum service.

(5) In bus interval the fare-elasticity of demand is greater than one. Both ridership and revenue would increase if the fare were lowered. This interval can contain the optimum only if the objective penalizes ridership.

4. A VARYING SUPPLY OBJECTIVE

The choice between lower fares and higher levels of service, which is made in selecting a point on the transit supply locus, may vary with changes in the cost-revenue ratio. As the cost-revenue ratio increases, due perhaps to government subsidies, the character of the transit solution may change. If a firm is to maintain a position of maximum ridership on the supply locus as the cost-revenue ratio increases from k_o to k_1, then it must both decrease the fare and increase bus-miles such that ϵ_B is equal to ϵ_F at the new ratio. If the firm varies from a position of maximizing ridership, the supply objective, in effect, is changing. One way to analyze this effect is to include the cost-revenue restriction in the supply objective. Two special forms of this general supply objective are of interest:

$$D^{\theta}B^{1-\theta}\ U(k) \qquad (33)$$

and

$$D^{\theta(k)}B^{1-\theta(k)}\ . \qquad (34)$$

In the former case, the firm adopts the same relative decisions concerning ridership and service, regardless of the cost-revenue ratio. The relationship of the fare-elasticity of demand to the service-elasticity will remain:

$$\epsilon_F = \theta\epsilon_B + (1 - \theta)\ . \qquad (35)$$

As the cost-revenue ratio increases, fares are reduced and service is expanded. Nevertheless, the relationship of the two elasticities remain constant. Thus, we may say, supply decisions are neutral with respect to changes in the operating ratio.

In the latter case, the relative elasticities may vary as the cost-revenue ratio changes. If θ is an increasing function of k, ridership becomes more important as the cost-revenue ratio increases. In this circumstance, changes that occur as the cost-revenue ratio increases tend to emphasize fare reduction at the expense of service expansion. This is a case of fare bias. If θ is a decreasing function of k, increases in the cost-revenue ratio tend to be translated into an expansion of bus service. This is called service bias.

Figure 4.7 shows an example of neutral response, fare bias, and service bias in the context of an increase in the cost-revenue ratio.

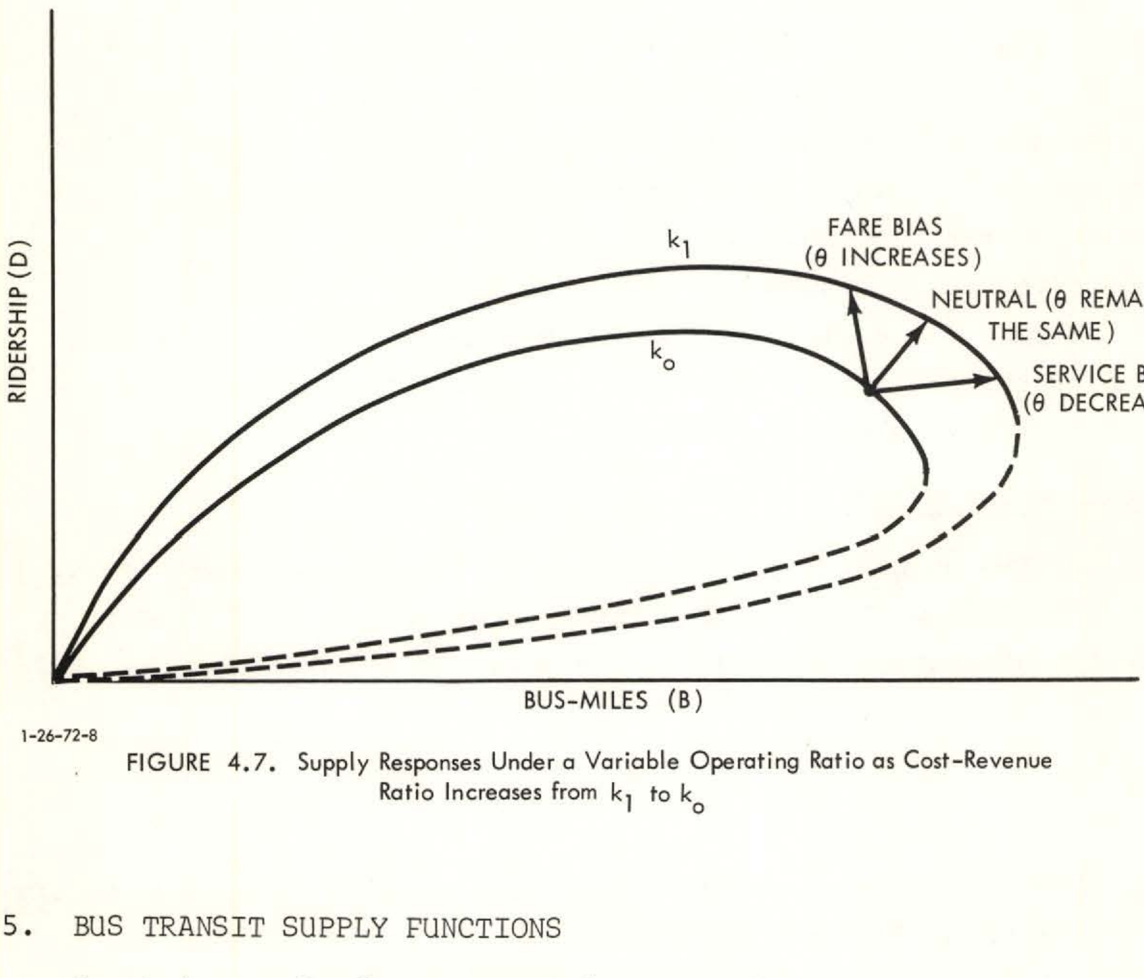

FIGURE 4.7. Supply Responses Under a Variable Operating Ratio as Cost-Revenue Ratio Increases from k_1 to k_o

5. BUS TRANSIT SUPPLY FUNCTIONS

An obvious role for econometric research into the supply side of the bus transit market is to test various supply hypotheses. A bus transit supply function is derived, expressed in terms of the quantity of bus-miles the firm is willing to provide. The derivation makes use of a supply hypothesis such as maximum ridership and the cross-section demand function specified in Section B. Five supply hypotheses discussed in the preceding subsection can be tested using the same general empirical supply function:

$$\ln B = \beta_0 + \beta_1 \ln POP + \beta_2 \ln AREA + \beta_3 \ln D + \beta_4 \ln c + \beta_5 \ln k_o . \qquad (36)$$

Each hypothesis specifies a different set of coefficients. By estimating the β's from cross-section data on bus transit markets, it is possible in principle to test each supply hypothesis.

The supply function is the third and final equation in the model of the transit market. The complete model consists of the demand function, the supply function, and the cost-revenue restriction. An alternative derivation leads to a supply function expressed in terms of the fare. This is a simple transformation of Eq. (1), using the cost-revenue restriction.

The five supply hypotheses under examination are maximum bus-miles, maximum ridership, and the three general cases discussed at the end of the preceding subsection: neutral, fare-biased, and service-biased supply objectives.

a. Maximum Bus-Miles

As derived on page 4-26, the condition for maximum bus-miles is $\epsilon_F = 1$. According to the demand function developed in Section B, the fare elasticity of demand is $\epsilon_F = \alpha_2 F$.
Thus,

$$F = \frac{1}{\alpha_2} \qquad (37)$$

Solving the cost-revenue ratio formula for bus-miles and substituting the optimal value for the fare yields

$$B = \frac{1}{\alpha_2} Dc^{-1}k_o \ . \qquad (38)$$

Thus, the bus-miles the firm is willing to supply under service maximization is directly proportional to demand and the cost-revenue constraint and inversely proportional to the cost per bus-mile. Note that this is linear in the logarithm of the variables.

b. Maximum Passengers

As shown on page 4-26, the condition for maximum ridership is $\epsilon_F = \epsilon_B$. The elasticity of demand with respect to bus-miles is

$$\epsilon_B = \alpha_1 \alpha' \left(\frac{B}{POP^{\lambda} AREA^{1-\lambda}} \right)^{-\alpha'} \tag{39}$$

The condition becomes

$$\alpha_2 F = \alpha_1 \alpha' \left(\frac{B}{POP^{\lambda} AREA^{1-\lambda}} \right)^{-\alpha'} . \tag{40}$$

Substituting for F in the cost-revenue constraint and solving for B, yields

$$B = \left(\frac{\alpha_1 \alpha'}{\alpha_2} \right)^{\frac{1}{1+\alpha'}} POP^{\lambda \frac{\alpha'}{1+\alpha'}} AREA^{(1-\lambda)\frac{\alpha'}{1+\alpha'}} D^{\frac{1}{1+\alpha'}} c^{\frac{1}{1+\alpha'}} k_o^{\frac{1}{1+\alpha'}} \tag{41}$$

This supply function is linear in the logarithm of the variables. The parameter α' represents the rate of decline in the service-elasticity of demand. This function predicts that bus-miles supplied by the firm are proportional to simultaneous increases in POP, AREA, and D. The sum of the exponents of these variables,

$$\lambda \frac{\alpha'}{1+\alpha'} + (1-\lambda)' \frac{\alpha'}{1+\alpha'} + \frac{1}{1+\alpha'} \tag{42}$$

is equal to one. If the rate of decline of demand elasticity is large (α' large) then the size of the urbanized area is relatively more important than demand. If α' is small, however, demand becomes relatively more important. The quantity of bus-miles the firm is willing to supply is inversely related to the cost per bus-mile and directly related to the regulatory constraint. However, these relationships are less than proportional.

c. Approximate Supply Functions for General Supply Hypotheses

As demonstrated in Subsection 3, maximum bus-miles and maximum passenger trips are two important but special cases of more general supply objectives. In particular, maximization of $D^{\theta}B^{1-\theta}$ is suggested as a supply objective which does not vary with changes in the cost-revenue ratio k_o. Unfortunately, in maximizing this objective subject to the cost-revenue restriction, it is not possible to obtain an analytical solution for B in terms of the other variables.[13] However, both maximum bus-miles ($\theta = 1$) and maximum passenger trips ($\theta = 0$) yield geometric (or multiplicative) functions of the same set of variables. Since the general objective is a geometric combination of bus-miles and passenger trips, a geometric combination of the solutions to the two special cases is suggested as an approximate solution to the general case $D^{\theta}B^{1-\theta}$. The parameter θ is used to make a linear interpolation of the exponents in Eqs. (38) and (41). The exponent of the demand variable D becomes

$$\beta_3 = (1-\theta) \cdot 1 + \theta \frac{1}{1+\alpha'} . \tag{43}$$

This approximate solution is written

$$B = \left(\frac{1}{\alpha_2}\right)^{1-\theta} \left(\frac{\alpha_1 \ \alpha'}{\alpha_2}\right)^{\theta \frac{1}{1+\alpha'}} \left(POP^{\lambda} \ AREA^{1-\lambda}\right)^{\theta \frac{\alpha'}{1+\alpha'}}$$

$$\left(Dc^{-1}k_o\right)^{(1-\theta) + \theta \frac{1}{1+\alpha'}} . \tag{44}$$

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13. In the case of $D^{\theta}B^{1-\theta}$ the optimal level of service B is given by a solution to

$$B = k_1 Dc^{-1} \left[\theta \frac{\alpha_1^{\alpha'}}{\alpha_2} \left(\frac{B}{POP^{\lambda} \ AREA^{1-\lambda}}\right)^{-\alpha'} + \frac{(1-\theta)}{\alpha_2} \right].$$

At $\theta = 0$, this expression equals the solution for maximum bus-miles; at $\theta = 1$ it equals the solution for maximum passenger trips.

The objective $D^{\theta}B^{1-\theta}$ implies that the supply objective does not vary with respect to the cost-revenue ratio. If the cost-revenue ratio is allowed to increase (e.g., through a program of subsidies), this objective implies that the greater relative costs are absorbed through reductions in fares and increases in service such that the same relative trade-offs exist between passenger trips and bus-miles.[14] Higher cost-revenue ratios may lead to a shift in the supply objective which emphasizes lower fares. This is defined in the previous subsection as a case of fare bias. If higher cost-revenue ratios lead to a shift in objective toward greater service levels, this is defined as service bias. Each exponent in the supply function represents an elasticity of bus-miles. Under maximum service, maximum ridership, or maximum $D^{\theta}B^{1-\theta}$ the supply elasticities with respect to trips demanded (D), the inverse of unit costs (c^{-1}), and the cost-revenue ratio (k_o), are all equal. In the case of service bias where a higher cost-revenue ratio implies a shift in emphasis toward bus-miles, the elasticity with respect to the cost-revenue ratio should be larger than the other two elasticities. In the case of fare bias, this elasticity should be smaller.

d. An Empirical Comparison of Supply Hypotheses

Table 4.1 presents the parameters from the two specific transit supply objectives and the three classes of general objectives. Under maximum ridership, the parameter v is used in place of $\frac{1}{1+\alpha'}$.

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14. Or at least, fare is reduced and service increased relative to what would have occurred if the cost-revenue ratio had not been allowed to rise. In the case of rising costs per bus-mile, an increase in the ratio of costs to revenues occurs without fare reduction or service augmentation.

For the three general objectives, the parameters are also simplified by a transformation:

$$x = (1 - \theta) + \theta \frac{1}{1+\alpha'} . \tag{45}$$

Under fare bias and service bias, the parameter y is a positive constant.

Three factors emerge from a comparison of the five sets of parameters in Table 4.1. First, only the objective of maximum bus-miles predicts absolute numerical values for the coefficients. The other hypotheses predict only relative values of the coefficients. Second, unless there is a priori knowledge about the demand parameter α', the hypothesis of maximum passenger trips is indistinguishable from any neutral supply objective (except maximum bus-miles). Without specific knowledge of the value of the parameter α', both v and x are known only to be positive constants between zero and one. In both cases, the coefficients of $\ln D$, $-\ln c$, and $\ln k_o$ are equal, and furthermore, the sum of the coefficients of $\ln$ POP, $\ln$ AREA, and $\ln D$ is equal to one. In this latter case, proportional increases in population, land area, and the quantity of trips demanded leads to an increase in bus-miles supplied in the same proportion.

The third observation is that tests of fare bias or service bias are, in effect, tests of whether an increase in the cost-revenue ratio has the same effect as an increase in passenger trips demanded or a decrease in the cost per bus-mile. Under the neutral supply hypothesis, each of these changes has the same effect on the number of bus-miles the firm is willing to supply.

Table 4.1

SUPPLY PARAMETERS UNDER ALTERNATIVE SUPPLY OBJECTIVES

		Special Objectives		General Objectives		
Variable	Coefficient	Maximum Bus-Miles	Maximum Passengers	Neutral	Fare Bias	Service Bias
ℓn POP	β_1	0	λ (1-v)	λ (1-x)	λ (1-x)	λ (1-x)
ℓn AREA	β_2	0	(1-λ)(1-v)	(1-λ)(1-x)	(1-λ)(1-x)	(1-λ)(1-x)
ℓn D	β_3	1	v	x	x	x
ℓn c	β_4	-1	-v	-x	-x	-x
ℓn k_o	β_5	1	v	x	x-y	x+y

D. THE COST-REVENUE RATIO

In this cross-section study of transit firms we assume that the cost-revenue ratio is determined by the types of institutions which own and regulate the bus transit operations. Transit operations may be publicly owned or privately owned. Among the five classifications of transit firms three are private firms and two are publicly owned operations, as described below:

1. PRIVATE/POWER: A small, but significant, percentage of privately owned transit operations are owned by much larger companies which also supply electric and gas power. These firms are public utilities on two counts, and both transit operations and power are subject to regulation. In all but one case, both operations are regulated by the same agency. In that exception the local government, which regulates transit operations, contracts with the power company to receive electricity. The importance of power-company-owned transit operations is the opportunity which is presented for subsidizing transit operations out of the profits from supplying power.
2. PRIVATE/LOCAL and 3. PRIVATE/STATE: The remaining private firms are regulated by either a local government agency or the state public utilities commission. In the case of state regulation, one may expect rather mechanical regulation based on profit. The local regulatory authority may be more sensitive to service and fare than to the profitability of transit operations. The local agency may also be more responsive to the wishes of the community or certain members of the community.

4. PUBLIC/TRANSIT AUTHORITY and 5. PUBLIC/CITY GOVERNMENT: One class of publicly owned firms are under the direct control of the municipal government. Authority over fares and schedules may rest with the city manager or the city council. Other public firms are operated by a transit authority which at least is nominally independent of the municipal government. Municipal governments may be more responsive to public protests against increases in fares or reductions in service. Government accounts may be such that there is no incentive for the managers of the firm to operate out of the fare box. Transit authorities may at least have a thin layer of insulation against political pressure. More importantly, such firms may be legally unable to operate at a deficit. This is particularly true if bond obligations of the transit authority place restrictions on the cost-revenue ratio.

The cost-revenue equation is simply:

$$\ell n\, k_o = \gamma_1 \text{ POWER} + \gamma_2 \text{ LOCAL} + \gamma_3 \text{ STATE} + \gamma_4 \text{ CITY} + \gamma_5 \text{ AUTH} . \tag{46}$$

The variables are dummy variables, which equal one if a firm is in that category and are zero otherwise. The coefficients simply represent the means of the logarithms of the cost-revenue ratio of firms in the appropriate categories.

Table 4.2 indicates the number of firms falling in each category for the two samples used in the study. The great increase in the proportion of publicly owned firms reflects overall trends in the industry.

Table 4.2

DISTRIBUTION OF FIRMS BY OWNERSHIP AND REGULATION, 1968 AND 1960

Type of Firm	1968	1960
Private/Power	8	6
Private/Local	10	14
Private/State	15	21
Public/City	8	1
Public/Authority	10	2
Total	51	44

E. EMPIRICAL ESTIMATES

The model of the transit market consists of three equations:

$$\ell n\, D = \alpha_o - \alpha_1\left(\frac{B}{POP^{\lambda}\ AREA^{1-\lambda}}\right)^{-\alpha'} + \alpha_2 F + \alpha_3\ \ell n\, POP + \alpha_4\ \ell n\, AREA$$

$$+ \alpha_5\ \ell n\, AUTOS + \alpha_6\ \ell n\, HWAY + \alpha_7\ INC_3 + \alpha_8\ INC_{10} + \alpha_9\ AGE_{18}$$

$$+ \alpha_{10}\ AGE_{65} + \epsilon_1\ . \qquad (47)$$

$$\ell n\, B = \beta_o + \beta_1\ \ell n\, POP + \beta_2\ \ell n\, AREA + \beta_3\ \ell n\, D + \beta_4\ \ell n\, c$$

$$+ \beta_5\ \ell n\, k + \epsilon_2\ . \qquad (48)$$

$$\ell n\, k = \gamma_1\ POWER + \gamma_2\ LOCAL + \gamma_3\ STATE + \gamma_4\ CITY + \gamma_5\ AUTH + \epsilon_3 . \qquad (49)$$

Furthermore, there is the identity,

$$\ell n\, k \equiv \ell n\, c + \ell n\, B - \ell n\, F - \ell n\, D, \qquad (50)$$

which defines the cost-revenue ratio.[1] The random error terms ϵ_1, ϵ_2, and ϵ_3 make this a stochastic, or probabilistic, model of transit operations.

In this econometric model, demand (D), bus-miles (B), the fare (F), and the cost-revenue ratio (k) are dependent, or endogenous, variables. The remaining variables are independent, or exogenous. Estimation of the parameters of the demand equation and the supply equation is complicated by the presence of three endogenous variables in each equation. The endogenous variables are correlated with the error terms in each equation. As a result, ordinary least squares (OLS) leads to inconsistent estimates of the parameters. Two-stage least squares (2SLS) is used to estimate the parameters of the demand and supply equations.[2,3] In this approach, endogenous variables on the right side of the equation are replaced with estimates that

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1. We do not make a distinction here between a "target" ratio k_o and an "attained" ratio k. If we choose to make this distinction, equation (49) could be replaced by

$$\ln k_o = \gamma_1 \text{ POWER} + \gamma_2 \text{ LOCAL} + \gamma_3 \text{ STATE} + \gamma_4 \text{ CITY} + \gamma_5 \text{ AUTH} + \epsilon_3' \quad (51)$$

and

$$\ln k = \ln k_o + \epsilon_4 \ . \quad (52)$$

In (52), the logarithm of the attained ratio equals the logarithm of the target ratio plus a random component. Substituting (51) into (52) yields equation (49) where $\epsilon_3 = \epsilon_3' + \epsilon_4$. Thus, in determining the cost-revenue ratio, there are random factors both in setting the target and attaining the target.

2. For a discussion of this problem see: J. Johnston, Econometric Methods (New York: 1963), Chap. 9, or A. Goldberger, Econometric Theory (New York: 1964), Chap. 7.

3. Simultaneous-estimation techniques fall into two categories. "Full-information" techniques, such as three-stage least squares or full-information maximum likelihood, estimates all the parameters of the model simultaneously. Single-equation techniques, such as 2SLS or limited-information maximum likelihood (LIML), estimate parameters for a single equation in the model. Full-information techniques, although very powerful, tend to be more subject to specification error than single-equation techniques. However, the major reason for not using full-information techniques is that the full system of equations is nonlinear in the parameters, although each single-equation is (Cont'd on next page.)

are assumed to be uncorrelated with the error term in the equation. Since the cost-revenue ratio equation does not contain other endogenous variables, OLS is appropriate for estimating the parameters of this equation.

Empirical results for the bus transit model are presented for the cost-revenue ratio, the supply equation, and the demand equation, in that order.

1. THE COST-REVENUE RATIO

The coéfficients of the cost-revenue equation appear in Table 4.3. In both 1968 and 1960, this simple classification of transit firms explains one-half of the total squared variation in the logarithm of the cost-revenue ratio (adjusted for degrees of freedom). Each coefficient represents the mean value of $\ln k$ (the logarithm of the cost-revenue ratio) for firms belonging to that category. Since $\ln 1 = 0$, a negative coefficient represents a ratio of total cost to total revenue which is less than 1.0, and a positive value represents a cost-revenue ratio greater than 1.0.

In the 1968 sample, private firms owned by power companies and public firms operated by city governments have cost-revenue ratios significantly greater than 1.0. The average cost-revenue ratios corresponding to these estimates are 1.42 for power companies and

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linear in the parameters. (Note how the variable B enters differently in the demand equation and the supply equation.) 2SLS is preferred to LIML because there are convenient normalization rules to follow in each equation. (2SLS requires that one endogenous variable be selected for the left side of the equation.) Furthermore, there is no information about the variances of ϵ_1, ϵ_2, ϵ_3. An advantage of LIML is that it is possible to utilize information about these variances in estimating the coefficients of the equation. All four techniques mentioned here are biased for finite samples. Each has the asymptotic property of consistency, which implies that the distribution of the estimate collapses to the true value of the parameter as the sample sizes become infinite.

Table 4.3

ESTIMATED COEFFICIENTS OF THE COST-REVENUE EQUATION
(With Standard Deviations)

Statistic	1968	1960
Dependent Variable	ℓn k	ℓn k
Independent Variable		
Private/Power	0.350 (0.067)	0.230 (0.040)
Private/Local	-0.001 (0.043)	-0.017 (0.022)
Private/State	0.028 (0.058)	-0.006 (0.028)
Public/City	0.283 (0.067)	-0.128[a] (0.085)
Public/Authority	0.087 (0.063)	0.015[b] (0.062)
R^2 (adjusted)	0.493	0.504
Standard Error of Regression	0.144	0.082
Number of Observations	51	44

a. Contains only one firm.

b. Contains only two firms.

1.33 for city-run operations. For both categories, total costs, including depreciation and normal profit, are at least one-third greater than total revenues. For power companies, a form of cross-subsidization may exist in which users of electricity and natural gas subsidize users of transit service. The general tax revenues of the municipality may be the source of subsidy for city-run operations. In other categories, the mean of ℓn k is not significantly different from zero. Costs, therefore, are not significantly greater than revenues for these firms. Private firms regulated by local governments, in fact, are successful on average in covering total costs. For state-regulated firms and firms operated by transit authorities, costs are slightly greater than revenues in this sample.

The primary differences between the 1960 and the 1968 results are attributable to differences in the institutional composition of the transit industry. The 1960 sample is marked by the virtual absence of publicly owned transit firms. Only two transit-authority firms and one city-run firm appear among the 44 firms in that year. It is interesting to note, however, that the single city-run transit operation has the best cost-revenue ratio of any firm in either year ($k = 0.88$).

Among private operations, the situation is similar to 1968. The estimated coefficients of firms owned by power companies corresponds to a cost-revenue ratio of 1.25. Private firms under both local and state regulation tend to cover total costs.

a. Alternative Estimates of the Ratio of Total Cost to Total Revenue

The hypothesis that the ratio of total cost to total revenue depends only on the classification of firms by ownership and regulation constitutes an institutional theory of the cost-revenue ratio. Other hypotheses about the ratio of cost to revenue are possible. The ratio may be influenced by other exogenous variables in the model, such as the cost per bus-mile. It is also possible that the structure of the transit model may be entirely different, such that the cost-revenue ratio is determined by demand and bus-miles, in a manner parallel to the supply equation of Section C. It is difficult to estimate such a relationship, even if one were derived, because the cost-revenue ratio is defined in terms of the fare, passenger trips, and bus-miles.

Table 4.4 reports the results of regressing the logarithm of the cost-revenue ratio against all the exogenous variables in the model. This reduced-form equation can give evidence of the effect of both endogenous and exogenous variables on the cost-revenue ratio. The effect of an endogenous variable such as quantity of passenger trips may show its effect through a variable like population which appears in the demand function. The coefficients in Table 4.4, however, offer support to the following institutional hypotheses about the cost-revenue ratio:

(1) The coefficients of the institutional variables are not significantly different from the results reported in Table 4.1.

(2) Only one other variable enters at the one percent level of significance. ℓn HWAY is the logarithm of the ratio of population to highway capacity in an urbanized area. (See Appendix IVB for definition of highway capacity.) A high ratio of population to urban highway capacity is associated with a high ratio of total cost to total revenue in 1968.[4] Although this is an interesting effect, ℓn HWAY is probably not acting as a surrogate for demand. As Subsection 3 shows, the coefficient of this variable is not significantly different from zero in the demand function.

(3) Finally, the cost per bus-mile has a small and insignificant effect on the ratio of total cost to total revenue in the 1968 estimates. The effect is larger in 1960 and is significant at the five percent level.

b. Conclusions from the Cost-Revenue Equation

In summary, the ratio of total cost to total revenue for a bus transit firm depends largely on the institutional structure of the transit industry. Not all publicly owned firms have high cost-revenue ratios, and not all firms with high cost-revenue ratios are publicly owned. In particular, publicly owned firms operated as part of the municipal government and privately owned firms operated by power companies appear willing to provide internal subsidies for transit operations.

Cost per bus-mile has a weak and insignificant effect on the cost-revenue ratio in 1968 but a somewhat stronger effect in 1960.

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4. No urban highway data is available for 1960.

Table 4.4

AN ALTERNATIVE ESTIMATE OF THE RATIO OF TOTAL COST TO TOTAL REVENUE

Statistic	Definition	1968	1960
Dependent Variable		$\ln k$	$\ln k$
Independent Variable			
POWER	Power company	.326[a]	.189[a]
STATE	State regulation	.005	-.004
CITY	City ownership	.276[a]	-.203[b]
AUTH	Transit authority	-.002	.031
$\ln c$	Cost per bus-mile	.076	.325[b]
$\ln$ POP	Population	-.148	-.040
$\ln$ AREA	Land area	.081	.053
$\ln$ AUTOS	Automobiles	.224	.068
$\ln$ HWAY	Highway capacity	.217[a]	
INC_3	Under $3,000	.118	.893
INC_{10}	Over $10,000	1.46	.081
AGE_{18}	18 and under	.502	1.41
AGE_{65}	65 and under	2.46	1.45
R^2		.717	.508
Standard error		.120	.082
Number of observations		51	44

a. Significant at the one percent level (two-tailed test, 37 degrees of freedom).

b. Significant at the five percent level (two-tailed test, 37 degrees of freedom).

Also, variables that have a significant effect on the number of passenger trips demanded do not affect the cost-revenue ratio. This may indicate that transit markets with high ratios of total cost to total revenue are not marked by deficient demand.

2. THE SUPPLY EQUATION

Estimates of the supply equation provide general evidence on the relationship of bus-miles of transit service to variables representing the size of the transit market, the number of passenger trips demanded, the cost per bus-mile, and the ratio of cost to revenue. The estimates of these parameters provide specific evidence on two empirical issues about the supply behavior of the bus transit industry. One issue is whether bus firms provide maximum bus-miles as opposed to maximum passenger trips or some combination of ridership and service. The second issue is whether firms with high cost-revenue ratios make the same choice between maximum ridership and maximum service or between low fares and high levels of service. Table 4.5 contains 2SLS estimates of the supply equation.

Table 4.5

2SLS ESTIMATES OF THE SUPPLY EQUATION

Statistic		1968	1960
Dependent Variable		$\ln B$	$\ln B$
Independent Variables			
Constant		1.42 (1.01)	-1.05 (.600)
$\ln POP$	Population	.248 (.142)	.055 (.132)
$\ln AREA$	Land area	.055 (.072)	.008 (.064)
$\ln D$	Passenger trips	.727 (.095)	.927 (.131)
$\ln c$	Cost per bus-mile	-.601 (.164)	-.446 (.165)
$\ln k$	Cost-revenue ratio	-.065 (.189)	-.511 (.244)
R^2		.982	.971
Standard error		.170	.133
Number of observations		51	44

This statistical technique is used to avoid the effects of correlation between the random term ϵ_2 and the variables $\ell n\, k_o$ and $\ell n\, D$. $\ell n\, k_o$ is replaced by an estimate based on the coefficients of the cost-revenue equation (Table 4.4). The estimate of $\ell n\, D$ is based on a regression of $\ell n\, D$ on all exogenous variables in the model.[5]

The supply equation has the form

$$\ell n\, B = \beta_o + \beta_1\, \ell n\, POP + \beta_2\, \ell n\, AREA + \beta_3\, \ell n\, D + \beta_4\, \ell n\, c + \beta_5\, \ell n\, k_o. \quad (53)$$

Under maximum bus-miles, bus service is proportional to the quantity of trips demanded and is not affected independently by market size. Furthermore, bus-miles is inversely proportional to the cost per bus-mile. This suggests three tests of the maximum bus-miles hypothesis against the alternative hypothesis that passenger trips or some combination of passenger trips and bus-miles are maximized:

Maximum Bus-Miles	Maximum Ridership, etc.
$\beta_1 + \beta_2 = 0$	$\beta_1 + \beta_2 > 0$
$\beta_3 - 1 = 0$	$\beta_3 - 1 < 0$
$\beta_4 + 1 = 0$	$\beta_4 + 1 > 0$

Evidence on the responsiveness of supply objectives to variation in the cost-revenue is based on a comparison of the coefficient of $\ell n\, k$ with the coefficient of $\ell n\, D$ and the coefficient of $- \ell n\, c$. Under a neutral response the three coefficients should be equal. Under fare-bias $\ell n\, k$ has a smaller effect on bus-miles than the other variables (and a larger effect on the average fare). Under service-bias $\ell n\, k$ has a larger effect than the other variables. The following statistical tests are used:

5. An alternative method in which $\ell n\, k_o$ is regressed on all exogenous variables in the model does not yield results which are substantially different from those in Table 4.5.

Neutral	Fare-biased	Service-biased
$\beta_5 - \beta_3 = 0$	$\beta_5 - \beta_3 < 0$	$\beta_5 - \beta_3 > 0$
$\beta_5 + \beta_4 = 0$	$\beta_5 + \beta_4 < 0$	$\beta_5 + \beta_4 > 0$
$\beta_3 + \beta_4 = 0$	$\beta_3 + \beta_4 = 0$	$\beta_3 + \beta_4 = 0$

The third test indicates whether the evidence is consistent with any of the three hypotheses.

Statistical inference is based on the assumption that the ratio of the estimated coefficient to the estimated standard deviation has approximately the t-distribution. In view of some controversy surrounding the distribution of 2SLS estimators, we report the outcome of tests using both 45 and 5 degrees of freedom in 1968 and both 38 and 4 degrees of freedom in 1960.[6]

a. 1968 Supply Estimates

The supply estimates for the 1968 sample lead us to reject the hypothesis of service-maximization. The outcomes of the three tests of this hypothesis are as follows:

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6. The distribution of 2SLS estimates continues to be a point of some controversy. The most common practice has been to assume the estimates are distributed like estimates in classical normal least-squares. Thus, the estimated coefficient is assumed to be normally distributed; the estimated variance is assumed to be x^2, with T - K - 1 degrees of freedom. T is the number of observations; K is the number of right-side variables (dependent and exogenous). The ratio of the estimated coefficient to the square root of the estimated variance has the t-distribution with T - K - 1 degrees of freedom. If the error terms in the model are normally distributed, it has been shown that 2SLS estimators are asymptotically normal. Thus, some grounds exist for using the t-statistic with 2SLS estimators.

Although it is common practice to use T - K - 1 degrees of freedom, P. Dhrymes "Alternative Asymptotic Tests of Significance and Related Aspects of 2SLS and 3SLS Estimated Parameters," Review of Economic Studies, XXXVI (2), April, 1969, has recently shown that tests on coefficients using 2SLS have the asymptotic t-distribution with degrees of freedom equal to the degree of over-identification of the equation. The degree of over-identification in this model is (Cont'd on next page.)

1. The effect of population and land area on bus-miles supplied:

Null hypothesis: $\beta_1 + \beta_2 = 0$

Alternative hypothesis: $\beta_1 + \beta_2 > 0$

$b_1 + b_2 = .303$ standard deviation = .095

$\underline{t}$ - ratio = 3.19

Level of significance:

0.5 percent with 45 degrees of freedom

2.5 percent with 5 degrees of freedom

2. The effect of demand on bus-miles supplied:

Null: $\beta_3 - 1 = 0$

Alternative: $\beta_3 - 1 < 0$

$b_3 - 1 = -.273$ standard deviation = -.095

$\underline{t}$ - ratio = 2.87

Level of significance:

0.5 percent with 45 degrees of freedom

2.5 percent with 5 degrees of freedom

3. The effect of cost per bus-mile on bus-miles supplied:

Null: $\beta_4 + 1 = 0$

Alternative: $\beta_4 + 1 > 0$

$b_4 + 1 = .399$ standard deviation = .164

$\underline{t}$ - ratio = 2.43

Level of significance:

1 percent with 45 degrees of freedom

5 percent with 5 degrees of freedom

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the number of exogenous variables excluded from the equation minus the number of "extra" dependent variables included in the equation. The degree of over-identification is five in 1968 and four in 1960.

The coefficient of each variable is an estimate of the elasticity of supply with respect to that variable. The tests show that the elasticity with respect to demand and cost per unit is less than one in absolute terms. The elasticity of supply with respect to market size is significantly greater than zero. Thus, the firms in the sample exhibit some of the characteristics of ridership maximization and similar objectives because changes in demand and cost affect not only service, but presumably transit fare as well.

The hypothesis that the cost-revenue ratio has no impact on the relative preference for low fares or high levels of service can also be rejected. The evidence clearly supports the hypothesis of fare-bias--that is, the firm tends to provide lower fares rather than greater levels of service at high cost-revenue ratios. The outcomes of three tests of the hypothesis of neutrality are as follows:

1. The relative effects of demand and the cost-revenue ratio on bus-miles supplied:

   Null: $\beta_5 - \beta_3 = 0$

   Alternative: $\beta_5 - \beta_3 \neq 0$

   $b_5 - b_3 = -.792$ standard deviation = .184

   $\underline{t}$ - ratio = -4.30

   Level of significance:

   0.1 percent with 45 degrees of freedom

   1 percent with 5 degrees of freedom

2. The relative effects of cost per bus-mile and the cost-revenue ratio on bus-miles supplied:

   Null: $\beta_5 + \beta_4 = 0$

   Alternative: $\beta_5 + \beta_4 \neq 0$

   $b_5 + b_4 = -.666$ standard deviation = .230

   $\underline{t}$ - ratio = -2.90

Level of significance:

1 percent with 45 degrees of freedom

5 percent with 5 degrees of freedom

3. The relative effects of cost per bus-mile and demand on bus-miles supplied:

Null: $\beta_3 + \beta_4 = 0$

Alternative: $\beta_3 + \beta_4 \neq 0$

$b_3 + b_4 = .126$ standard deviation = .140

$\underline{t}$ = ratio = 0.90

Not significant.

Thus, the cost-revenue ratio has a significantly smaller effect on bus-miles than either demand or cost per bus-mile. The relative effects of demand and cost per bus-mile are not significantly different. Estimates of a fare equation underline the results of this section. This represents an equivalent but alternative formulation of supply behavior.

$$\underset{}{\ell n\, F} = \underset{(1.13)}{1.013} + \underset{(.159)}{0.055}\,\ell n\, POP + \underset{(.080)}{0.133}\,\ell n\, AREA - \underset{(.106)}{0.083}\,\ell n\, D + \underset{(.184)}{0.034}\,\ell n\, c - \underset{(.212)}{0.948}\,\ell n\, k_o. \qquad (54)$$

Thus, the negative impact of the cost-revenue ratio on the transit fare is far larger than the effects of either demand or cost.

b. 1960 Supply Estimates

The results of tests based on the 1960 estimates are not so clear-cut as the 1968 results. Service maximization can be rejected on only one of the three tests. The impact of the cost-revenue ratio on bus-miles supplied is, however, significantly different from the impact of demand and cost. The outcomes of the six tests are as follows:

Service Maximization:

1. $\beta_1 + \beta_2 = 0$

$b_1 + b_2 = .063$ standard deviation = .130

$\underline{t}$ - ratio = 0.48

Not significant.

2. $\beta_3 - 1 = 0$

$b_3 - 1 = .073$ standard deviation = .130

$\underline{t}$ - ratio = 0.56

Not significant.

3. $\beta_4 + 1 = 0$

$b_4 + 1 = .554$ standard deviation = .165

$\underline{t}$ - ratio = 3.36

Level of significance:

0.5 percent with 38 degrees of freedom

2.5 percent with 4 degrees of freedom

Neutrality:

4. $\beta_5 - \beta_3 = 0$

$b_5 - b_3 = -1.438$ standard deviation = .278

$\underline{t}$ - ratio = -5.17

Level of significance:

0.1 percent with 38 degrees of freedom

1 percent with 4 degrees of freedom

5. $\beta_5 + \beta_4 = 0$

$b_5 + b_4 = -.956$ standard deviation = .284

$\underline{t}$ - ratio = -3.37

Level of significance:

1 percent with 38 degrees of freedom

5 percent with 4 degrees of freedom

6. $\beta_3 + \beta_4 = 0$

$b_3 + b_4 = .482$ standard deviation = 2.82

$\underline{t}$ - ratio = 2.82

Level of significance:

1 percent with 38 degrees of freedom

5 percent with 4 degrees of freedom.

The 1960 supply estimates imply that higher cost-revenue ratios not only are biased toward lower fares, but actually decrease the quantity of service supplied by the firm. Thus, increases in the cost-revenue ratio correspond to more than proportional decreases in transit fares. The 1960 estimate of the fare equation is:

$$\ln F = \underset{(.548)}{-.967} + \underset{(.123)}{0.040} \ln POP + \underset{(.067)}{0.013} \ln AREA - \underset{(.116)}{0.072} \ln D + \underset{(.171)}{0.601} \ln c - \underset{(.243)}{1.59} \ln k_o . \quad (55)$$

c. Conclusions from Estimates of the Supply Equation

The evidence from both 1968 and 1960 strongly supports the hypothesis that higher cost-revenue ratios imply lower fares rather than higher levels of service. Accordingly, the supply objective shifts away from the objective of maximum bus-miles as the cost-revenue ratio grows. The evidence is less strong on the general question of maximum ridership or maximum service. In 1968 it is possible to reject the hypothesis of maximum service on the basis of a significant effect of market size on bus-miles supplied and on the basis that the effects of passenger trips demanded and the cost per bus-mile are less than proportional. In 1960 the market size coefficients and the passenger trips coefficient support the hypothesis of maximum bus-miles. Only the coefficient of the cost variable leads to a rejection of this hypothesis.

3. CONDITIONAL ESTIMATES OF THE DEMAND FUNCTION

The unit of transit supply analysis is the transit firm. The bus transit model expresses the behavior of the firm in terms of aggregate levels of service and average fares. Tests of supply hypotheses are based directly on observed fares and levels of service. The demand for transit is also an integral part of the model, but a cross-section sample of transit markets may not provide the best data for estimating the demand for transit. The unit of demand analysis is the individual or the household. At the level of aggregate demand we may not be able to observe many of the important variables in the demand for bus transit. Nevertheless, estimates of an aggregate demand function may provide useful information not only about the relationship of demand to aggregate service variables like fare and bus-miles, but also about the variation in transit demand among urbanized areas.

Estimation of the aggregate demand function as formulated in the model is made difficult by the algebraic form of the bus service variable. In the logarithmic form of the function this term is

$$-\alpha_1\left(\frac{B}{POP^{\lambda}\ AREA^{1-\lambda}}\right)^{-\alpha'}$$

Neither α' nor λ can be estimated using linear regression techniques. The estimated parameters presented in Table 4.6 are conditional on $\alpha' = 0.3$ and $\lambda = 1$. Attempts at nonlinear regression reveal that the data are not sensitive enough to provide good estimates of three parameters in connection with the service variable. In particular, estimates of α_1' and α' have extremely large covariances, so that experimentation with different values of α' seems to affect only the estimate of α_1 and not estimates of the other parameters. The choice of $\lambda = 1$ implies that population is the relevant measure of market size. This is at least partially supported by estimates of the supply equation in which the measure of land area is never statistically significant.

Table 4.6

CONDITIONAL 2SLS ESTIMATES OF THE DEMAND FUNCTION WITH TESTS THAT THE COEFFICIENTS EQUAL ZERO

Right-Side Variable	1968			1960		
	Coefficients	Level of Significance		Coefficients	Level of Significance	
		40 degrees of freedom	3 degrees of freedom		38 degrees of freedom	2 degrees of freedom
Constant	a			a		
$-\left(\frac{B}{POP}\right)^{-0.3}$	8.81 (2.00)	0.1%	5%	6.54 (1.12)	0.1%	5%
F	-3.06 (1.60)	10	-	-4.52 (1.22)	0.1	10
ℓn POP	1.10 (.13)	0.1	1	1.11 (.064)	0.1	1
ℓn AREA	.0208 (.11)	-	-	.0021 (.063)	-	-
ℓn AUTOS	-.175 (.40)	-	-	-.106 (.11)	-	-
ℓn HWAY	.156 (.16)	-	-	-		
INC_3	-3.02 (1.03)	1	10	-1.61 (1.08)	-	-
INC_{10}	-3.57 (1.97)	10	-	-0.40 (1.20)	-	-
AGE_{18}	-5.95 (2.44)	5	10	-1.74 (1.14)	-	-
AGE_{65}	-8.17 (3.42)	5	10	-0.87 (1.61)	-	-

	1968	1960
R^2 (adjusted)	.976	.986
Standard Error of Regression	.227	.113
Number of Observations	51	44

a. Constant terms are not comparable because of different units of measurement.

In discussing demand estimates, we discuss results from both 1968 and 1960 at the same time.

a. The Impact of Service and Fare on Demand

The two most important variables in the demand function, at least from the standpoint of the ability of the firm or the regulator to influence demand, are fare and bus-miles. An increase in the fare is expected to decrease the number of persons willing to use the bus transit, while increases in service are expected to increase demand for bus transit.

The elasticity of demand with respect to bus-miles is assumed to be

$$0.3\ \alpha_1\left(\frac{B}{POP}\right)^{-0.3}.$$

Estimates of α_1 are significantly greater than zero for both 1968 and 1960; thus, we conclude that an increase in bus service leads to an increase in the number of persons willing to use bus service at the prevailing fare. The estimated coefficients, 8.81 in 1968 and 6.54 in 1960, indicate elasticities of demand somewhat larger than expected. At the mean levels of service prevailing in 1968 and 1960, the service elasticities of demand are 1.35 and .92, respectively. Under service maximization, ridership maximization, or other types of motivation discussed in Section C, the firm will operate where the service-elasticity is greater than one. These estimated elasticities are not, however, significantly greater than one.

Increases in fares lead to decreases in the demand for bus transit by making other modes of travel more attractive and by decreasing the demand for urban transportation. Estimates of the effects of fares on demand tend to confirm the assumptions, although the estimated coefficient in 1968 has an extremely weak level of significance. At the mean fares of 22 cents in 1968 and 18 cents in 1960, the fare-elasticities are -.67 and -.81, respectively. The industry's rule-of-thumb is -0.30, substantially smaller than these estimates.

Table 4.7 contains estimates of the service and fare parameters in 1968 under six different functional forms. This provides a check on the high service-elasticity of demand and the insignificant fare-elasticity of demand estimated from this sample. The other parameter estimates in the demand equation are not included in Table 4.7. Eq. (1) is the result reported in Table 4.6 where the parameter α' is assumed to be 0.3. In Eq. (2) $\alpha' = 1.0$. Increases in service have a stronger effect in reducing the service-elasticity of demand at an α' of 1.0 than at 0.3. The elasticity is

Table 4.7

2SLS ESTIMATES OF ALTERNATIVE FORMS OF THE DEMAND FUNCTION, 1968

1. $\ln D = \underset{(2.00)}{8.81}\left(\frac{B}{POP}\right)^{-0.3} - \underset{(1.60)}{3.06}\,F \qquad R^2 = .976$

2. $\ln D = \underset{(2.6)}{10.96}\left(\frac{B}{POP}\right)^{-1.0} - \underset{(1.7)}{2.91}\,F \qquad R^2 = .973$

3. $\ln D = \underset{(0.32)}{1.39}\ln B - \underset{(1.6)}{3.17}\,F \qquad R^2 = .976$

4. $\ln D = \underset{(0.30)}{1.32}\ln B - \underset{(0.31)}{0.76}\ln F \qquad R^2 = .979$

5. $\ln D = \underset{(2.4)}{6.49}\left(\frac{B}{POP}\right)^{-0.3} \underset{(20.0)}{-61.3}\,\frac{F}{AREA^{0.5}} \qquad R^2 = .968$

6. $\ln D = 8.12\left(\frac{B}{POP}\right)^{-0.3} \underset{(5.1)}{-13.4}\,\frac{F}{AREA^{0.25}} \qquad R^2 = .979$

still greater than one at the mean level of service. Both Eqs. (3) and (4) tend to confirm the results of Eq. (1). The coefficient of ℓn B is the service-elasticity and is greater than one. In Eq. (4), the coefficient of the fare variable is also an elasticity and is approximately the same as the elasticity at the mean fare (-.67) in Eq. (1). Equations (5) and (6) take the service variable from Eq. (1). The fare variable is weighted by an algebraic root of the land area in these equations. This attempts to adjust the average fare for differences in the average length of a bus trip. In Eqs. (4) to (6), the fare parameter is significantly greater than zero. The R^2 is better in (4) and (6) than in (1). The problem of an unexpectedly large service-elasticity of demand, however, is not eliminated by these changes in the functional form.

b. The Response of Demand to Increases in the Size of the Market

The coefficients of ℓn POP and ℓn AREA describe what happens to demand if population, land area, bus-miles, automobile ownership, and highway capacity grow in the same proportion. Thus, the bus-service variable, ℓn AUTOS, and ℓn HWAY--all expressed in per capita terms--do not vary. The sum of the estimated coefficients ($\beta_3 + \beta_4$) is 1.12 in 1968 and 1.11 in 1960. As we move from small to large cities, the demand for transit increases approximately 10 percent faster than population and land area. In 1960, the sum of these estimated coefficients is significantly greater than one at the five percent level (with 34 degrees of freedom).

c. Automobiles and Highway Capacity

Automobiles provide the chief substitute for bus transit in the urbanized areas included in this study. Increases in highway capacity, *ceteris paribus*, reduce the time required for both auto and bus travel. Neither variable has a significant effect on the demand for bus transit in our estimates of the demand function.

d. Socio-Economic Characteristics: The Income Distribution and the Age Distribution

Among the arguments put forth for maintaining and subsidizing bus transit operations is that such actions constitute a redistribution of income in favor of low-income groups. The old, the young, and the poor are less likely to have available automobile transportation and may have to rely on mass transit. An alternative hypothesis, however, holds that the chief use of mass transit is for work trips, and thus the primary beneficiaries of bus transit are members of the labor force. The demand for bus transit is formulated as a function of the proportions of households earning less than $3,000 per year (1960) and more than $10,000 per year, and as a function of the proportions of the population under 18 and over 65. Estimates of this function enable us to associate levels of demand with different distributions of income and age.

To state the results most conservatively, there is no evidence that higher proportions of low-income households or higher proportions of youths and senior citizens imply a higher demand for bus transit. In the 1968 demand function, higher proportions of the old, young, and poor imply a lower demand for bus transit (at marginal levels of significance or better). In 1960, the estimated coefficients imply similar effects, but the results are not statistically significant. The only result which verifies traditional modal choice arguments is the effect on demand of increases in the proportion of households earning more than $10,000. The increase in the proportion of higher income families implies a lower demand for bus transit. (This result is not quite significant in 1968 and very insignificant in 1960.) High transit demand is associated with a high proportion of the population between 18 and 65 and a high proportion of households earning between $3,000 and $10,000 in 1960.

Table 4.8 reports the effects of a one percent increase in each of the six income and age categories. An increase in one category occurs at the expense of decreases in the other two categories.

Thus, the coefficients in Table 4.6 alone do not give the effects of these changes.

Table 4.8

EFFECTS ON TRANSIT DEMAND OF CHANGES IN AGE AND INCOME DISTRIBUTION

A 1% increase in:	Leads to an increase in demand of:	t-ratio	Level of Significance	
			40 degrees of freedom	3 degrees of freedom
% under $3,000	-2.31%	-2.92	1%	10%
% between $3,000 and $10,000	3.24	2.47	5	10
% over $10,000	-2.82	-1.58	-	-
% 18 and under	-4.72	-2.05	5	-
% between 18 and 65	6.51	2.84	1	10
% over 65	-5.79	-1.82	10	-

Appendix IVA

THE COST OF BUS TRANSIT OPERATIONS

Appendix IVA

THE COST OF BUS TRANSIT OPERATIONS

In the models of supply behavior included in the text, the firm acts as though all costs are variable and the cost per bus mile is a constant, regardless of the scale of operations. This Appendix discusses the cost of transit operations in some detail, including an evaluation of the assumptions of the model. The Appendix is organized into four sections: (1) the definition of transit costs as the term is used in this paper, (2) a discussion of operating and capital costs, (3) creation of a formula for capital costs, and (4) estimation of the parameters of a cost function. In estimating the cost function we are particularly interested in the existence of cost economies and diseconomies for larger firms and in the effects of wage rates and bus characteristics (fleet age, seating capacity) on total cost.

4A1 THE COST OF TRANSIT OPERATIONS TO THE FIRM

The concept of cost relevant for this paper is the cost of transit operations borne by the firm. This includes the direct cost of operating buses (drivers' wages, fuel, oil, tires), maintenance of the equipment, administrative expense, insurance, taxes, rents associated with offices and bus barns, and the costs of bus capital.

No portion of the cost of freeways, arterials, roads, or traffic-control devices is included in transit costs unless it appears in a road-use tax or similar levy.[1] In this respect, bus transit systems differ from rail systems. Rail companies must provide and maintain their own roadbed rights-of-way. In effect, they must provide their own "social overhead capital," while bus companies may share

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1. An unusual kind of "road-use tax" occurs in some northern towns where bus transit companies have the responsibility for snow removal.

government-built roads with other modes of transportation.[2] In terms of vehicle miles, there are economies of scale for rail which do not exist for bus systems because the stations, roadbeds, and rights-of-way of a rail system constitute a large element of fixed cost. In a rail system, costs do not increase proportionally with vehicle miles unless track mileage also increases.

The operation of vehicles in a crowded urban environment creates externalities of various kinds. Exhaust fumes may foul the air, leading to adverse health effects or at least to a decline in the utility of urban residents and workers. An additional vehicle on a crowded freeway or city street adds to congestion and imposes delays on other urban travelers. These are real costs, but neither is borne directly by the bus transit firm. Proponents of transit argue that additional bus transit service leads to a reduction in both air pollution and congestion. Increased bus service, by attracting additional ridership, is supposed to result in a net decline in vehicular traffic. Consequently, air pollution and congestion diminish. In this case, the omission of externalities from cost considerations may overstate the real cost of transit operations.

4A2 OPERATING AND CAPITAL COSTS

Costs are developed for two samples of firms (1968 and 1960) on the basis of data supplied by the firms to the American Transit Association (ATA). Total costs consist of operating costs and capital costs. Operating costs consist of wages and salaries, rents, fuel and lubricants, tires, materials, taxes, and other items used and paid for in the course of transit operations. The definition is the same as that used by the ATA, with the exception that depreciation and amortization are included here as capital cost rather than an operating cost.

Wells' "Economic Characteristics of the Urban Bus Transit Industry: 1960-1969"[3] provides a breakdown of operating cost by function

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2. In the case of exclusive freeway lanes for buses, the cost is not paid by the bus company.

3. J. D. Wells and Sharron Thomas, op. cit.

(Table 4A.1). Drivers' wages make up the largest single item in operating costs (44 percent). Other labor costs occur in equipment, maintenance, and garage expense and in administrative and general expense and may swell the wages and salaries portion of operating cost to 65 percent.

Firms incur capital costs because capital equipment declines in value (depreciates) with use and age and because their financial investment in equipment must earn a return. This return is an opportunity cost and consists of interest payment or "normal" profit, depending on the method of finance used by the firm. Capital employed in the production of transit service includes buses, the bus "barn" (building and equipment), offices, and stations. Not all of the cost of capital services is included under capital cost. Maintenance expense is part of the cost of using capital goods; yet this is included in operating expenses. Buildings and offices may be leased rather than owned by the firm. These rents are included in operating costs rather than capital costs.

Table 4A.1

DISTRIBUTION OF OPERATING EXPENSES

Category Name	Percent of Total	
	1960	1969
Total operating costs	100.00	100.00
Equipment, maintenance and garage	20.50	17.60
Transportation	52.61	56.64
Drivers' and helpers' wages, etc.	(42.14)[a]	(44.25)[a]
Station	.64	1.11
Traffic, advertising, etc.	.95	1.39
Insurance and safety	5.65	4.75
Administrative and general	10.71	11.75
Operating taxes and licenses	8.43	6.24
Operating rents, net	.51	.51
Number of firms in sample	107	76

a. Included in Transportation Expense.

To obtain capital costs for the firm, we estimate the value of the capital stock and apply a consistent formula for depreciation, interest, and normal profit to all firms in the sample. One problem with the ATA data on depreciation and amortization is that firms use different schedules for buses. Thus, there is no comparability among firms. Furthermore, some publicly owned firms report no depreciation data whatsoever. The estimate of the value of the capital stock of the firm is based on data reported to the ATA on the number of buses operated by the firm and their year, model, and seating capacity.

Basing capital stock estimates only on bus capital tends to understate both the capital and the capital costs of the firm. Although actual data on capital and assets are scanty, there is evidence that the capital stock owned by the firm consists overwhelmingly of bus capital. Meyer, Kain, and Wohl, for instance, estimated the investment in yards and shops per bus to be one-seventh of the cost per bus. Because of the longer life of yards and shops (50 years vs. 11 years) other capital costs are only one-thirteenth as great as the cost of buses. Second, operating cost data indicate that one-half of one percent of costs are for operating rents. Some of the non-bus capital costs are undoubtedly covered in this category. Third, some yards and shops are quite old and, thus, the capital cost of these is reduced proportionally. The total underestimate of capital costs may be one-thirteenth, (eight percent) or smaller. Since capital costs amount to only ten percent of total costs, the overall error would be smaller than one percent.

4A3 THE CAPITAL COST FORMULA[4]

The cost of capital services depends on the value of the capital stock, the rate of depreciation, and the rate of return or rate of

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4. Considerable development in the theory of the user's cost of capital services has occurred in recent years. This section represented a simplified version of this theory. For the economist and ambitious layman wishing to investigate this subject in greater depth, a good summary of the present state of the art is: U.S. Department

interest reflecting opportunity costs. We use a "declining-balance" formula in which depreciation is a constant proportion of the current value of the asset. (Depreciation which is a constant proportion of the <u>initial</u> value of the asset is a "straight-line" formula.) The opportunity cost of the investment is measured by the long-term loan rate of interest available to the firm. This is perhaps a conservative estimate, since it assumes the firm uses the funds to reduce borrowing rather than make an investment which yields some higher rate of return.

For a single bus the capital cost is the product of the value of the bus (V) and the depreciated rate plus the interest rate:

$$V(S,A)(\delta + r). \tag{A1}$$

The value (V) is a function of the age (A) and seating capacity (S) of the bus. Given the kind of depreciation formula used here, the value of the bus declines exponentially with age. If $V_0(S)$ is the value of a new bus, the capital cost is:

$$V_0(S)\, e^{-\delta A}\, (\delta + r). \tag{A2}$$

Ideally, capital costs for a bus fleet should be the sum of costs for individual buses. As an alternative to this long, involved computation, we assume that all fleets are composed of identical buses, each of which has an age and seating capacity equal to the average for that fleet. Total capital costs equal the product of the number of buses and the capital cost for the "typical" bus.

A number of firms in the 1968 sample have been recipients of capital grants from UMTA. UMTA capital grants which pay up to two-thirds the purchase price of capital goods reduce the capital costs of the firm. We adjusted for this by defining the proportion of capital purchased under the UMTA program. This adjustment factor

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of Labor, Bureau of Labor Statistics, <u>Capital Stocks, Production Functions, and Investment Functions for Selected Input-Output Sectors</u> (Washington, D. C., 1970), Report No. 355. This report was prepared by Jack Faucett Associates.

is (1 - 0.67s), where 0.67 represents the maximum proportion of the total cost which can be paid by UMTA.

Where n is the number of buses in the fleet, the capital costs are defined as:

$$C = n(1 - 0.67s)\ V_0(S)\ e^{-\delta A}\ (\delta + r). \qquad (A3)$$

The rate of depreciation (δ) is 0.10. Thus, the value of the bus declines about 10 percent per year. Under the declining-balance formula, the bus has fallen to half its original value after seven years. The long-term borrowing rate of interest depends on whether the firm is publicly or privately owned. The debt obligations of publicly owned bus firms are tax exempt and bear a substantially lower rate of interest. In 1960, high-grade municipal bonds had a yield of 3.73 percent, while grade Baa private bonds had a yield of 5.19 percent. In 1968, the differential was even greater: 4.51 for public and 6.94 for private. For a private firm in 1968, capital costs amounted to 17 percent (10 percent plus 6.94 percent) of the estimated value of the capital stock.

It is surprisingly difficult to establish the average price of a new bus. Different models have different prices, although the seating capacities may be the same. There is a wide range of optional equipment available such as air-conditioning and power steering which can increase the price of a bus by almost $10,000. Finally, the list price apparently bears only a slight relationship to the price at which buses are actually sold. To get an estimate of the average price actually paid for a new bus, we analyzed 24 fleet purchases made under the capital grants program between 1965 and 1970. We found the average purchase price for a 45-passenger bus to be $29,000. (The range was from $24,000 to $33,000.) Reducing or increasing seating capacity from this standard size affected the price by about $1,000 per seat. This differential is larger than the differential on the price lists, indicating perhaps that purchasers of larger buses are less likely to buy a spartan model and more likely to purchase optional equipment. The formula for the value of a new bus is:

$$V(S) = \$29{,}000 + \$1{,}000\ (S - 45). \qquad (A4)$$

This formula was applied to both 1968 and 1960 data. The wholesale price index for transportation equipment increased only from 98.8 to 102.8 during this period.

Capital costs were computed for all firms in the two samples and added to operating costs. On average, these capital costs were approximately 10 percent of total costs. The range was rather large. In one firm with an entirely new fleet of large buses, capital costs were almost 20 percent of total costs. In other firms with extremely old fleets, the ratio was as low as three percent.

4A4 COST FUNCTIONS FOR BUS TRANSIT OPERATIONS

The issues in the cost of transit operations center on the existence of economies of scale for large firms, the impact of wage rates on the cost of bus transit, and the effect of fleet characteristics on costs. The tool used in economic analysis to bring evidence to bear on these issues is the cost function. In this Appendix we present econometric results based on estimates of this cost function:

$$\ell n\, C = \delta_0 + \delta_1 \ell n\, B + \delta_2 \ell n\, w + \delta_3 \ell n\, VEL + \delta_4 A + \delta_5 S + \delta_6 PUB + \delta_7 s \;, \qquad (A5)$$

where C = total costs,
B = bus-miles,
w = hourly wage rate of operating personnel,[5]
VEL = bus-miles per bus-hour attained by the firm,
A = average age of fleet,
S = average seats per bus,
PUB = 1 for publicly owned firm; 0 otherwise,
s = proportion of fleet purchased with capital grant.

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5. Source: ATA Labor Practices Manual. Reported data include cost-of-living allowance (if any) but does not place any value on fringe benefits.

Table 4A.2 presents estimates of the coefficients of the cost function. We note the following results:

- Evidence indicates the lack of substantial economies or diseconomies of scale. Increasing transit operations by increasing bus-miles by 100 percent increases costs by 98 percent and 101 percent, according to our estimates. There is no evidence supporting the hypothesis that larger bus systems have lower costs per bus-mile. Apparently, our assumption of a constant cost per bus-mile is not wrong.

Table 4A.2

COST FUNCTIONS FOR 1968 AND 1960

Statistic	1968	1960
Dependent Variable	ℓn Total Cost	ℓn Total Cost
Constant	0.930 (0.557)	0.864 (0.417)
ℓn B	0.982 (0.0327)	1.013 (0.0223)
ℓn w	0.883 (0.181)	0.785 (0.120)
ℓn VEL	-0.779 (0.173)	-0.862 (0.161)
A	-0.00084 (0.0055)	-0.00375 (0.00538)
S	0.0010 (0.0053)	0.00197 (0.00474)
SUB	-0.059 (0.153)	
PUB	-0.106 (0.0466)	-0.0954 (0.04444)
R^2	.990	.994
Observations	40	45
Standard error	.121	.082

- In both estimates, increases in the wage rate have very strong effects on total costs. Although labor is only around 60 percent of total costs, a 100 percent increase in wage rates increases costs by 88 and 78 percent.
- Differences in miles per bus-hour do have a strong effect on costs. Coefficients of -0.78 and -0.86, however, indicate that the decrease in costs is slightly less than proportional to the increase in VEL.
- Newer buses, larger buses, and unsubsidized buses are more costly from the standpoint of interest and depreciation. Estimates of the cost coefficients of A, S, and s bear this out. On the basis of the capital cost formula, an extra year of age decreases the value of capital and thus capital cost by about ten percent. Total costs should decrease about one percent as the bus fleet ages (since capital costs are ten percent of total costs). This can be offset if older buses are less productive or require more maintenance. The coefficient of fleet age is negative but not as large as predicted. Instead of a coefficient -0.0100 we have -0.0008 and -0.0038. The differences between predicted and actual, however, show only a very weak statistical significance but indicate that older buses require more maintenance or are otherwise less productive.
- Because of lower interest rates, capital costs of public firms should be 10 to 20 percent lower than for private firms. Thus, total costs should be one to two percent lower. Estimates of the cost function reveal, however, that the total cost of transit operations for public firms is 10 percent lower than the cost of transit operations for private firms. This difference unquestionably warrants further investigation.

4A5 ALTERNATIVE DERIVATIVES OF THE COST FUNCTION

The roots of the cost function are imbedded in the production function. In fact, it is often possible to derive the cost function from the production function if it is assumed that the firm produces transit service in a way that minimizes cost. One of the simplest two-factor production functions is the Cobb-Douglas:

$$Q = \gamma K^{\alpha} L^{\beta} \quad . \qquad \text{(A6)}$$

Q is output; K and L are factors of production. The parameter γ is called an efficiency parameter. α and β are called share parameters. $\alpha + \beta$ determines economies of scale. If $\alpha + \beta$ is less than one, diseconomies of scale exist. If greater than one, economies of scale exist.

If the firm employs K and L such that the ratios of the costs of a unit of the factors is equal to the ratio of the marginal products, the cost function is:[6]

$$C = \gamma^{-\frac{1}{\alpha+\beta}} Q^{\frac{1}{\alpha+\beta}} P_K^{\frac{\alpha}{\alpha+\beta}} P_L^{\frac{\beta}{\alpha+\beta}} \cdot \left[\frac{\alpha+\beta}{\beta}\left(\frac{\beta}{\alpha}\right)^{\alpha}\right] \quad . \qquad \text{(A7)}$$

C is total cost; P_K is the price per unit of K; P_L is the price per unit of L. Note that this function is linear in the logarithms of the variables.

We can draw an analogy between this cost function and the cost function for bus transit. The quantity is B, bus miles. One factor price can be the wage rate w. Another factor price depends on the age (A) and size (S) of the capital equipment and also on whether the firm is public or private (PUB). Finally, perhaps the efficiency parameter γ may depend on the attainable miles per bus-hour in the bus system (VEL). (The CES production function, which permits factors to be less substitutable than in the Cobb-Douglas case, yields a

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6. The relationship between cost and production functions is described in detail in C. Ferguson, The Neoclassical Theory of Production and Distribution (Cambridge: 1969), Chapter 7.

similar result.) If we are willing to assume the production function for bus transit is the Cobb-Douglas function and that firms minimize cost in the manner described, it is possible to estimate the parameters of the production function from the cost function.

Appendix IVB

VARIABLES CONTAINED IN THE DEMAND FUNCTION

Appendix IVB

VARIABLES CONTAINED IN THE DEMAND FUNCTION

Symbol	Definition	Source
D	Annual revenue passengers	ATA[a]
B	Bus-miles per year	ATA[a,b]
F	Average revenue per passenger	ATA[a]
POP	Population of urbanized area	DOT: 1968[c] Census: 1960[d]
AREA	Land area of urbanized area	DOT: 1968[c] Census: 1960[d]
INC_3	Percentage of households earning less than $3,000 per year (1959)	Census[d]
INC_{10}	Percentage of households earning more than $10,000 per year (1959)	Census[d]
AGE_{18}	Percentage of population 18 years of age or under (1960)	Census[d]
AGE_{65}	Percentage of population 65 years of age or over (1960)	Census[d]
AUTOS	Automobiles per capita	Rand McNally: 1968[e] Census: 1960[d]
HWAY	Population per unit of highway capacity[f]	DOT

a. Annual revenue passengers (D), bus-miles per year (B), and the average revenue per passenger (F) are taken from American Transit Association, Transit Operating Reports - 1968 and Transit Operating Reports - 1960, Part II, "Motor Bus Operations," (Washington: 1969, 1961).

b. A problem exists in defining bus-miles of transit operations because almost all bus firms have charter operations. Operating data includes both charter and transit operations. For most firms in the sample, charter is less than three percent of passenger revenue, but for several firms in both 1960 and 1968, charter revenue was over 10 percent of passenger revenue. Consequently, it was necessary to adjust bus-miles to revenue mileage due to charter operations. In doing so, we made two assumptions: (1) the cost per bus-mile is the same for charter and passenger operations, (2) the revenue from charter operations exactly covers the fully apportioned cost of transit operations. In effect, we multiplied bus-miles by the factor $(1 - \frac{CR}{TC})$, where CR is charter revenue and TC is total operating and capital costs.

c. The urbanized area is supposed to be the geographical area which is urban-in-fact. The city measures only the legal boundaries of the central city. The SMSA (Standard Metropolitan Statistical Area) is a county or multi-county unit over most of the country. Unfortunately, the Bureau of the Census and the Department of Transportation have disagreed in the past on the definition of an urbanized area. Our population and land-area data are based on the Census definition in 1960 and the DOT definition in 1968. Significant differences in the two definitions are most prevalent in the large urban agglomerations. Thus, DOT recognizes the Bay Area, the Puget Sound area, and the tri-state New York area as unified urbanized areas, while the Census tends to break these areas down into the individual cities. Since our data is based on smaller cities almost exclusively, it is felt that disparity between the two definitions does not have a serious impact on our estimates. DOT has made estimates of population and land area of urbanized areas for 1968 which are used in this study.

d. Population and land area for urbanized areas is taken from Bureau of the Census, U.S. Census of Population, 1960, Vol. I, Characteristics of the Population, Part I, United States Summary (Washington: 1963), Table 22, pp. 1-49.

The income distribution of households in urbanized areas came from Ibid., Table 152, pp. 1-333. The age distribution of the population is found in Ibid., Table 63, pp. 1-181. For some of the smaller cities, data is found only in the state volumes, Table 13.

The data on automobile availability by urbanized area in Census data, supplied in this case by DOT.

e. Automobile ownership for 1968 is taken from auto registrations reported in Rand McNally & Co., Commercial Atlas and Marketing Guide, 101st Ed. (New York: 1970). In using these data, it was necessary to use autos per capita on a county basis rather than on an urbanized area basis.

f. DOT has devised a set of formulas for estimating the capacity of urban highway systems. Capacity is based on the mileage of freeways and of surface arterials in the urbanized area. Capacity per freeway mile is estimated to be 8720 autos per hour, regardless of the size of the urbanized area. The capacity of surface arterials was found to vary with the size of the urbanized area, varying from 2225 vehicles per hour for smaller cities to 2760 vehicles per hour for the largest cities.

Appendix IVC

1968 AND 1960 SAMPLES OF BUS FIRMS AND URBANIZED AREAS

Appendix IVC

1968 AND 1960 SAMPLES OF BUS FIRMS AND URBANIZED AREAS

Each of the 51 firms in the 1968 sample and the 44 firms in the 1960 sample (Table 4C.1) is assigned to one of the following categories:

- Private ownership/power company operation (Power)
- Private ownership/local regulation (Private-Local)
- Private ownership/state regulation (Private-State)
- Public ownership/city council control (City)
- Public ownership/transit authority control (Authority).

Information on public or private ownership of transit firms appears in R. L. Banks & Associates, Inc., "Study and Evaluation of Local Transit Regulation and Regulatory Bodies," DOT-UT-75, Washington: 1970, preliminary draft, Table IV-4. The regulation of intracity bus transit operations by the state public utilities commission or by the local governments varies from state to state. An ATA mimeograph (July, 1968) gives a state-by-state summary of this jurisdiction over intracity fares. A third issue is the control of publicly owned transit operations. The ATA mimeograph, "Regulation of Fares," (1968) indicates whether a city government or a transit commission controls fares and service in the larger bus systems in the industry.

<u>Table 4C.1</u>

CATEGORIZATION OF BUS FIRMS, 1968 AND 1960 SAMPLES

1968 SAMPLE

Company Name	Location	Classification
Fitchburg & Leominster St. Railway Co.	Fitchburg-Leominster, Mass.	Private-State
Greater Portland Transportation Co.	Portland, Me.	Private-State
Manchester Transit, Inc.	Manchester, N.H.	Private-State
Union St. Railway Company	New Bedford, Mass.	Private-State
Niagara Frontier Transit System, Inc.	Buffalo, N.Y.	Private-Local
Erie Metropolitan Transit Authority	Erie, Pa.	Authority
Harrisburg Railways Company	Harrisburg, Pa.	Private-State
New Castle Transportation Authority	New Castle, Pa.	Authority
Raleigh City Coach Lines, Inc.	Raleigh, N.C.	Private-State
Charlotte City Coach Lines, Inc.	Charlotte, N.C.	Private-State
Duke Power Company	Greensboro, N.C.	Power
Duke Power Company	Spartanburg, S.C.	Power
Duke Power Company	Durham, N.C.	Power
Greenville City Coach Lines, Inc.	Greenville, S.C.	Private-Local
Jacksonville Coach Co.	Jacksonville, Fla.	Private-Local
Savannah Transit Authority	Savannah, Ga.	Authority
Southern Coach Lines, Inc.	Chattanooga, Tenn.	Private-Local
Asheville Transit Authority	Asheville, N.C.	Authority
Akron Transportation Company	Akron, Ohio	Private-Local
Charleston Transit Company	Charleston, W.Va.	Private-State
Co-operative Transit Company	Wheeling, W.Va.	Private-State
Greater Lafayette Bus Co., Inc.	Lafayette, Ind.	Private-State
Milwaukee & Suburban Transportation Corp.	Milwaukee, Wisc.	Private-State
Wisconsin Public Service Corp.	Green Bay, Wisc.	Power
Oshkosh City Lines, Inc.	Oshkosh, Wisc.	Private-State
Twin City Transit, Inc.	Little Rock, Ark.	Private-Local
Interstate Power Company	Dubuque, Iowa Div.	Power
Kansas City Area Transportation Authority	Kansas City, Mo.	Authority
Bi-State Transit System	St. Louis, Mo.	Authority
City Bus Company	San Angelo, Tex.	City
Fort Worth Transit Co., Inc.	Fort Worth, Tex.	Private-Local
City of Lafayette Municipal Transit	Lafayette, La.	City
Albuquerque Transit System	Albuquerque, N.M.	City
Sacramento Transit Authority	Sacramento, Calif.	Authority
Flint City Coach Lines, Inc.	Flint, Mich.	City
Grand Rapids Transit Authority	Grand Rapids, Mich.	Authority
Baltimore Transit Company	Baltimore, Md.	Private-State
Memphis Transit Authority	Memphis, Tenn.	Authority
Metropolitan Dade County Transit Authority	Miami, Fla.	Authority
South Carolina Electric & Gas Co.	Columbia S.C.	Power
South Carolina Electric & Gas Co.	Charleston, S.C.	Power
Nashville Transit Company	Nashville, Tenn.	Private-Local
Cincinnati Transit Company	Cincinnati, O.	Private-Local
Columbus Transit System	Columbus, O.	Private-Local
Twin City Lines, Inc.	Minneapolis-St. Paul, Minn.	Private-State
Omaha Transit Company	Omaha, Neb.	Private-State
Springfield City Utilities	Springfield, Mo.	City
Dallas Transit System	Dallas, Tex.	City
New Orleans Public Service, Inc.	New Orleans, La.	Power
San Antonio Transit System	San Antonio, Tex.	City
Fresno Municipal Lines	Fresno, Calif.	City

1960 SAMPLE

Company Name	Location	Classification
Connecticut Railway & Light Co.	Bridgeport, Conn.	Private-State
Fitchburg & Leominster St. Railway Co.	Fitchburg-Leominster, Mass.	Private-State
Union St. Railway Co.	New Bedford, Mass.	Private-State
United Transit Company	Providence, R.I.	Private-State
Niagara Frontier Transit System Inc.	Buffalo, N.Y.	Private-State
Rochester Transit Corp.	Rochester, N.Y.	Private-State
United Traction Company	Albany, N.Y.	Private-State
Harrisburg Railways Company	Harrisburg, Pa.	Private-State
Lehigh Valley Transit Company	Allentown, Pa.	Private-State
Reading Bus Company	Reading, Pa.	Private-State
Capital Transit	Trenton, N.J.	Private-State
Wilkes-Barre Transit Corp.	Wilkes-Barre, Pa.	Private-State
Raleigh City Coach Lines, Inc.	Raleigh, N.C.	Private-State
Charlotte City Coach Lines, Inc.	Charlotte, N.C.	Private-State
Columbus Transportation Company	Columbus, Ga.	Private-Local
Duke Power Company	Greensboro, N.C.	Power
Duke Power Company	Durham, N.C.	Power
Knoxville Transit Lines	Knoxville, Tenn.	Private-Local
Lynchburg Transit Company	Lynchburg, Va.	Private-Local
Safety Motor Transit Company	Roanoke, Va.	Private-Local
Savannah Transit Authority	Savannah, Ga.	Authority
City Coach Lines, Inc.	Winston-Salem, N.C.	Private-State
Akron Transportation Company	Akron, Ohio	Private-Local
Charleston Transit Company	Charleston, W.Va.	Private-State
Co-operative Transit Company	Wheeling, W.Va.	Private-State
Superior Transit Company	Duluth, Minn.	Private-State
Citizens Coach Company	Little Rock, Ark.	Private-Local
Sacramento Transit Authority	Sacramento, Ca.	Authority
San Diego Transit System	San Diego, Ca.	Private-Local
City Coach Lines, Inc.	Muskegon, Mich.	Private-Local
South Carolina Electric & Gas Co.	Columbia, S.C.	Power
South Carolina Electric & Gas Co.	Charleston, S.C.	Power
Cincinnati Transit Company	Cincinnati, O.	Private-Local
Columbus Transit Company	Columbus, Ohio	Private-Local
Louisville Transit Company	Louisville, Ky.	Private-Local
Indianapolis Transit System, Inc.	Indianapolis, Ind.	Private-State
Springfield Transportation Company	Springfield, Ill.	Private-State
Twin City Rapid Transit Company	Minneapolis-St. Paul, Minn.	Private-State
St. Joseph Light & Power Company	St. Joseph, Mo.	Power
Dallas Transit Company	Dallas, Tex.	Private-Local
New Orleans Public Service, Inc.	New Orleans, La.	Power
Nueces Transportation Company	Corpus Christi, Tex.	Private-Local
San Antonio Transit System	San Antonio, Tex.	City
Rose City Transit Company	Portland, Ore.	Private-Local

CHAPTER V

REGULATORY CONSTRAINTS AND THE ECONOMIC BEHAVIOR OF URBAN TRANSIT FIRMS

by

Marilyn Flowers

SUMMARY

The provision of transit service in urban areas of the United States is subject to regulation by state and/or local officials. This Paper presents an analysis of the effects of certain regulatory constraints imposed on transit suppliers. The public regulation of private transit enterprise is the primary focus, although much of the analysis is equally relevant in cases of public ownership and operation of a transit system.

The Paper is divided into three major parts: (1) a survey of the regulatory framework within which many private bus firms operate; (2) a theoretical analysis of the regulatory process; and (3) a listing of some key regulatory issues and their potential impact on federal policy.

The theoretical model indicates that, given the existence of a monopolistic transit supplier, public regulation is desirable in that it brings about higher levels of ridership and/or service than would be provided by an unregulated monopolist. However, simultaneous achievement of regulatory objectives of maximum ridership and maximum service is possible only in limited circumstances, and regulators must usually make a tradeoff between these objectives.

The regulatory framework within which public transportation is provided may result in inflexibility in the response of the transportation system as a whole to changes in population patterns and to the nature of the demand for public transportation.

A further problem associated with public regulation is the possibility that imposition of a regulatory earnings constraint will seriously weaken management's incentive to minimize production costs.

A. INTRODUCTION

1. OBJECTIVES

The provision of transit service in urban areas of the United States is subject to regulation by state and/or local officials. The extent of public control varies among localities, ranging from public regulation of certain aspects of the operations of private transit firms to complete public ownership and operation of the transit system. This Paper presents an analysis of the effects of certain regulatory constraints imposed on transit suppliers. Attention is focused primarily on public regulation of private transit enterprise, although much of the analysis is equally relevant in cases of public ownership.

The objectives of the analysis are threefold: (1) to indicate the probable effects of public regulation on both the quantity of transit service that is provided and the number of riders that transit suppliers are able to attract to their service, (2) to identify some of the conflicts that exist not only among public and private objectives with respect to the transit system, but also among alternative public objectives, and (3) to indicate the possible role regulatory constraints may be playing in the financial difficulties of private transit suppliers.

2 OVERVIEW

Section B is devoted to a discussion of the regulatory framework within which private transit firms operate. It indicates aspects of the transit operation that are subject to regulatory controls and some of the variations in the regulatory framework that exist among jurisdictions.

Section C contains a geometric model of the demand and supply of urban transit service. This model is used to analyze the effects of public regulation on the quantity and utilization of transit service in an urban area, the extent of regulation required to achieve public objectives and to indicate some of the potential conflicts that exist among alternative public objectives.

Section D indicates some of the key issues in the area of public transit regulation that are raised by the preceding discussion and analysis. These issues relate primarily to the role regulatory constraints may be playing in the decline of private transit enterprise and the implication for federal policy of the existence of these constraints.

B. SPECTRUM OF REGULATORY CONSTRAINTS

Although there is a substantial degree of commonality in the regulations confronting most private transit firms, some differences do exist both with respect to aspects of the firms' operations that are subject to regulation and the mechanisms by which regulatory constraints are enforced. This section is devoted primarily to a general description of regulatory framework within which private transit firms operate, with emphasis on some of the significant variations that exist among regulatory jurisdictions. The information used in this section was obtained from a series of interviews with transit and regulatory officials in several locations and from examination of relevant documents, e.g., franchises, public utility codes, and regulatory and court decisions.

1. REGULATION OF FARE AND SERVICE

In most localities, both the fare and the service provided by private transit firms are subject to public regulation. Service is regulated not only with respect to quality, through the setting of safety standards for transit vehicles and health and training standards for operators, but also with respect to the quantity of service. The initial grant of operating rights to a private transit supplier is usually a grant to provide regularly scheduled service over certain specifically defined routes. Any alteration, expansion, or abandonment of those routes or the opening of new routes typically must have prior regulatory approval. In some jurisdictions, even the scheduling of service is subject to control of regulatory authorities. The Washington Metropolitan Area Transit Commission, for example, must approve any changes in scheduling in which existing or proposed headway is ten minutes or more.[1] In addition to responding to requests by transit management for permission to alter route structure or scheduling, regulatory bodies often have the authority to require transit firms to extend their operations into new areas.

Both fare and service decisions must be made by regulatory bodies within the context of allowing the firm to achieve a level of earnings sufficient to sustain its operations. However, only fare decisions are typically made on purely economic grounds. Numerous other considerations often enter into service regulation and usually the fact that a route taken by itself is unprofitable is not sufficient justification for its abandonment. The policy stated in the Washington Metropolitan Area Transit Regulation Compact is fairly typical in this respect.

> The fact that a carrier is operating a route or providing a service at a loss shall not, of itself, determine whether abandonment of the route or service is in the public interest, as long as the carrier earns a reasonable return.[2]

2. RATE OF RETURN

The determination of what constitutes a reasonable level of earnings is a key issue in public regulation and is subject to significant variation among regulatory jurisdictions. Sources of variation include methods of measuring earnings for regulatory purposes, the legal framework within which regulatory decisions are made, and methods of allowing the firm to achieve the allowed level. Most regulatory bodies use one or the other of two methods of measuring earnings for regulatory purposes. The first method, and the one that is standard in the regulation of most public utilities, is to allow a percentage return on some measure of the value of the capital stock of the firm

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1. Rules of Practice and Procedure and Regulations of the Washington Metropolitan Area Transit Commission, Regulation No. 60.

2. Washington Metropolitan Area Transit Regulation Compact, Public Law 86-794, September 15, 1960.

(usually original cost less accrued depreciation). The other method sets a minimum allowable operating ratio--the ratio of operating expenses (which do not include the cost of capital) to total revenue. The operating ratio is used primarily for the regulation of motor carriers. The significance of the variation in the two methods is not immediately apparent. Obviously, the same amount of net earnings can be evaluated using either method. In fact, some regulatory bodies use both methods, allowing a given operating ratio as long as the return on capital does not exceed a given level. Later discussion will indicate some possible differences in the effect of the two methods on the incentive for a private firm to produce its service efficiently.

Legal requirements with respect to the level of earnings to be allowed vary among regulatory jurisdictions. In most cases, the franchise or public utility code states only that the firm must be allowed some "fair" or "reasonable" return, leaving exact determination of the return to the discretion of the regulatory body. Certain legal guidelines are set in these cases, however, with respect to what must be taken into consideration by the regulatory body in determining the return. These guidelines are usually stated in fairly general terms of allowing the firm to maintain its credit standing and attract new capital. The U.S. Court of Appeals (D.C. Circuit) in reviewing rate decisions of the Washington Metropolitan Area Transit Commission stated that, in addition to covering legitimate operating expenses, the company should also be allowed:

> ...the sum of money needed to attract the capital, both debt and equity required to assure financial stability and the resulting capacity of the utility to render the service upon which the public depends. To determine that sum entails inquiries and findings...into such things as the capital programs in prospect, what such programs entail in terms of down payments as well as financing, the cost of borrowing money, working capital needs, the desirable ratio of debt to equity, the incentives required by a stockholder to keep his money in the business and the dividends and growth rates requisite to supply these

> incentives, the opportunities in these respects provided in comparable business and the related matters which must be prayerfully explored by the conscientious regulator.[3]

Some franchises do state the exact return to be allowed, The franchise granted to the Nashville (Tenn.) Transit Company, for example, provides that

> the [company] shall be entitled to earn for any period of one (1) year of its operations as net profit...an amount represented by six and five-tenths per centum (6.5 percent) of its capital value or by four and twenty-five hundredths per centum (4.25 percent) of its total gross revenue, whichever is the greater.[4]

The Nashville franchise provides that earnings in excess of the allowed return be accumulated in a "Fare Regulator Fund." When earnings fall below that return, sufficient funds are withdrawn from the fund to increase total earnings to the allowed level. If the fund is exhausted, a fare increase is automatic.

At the other end of the legal spectrum are franchises such as those held by some private firms operating in New York City that are purely contractual agreements in which the company agrees to provide service along certain streets at a fare not to exceed some maximum level for a specified period of time with no provision regarding any rate of return the company will be allowed to achieve.

Although a private transit firm must be allowed a return sufficient to continue in operation, the return need not be earned entirely from transit operations. A few transit operations in the country are still run by gas and electric utilities and receive subsidies from the utility operation. More common is the policy adopted by many regulatory bodies of encouraging transit firms to engage in charter operations and to subsidize transit operations from charter revenues.

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3. D.C. Transit System, Inc., v. Washington Metropolitan Area Transit Commission, 121 U.S. Appl. D. C. 375 (1965).

4. 1958 Lease agreement between City of Nashville, Tennessee and Nashville Transit Company, p. 23.

In these cases, regulatory authorities use their licensing authority to protect the charter operation from competition and, in rate cases involving the transit operations, consider the combined earnings of the transit and charter operations.

3. CONSTRAINTS ON COMPETITION

The monopoly position that most bus companies occupy with respect to providing that mode of public transportation within the areas they serve is usually protected as a matter of public policy. Most regulatory bodies are unwilling to grant a bus company permission to extend its service into areas where it will compete with service being provided by another transit firm. In fact, they are usually legally prohibited from taking such action except in very limited circumstances.[5] The Washington Metropolitan Area Transit Regulation Compact is fairly typical in this respect. It provides:

> ...that no certificate [of public convenience and necessity] shall be issued to operate over the routes of any other holder of a certificate until it shall be proven to the satisfaction of the Commission, after hearing, upon reasonable notice, that the service rendered by such certificate holder, over such route is inadequate to the requirements of the public necessity and convenience and provided further, if the Commission shall be of the opinion that the service rendered...is in any respect inadequate...such certificate holder shall be given reasonable time and opportunity to remedy such inadequacy before any certificate shall be granted to operate over such route.[6]

A few general observations can be made about the effect of limiting competition in the provision of bus service. Public officials are probably able to extract from a transit monopolist certain services that they would not be able to obtain under conditions of competitive supply. These include the provision of service in certain areas or at certain times of day when not enough demand exists to

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5. The legal requirement that transit firms be protected from competition with other transit companies is not universal, however.

6. Washington Metropolitan Area Transit Regulation Compact, Public Law 86-794, September 15, 1969.

justify provision of the service on economic grounds and such other services as special reduced fares for school children, street cleaning, and snow removal. These services are, of course, subsidized by the profitable routes.

On the other hand, the existence of several transit monopolists serving different sections of an urban area may result in a certain degree of inflexibility in the responsiveness of the transit system as a whole to shifts in population and travel patterns. The attractiveness of the transit service provided to people moving into new areas may be considerably lessened by the extra transfers required if the origin and destination of their trips lie within territories served by different companies. The type of conflict that can arise under these circumstances is exemplified in a decision of the U.S. Court of Appeals (D.C. Circuit) that set aside an order of the Washington Metropolitan Area Transit Commission requiring two suburban carriers to extend their service further into Washington, D.C.--into areas previously served exclusively by the D.C. Transit System, Inc. The court held that while the route extensions might be beneficial to suburban residents:

> ...[their] convenience is not under the regulatory scheme, the sole criterion. [D.C.] Transit has rights and responsibilities under that scheme as well. Its ability to provide good transportation service to the residents of the District of Columbia at reasonable rates is intimately related to the degree of utilization of its service....To take away a part of Transit's volume by putting new competition on its routes may conceivably have a significantly adverse impact upon those bus riders in the District who must look to Transit for intra-District service.[7]

4. OTHER REGULATIONS

Additional aspects of the transit operation are subject to regulation in some jurisdictions but not in others. These include

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7. D. C. Transit System, Inc. v. Washington Metropolitan Area Transit Commission, 126 U.S. App. D.C. Reports.

control over investment and financial practices. This regulation takes the form of a requirement for prior regulatory approval of any issuance of securities or incurring of long-term debt. Corporate structure is subject to varying degrees of control, usually taking the form of a requirement that mergers with other common carriers have prior regulatory approval. Regulatory involvement in corporate structures, including non-transit enterprises, involves extensive auditing to assure that only legitimate transit expenses are included in the accounts used in rate proceedings.

C. EFFECTS OF REGULATION ON THE QUALITY AND UTILIZATION OF URBAN TRANSIT SERVICE

1. ANALYTICAL MODEL

Three elements of regulatory policy that appear to be of special importance in determining the quantity and utilization of transit service are (1) regulation of fare, (2) regulation of service levels, and (3) the imposition of a regulatory constraint on earnings. This section is devoted to development of a relatively simple geometric model of the demand and supply of transit service. The model will then be used for analyzing some of the potential effects of alternative regulatory policies on both total ridership and the amount of service available in an urban area. The main purpose of this analysis is to identify some of the potential conflicts among three possible objectives of regulatory policy--minimizing fare, maximizing utilization of the transit system, and maximizing the supply of transit service. The analysis assumes that transit service is privately supplied by a single profit-maximizing transit firm.

A key assumption of this model is that demand for transit service is a function of both fare and the level of service that is provided, measured in the number of bus trips that are supplied.[1] This assumption seems intuitively reasonable. An increase in the level of service while holding fare constant can attract more riders either if the additional trip is used to open a new route, thus making bus service easily accessible to a larger number of people or if the

1. A "bus trip", as the term is used in this paper, should not be confused with a "passenger trip". A "bus trip" is just that--a trip by a bus along a specified route. A "bus trip" thus will supply a number of "passenger trips" equal to the capacity of the bus, not all of which are necessarily consumed, since any number of passengers up to capacity may actually ride the bus.

additional trip results in more frequent service along an already existing route, thus increasing the attractiveness of transit by granting potential riders more flexibility in adjusting their departure and arrival times. If we assume some maximum fare at which no one will choose to ride the bus, no matter how convenient the service is in terms of geographic accessibility and scheduling,[2] demand for transit might be similar to that shown in Figure 5-1, with D_1, D_2, and D_3 representing demand at successively higher levels of service.

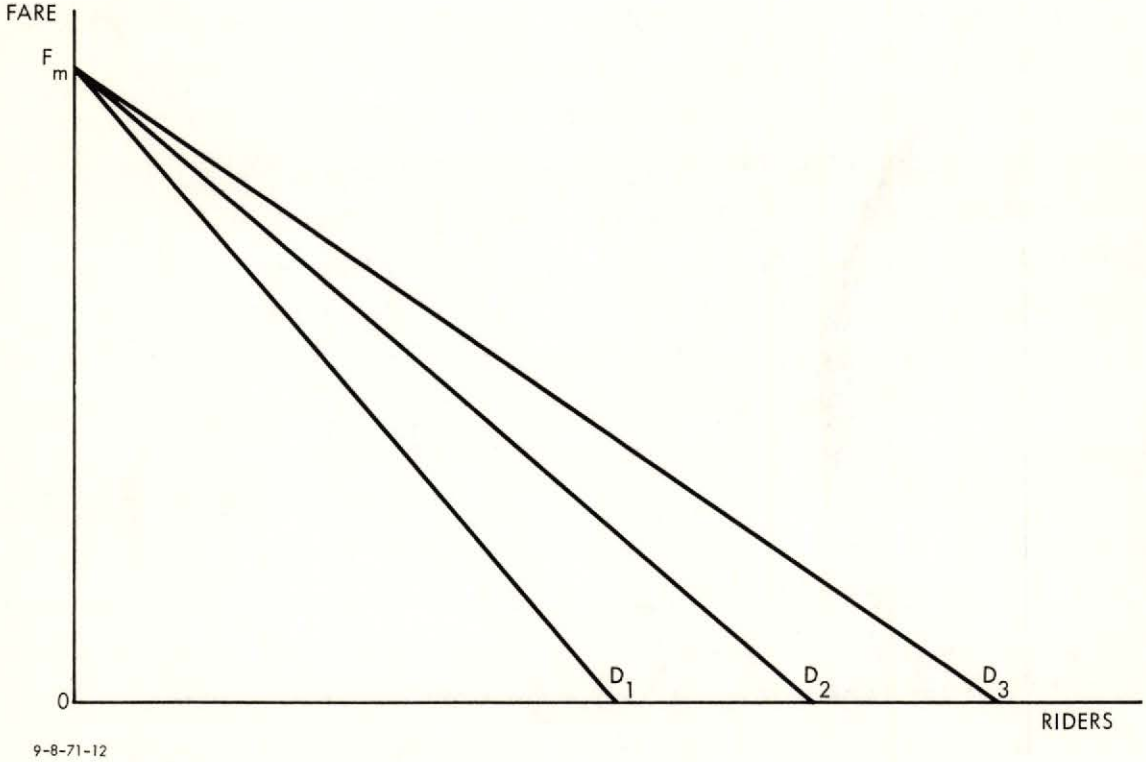

FIGURE 5.1 Demand for Transit as a Function of Fare

2. This maximum fare, for example, might be equal to the taxi fare.

A further assumption about demand that will be made in this model is that the rate at which riders can be attracted to the transit system purely by service increases will begin to decline after some number of bus trips and that the number of passengers that can be attracted to transit even at zero fare will approach some maximum number as service approaches the continuous level.[3] Under this assumption, the functional relationship of riders to service levels at various fares would be similar to that shown in Figure 5-2, with A representing the relationship of riders to service at zero fare and B and C representing the rider-service relationship at successively higher fares.

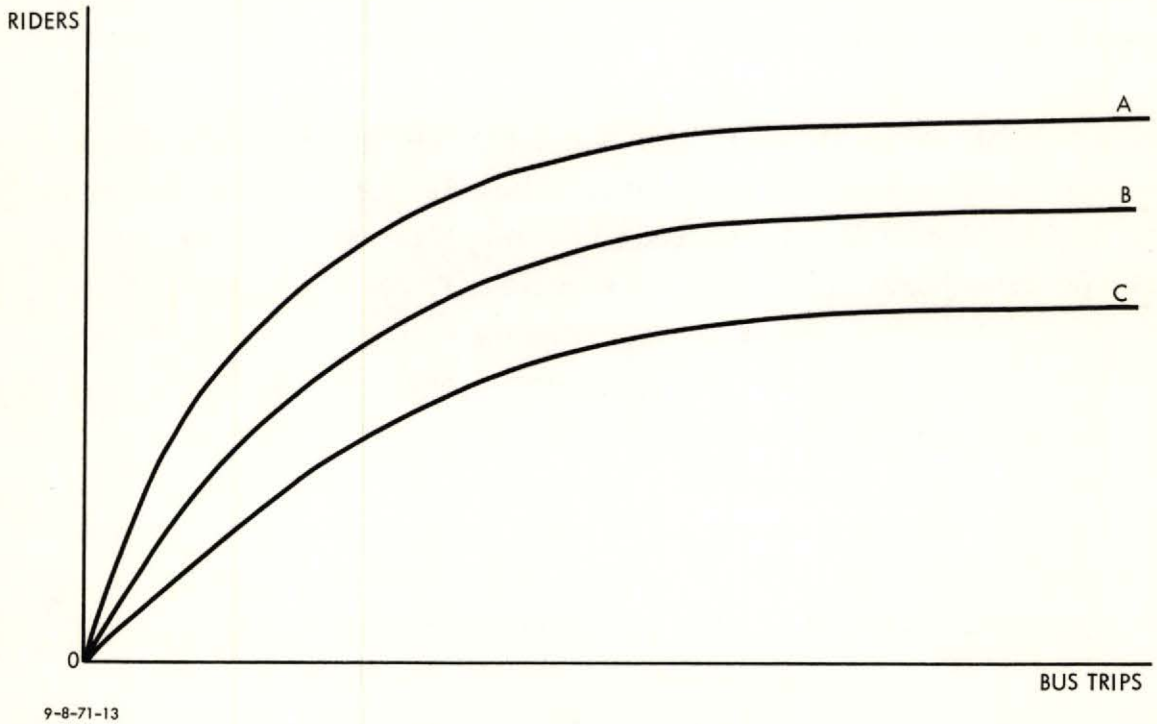

FIGURE 5.2 Demand for Transit as a Function of Level of Service

3. Continuous both in terms of the scheduling of service along all routes and in terms of a route structure so dense that every street lies on a bus route.

The assumptions about demand described in Figures 5-1 and 5-2 make it possible to specify a three-dimensional demand relationship such as that shown in Figure 5-3a. Demand for transit service is represented by a surface connecting A, the functional relationship of passengers to service levels at zero fare, and F_m, the fare at which no riders will be attracted to the transit system, regardless of the level of service that is provided. D_1, for example, measures the number of riders using the transit system at different fare levels if T_1 bus trips are provided. D_2 represents the rider-fare relationship if T_2 bus trips are provided. Thus, if the fare charged is F_1, R_1 riders will use transit if T_1 trips are provided, and R_2 riders will use transit if the level of service is increased to T_2.

Given the demand relationship specified in Figure 5-3a, the relationship of total revenue to riders and service levels would be similar to that shown in Figure 5-3b. Curve A is exactly the same in Figure 5-3b as it is in Figure 5-3a. Total revenue is zero at zero fare. Total revenue also equals zero if the fare is set equal to or higher than F_m. TR_1 is thus the total revenue relationship resulting from holding service constant at T_1 and increasing fare from zero to F_m. TR_2 is the total revenue relationship resulting from the same variation in fares but with service level T_2.

Production costs are assumed to be functionally related to the level of service in a manner similar to that shown in Figure 5-4. This cost function is assumed to include some fixed costs and also the cost of capital or normal return. As Figure 5-5a indicates, profit possibilities confronting the transit supplier can thus be derived by drawing the cost function as a plane intersecting the total revenue function developed in Figure 5-3b. Any excess of total revenue over total cost represents positive economic profits. The profit function in Figure 5-5b is thus directly derived from Figure 5-5a. π_0 on Figure 5-5b represents all the points in 5-5a at which total cost plane intersects the outer edges of the total revenue functions. It is, in other words, a locus of all the rider-service combinations at which the firm will earn revenue exactly

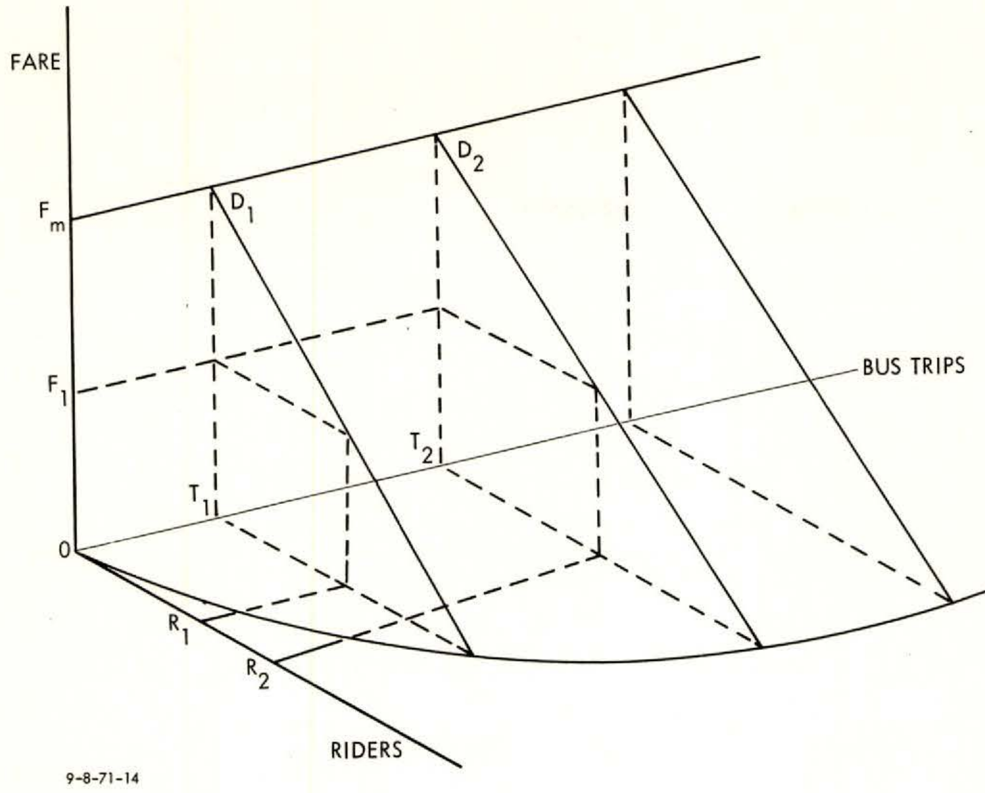

FIGURE 5.3a Demand for Transit as a Function of Fare and Service Levels

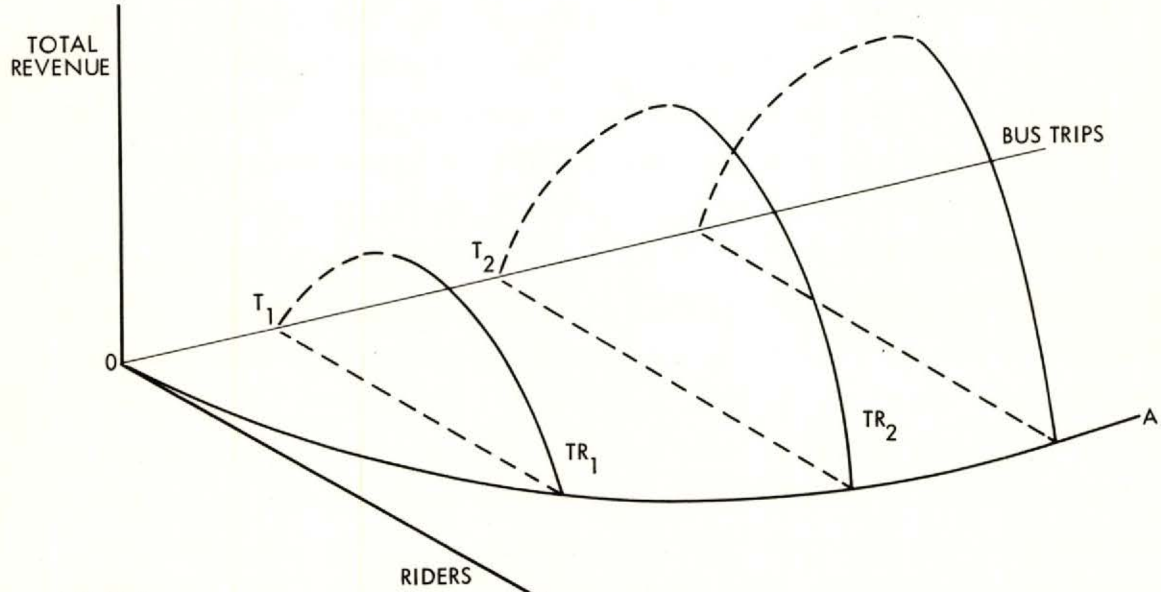

FIGURE 5.3b Total Revenue Function

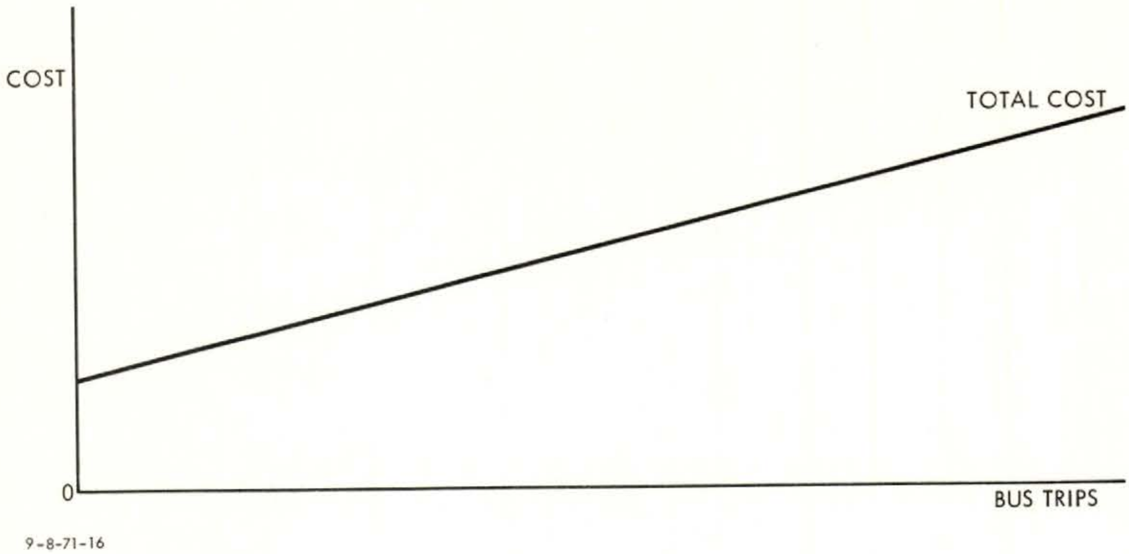

FIGURE 5.4 Product Cost Function

equal to the cost of providing the service, including a normal return on capital. For service levels T_1 and T_3, for example, there exists a fare-ridership fare at which the firm will just be able to break even. The maximum total revenue attainable at these service levels will just equal the cost of providing the service. If T_2 trips are supplied, the firm will earn no profit if fare is set either at the level which attracts R_1 riders to the transit system or at the lower level sufficient to attract R_3 passengers. If fare is set to maximize total revenue, the firm will carry R_2 passengers and earn a profit of π_2.

If the outer points of successively higher horizontal slices of the profit function in Figure 5-5b are projected onto the passenger-service plane, an isoprofit relationship such as the one in Figure 5-6 emerges. Each isoprofit curve represents the locus of all passenger service combinations at which a given absolute amount of profit can be attained. π_0 is simply repeated from Figure 5-5b.

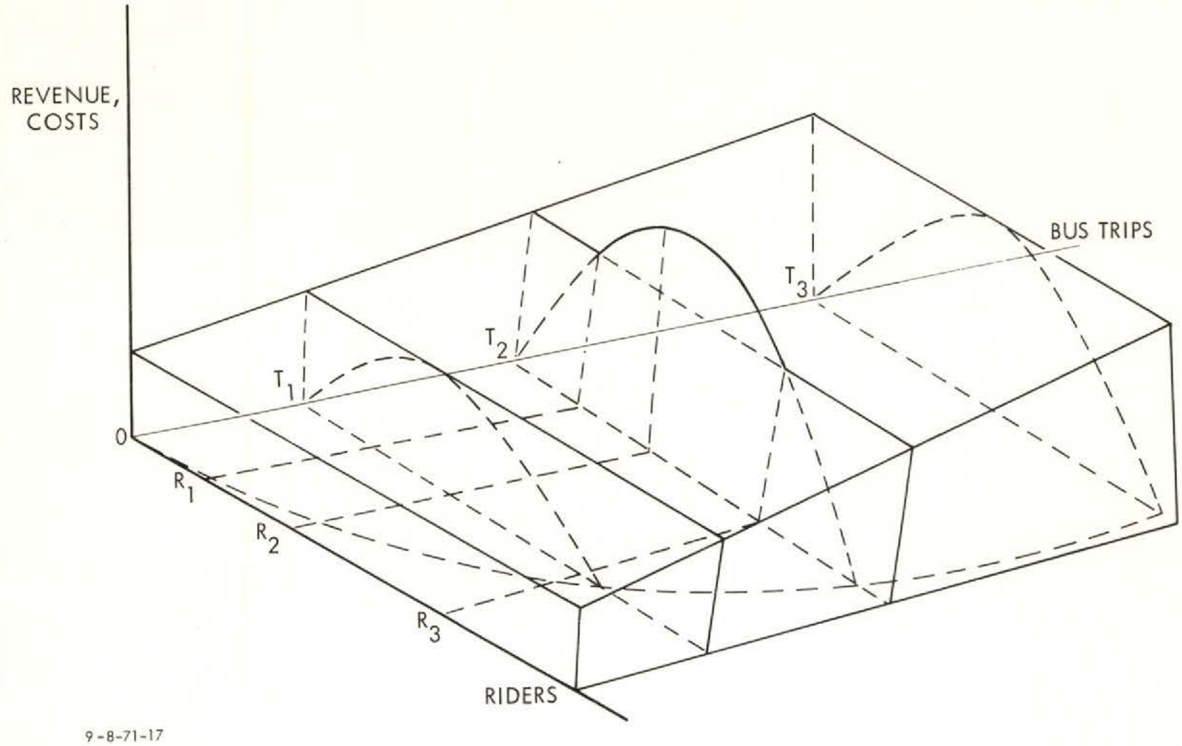

FIGURE 5.5a Total Revenue and Total Cost Function

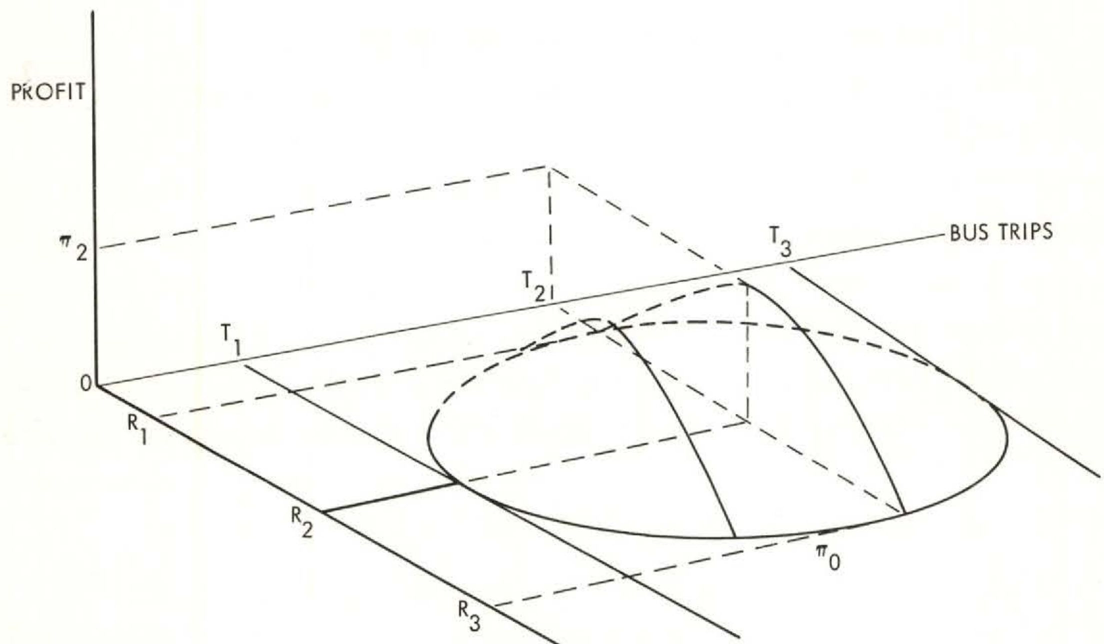

FIGURE 5.5b Profit Function

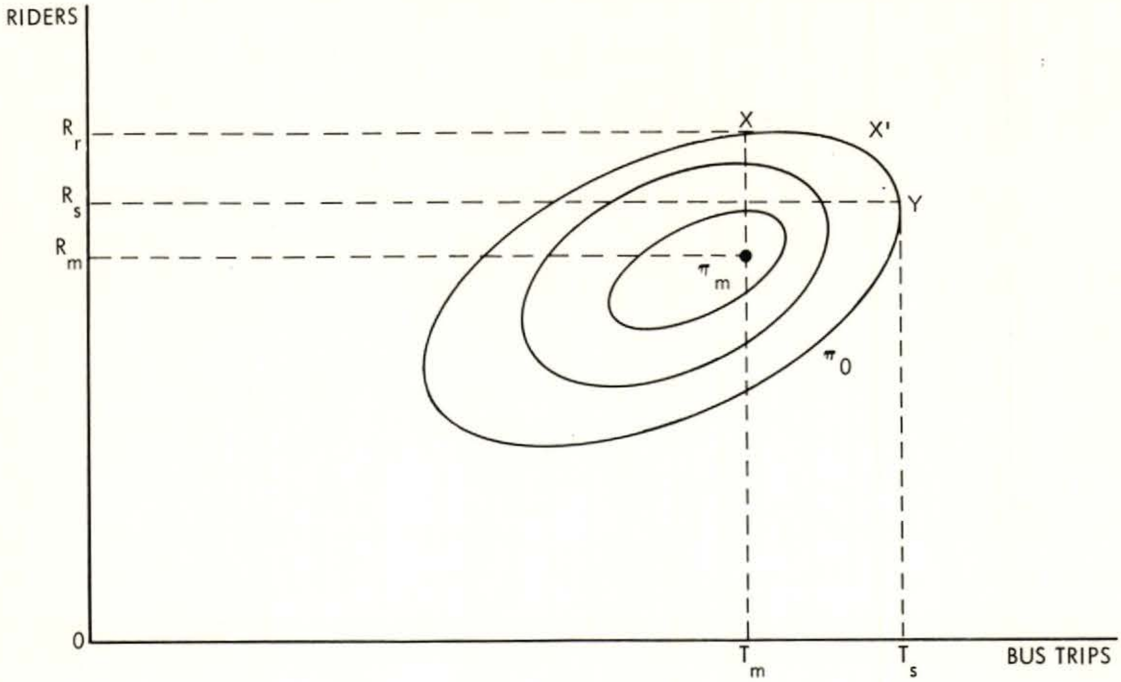

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FIGURE 5.6 Isoprofit Relationships

Isoprofit curves interior to π_0 represent successively higher amounts of profit. (Conversely, if the firm operates at any point exterior to π_0, it will operate at a loss.) Maximum profit, π_m, is represented by a single point interior to all other isoprofit curves. In the absence of regulation, the transit firm will provide T_m trips and set fare such that R_m passengers would ride the buses.

2. EFFECT OF REGULATION ON RIDERSHIP AND LEVEL OF SERVICE

We will assume that the objective of public regulation is to increase ridership and/or increase the amount of transit service that would be provided if the firm were permitted to operate at $[R_m, T_m]$. However, a regulatory objective of maximizing ridership and an objective of maximizing the level of service are not harmonious. The conflict between the two objectives can be seen by returning to

Figure 5-6. As long as transit service is provided by private enterprise, regulators are constrained in the achievement of their objectives with respect to ridership and service by isoprofit curve π_0. In the absence of subsidization, no private firm will be able to operate for any appreciable length of time at any point exterior to π_0. The optimal regulatory policy will force the firm to operate at some point on isoprofit curve π_0. (It is possible to move from any point interior to π_0 to a point on π_0 which provides both a higher level of service and greater ridership.) The regulatory policy that maximizes ridership will force the firm to operate at point X in Figure 5-6. T_m trips[4] are supplied and fare is set such that R_r riders are using the transit system. The regulatory policy that maximizes the level of service will produce operation at point Y. A larger number of trips will be supplied than the ridership-maximizing solution, but fewer passengers, R_s, will be riding the buses.[5]

Given the necessity of making a trade-off between ridership and service levels, regulators may not adopt a policy of either ridership or service maximization. Instead, they may choose to operate at some point such as X' in Figure 5-6. The optimal regulatory policy will result in an operation on isoprofit curve π_0 at or between points X

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4. The demand and cost assumptions of this model are such that the profit-maximizing level of service and the ridership maximizing level of service are the same. The ridership-maximizing solution is differentiated from the profit-maximizing solution by a lower fare. In later discussion the notation T_r will be used to refer to the ridership-maximizing level of service in order to correlate the notation for maximum ridership (R_r) and the level of service required to achieve maximum ridership (T_r).

5. The assumptions about public objectives made in this paper may seem extremely general. Public objectives are, in fact, often stated in more specific terms of easing traffic congestion, assuring public transit service for nondrivers, assuring low fares for poor people. The model developed in this paper cannot handle this multiplicity of objectives except in the most general sense of assuming that the objectives of maximizing ridership or service are possible surrogates for other public objectives, i.e., minimizing automobile usage or providing service to nondrivers, respectively. The primary point to be made is that no unique regulatory solution will achieve all public objectives with respect to transit.

and Y. It is possible to move from any point interior to π_0 or on π_0, but exterior to the region bounded by X and Y to some point within that region which provides both a higher level of service and greater ridership.

In order to achieve their objective, regulatory authorities can control two key variables in the model, fare and level of service. The effectiveness of alternative regulatory policies in achieving the the objectives of public regulation can be analyzed using Figure 5-7. Imposed on the isoprofit curves are a series of the passenger-service relationships described in Figure 5-2. Each curve is associated with a unique fare. A is the zero fare case. B, C, D, and E are the rider-service relationships at successively higher fares.

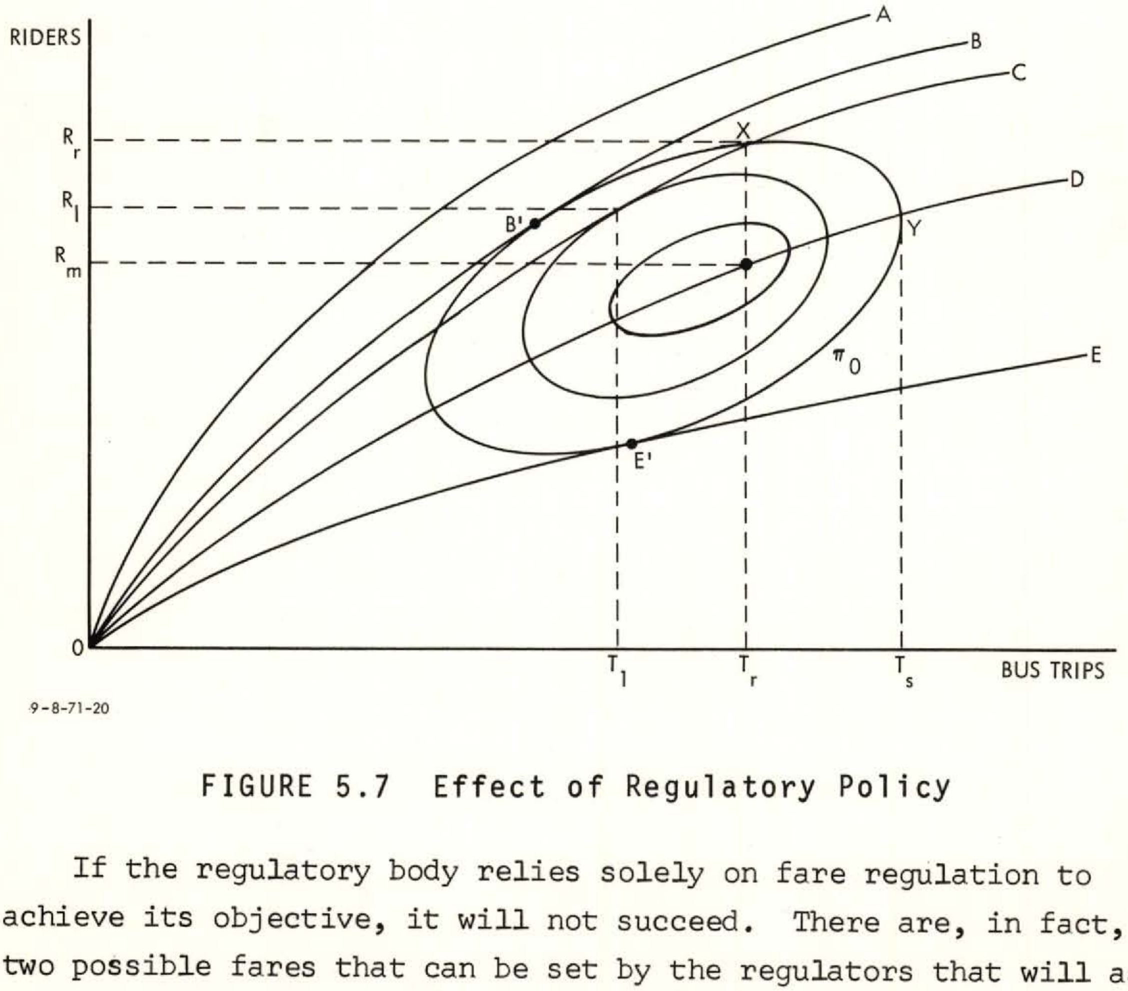

FIGURE 5.7 Effect of Regulatory Policy

If the regulatory body relies solely on fare regulation to achieve its objective, it will not succeed. There are, in fact, only two possible fares that can be set by the regulators that will assure operation on π_0 in the absence of additional regulatory constraints and neither is consistent with operation at or between points X and Y. Fare B is the minimum fare and fare E the maximum fare that can be charged consistent with allowing the firm to cover its operating costs. A regulatory requirement that either of these fares be charged will result in operations at points B' and E', respectively.[6] Fare C is necessary to achieve maximum ridership, but requiring that fare to be charged is not sufficient to achieve the regulatory objective. In the absence of additional regulatory constraints, the firm is free to operate at any point along ray C. It will choose to operate at that point that allows the maximum amount of profit to be earned. Maximum profit is achieved by providing T_1 bus trips. Ridership at this point will be R_1, less than the objective of R_r. Similarly, fare D is necessary to achieve operation at Y, but in the absence of constraints other than a requirement fare D be charged, the firm will not supply T_s trips, but instead will maximize profit by providing T_r trips.

If the objective of the regulators is to maximize service, fare regulation is unnecessary. Regulators can simply require the firm to provide level of service T_s. Given this requirement, it is impossible for the firm to operate at any point other than Y. To achieve operation at X, however, or at any point between X and Y, both the level of service and the fare must be set by the regulatory body.

A key determinant of where the transit system operates with respect to the trade-off between service and passengers is the manner in which the firm is allowed to respond over time to changing demand and cost conditions. Private transit systems in most cities are

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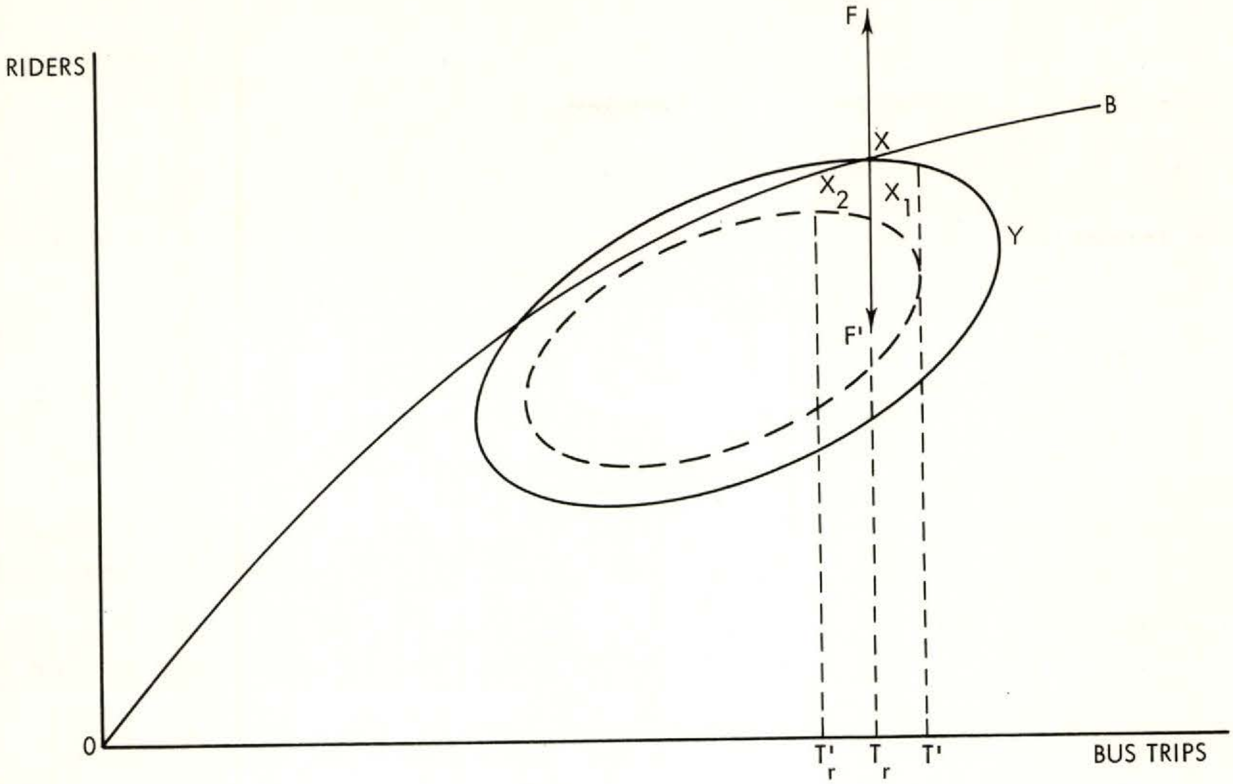
6. Rays B and E are target to isoprofit curve π_0 at B' and E', respectively. The tangencies determine the only points at which profitable operations are possible if these fares are set by the regulators. This raises an interesting issue. If regulatory authorities should choose to adopt fare as an objective rather than an instrument of control and seek to minimize fare, they may well be sacrificing both ridership and service levels. Both ridership and service can be increased by movement from B' in Figure 5-7 to some point on isoprofit curve π_0 within the region bounded by X and Y.

confronted with rising costs and generally declining demand. There appears to be substantial reliance on fare increases to maintain profitable operations, with service reduction being adopted only as a last resort. As Figure 5-8 shows, this policy will almost inevitably bias the system towards the service-maximizing solution. An increase in costs will result in an inward shifting of isoprofit curve π_0 similar to that shown by the dotted curve in Figure 5-8. Actions that can be taken to maintain the earnings of the firm are service adjustment or fare increases, or some combination of the two. It is immediately apparent from Figure 5-8 that if the firm was providing any level of service greater than T' prior to the cost increase, some service reduction must be allowed to prevent the firm from operating at a loss. However, regardless of where the firm was operating prior to the cost increase (as long as it was between X and Y), the regulatory action that minimizes service loss will not minimize passenger loss. If, for example, the firm was operating at X prior to the cost increase, the effect of alternative regulatory action with respect to fare and service adjustment can be defined in terms of movement within the areas bounded by rays B, F, and F'. Reduction in service, with no change in fare, will move the system to some point on ray B. Movement along rays F and F' result from holding service constant and decreasing or increasing fare, respectively. Thus, movement to any point within the area bounded by F' and B (and to the left of F') is the result of some combination of fare increase and service reduction. (Conversely, movement within the area bounded by F and B results from combining service reduction and a fare decrease.) If regulators rely solely on a fare increase to maintain the earnings of the private firm, the firm will operate at point X_1. This is not the policy that minimizes passenger loss, however. That policy would involve movement to X_2 on Figure 5-8 by combining a fare increase less than the one required to attain X_1 and reduction in service to T'_r.



9-8-71-21

FIGURE 5.8 Regulatory Adjustment in Fare and Service Levels Following an Increase in Costs

3. EFFECTS ON EFFICIENCY

A key issue in the regulation of any industry is that of possible adverse effects of the regulation, especially imposition of a regulatory-earnings constraint, on the firms' incentives to produce in the most efficient manner. The divergence between possible profit and allowed profit resulting from fare and service regulation can weaken the firm's incentive to minimize production costs by making it possible for the firm to produce inefficiently without being penalized by a reduction in the level of profit it is able to attain. A return to Figure 5-8 can help clarify this point Inefficiency increases production costs for all levels of service and thus will result in an inward shifting of isoprofit curve π_0

similar to that shown by the dotted curve in Figure 5-8. A profit-maximizing firm will be indifferent with respect to operations at some point on the heavy exterior isoprofit curve or on the dotted interior curve, since the absolute level of profit is exactly the same in both cases. The social cost of the inefficiency is immediately apparent, however. The inefficiency reduces the number of riders the transit system can profitably attract at any level of service (i.e., necessitates a higher fare at every level of service to achieve profitable operations) and also reduces the maximum level of service that can be provided by the transit system (to T'). Especially important in an industry such as transit, in which labor costs comprise a substantial portion of total costs, is the possibility that a regulatory earnings constraint will result in disproportionate wage increases emerging from the collective-bargaining process. As long as the profit position of the firm can be maintained through adjustment of fare or service levels or both, management has no real reason to resist union demands and possibly bear the cost of a strike.

Theoretical analysis of the economics of regulation indicates that imposition of an earnings constraint can not only weaken the incentive to minimize costs but can, in fact, provide positive incentives for inefficient behavior. The nature of the inefficiency varies with the method of measuring earnings for regulatory purposes adopted by the regulatory authorities. The primary conclusions of the analysis are: (1) that if the firm is constrained to achieve some maximum percentage return on its invested capital, and if the allowed return exceeds the cost of capital (i.e., allows some positive economic profit) but is below that required for profit maximization, the firm will be able to achieve a higher level of profit by utilizing capital and labor resources in proportions such that the ratio of capital to labor is greater than that which minimizes costs; and (2) if the operating ratio is employed and demand is inelastic, the firm will be able to achieve a higher level of profit by any arbitrary increase in production costs.

Figures 5-9 and 5-10 present a simple geometric clarification of the former case.[7] If we assume that the amount of capital employed in the production process increases with the level of service provided, an earnings constraint that allows a return to capital greater than the cost of capital can be drawn as a plane intersecting the profit function (taken from Figure 5-5b) such as is shown in Figure 5-9. (The plane slopes upward with increasing service levels since a constant percentage return on capital will obviously result in a greater amount of profit as the base against which the return is measured increases.)

In Figure 5-10, the problem is reduced to a two-dimensional figure to simplify the exposition. π_1 measures the maximum profit attainable at each level of service and C_1 the regulatory earnings constraint. The firm will be able to maximize profits subject to the constraint by providing T_1 trips. Profit will be π_1'. If the firm increases the amount of capital employed in the production process above that required to produce at minimum cost, two things happen. Possible profit (as opposed to allowed profit) is reduced at every level of service, since production costs have been increased by the inefficiency. π_2 measures the amount of profit attainable after the increase in costs. However, because the amount of capital employed in the production process is increased at every level of service, the regulatory constraint (allowed profit) increases to C_2. By overcapitalizing, the firm is able to achieve a higher profit level, π_2'.

In cases where the earnings constraint is imposed in the form of a minimum allowable operating ratio, any increase in operating costs

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7. This analysis is used in an article by Elizabeth Bailey and John Malone, "Resource Allocation and the Regulated Firm," Bell Journal of Economics and Management Science, I, No. 1 (Spring, 1970), pp. 129-141, which also contains a mathematical proof of the results. A more extensive geometric proof of the results can be found in an article by William Baumol and Alvin Klevorick, "Input Choices and Rate of Return Regulation: An Overview of the Discussion," Bell Journal of Economics and Management Science, I, No. 2 (Autumn, 1970), pp. 162-189.

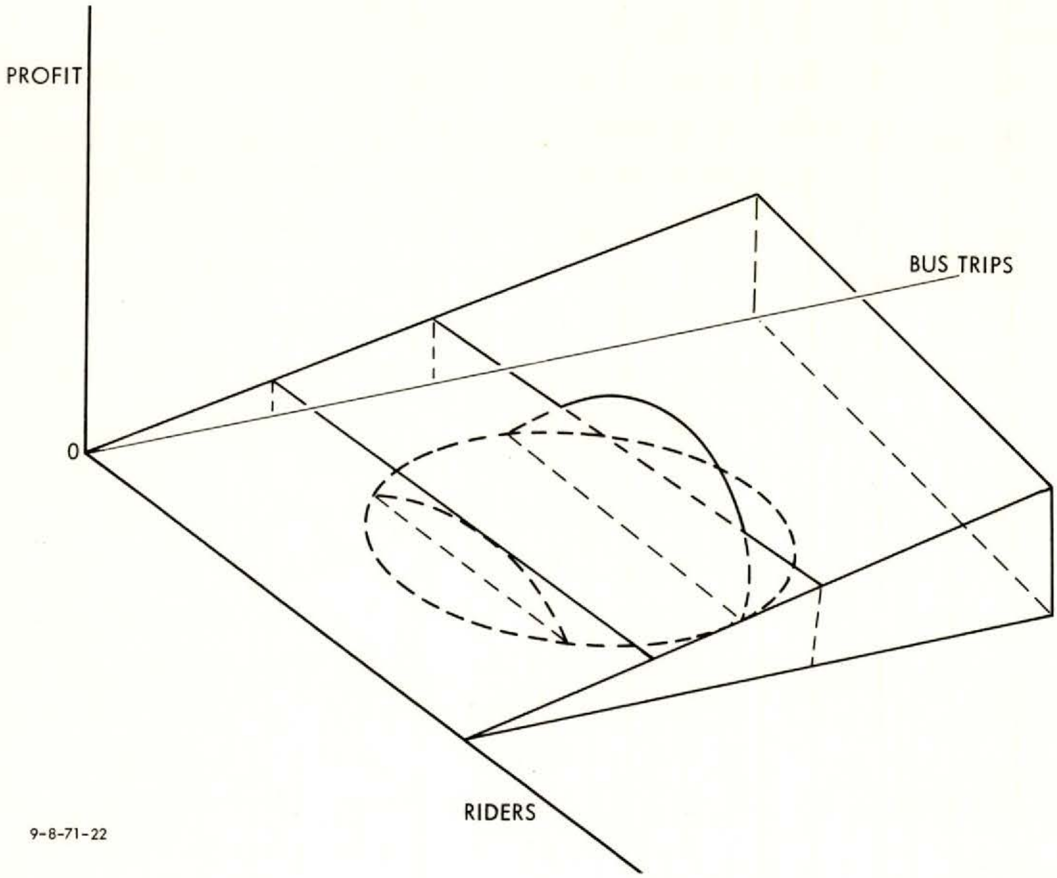

FIGURE 5.9 Regulatory Profit Constraint

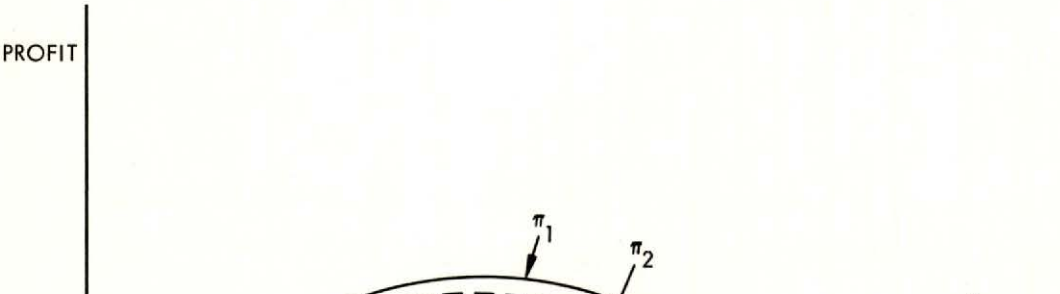

FIGURE 5.10 Effect of Profit Constraints on Efficiency

can increase the amount of profit the firm is able to achieve if demand is inelastic. Some simple algebra can clarify this point.[8]

Use of the operating ratio involves allowing the firm to maintain some constant ratio of operating expenses (OE) -- all costs except the cost of capital -- to total revenue (TR). A 10 percent increase in labor costs, for example (assuming the level of service remains constant), must be matched by a 10 percent increase in revenue in order to maintain a constant operating ratio (δ). That is:

$$\frac{OE}{TR} = \frac{1.10\ (OE)}{1.10\ (TR)} = \delta\ .$$

However, the increase in total revenue required to maintain a constant operating ratio increases the rate of return on investment that the firm is allowed to achieve. This return (R) is measured by the ratio of total revenue minus operating expenses to the capital investment (K) of the firm. Prior to the cost increase and the accompanying adjustment in total revenue allowed by the regulators, the rate of return is as follows:

$$\frac{TR-OE}{K} = R\ .$$

A 10 percent increase in both costs and revenues required to maintain a constant operating ratio produces the following result:

$$\frac{1.10(TR-OE)}{K} = 1.10(R)\ .$$

If the firm was earning a return of 7 percent on its investment prior to the fare increase, it will achieve a return of 7.7 percent after the increase.

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8. For a generalized mathematical and geometric proof of these results, see Bailey and Malone, op. cit.

D. KEY REGULATORY ISSUES

The model developed in the preceding section and the interviews conducted with transit and regulatory officials in several localities suggest a number of major issues in the area of transit regulation. These issues relate primarily to the role of regulatory constraints in causing the observed decline of private transit enterprise and to the implications the existence of these constraints have for Federal policy.

1. RELATIONSHIP OF REGULATORY CONSTRAINTS TO THE DECLINE OF PRIVATE TRANSIT ENTERPRISE

A few of the more important questions that must be answered with respect to the role of regulatory constraints in the decline of private transit enterprise are listed below:

(1) To what extent are regulatory authorities actually aware of the trade-off between service levels and ridership?

(2) Do regulators consistently set fares too low?

(3) Are service requirements too large and inflexible?

(4) Is regulatory lag a serious problem for most transit firms, especially when rapidly rising costs have necessitated more frequent requests for fare increases?

(5) Have regulatory service requirements and profit constraints, especially use of the operating ratio, resulted in transit firms adopting inefficient labor practices? Have these practices become institutionalized, resulting in serious inflexibility in the response to changing demand conditions?

(6) Do regulatory constraints prevent firms from adopting more demand responsive modes of transportation?

(a) Do limits on intramodal competition present serious difficulties in providing attractive and coordinated service in urban areas served by more than one transit firm?

(b) Do constraints on intermodal competition prevent firms from adopting innovations that represent a departure from the traditional nature of transit service? For example, can a transit firm provide dial-a-bus service that would compete with taxi service?

(c) Is restricted entry into the transit market necessary or desirable?

2. FEDERAL POLICY IMPLICATIONS

The answers to the questions listed above have important implications for Federal policy with respect to urban mass transit. Some of the more important issues that are raised are listed below.

(1) If regulatory constraints are a cause of the low profitability of private transit enterprise, are federal subsidies, either capital or operating, desirable or feasible in the absence of any changes in the regulatory framework?

(a) Will the availability of Federal funds simply provide regulatory authorities with an option to avoid approving needed fare and service adjustments?

(b) Will Federal funds be required in continuing and continually increasing amounts to sustain private transit operations?

(c) Will Federal funds support inefficient transit systems and possibly provide further incentives for inefficiency?

(2) Does public ownership change anything?

(a) Does public ownership and the increased possibility of public subsidy merely perpetuate an inefficient transit system?

(b) Will the management of public transit authorities be any more willing than public regulatory authorities to make fare and service adjustments if subsidies are available.

(3) Can the Federal government effectively administer a program of operating subsidies without control of the two key variables, fare and service, each of which affect the size of the operating deficit?

(a) Is removal of regulatory constraints a feasible alternative to public subsidy of urban transit?

(b) Is it possible to develop any standard criteria for evaluating the adequacy of the fare and service levels of an urban transit system that can be used by Federal administrators in determining relative need for Federal aid?

3. RECOMMENDATIONS FOR FURTHER STUDY

As indicated above, regulatory constraints imposed on urban transit operations by either state or local governments may seriously limit the long-term effectiveness of some Federal programs in increasing the supply and utilization of urban mass transit facilities. This paper presents only a very general survey of transit regulation. In view of the potential impact of transit regulation on federal programs, further study of a more empiric nature would undoubtedly be beneficial to Federal policymakers. Such a study would be geared first to attaining quantitative answers to the questions raised in Subsection A of this section, and then determining the exact nature of the interface of Federal programs with the regulatory framework and developing specific recommendations for Federal policy. With respect to Federal policy, not only should an effort be made to design Federal programs that minimize the potential adverse effects of regulatory constraints, but a major question that should be examined is whether removal of regulatory constraints is a feasible alternative to Federal subsidies of transit operators.

PART THREE

URBAN RAIL RAPID TRANSIT

CHAPTER VI

U. S. AND CANADIAN RAIL RAPID TRANSIT OPERATIONS

by

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M. Kamrass
J. D. Wells

SUMMARY

Rail rapid transit systems are defined herein as rail facilities operating within urban areas on exclusive (or nearly exclusive) rights-of-way, whether below ground, above ground, or at surface level. Rail rapid transit systems generally use vehicles that are lighter and capable of higher acceleration than conventional railroad equipment.

There are ten U.S. and two Canadian properties included in our definition of rail rapid transit systems. Annual data on the physical characteristics and operations of nine of the ten U.S. and both Canadian properties are presented, by property, in both graphic and tabular form for 1960 through 1970.

For the eight U.S. properties that existed in 1960, total annual revenue passengers declined by 7.3 percent from 1960 to 1970. Total revenue, on the other hand, increased by 75 percent, reflecting fare increases. However, the increases in revenue were not as large as the increases in expenses. As a result, the U.S. industry as a whole shifted from a loss of $0.4 million in 1960 to a gross deficit of $80 million in 1970 (not including any depreciation or interest charges).

A number of "performance" ratios are calculated for the different properties. These ratios included such items as operating ratio, cost per car-mile, revenue per passenger, passengers per car, etc. A comparison of these ratios across properties indicates that properties are quite heterogeneous in their characteristics. This finding implies that measures to improve financial conditions might be different for different properties.

A. INTRODUCTION

The 1970 Urban Mass Transportation Assistance Act authorized the Federal Government to provide more than $3 billion to aid urban mass transit over the next five years. A large proportion of these funds will be channeled into rail rapid transit. Ten year capital investment requirements for rail rapid transit alone (excluding commuter rail) have been estimated to be between $16 and $22 billion, and it is presumed that the Federal Government will provide the major share.[1]

The probable magnitude of the Federal Government involvement with rail rapid transit makes it especially important that all aspects of such operations, including their economic and technical characteristics, be reviewed and understood. This paper focuses on the economic aspects. First, it examines the general economic profiles of individual systems from 1960 through 1970. Then, the individual profiles are compared to determine whether there are significant similarities or differences in behavior.

1. BASIC CONCEPTS

a. Rail Rapid Systems

Rail rapid transit systems are defined herein as rail facilities operating within urban areas on exclusive rights-of-way, whether

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1. Range derived from statements by Dr. Ronan, President, Institute for Rapid Transit, Hearings before the Subcommittee on Housing and Urban Affairs, U.S. Senate, July 23, 1969, and F. M. Graves and R. E. Rechel, Estimates of Prospective Capital Investment in Urban Public Transportation, Institute of Public Administration (Washington, D. C. October 15, 1969).

below ground, above ground, or at surface level. In the larger cities the rights-of-way are usually below ground level in the center of the city and at ground level in the outlying areas of the city. We have included systems which largely have their own rights-of-way but which operate, to a minor extent, on regular streets or cross-roads at grade level at some points. Rail rapid transit systems generally use lighter vehicles capable of higher acceleration than conventional railroad equipment. We include in our definition of rail rapid transit the "high-speed trolley"--a streetcar line on its own right-of-way. We have excluded streetcar operations that share city streets with automobile traffic; these operations are generally being phased out and no plans exist for building new systems of this type.

b. Property

The term property is used throughout the industry to refer to a certain urban transit activity, e.g., rail rapid transit, bus, commuter rail, etc. It is about synonomous with the notion of a single-plant operation. Thus, the New York rail rapid transit system is a property (or plant). Its bus operation is also a property, and so on.

c. Total Operating Revenue

Total operating revenue is all revenue from all operations of the property during the given year; it does not include subsidy revenue. Typically, well over 95 percent of this revenue is from passenger operations, but some freight and other revenue, such as advertising and station concessions, is included.

Total operating revenue is the most meaningful measure of revenue because it reflects the overall economic viability of the property. Moreover, total operating expenses include some nonpassenger activities which are not separated for direct comparison with the revenue they generated. Thus, total operating revenue, rather than passenger revenue, is more comparable to total operating expenses. As noted below, the use of total operating revenue presents a minor degree of noncomparability when computing revenue per passenger.

d. Operating Expenses

Operating expenses are defined as Total Annual Operating Expenses less annual depreciation. This measure of expense best reflects the out-of-pocket operating costs of the properties. Moreover, there are large inconsistencies in reporting depreciation. For an old system whose facilities and rolling stock are completely depreciated, this item could be zero, whereas for a new system it could be substantial. Further, the amount of public capital subsidy, the time period over which the capital stock is depreciated, and the depreciation schedule all affect bookkeeping treatment of depreciation. Hence, to obtain consistent data between systems, we believed that depreciation should be excluded. Operating taxes, which consist mostly of social security taxes, are included.

Interest expense is an important item that is not included for two reasons. First, the amount of interest is usually dominated by the size of capital expenditures and for this reason the proportion that can be assigned to annual operating expenses is somewhat arbitrary. Second, some systems, e.g., the Massachusetts Bay Transportation Authority (MBTA) also operate bus systems that are financed on a systemwide basis. The interest expense for each mode is not reported separately.

e. Gross Operating Profit (Deficit)

Gross Operating Profit is defined simply as Total Revenue minus Operating Expenses. Both interest and depreciation must still be deducted to arrive at a net operating profit concept.

f. Operating Ratio

Operating ratio is Operating Expenses divided by Total Revenue. A ratio less than one indicates that revenues cover out-of-pocket expenses, i.e., there is a gross operating profit. A ratio greater than one indicates that the operation is not covering out-of-pocket expenses, i.e., the property has a gross operating deficit.

g. Revenue Passengers

Revenue passengers are passengers (annually) from whom a fare has been collected somewhere in the system. It does not include passengers who have transferred free onto the system from another mode, free passengers, or passengers for whom payment is made via subsidies.

h. Revenue per Passenger

The revenue-per-passenger ratio is defined as Total Operating Revenue divided by the number of revenue passengers and is approxi-imately equal to average fare. The term "fare" is used interchangeably in this paper with "revenue per passenger" or "average fare," and should not be confused with specific fares. The figure reflects not only the basic adult fare but reduced fares to senior citizens and children as well as transfer fares. Revenue other than from passengers causes the ratio to be slightly greater than average fare in some cases. This difference usually cannot be detected at the two-significant-digit level; therefore, the ratio is stated only to two significant digits. Some properties have a single fare for the entire system, while others use a "zone" fare system wherein the fare varies with the length of trip. For zone-fare systems, the revenue per passenger reflects the mix of zone fares collected.

i. Passenger Car-Miles

Passenger car-miles is the sum of the total number of miles that each passenger car has moved during the year.

j. Active Passenger Cars

Active passenger cars are those cars in the fleet that are actually used, as opposed to those that have been retired but may still be on the books as part of the fleet. In most cases, there is no difference between total cars in the fleet and active cars.

k. Miles of Single Track

The miles-of-single-track figure corresponds to single-lane mileage in a highway system. It represents all of the trackage in the system, including multiple trackage in terminals.

2. NATURE OF THE DATA

a. Data Sources

A complete and consistent data series for all rail transit properties is not available in the open literature. The best source of data are the Annual Operating Reports published by the American Transit Association (ATA), but these reports do not include all properties. Moreover, some of the properties that are included have not reported all data to the ATA. Accordingly, although we have used the ATA data as a primary source of consistent data for individual properties, these data have been supplemented by data from annual reports, Interstate Commerce Commission reports, other published sources, and data obtained directly from the properties when it could not be obtained from the open literature.

b. Data Categories

The basic data categories used are those adopted by the ATA (see Appendix VIA) which are, themselves, based on the ICC system of accounts. The aggregates used in this paper were determined after we made sure that the individual categories added properly to the totals. Thus, it is reasonably certain that at least the aggregates are comparable. However, it should be noted that for properties which are also part of a general operation--which might include bus, trolley-bus, surface rail, or all of these--it was necessary to use allocation procedures to estimate the rail rapid transit portion.

c. Geographical Representation

In addition to U.S. properties, we have included the Montreal and Toronto systems because both are post-World War II systems. Of the U.S. properties, only the Cleveland system and the Lindenwold

Line between Philadelphia and southern New Jersey have been built since World War II.

d. Data Limitations

It should be recognized that the data are limited with respect to the level of detail required to explain the economic behavior of either the individual properties or the rail rapid transit industry in general. Much more detailed data are necessary if the problem of causal relationships is to be addressed.

3. ORGANIZATION OF REMAINING SECTIONS

The remainder of this paper is organized into two sections. Section B focuses on individual properties and presents for each property the several trends of key operating statistics. Section C is devoted to a comparative analysis of the operations of the properties. Among other things, the properties are ranked according to relative operating performance, as reflected by certain performance ratios computed from the basic data.

B. RAIL RAPID TRANSIT PROFILES

The profiles of the individual properties involve descriptive, graphic, and tabular presentations. For convenience, the descriptive material for each property is confined to a single page which appears opposite the corresponding graphs. Each table contains the basic data for the graphs and some additional ratios that are used in the next chapter.

Note that all graphs have semi-logarithmic scales. Therefore, they can be compared in relative terms, i.e., the same slope on two or more curves implies the same percentage change. The same cycle semi-logarithmic paper was used for all graphs. The lines on the graphs merely connect annual data points; they do not reflect monthly values.

Most of the profiles cover the 11-year period, 1960 through 1970. These profiles, by individual property, are discussed in order of descending total operating revenue for 1970. Much of the descriptive material on the properties was obtained from Urban Transit Development in Twenty Major Cities, published in 1967 by the Automotive Safety Foundation, Washington, D.C. Data for the tables and graphs were obtained from the ATA, the individual properties, or both.

The policy of the Authority, at least until 1970, has been to keep fares low to stimulate use of the transit system as an essential component of the economic welfare of the city. Operating deficits are made up by the city of New York.

Over the ten-year period from 1960 through 1969, this property incurred steadily increasing operating losses. In 1960, total operating revenue was only approximately $1 million lower than operating expenses, while by 1969 this deficit had widened to approximately $80 million. The operating ratio increased from 1.01 to 1.28. Effective January 4, 1970, the basic fare increased from 20 to 30 cents. As a result, total operating revenue in 1970 was $109 million greater than in 1969. However, operating expenses increased to $86 million, so that the operating loss was reduced to $56 million, and the operating ratio dropped to 1.14.

Over this period, the number of passengers fluctuated considerably, but in 1970 it was about 7 percent lower than in 1960. The revenue per passenger reflects a fare increase of from 15 to 20 cents, put into effect in July 1966. This fare increase apparently reduced the ridership over the period 1965 to 1967. The large drop in ridership in 1966 was at least partly due to a two-week strike in January 1966 which completely halted all services. The big fare increase in 1970 apparently again reduced ridership sharply.

Passenger car-miles were constant from 1960 to 1966; from 1966 to 1970 they steadily increased by a total of about 19 percent.

The pattern of number of active passenger cars is roughly opposite that of the car-mile pattern; the number of cars increased from 1960 to 1966 by a total of about 8 percent, then remained approximately constant through 1970. Note that the number of cars and car-miles both increased significantly from 1960 to 1970, while ridership declined. The track mileage shows that the system has been expanded only slightly.

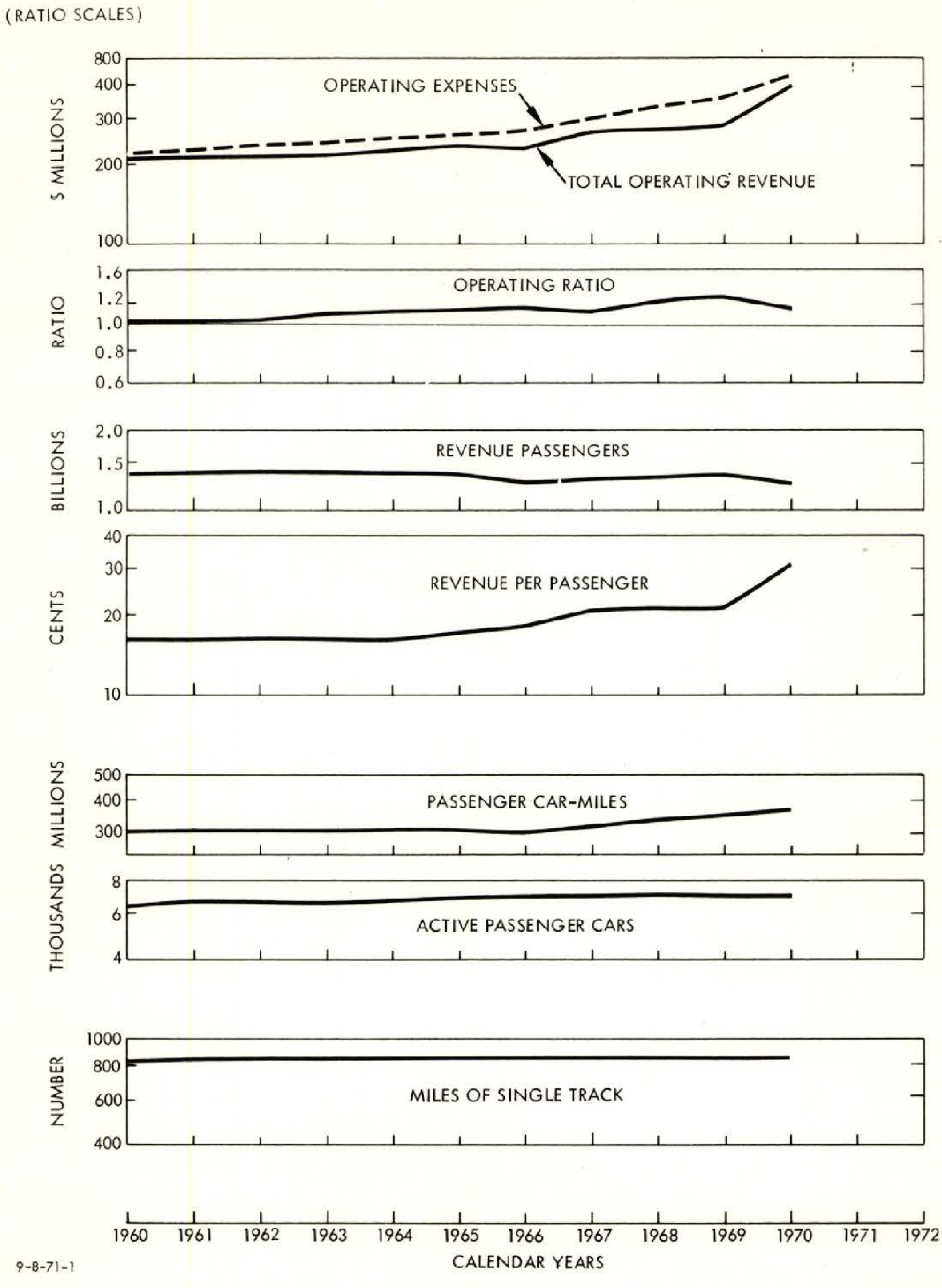

FIGURE 6.1 New York Transit Authority

Table 6.1

NEW YORK CITY TRANSIT AUTHORITY
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)	213,858	215,732	219,762	216,869	223,349	236,593	231,297	272,534	272,831	281,802	391,212
Total Operating Expenses Less Depreciation ($ thousands)	215,090	222,385	229,370	239,805	252,333	261,080	267,875	302,043	337,797	362,015	447,781
Gross Operating Profit (deficit) ($ thousands)	(1,232)	(6,653)	(9,608)	(22,936)	(28,984)	(24,487)	(36,578)	(29,509)	(64,966)	(80,213)	(56,569)
Operating Ratio	1.01	1.03	1.04	1.11	1.13	1.10	1.16	1.11	1.24	1.28	1.14
Revenue Passengers (millions)	1,348.9	1,359.9	1,383.5	1,356.8	1,383.2	1,354.1	1,262.9	1,302.6	1,305.9	1,343.3	1,257.6
Total Revenue per Revenue Passenger (dollars)	.16	.16	.16	.16	.16	.17	.18	.21	.21	.21	.31
Passenger Car-Miles (millions)	305.1	300.8	304.1	306.1	314.3	314.7	302.0	319.7	339.8	344.6	359.8
Active Passenger Cars	6,482	6,601	6,516	6,559	6,655	6,707	6,969	6,958	7,080	6,961	6,924
Total Miles of Single Track	837	841	841	841	841	841	841	846	847	842	842
Cost per Revenue Passenger (dollars)	.16	.16	.17	.18	.18	.19	.21	.23	.26	.27	.36
Cost per Passenger Car-Mile (dollars)	.70	.74	.75	.78	.80	.83	.89	.94	.99	1.05	1.24
Revenue per Passenger Car-Mile (dollars)	.70	.72	.72	.71	.71	.75	.77	.85	.80	.82	1.09
Passengers per Passenger Car-Mile	4.42	4.52	4.55	4.43	4.40	4.30	4.18	4.07	3.84	3.90	3.49
Passengers per Active Car (thousands)	208.1	206.0	212.3	206.9	207.8	201.9	181.2	187.2	184.4	193.0	181.6
Car-Miles per Active Car (thousands)	47.1	45.6	46.7	46.7	47.2	46.9	43.3	45.9	48.0	49.5	52.0

Source: Annual Reports of the American Transit Association.

CHICAGO TRANSIT AUTHORITY (CTA)

The CTA is an independent authority. Total operating revenue has increased over the period shown, apparently as a result of fare increases which have been especially high since 1967. Operating expenses were very nearly equal to revenue from 1960 to 1969. The operating ratio for these years fluctuated narrowly between 0.97 and 1.03. However, in 1970, the financial results worsened markedly. The operating profit of about $1.1 million in 1969 became a deficit of about $5.3 million in 1970; the corresponding operating ratios increased from 0.98 to 1.11.

The number of revenue passengers has fluctuated but in 1970 was lower than in 1960, apparently as a result of sharp fare increases in recent years. The revenue per passenger increased over the time period covered; the basic adult fare was raised from 25 cents to 30 cents in November 1967, to 40 cents in December 1968, and to 45 cents in July 1970.

Passenger car-miles remained constant from 1960 through 1969 but increased significantly in 1970. The number of passenger cars has fluctuated over this period, but was somewhat greater in 1970 than in 1960. A five-mile, non-stop run named "Skokie Swift" was opened in April 1964. Single-track mileage was increased by about 35 miles in 1969 with the opening of the Dan Ryan and Kennedy Expressway routes.

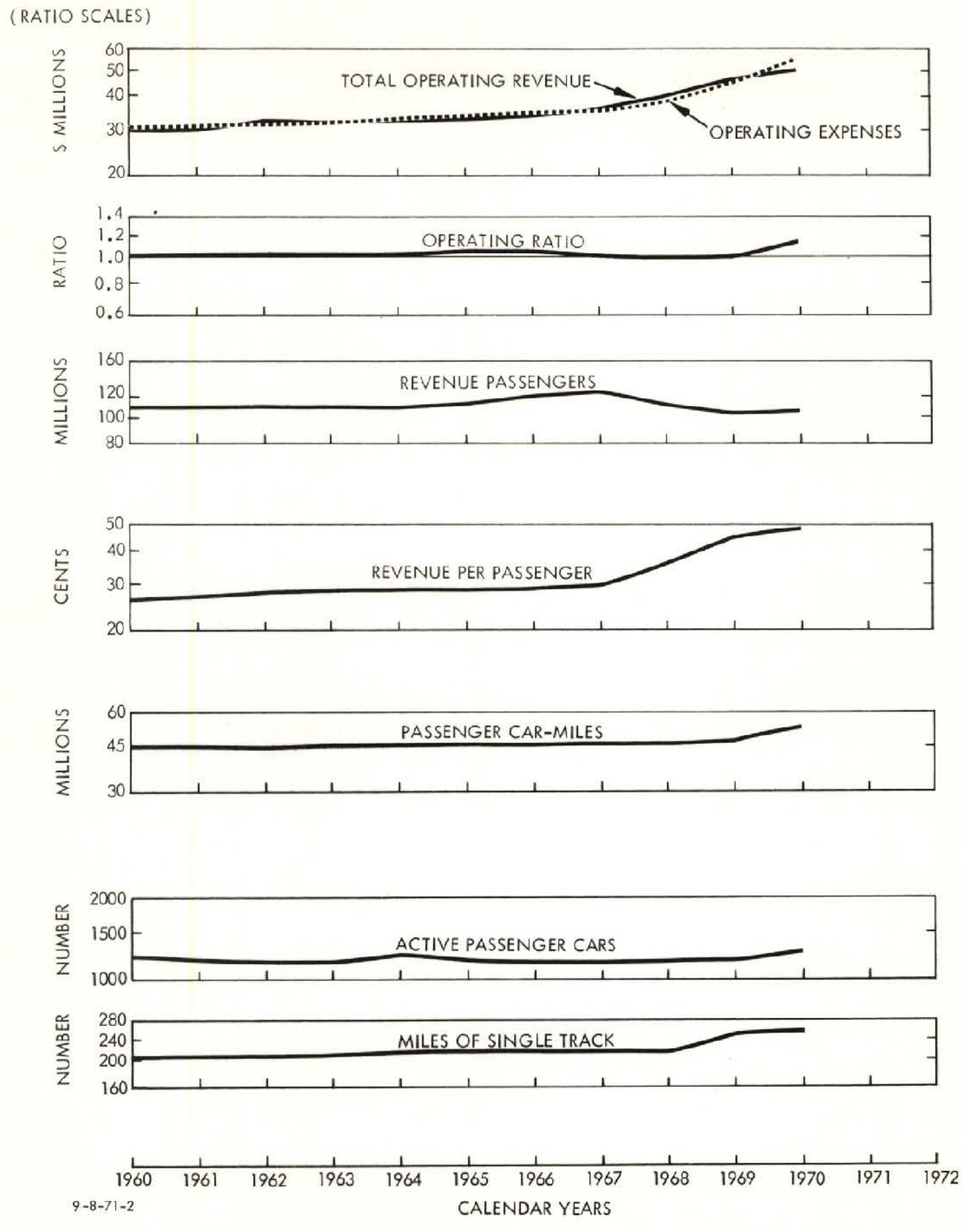

FIGURE 6.2 Chicago Transit Authority

Table 6.2

CHICAGO TRANSIT AUTHORITY
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)	29,709	29,853	32,077	31,086	31,324	31,990	33,290	35,603	38,452	45,044	49,348
Total Operating Expenses Less Depreciation ($ thousands)	29,817	30,424	31,712	31,076	31,401	32,979	34,450	35,499	37,883	43,940	54,605
Gross Operating Profit (deficit) ($ thousands)	(108)	(571)	365	10	(77)	(989)	(1,160)	104	569	1,104	(5,257)
Operating Ratio	1.00	1.02	.99	1.00	1.00	1.03	1.03	1.00	.99	.98	1.11
Revenue Passengers (millions)	112.9	110.1	114.1	111.1	111.2	114.6	117.6	120.7	110.8	103.1	105.6
Total Revenue per Revenue Passenger (dollars)	.26	.27	.28	.28	.28	.28	.28	.29	.35	.44	.47
Passenger Car-Miles (millions)	44.63	44.19	43.96	43.82	43.86	44.17	45.44	45.08	44.79	45.62	51.49
Active Passenger Cars	1,220	1,176	1,170	1,168	1,234	1,160	1,159	1,158	1,157	1,155	1,246
Total Miles of Single Track	204	203	202	202	211	211	211	211	209	243	243
Cost per Revenue Passenger (dollars)	.26	.28	.28	.28	.28	.29	.29	.29	.34	.43	.52
Cost per Passenger Car-Mile (dollars)	.67	.69	.72	.71	.72	.75	.76	.79	.85	.96	1.06
Revenue per Passenger Car-Mile (dollars)	.67	.68	.73	.71	.71	.72	.73	.79	.86	.99	.96
Passengers per Passenger Car-Mile	2.53	2.49	2.60	2.53	2.54	2.59	2.59	2.68	2.47	2.26	2.05
Passengers per Active Car (thousands)	92.6	93.6	97.5	95.1	90.1	98.8	101.4	104.3	95.8	89.2	84.8
Car-Miles per Active Car (thousands)	36.6	37.6	37.5	37.5	35.5	38.1	39.2	38.9	38.7	39.5	41.3

Based on "Comparative Statement of Income and Expense by Types of Service," obtained directly from Chicago Transit Authority.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY (MBTA)

The Metropolitan Transit Authority (MTA) was established in 1947 and covered an area including Boston and 13 surrounding cities and towns. The MTA was superseded by the MBTA in 1964 with its jurisdiction extended to cover 78 cities and towns in the Boston region. A major feature of the legislation setting up the MBTA was the authorization of a $225 million revenue bond issue supported by a statewide two-cents-per-pack tax on cigarettes. However, operating deficits must be assessed to the various cities and towns comprising the MBTA area. These jurisdictions raise this money mainly from property taxes.

The MBTA operates about 34 miles of high-platform rail rapid transit lines and 36 miles of streetcar lines, about 18 of which are also considered to be rail rapid transit for they are in subways or grade-separated rights-of-way.

From 1960 through 1969 operating expenses and revenue were approximately equal; the operating ratio fluctuated between 0.93 and 1.06.[1] However, in 1970, operating expenses increased sharply while revenue dropped; as a result, the operating ratio jumped from 1.06 to 1.32. The number of revenue passengers declined from 1960 to 1963, remained constant for several years, then started to climb in 1967 and 1968. The first fare increase in seven years went into effect in December 1968, when the basic adult fare was increased from 20 cents to 25 cents. Apparently as a result of this fare increase, the number of revenue passengers dropped in 1969 and 1970. The number of car-miles declined slowly but fairly steadily from 1960 to 1970. Number of passenger cars was fairly constant until 1970, when the fleet was increased by 95 cars. Some trackage was closed in the early 1960s, but track mileage has remained constant since 1963.

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1. The operating ratio for the total MBTA system, which includes buses and streetcars, is much higher; for example, in 1963 it was 1.74 and in 1969 it was 1.46.

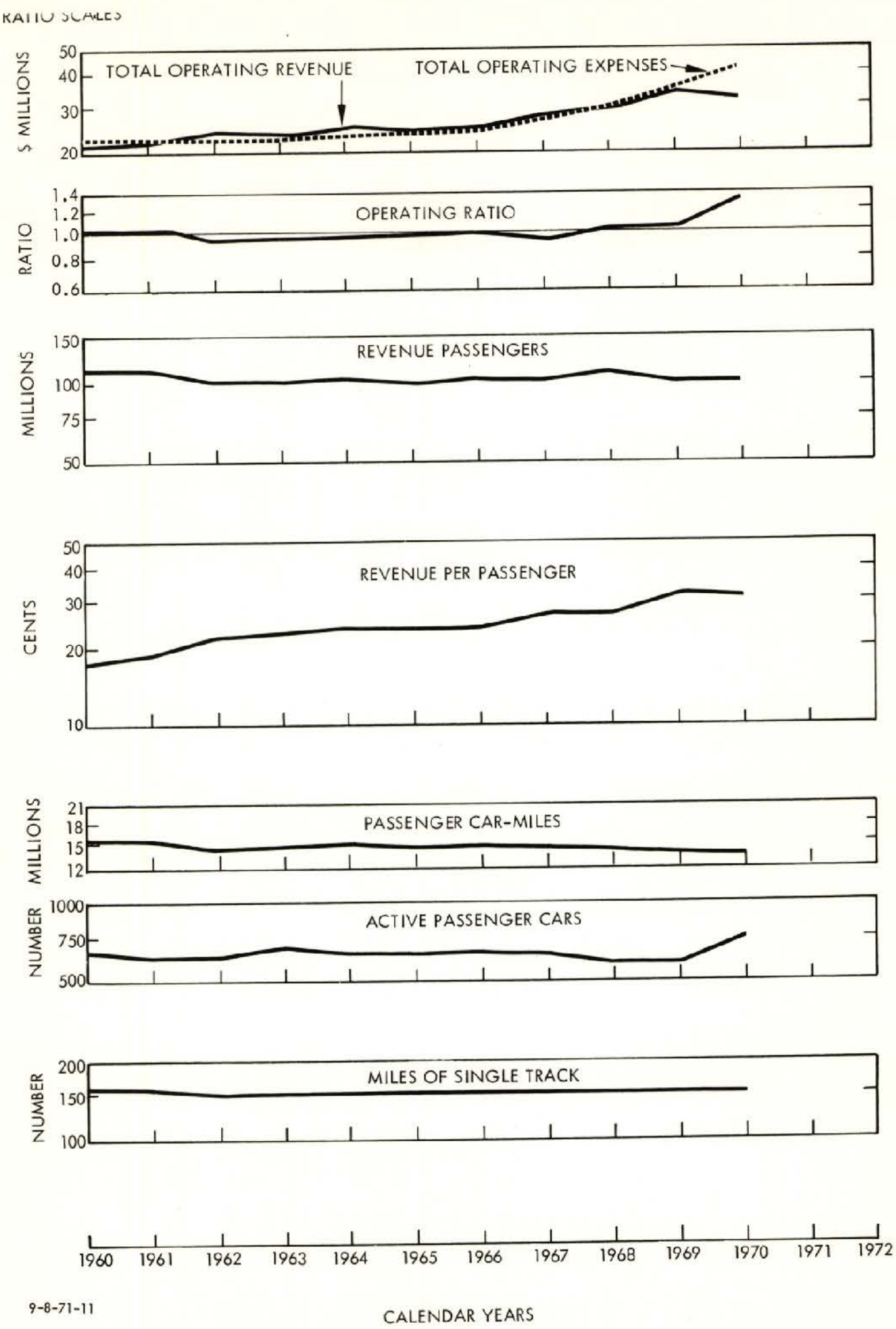

FIGURE 6.3 Massachusetts Bay Transit Authority (MBTA)

Table 6.3

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY (MBTA)
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)	21,560	22,030	24,040	23,620	24,650	23,830	24,800	27,800	29,300	33,000	31,600
Total Operating Expenses Less Depreciation ($ thousands)	22,452	22,354	22,266	22,403	23,593	23,358	24,588	26,448	29,535	35,049	41,800
Gross Operating Profit (deficit) ($ thousands)	(892)	(324)	1,774	1,217	1,057	472	212	1,352	(235)	(2,049)	(10,200)
Operating Ratio	1.04	1.01	.93	.95	.96	.98	.99	.95	1.01	1.06	1.32
Revenue Passengers (millions)	116.7	113.3	104.6	101.3	103.0	100.9	102.8	104.4	110.0	102.2	100.9
Total Revenue per Revenue Passenger (dollars)	.18	.19	.22	.23	.24	.24	.24	.27	.27	.32	.31
Passenger Car-Miles (millions)	15.795	15.005	14.740	14.558	14.920	14.626	14.640	14.540	14.285	13.826	13.652
Active Passenger Cars	649	636	618	650	643	642	642	642	623	623	718
Total Miles of Single Track	160	158	152	151	151	151	151	151	151	151	151
Cost per Revenue Passenger (dollars)	.19	.20	.21	.22	.23	.23	.24	.25	.27	.34	.41
Cost per Passenger Car-Mile (dollars)	1.42	1.48	1.51	1.54	1.58	1.60	1.68	1.82	2.07	2.53	3.06
Revenue per Passenger Car-Mile (dollars)	1.36	1.47	1.63	1.62	1.65	1.63	1.69	1.91	2.05	2.38	2.31
Passengers per Passenger Car-Mile	7.37	7.55	7.09	6.95	6.90	6.89	7.02	7.18	7.70	7.39	7.39
Passengers per Active Car (thousands)	179.8	178.1	169.3	155.8	160.2	157.2	160.1	162.6	176.6	164.0	140.5
Car-Miles per Active Car (thousands)	24.3	24.8	24.6	23.2	23.4	23.5	23.5	23.5	24.2	24.2	21.0

Data were obtained directly from the MBTA.

TORONTO TRANSIT COMMISSION

In 1953, the Municipality of Metropolitan Toronto was incorporated as a federation of the City of Toronto and 12 neighboring suburbs. Public transportation was among the functions taken over by the Metropolitan government, and the Toronto Transit Commission was formed to operate all transit facilities. In 1954, the Yonge Street subway was opened; it was the first new subway system opened in North America after World War II. Since then, several extensions to the system have been opened.

Operating expenses have been less than revenue in every year except 1963, when they were less than one percent greater than revenue.[1] From 1966 to 1969, the operating ratio improved markedly, going from 0.96 to 0.73; in 1970 it rose slightly to 0.76. Over this period, new trackage was opened and fares increased significantly. The figures shown for revenue passengers exclude passengers who have transferred free onto the system from another mode. Actual passengers carried on the rapid transit system are estimated by the Commission at 1.6 times the fares collected on that system. Revenue passengers have increased roughly in proportion to track mileage. Passenger car-miles and number of cars have been increased along with the extension of the track mileage.

1. Figures are in Canadian dollars. In 1960 Canadian and U.S. dollars were approximately equal; in 1961 a Canadian dollar was valued at about $0.96 U.S.; from 1962 to 1970 it was valued at approximately $0.93 U.S.

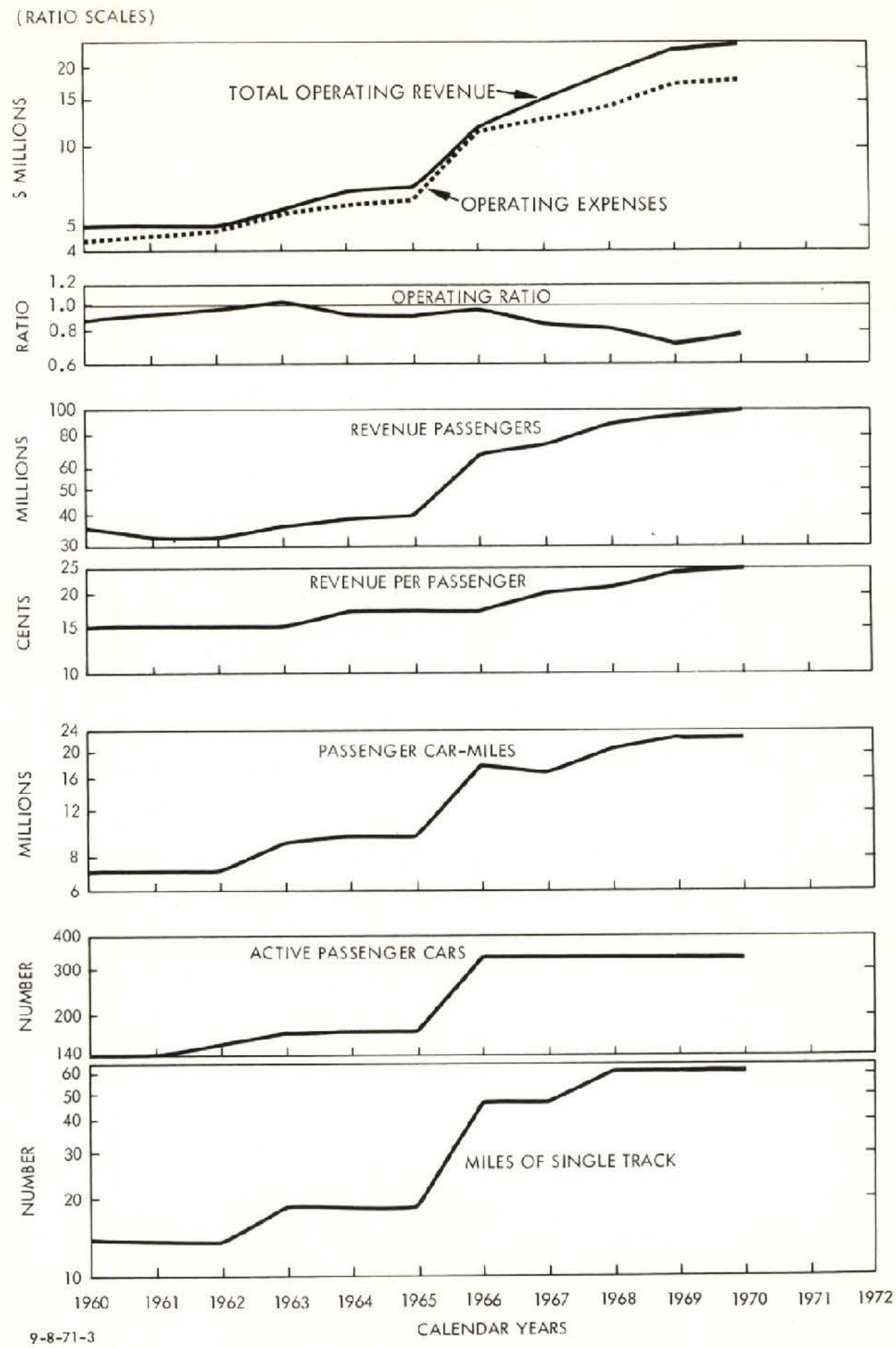

FIGURE 6.4 Toronto Transit Commission

Table 6.4

TORONTO TRANSIT COMMISSION
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)	5,030	4,990	4,950	5,550	6,600	6,870	11,680	15,030	18,320	23,300	24,400
Total Operating Expenses Less Depreciation ($ thousands)	4,336	4,543	4,654	5,577	5,926	6,169	11,221	12,655	14,833	17,021	18,548
Gross Operating Profit (deficit) ($ thousands)	694	447	296	(27)	674	701	458	2,375	3,488	6,279	5,852
Operating Ratio	.86	.91	.94	1.00	.90	.90	.96	.84	.81	.73	.76
Revenue Passengers (millions)	34.7	33.0	32.9	36.5	38.1	39.7	67.1	75.8	89.2	95.4	98.5
Total Revenue per Revenue Passenger (dollars)	.15	.15	.15	.15	.17	.17	.17	.20	.21	.24	.25
Passenger Car-Miles (millions)	7.1	7.0	7.0	9.0	9.5	9.3	17.8	16.4	20.5	22.7	22.7
Active Passenger Cars	140	140	158	170	170	170	334	334	334	334	334
Total Miles of Single Track	13	13	13	18	18	18	46	46	60	60	60
Cost per Revenue Passenger (dollars)	.13	.14	.14	.15	.16	.16	.17	.17	.17	.18	.19
Cost per Passenger Car-Mile (dollars)	.61	.65	.67	.62	.63	.66	.63	.77	.72	.75	.82
Revenue per Passenger Car-Mile (dollars)	.71	.71	.71	.62	.70	.73	.66	.92	.89	1.03	1.07
Passengers per Passenger Car-Mile	4.91	4.70	4.73	4.07	4.02	4.25	3.77	4.62	4.34	4.21	4.34
Passengers per Active Car (thousands)	247.6	235.7	208.1	214.7	223.7	233.7	200.9	226.9	267.1	285.7	294.9
Car-Miles per Active Car (thousands)	50.4	50.1	44.0	52.8	55.7	54.7	53.3	49.2	61.5	68.0	68.0

The ATA does not publish rail rapid transit data for Toronto. Data were obtained from (1) Toronto Transit Commission Annual Reports, (2) Toronto Transit Commission annual data sheets, "Service Costs for the Period (calendar year) Divided Among Types of Equipment Operated," and (3) Dominion Bureau of Statistics, Urban Transit annual reports.

Revenue is not broken down by mode of service; the total revenue was prorated in proportion to the number of revenue passengers carried by each mode.

Some common expense categories were not broken down by mode. These common expenses were prorated in proportion to the direct operating expenses of each mode.

SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY (SEPTA)

In 1968, SEPTA acquired the Philadelphia Transportation Company--at that time the nation's largest remaining privately owned urban transit system. SEPTA reports two rail property operations to the ATA--one covers rapid transit operations and the other covers streetcar operations on city streets. We will consider rapid transit operations (as we define them) only.

SEPTA's rapid transit total operating revenue has increased markedly over the time period shown, despite a drop in ridership from about 75 million to about 63 million passengers. Fares have been increased fairly steadily but slowly over the entire period so that total revenue has generally increased even though the number of passengers has decreased. Operating expenses were well below revenue for the entire period 1960 through 1969. During this period, the operating ratio fluctuated narrowly between 0.88 and 0.93. In 1970, expenses exceeded revenue for the first time and the operating ratio jumped from 0.92 in 1969 to 1.02. Passenger car-miles, which declined from 1960 to 1963, have since remained constant. The number of passenger cars dropped in 1961, but has been nearly constant since then. Note that from 1960 to 1970 the capacity of service offered, in terms of car-miles and number of cars, has been reduced in line with the drop in number of passengers. Seven miles of single track were abandoned in 1969.

Figure 6.5 does not include data for SEPTA's Red Arrow Division, which was acquired along with other transportation properties of the Philadelphia Suburban Transportation Company and its subsidiary, Red Arrow Lines, Inc., in January 1970. The Red Arrow Division includes two separate rail transit operations--one a grade-separated rapid transit line and the other a conventional streetcar-type operation. Since the 1950s, cost and performance data for the two rail networks have been consolidated; hence, data needed for analysis of the rail rapid transit operation simply are not available.

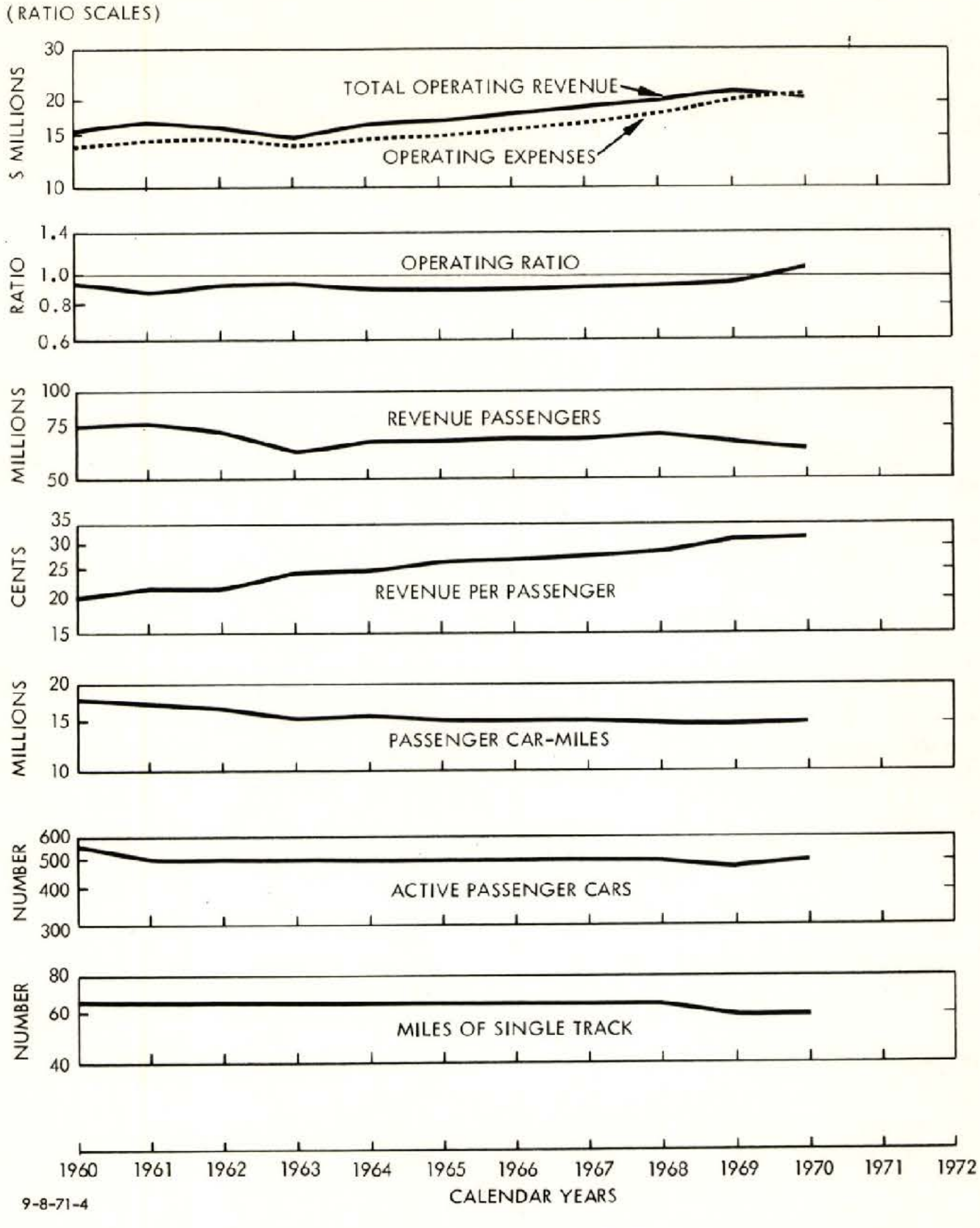

FIGURE 6.5 Southeastern Pennsylvania Transportation Authority (SEPTA)

Table 6.5

SOUTHEASTERN PENNSYLVANIA TRANSIT AUTHORITY (SEPTA)
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)	15,045	16,542	15,886	14,797	16,109	16,883	17,612	18,461	19,364	21,006	20,305
Total Operaing Expenses Less Depreciation ($ thousands)	13,872	14,582	14,645	13,765	14,343	14,834	15,523	16,661	17,709	19,301	20,628
Gross Operating Profit (deficit) ($ thousands)	1,173	1,960	1,241	1,032	1,766	2,049	2,089	1,800	1,655	1,705	(323)
Operating Ratio	.92	.88	.92	.93	.89	.88	.88	.90	.91	.92	1.02
Revenue Passengers (millions)	74.5	76.6	72.6	61.6	67.1	66.0	68.4	68.5	70.1	66.0	62.7
Total Revenue per Revenue Passenger (dollars)	.20	.22	.22	.24	.24	.26	.26	.27	.28	.32	.32
Passenger Car-Miles (millions)	17.516	16.770	16.284	14.922	15.384	14.779	14.797	14.782	14.623	14.566	14.790
Active Passenger Cars	553	496	496	496	496	493	493	493	493	467	490
Total Miles of Single Track	65	65	65	65	65	65	65	65	65	58	58
Cost per Revenue Passenger (dollars)	.19	.19	.20	.22	.21	.22	.23	.24	.25	.29	.33
Cost per Passenger Car-Mile (dollars)	.79	.87	.90	.92	.93	1.00	1.05	1.13	1.21	1.33	1.39
Revenue per Passenger Car-Mile (dollars)	.86	.99	.98	.99	1.05	1.14	1.19	1.25	1.32	1.44	1.37
Passengers per Passenger Car-Mile	4.25	4.57	4.46	4.13	4.36	4.47	4.63	4.63	4.79	4.53	4.24
Passengers per Active Car (thousands)	134.7	154.4	146.4	124.2	135.4	133.9	138.8	138.9	142.2	141.4	127.9
Car-Miles per Active Car (thousands)	31.7	33.8	32.8	30.1	31.0	30.0	30.0	30.0	29.7	31.2	30.2

Most of the expense data were obtained directly from SEPTA, which provides common system expenses and direct operating expenses for each of the four modes operated: bus, trackless trolley, surface railway, and rapid transit. Common system expenses were allocated to rapid transit in proportion to the relative direct operating expenses. A small discrepancy exists in the SEPTA data; the sum of the operating expenses for the four modes, plus the common system expenses, do not exactly equal total operating expenses.

In the "Statistics" section, ATA data were supplemented by data obtained directly from SEPTA. In the few cases where the sources did not agree, the data obtained directly from SEPTA were used.

MONTREAL URBAN COMMUNITY TRANSIT COMMISSION

The Montreal subway was opened in October 1966.[1] The system, of French design, is the only one in Canada or the United States in which the cars operate on rubber tires and concrete rails. Its total operating revenue has exceeded total operating expenses less depreciation in each year to date. Because of the start-up period in 1966, EXPO during the summer of 1967, and a month-long strike in the fall of 1967, the comparability of the relationships of expenses to revenue is somewhat questionable for the first two calendar years which should not be considered normal operating years. Operating ratio climbed steeply in the first two years but has stabilized in the last three years between 0.82 and 0.84. The peak in revenue passengers and revenue associated with EXPO is clearly shown in the profile. Free transfers are allowed between the subway and the surface bus system, so that total subway passengers are about 74 percent greater than revenue passengers. There have been two fare increases over the period shown--one in January 1967 and one in March 1969.

The number of car-miles has declined steadily from the peak in 1967, despite an increase in the number of passenger cars in 1969.

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1. Data for 1966 appear in Table 6.6 but have not been plotted in Figure 6.6 because of operations started near the end of the year. Figures are in Canadian dollars.

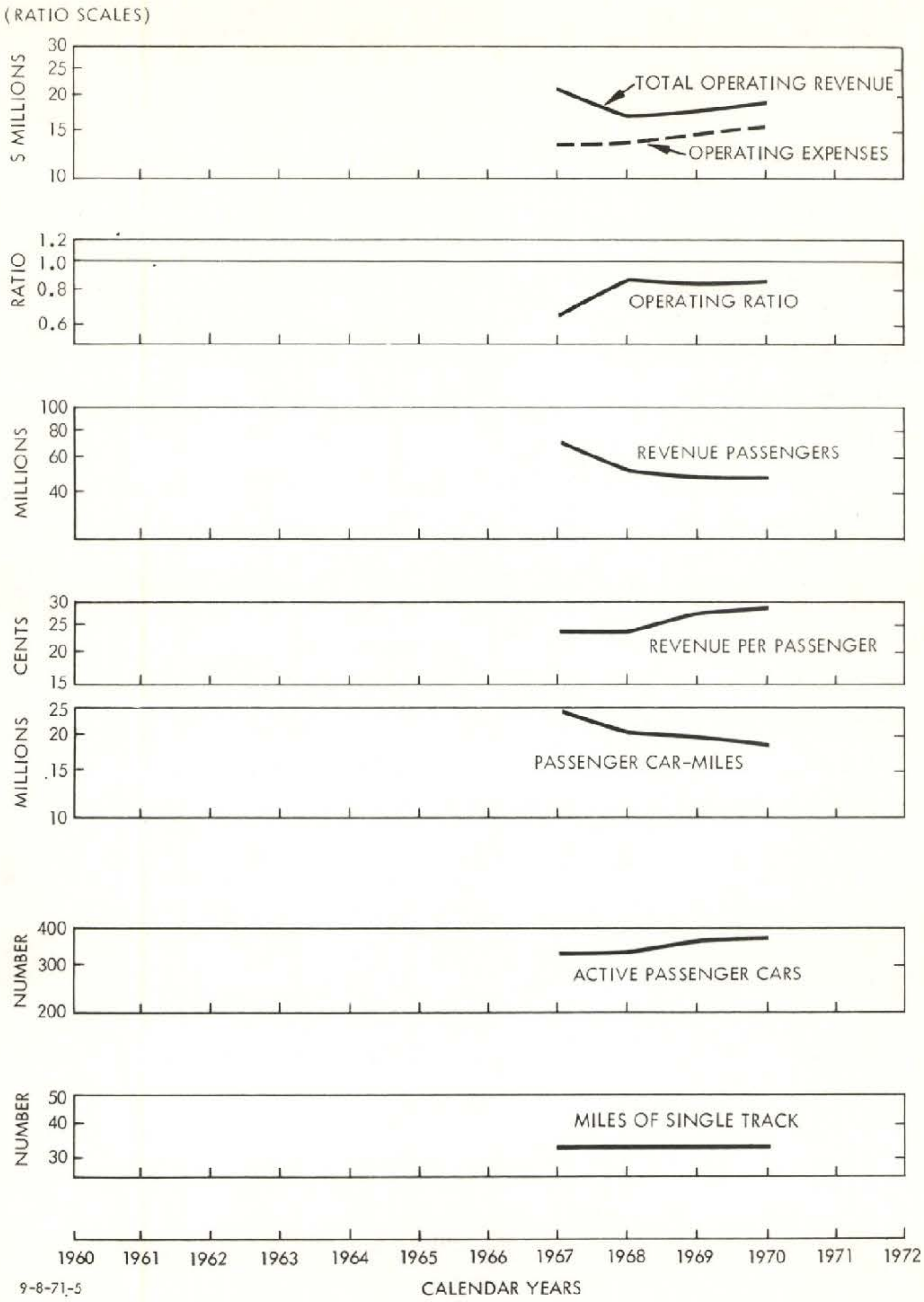

FIGURE 6.6 Montreal Urban Community Transit Commission

Table 6.6

MONTREAL URBAN COMMUNITY TRANSIT COMMISSION
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)							2,458	21,200	16,573	17,753	18,240
Total Operating Expenses Less Depreciation ($ thousands)							1,399	13,054	13,960	14,510	15,400
Gross Operating Profit (deficit) ($ thousands)							1,059	8,146	2,613	3,243	2,840
Operating Ratio							.57	.62	.84	.82	.84
Revenue Passengers (millions)							14.5	91.0	71.4	66.4	65.9
Total Revenue per Revenue Passenger (dollars)							.17	.23	.23	.27	.28
Passenger Car-Miles (millions)							4.675	24.213	20.363	19.351	18.370
Active Passenger Cars							324	324	324	369	369
Total Miles of Single Track							.27	33	33	33	33
Cost per Revenue Passenger (dollars)							.10	.14	.20	.22	.23
Cost per Passenger Car-Mile (dollars)							.30	.54	.69	.75	.84
Revenue per Passenger Car-Mile (dollars)							.53	.88	.81	.92	.99
Passengers per Passenger Car-Mile							3.10	3.76	3.51	3.43	3.59
Passengers per Active Car (thousands)							44.7	280.8	220.4	179.9	178.5
Car-Miles per Active Car (thousands)							14.4	74.7	62.8	52.4	49.8

Total operating expenses were obtained directly from the Commission because of incomplete reporting of expenses to the ATA. The Commission keeps its books on a fiscal-year basis with the fiscal year ending April 30, while the ATA data are recorded on a calendar-year basis. Accordingly, it was necessary to adjust the expenses to a calendar-year basis.

PORT AUTHORITY TRANS HUDSON CORPORATION (PATH)

PATH began operations in 1908 as the privately owned Hudson and Manhattan Railroad. In 1962, following passage of legislation by New Jersey and New York, PATH, a subsidiary of the Port of New York Authority (PONYA), was created to acquire, operate, and modernize the bankrupt interstate transit system, which faced the prospect of abandonment. This is a 14-mile system operating from Newark, Jersey City, and Hoboken to terminals in downtown and midtown Manhattan. It serves as the major connecting link between the New Jersey suburban railroads and the Manhattan business district. In 1960 and 1961, its operating expenses were less than operating revenue. However, since 1961, expenses have grown more rapidly than revenue. From 1961 to 1965, the operating ratio rose rapidly from 0.98 to 1.66. This increase was due to large wage increases won by the unions and to a general upgrading in service following takeover by the Port of New York Authority. Since 1965, the operating ratio has fluctuated between 1.53 and 1.66; in 1970 it was 1.57. The number of revenue passengers declined through 1965, but since then has increased markedly. This increase was due, in part, to the introduction of 162 new air-conditioned cars that were on the tracks by the end of 1965. Together with 47 1958-model cars, PATH provided the first fully air-conditioned rail transit fleet in the United States. Passenger growth was further spurred by the abandonment of two railroad ferry services across the Hudson River in 1967. In addition, in April 1967, service was extended westward from Journal Square in Jersey City to Penn Station in Newark. The revenue per passenger since 1962 has been fairly constant; there have been no fare increases since PONYA took over the property in 1962.

With the opening of service to Newark in 1967, the number of passenger cars was also increased. Passenger car-miles were fairly constant from 1960 to 1965. Since then, car-miles have increased sharply, as would be expected from the increases in number of passengers, number of cars, and miles of track.

RATIO SCALES)

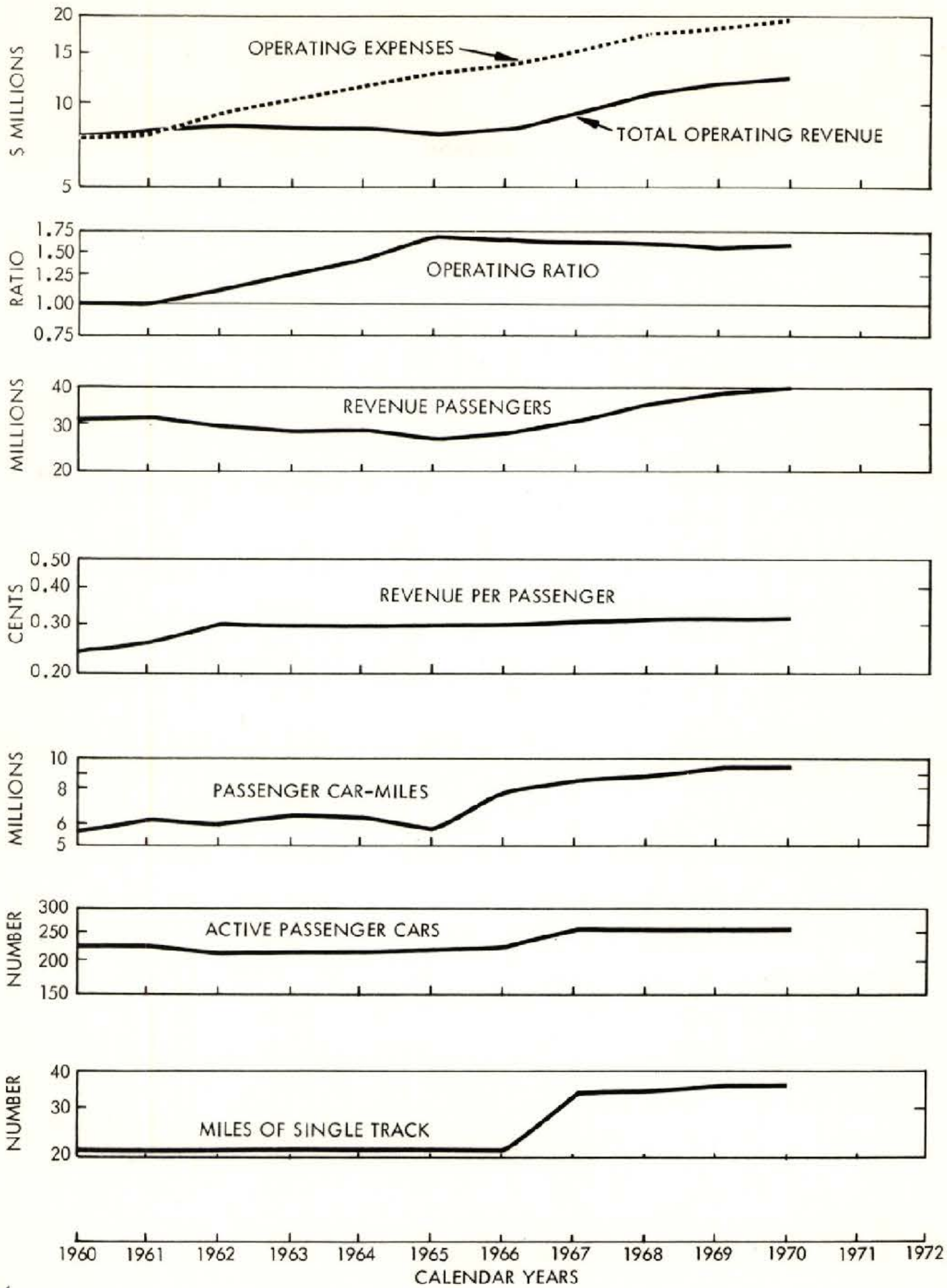

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FIGURE 6.7 Port Authority Trans-Hudson Corp. (PATH)

Table 6.7

PORT AUTHORITY TRANS HUDSON CORPORATION (PATH)
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)	7,666	7,909	8,353	8,111	8,127	7,627	7,948	9,275	10,778	11,624	12,062
Total Operating Expenses Less Depreciation ($ thousands)	7,510	7,723	9,174	10,132	11,276	12,646	13,085	14,932	17,086	17,819	18,902
Gross Operating Profit (deficit) ($ thousands)	156	186	(821)	(2,021)	(3,149)	(5,019)	(5,137)	(5,657)	(6,308)	(6,195)	(6,840)
Operating Ratio	.98	.98	1.10	1.25	1.39	1.66	1.65	1.61	1.59	1.53	1.57
Revenue Passengers (millions)	31.4	31.6	29.2	28.0	28.1	26.4	27.8	30.5	34.8	37.8	39.0
Total Revenue per Revenue Passenger (dollars)	.24	.25	.29	.29	.29	.29	.29	.30	.31	.31	.31
Passenger Car-Miles (millions)	5.532	6.108	5.981	6.371	6.230	5.799	7.647	8.668	8.876	9.476	9.251
Active Passenger Cars	223	223	212	211	211	213	215	253	253	252	252
Total Miles of Single Track	21	21	21	21	21	21	21	34	34	35	35
Cost per Revenue Passenger (dollars)	.24	.24	.31	.36	.40	.48	.47	.49	.49	.47	.49
Cost per Passenger Car-Mile (dollars)	1.36	1.26	1.53	1.59	1.81	2.18	1.71	1.72	1.92	1.88	2.04
Revenue per Passenger Car-Mile (dollars)	1.39	1.29	1.40	1.27	1.30	1.32	1.04	1.07	1.21	1.23	1.30
Passengers per Passenger Car-Mile	5.68	5.17	4.88	4.40	4.52	4.55	3.64	3.52	3.92	3.98	4.21
Passengers per Active Car (thousands)	141.0	141.5	137.7	132.9	133.3	123.9	129.5	120.6	137.5	149.8	154.6
Car-Miles per Active Car (thousands)	24.8	27.4	28.2	30.2	30.0	27.2	35.6	34.3	35.1	37.6	36.7

PATH data were published by the ATA only for 1968 and 1969. A uniform set of data were obtained directly from this property for 1961 through 1970. Where it differed from the ATA data, we used the PATH data. We also had available ICC reports for PATH for 1960 through 1968. Missing 1960 data were estimated by using ICC data for 1960, 1961, and 1962 and the data obtained directly from PATH for 1961 and 1962.

PORT AUTHORITY TRANSIT CORPORATION OF
PENNSYLVANIA AND NEW JERSEY
(LINDENWOLD LINE)

This "corporation" is a publicly owned subsidiary of the Delaware River Port Authority and is often referred to as the Lindenwold Line. It was opened January 4, 1969. Automated trains travel at speeds up to 75 mph between Lindenwold, New Jersey, and downtown Philadelphia, a 14-1/2 mile trip that takes 22 minutes and costs 60 cents. All cars and stations are air-conditioned. Closed-circuit television maintains constant surveillance of fare-collection zones and entry gates in the line's stations. Electronically coded tickets are sold from vending machines and collected in automatic gates. With the small number of employees needed with a new, highly automated system, the line was expected to operate profitably; however, in the first two years, revenue failed to cover operating expenses. The operating ratio improved considerably in 1970 to 1.04 from 1.29 in 1969; the management expects it to be about the same in 1971 as in 1970. Number of passengers increased over 40 percent in 1970. Fares were the same in both years; the slight increase in average revenue per passenger was due to a change in the mix of zone fares collected. Passenger car-miles were about 25 percent greater in 1970 than in 1969. Number of cars and miles of track remained unchanged.

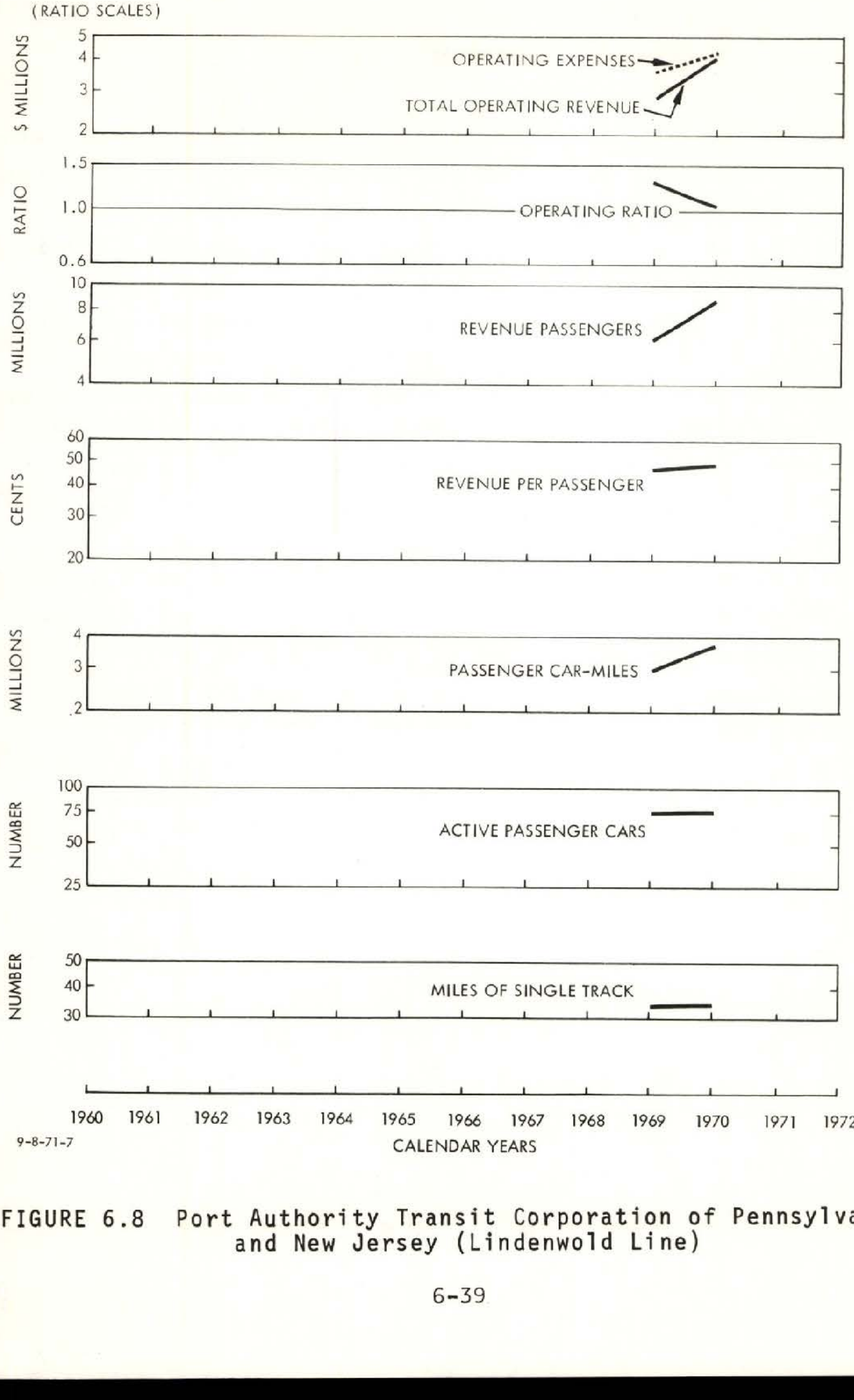

FIGURE 6.8 Port Authority Transit Corporation of Pennsylvania and New Jersey (Lindenwold Line)

Table 6.8

PORT AUTHORITY TRANSIT CORPORATION OF PENNSYLVANIA AND NEW JERSEY (LINDENWOLD LINE)
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)										2,822	4,195
Total Operating Expenses Less Depreciation ($ thousands)										3,654	4,342
Gross Operating Profit (deficit) ($ thousands)										(832)	(147)
Operation Ratio										1.29	1.04
Revenue Passengers (millions)										6.04	8.66
Total Revenue per Revenue Passenger (dollars)										.47	.48
Passenger Car-Miles (millions)										2.933	3.670
Active Passenger Cars										75	75
Total Miles of Single Track										34	34
Cost per Revenue Passenger (dollars)										.60	.50
Cost per Passenger Car-Mile (dollars)										1.25	1.18
Revenue per Passenger Car-Mile (dollars)										.96	1.14
Passengers per Passenger Car-Mile										2.06	2.36
Passengers per Active Car (thousands)										80.6	115.4
Car-Miles per Active Car (thousands)										39.1	48.9

All data obtained from Annual Reports of the American Transit Association.

CLEVELAND TRANSIT SYSTEM

This municipally owned system, opened in 1955, is one of the two post-World War II systems in the United States. It was built largely on existing railway rights-of-way. The total operating revenue[1] exceeded expenses by a significant percentage in 1960, 1961, and 1962, but since then expenses have increased more rapidly than revenue, until in 1969 the operating ratio had increased to 1.15. In 1970, at least partly due to a strike from July 1-17, operating revenue dropped. Expenses continued to increase in 1970, so that the operating ratio jumped to 1.34. For the period shown to 1968 the total number of passengers declined steadily. Following the opening in late 1968 of Cleveland's Hopkins International Airport, a slight increase in the number of passengers was reported in 1969. However, with the strike and continued fare increases, the number of passengers dropped sharply in 1970. Revenue per passenger has increased over the period covered and this increase has been relatively rapid since 1966.

Car-miles decreased in every year except 1969; this increase was associated with the opening of the airport line. The number of passenger cars was increased markedly in 1967, apparently in anticipation of the opening of the line to the airport.

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1. Although we have used the total operating revenue reported by the Cleveland Transit System (CTS) to the ATA, the management of CTS believes that the rail rapid transit revenue potential is greater than the revenue reported, which represents rapid transit fare box cash, plus a proration of system pass and ticket sales because bus and rapid transit operations are run as an integrated system; both types of operation are on the same fare structure. In many instances, it is possible to pay the full rapid transit fare on a "feeder" bus and receive a transfer to the rapid system. Nothing is deposited in rapid transit fare boxes for this type of ride. As a result, in 1970 rapid transit fare box revenue represented only 12 percent of the total passenger revenue, while rapid-transit mileage represented 16.4 percent of the total vehicle miles. (Reference: letter of William E. Deckman, Comptroller, CTS, to Dr. John Wells, IDA, of July 9, 1971.)

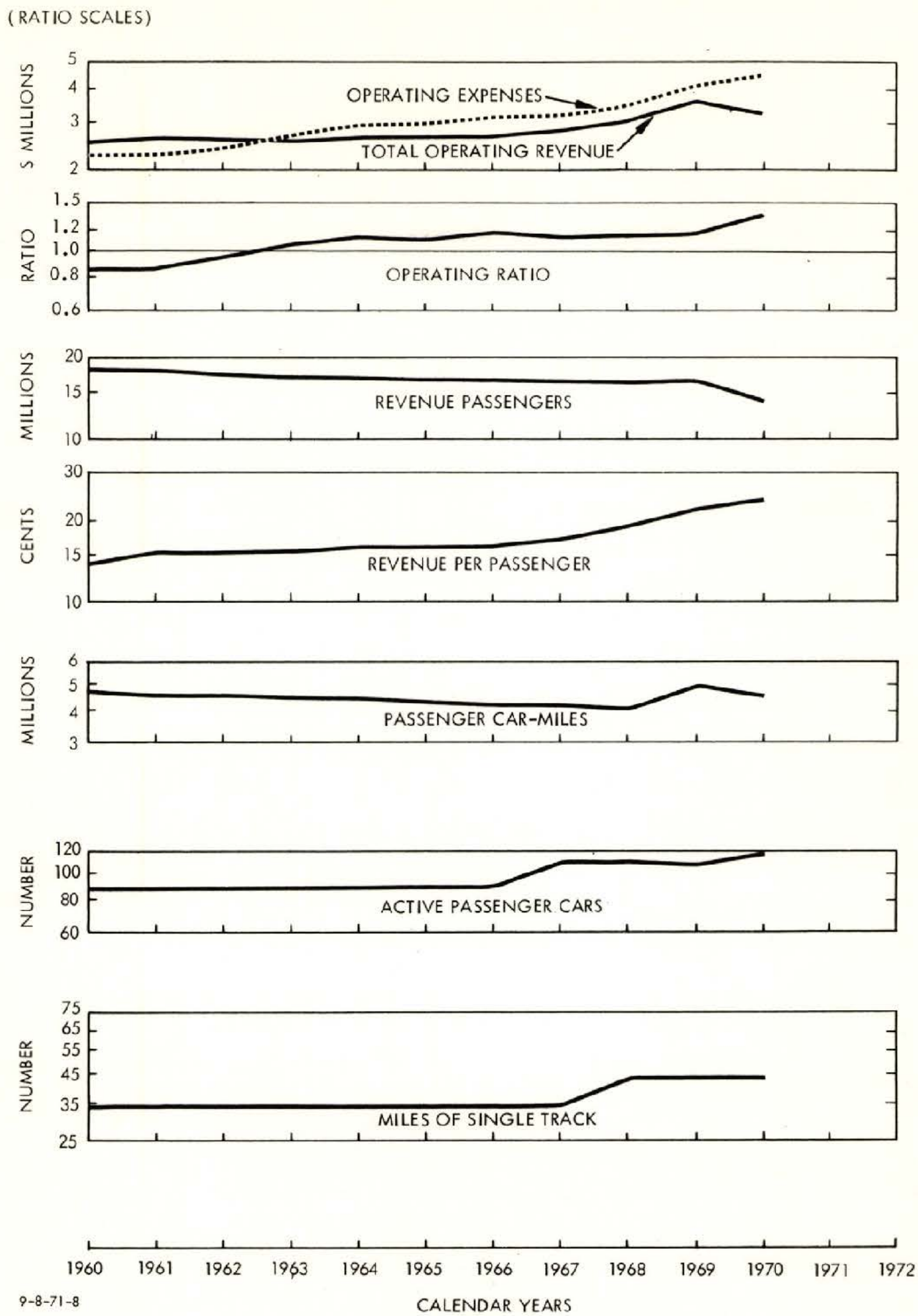

FIGURE 6.9 Cleveland Transit System

Table 6.9

CLEVELAND TRANSIT SYSTEM
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)	2,563	2,613	2,552	2,538	2,612	2,651	2,667	2,814	3,078	3,635	3,345
Total Operating Expenses[b] Less Depreciation ($ thousands)	2,237	2,269	2,398	2,673	2,935	2,928	3,102	3,124	3,462	4,180	4,473
Gross Operating Profit (deficit) ($ thousands)	326	344	154	(135)	(323)	(277)	(435)	(310)	(384)	(545)	(1,128)
Operating Ratio	.87	.87	.94	1.05	1.12	1.10	1.16	1.11	1.13	1.15	1.34
Total Passengers[a] (millions)	18.3	17.8	17.3	17.0	16.8	16.7	16.6	16.3	16.2	16.5	14.1
Total Revenue per Passenger (dollars)	.14	.15	.15	.15	.16	.16	.16	.17	.19	.22	.24
Passenger Car-Miles (millions)	4.703	4.529	4.529	4.467	4.433	4.258	4.198	4.149	4.065	4.810	4.561
Active Passenger Cars	88	88	88	88	88	88	88	108	108	106	117
Total Miles of Single Track	34	34	34	34	34	34	34	34	43	43	43
Cost per Total Passenger[a] (dollars)	.12	.13	.14	.16	.18	.18	.19	.19	.21	.25	.32
Cost per Passenger Car-Mile (dollars)	.48	.50	.53	.60	.66	.69	.74	.75	.85	.87	.98
Revenue per Passenger Car-Mile (dollars)	.54	.58	.56	.57	.59	.62	.64	.68	.76	.76	.73
Passengers per Passenger Car-Mile	3.89	3.93	3.82	3.80	3.78	3.91	3.97	3.93	3.98	3.43	3.09
Passengers per Active Car (thousands)	207.9	202.3	196.8	192.8	190.5	189.3	189.2	150.8	149.7	155.6	120.5
Car-Miles per Active Car (thousands)	53.5	51.5	51.5	50.8	50.4	48.4	47.7	38.4	37.6	45.4	39.0

[a] Revenue passengers not reported.

[b] Operating expenses presented herein were obtained by using data from the Cleveland Transit System annual reports for 1960 through 1969 and data obtained directly from CTS for 1970. These reports show expenses for each of the four modes operated by CTS and an unallocated "Administrative and General" account. The "Administrative and General" account was allocated to the rapid transit mode in proportion to its relative direct operating costs. The results of this method of allocation checked with the rapid transit operating expenses reported by the ATA for 1968 and 1969.

SHAKER HEIGHTS DEPARTMENT OF TRANSPORTATION

This line, completely owned and operated by the city of Shaker Heights, connects that community with downtown Cleveland. Built in the 1920s, it is 13 miles long. The service consists of PCC cars (streetcars) operating in multiple on a grade-separated right-of-way for most of the route from downtown. In Shaker Heights, the line diverges and continues at surface level in the median strip of two arterial streets; the service involves no street running at all, but there are some grade crossings.

Its total operating revenue has exceeded total operating expenses, less depreciation, over the entire period shown. It appeared that this company was to suffer the fate of most companies in the period 1960 through 1967, during which expenses slowly approached total operating revenues; however, in 1968 and 1969, due to fairly heavy fare increases, the operating ratio improved. In 1970, operating expenses again nearly equalled revenue. The number of revenue passengers has declined steadily over the period shown, while average fares have increased. The number of car-miles has been remarkably stable. The system has not changed physically insofar as number of passenger cars and miles of track are concerned.

(RATIO SCALES)

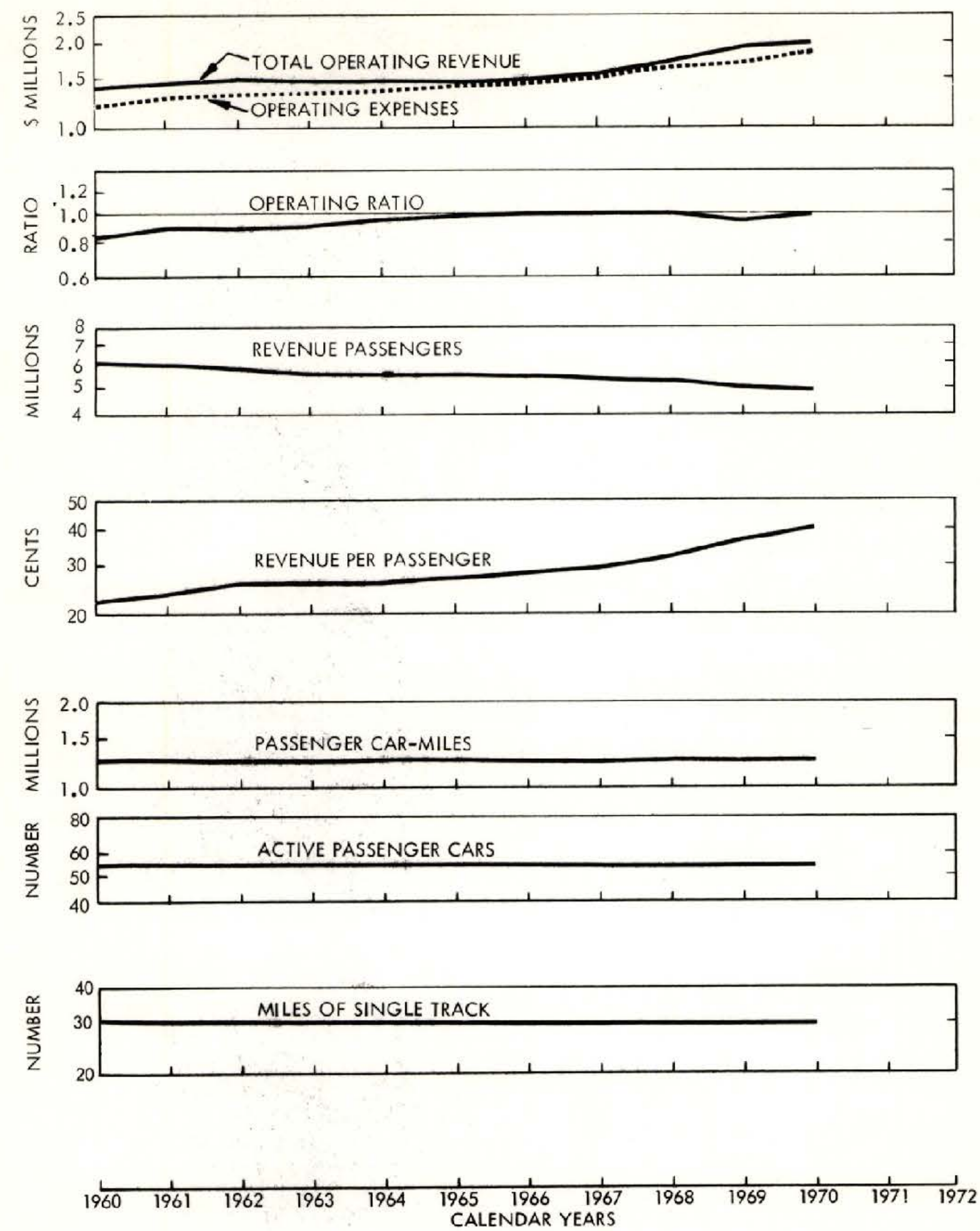

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FIGURE 6.10 Shaker Heights Department of Transportation

Table 6.10

SHAKER HEIGHTS DEPARTMENT OF TRANSPORTATION
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)	1,408	1,430	1,481	1,449	1,455	1,452	1,499	1,535	1,685	1,815	1,908
Total Operating Expenses Less Depreciation ($ thousands)	1,211	1,275	1,314	1,325	1,387	1,409	1,471	1,518	1,648	1,680	1,874
Gross Operating Profit (deficit) ($ thousands)	197	155	167	124	68	42	28	17	38	135	34
Operating Ratio	.86	.89	.89	.91	.95	.97	.98	.99	.98	.93	.98
Revenue Passengers (millions)	6.18	6.04	5.78	5.65	5.54	5.48	5.38	5.27	5.20	4.98	4.83
Total Revenue per Revenue Passenger (dollars)	.23	.24	.26	.26	.26	.27	.28	.29	.32	.36	.40
Passenger Car-Miles (millions)	1.274	1.265	1.250	1.230	1.246	1.247	1.238	1.232	1.235	1.221	1.226
Active Passenger Cars	55	55	55	55	55	55	55	55	55	55	55
Total Miles of Single Track	30	30	30	30	30	30	30	30	30	30	30
Cost per Revenue Passenger (dollars)	.20	.21	.23	.23	.25	.26	.27	.29	.32	.34	.39
Cost per Passenger Car-Mile (dollars)	.95	1.01	1.05	1.08	1.11	1.13	1.19	1.23	1.33	1.38	1.53
Revenue Per Passenger Car-Mile (dollars)	1.11	1.13	1.18	1.18	1.17	1.16	1.21	1.25	1.36	1.49	1.56
Passengers per Passenger Car-Mile	4.85	4.77	4.62	4.59	4.45	4.39	4.35	4.28	4.21	4.08	3.94
Passengers per Active Car (thousands)	112.4	109.8	105.1	102.7	100.7	99.6	97.8	95.8	94.5	90.5	87.8
Car-Miles per Active Car (thousands)	23.2	23.0	22.7	22.4	22.7	22.7	22.5	22.4	22.5	22.2	22.2

All data obtained from Annual Reports of the American Transit Association.

PUBLIC SERVICE COORDINATED TRANSPORT, NEWARK

The Newark subway is a four-mile route operated within the city of Newark by privately-owned Public Service Coordinated Transport. It utilizes a fleet of 30 PCC cars (streetcars). The only significant interruption in operations occurred during a 16-day strike in March, 1964. Total operating revenue has exceeded total operating expenses less depreciation since 1965. This is the only U.S. property that has shown a long-term trend improvement in operating ratio over this period of time; it has dropped from about 1.10-1.15 at the beginning of the period to 0.92 in 1970. After a slow decline over several years, the number of passengers increased moderately in 1969. The company believes that this increase was due at least partly to the opening of new housing near the route, including some for senior citizens. The number of passengers in 1970 was about 5 percent lower than in 1961. Average fare has increased fairly steadily since 1963. Car-miles decreased only about 5 percent from 1961 to 1970. Rolling stock and track mileage have remained constant.

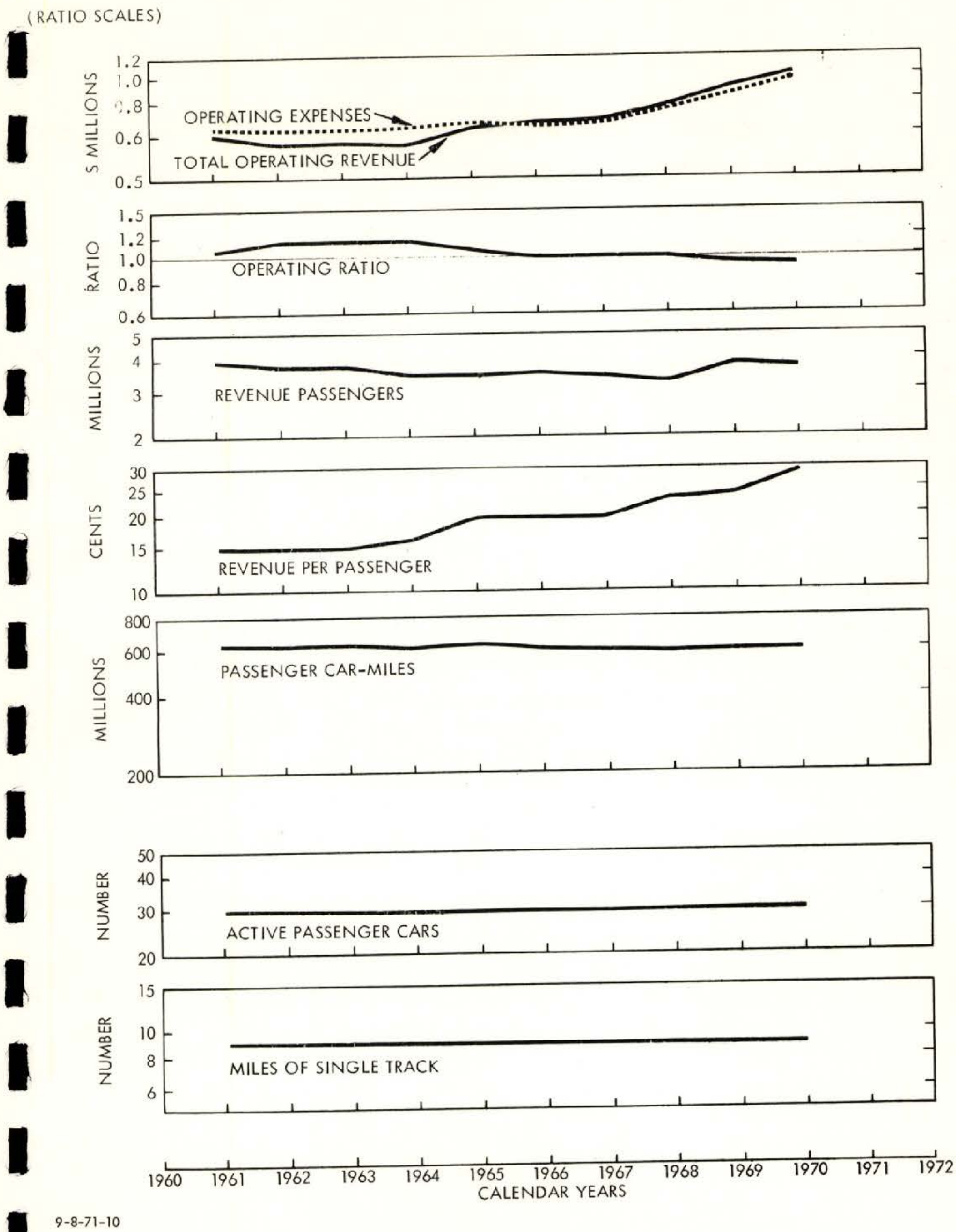

FIGURE 6.11 Public Services Coordinated Transport, Newark

Table 6.11

PUBLIC SERVICES COORDINATED TRANSPORT, NEWARK
SELECTED RAIL RAPID TRANSIT OPERATING STATISTICS, 1960-1970

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Operating Revenue ($ thousands)		591	552	554	541	637	659	676	745	914	1,077
Total Operating Expenses Less Depreciation ($ thousands)		639	624	626	629	675	652	660	744	859	988
Gross Operating Profit (deficit) ($ thousands)		(48)	(72)	(72)	(88)	(38)	7	16	1	55	89
Operating Ratio		1.08	1.13	1.13	1.16	1.06	.99	.98	1.00	.94	.92
Revenue Passengers (millions)		3.96	3.70	3.71	3.48	3.44	3.54	3.48	3.28	3.80	3.69
Total Revenue per Revenue Passenger (dollars)		.15	.15	.15	.16	.19	.19	.19	.23	.24	.29
Passenger Car-Miles (millions)		0.639	0.626	0.635	0.608	0.637	0.612	0.598	0.585	0.592	0.604
Active Passenger Cars		30	30	30	30	30	30	30	30	30	26
Total Miles of Single Track		9	9	9	9	9	9	9	9	9	9
Cost per Revenue Passenger (dollars)		.16	.17	.17	.18	.20	.18	.19	.23	.23	.27
Cost per Passenger Car-Mile (dollars)		1.00	1.00	1.00	1.03	1.06	1.07	1.10	1.27	1.45	1.64
Revenue per Passenger Car-Mile (dollars)		.92	.88	.87	.89	1.00	1.08	1.13	1.27	1.54	1.78
Passengers per Passenger Car-Mile		6.19	5.91	5.84	5.73	5.41	5.78	5.82	5.61	6.42	6.10
Passengers per Active Car (thousands)		131.8	123.5	123.7	116.0	114.8	118.0	116.0	109.3	126.7	141.9
Car-Miles per Active Car (thousands)		21.3	20.9	21.2	20.3	21.2	20.4	19.9	19.5	19.8	23.3

The City of Newark owns the subway right-of-way and the company paid the city an "operating rent" of $120,000 per year for the entire period. This payment is equivalent to a depreciation charge for companies owning their own right-of-way. For 1962 through 1965, the ATA included this payment in "Total Operating Expenses," but did not include it in any of the component expense items. Accordingly, we added $120,000 to "Depreciation" for these years. Starting in 1966, the ATA included the $120,000 in "General Miscellaneous" (line 10); for 1966 through 1970, we transferred the $120,000 from "General Miscellaneous" to "Depreciation." Hence, for the entire period, the $120,000 is not included in our definition of "Total Operating Expenses Less Depreciation."

STATEN ISLAND RAPID TRANSIT RAILWAY COMPANY

The Staten Island Rapid Transit Railway Company operates a 14-mile, 48-car rapid transit line on Staten Island. The line operates on tracks over which freight is also carried. It carries approximately 14,000,000 passengers annually--about equal to the number of rapid transit passengers carried by the Cleveland Transit System. The City of New York has made a commitment to purchase the line from its present owners, the Baltimore & Ohio/Chesapeake & Ohio Railway, at a cost of $3.5 million. When this transaction is completed, the system will be run by the Staten Island Rapid Transit Operating Authority, which will be a subsidiary of the Metropolitan Transportation Authority (MTA).

New York State, through the MTA, and New York City are planning to rehabilitate the line and provide 52 new air-conditioned cars. The state has committed $18.75 million for modernization, and the city will pay the remaining cost, about $25 million.[1]

It was not possible to obtain operating data on this system from its present owners in time for the data to be used in this report.

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1. First National City Bank, Public Transportation in the New York Region (New York City, November 1970), pp. 22-24.

C. COMPARATIVE OPERATING CHARACTERISTICS

The previous chapter examined the properties on an individual basis, this chapter compares their operating characteristics. To accomplish this, the statistics pertaining to each firm discussed in Section B have been rearranged and compared by property. The general tables appear in Appendix VIB. Only the key features are explored in the following sections.

1. RELATIVE SIZE OF OPERATION

It is important to recognize that there is considerable variation in the sizes of the operations, and that the relative positions of the firms sometimes change, depending upon the variable used to indicate size. This is shown in Tables 6.12 through 6.14. In 1970, the New York system accounted for roughly 70 percent of the total for all U. S. firms, regardless of the size measure used (including operating deficit); the lone exception was "miles of single track" where it represented about 58 percent. Chicago was next in size and occupied an intermediate position between New York and a group of five properties that are all about the same size, i.e., MBTA, Toronto, SEPTA, Montreal and PATH. The next two properties, Cleveland and Lindenwold, are about the same size, approximately one-third the size of the previous group. Shaker Heights and Newark can be considered together as the smallest group.

Some additional points are worth noting. First, there is little or no relationship between the size of the firm and its "profitability." In 1970 the only U. S. operations that showed profits were the two smallest properties. In 1969, these and two large properties showed profits. In 1960, all the middle-sized firms showed profits while the largest and smallest showed deficits.

Table 6.12

SIZE INDICATORS FOR 1970, BY PROPERTY

Property	Total Revenue ($ thousands)	Operating Expenses ($ thousands)	Gross Operating Profit ($ thousands)	Gross Operating Deficit ($ thousands)	Revenue Passengers (millions)	Passenger Car-Miles (millions)	Active Passenger Cars	Total Miles of Single Track
New York	391,212	447,781		(56,569)	1,257.6	359.82	6,924	842
Chicago	49,348	54,605		(5,257)	105.6	51.49	1,246	243
MBTA	31,600	41,800		(10,200)	100.9	13.65	718	151
SEPTA	20,305	20,628		(323)	62.7	14.94	490	58
PATH	12,062	18,902		(6,840)	39.0	9.25	253	35
Cleveland	3,345	4,473		(1,128)	14.1	4.56	117	43
Lindenwold	4,195	4,342		(147)	8.7	3.67	75	34
Shaker Heights	1,908	1,874	34		4.8	1.23	55	30
Newark	1,077	988	89		3.7	.60	30	9
Total, U. S. Systems	515,052	595,393	123 (80,341)	(80,464)	1,597.1	459.21	9,908	1,445
Toronto	24,400	18,548	5,852		98.5	22.7	334	60
Montreal	18,240	15,400	2,840		65.9	18.37	369	33
		Percentage Distribution of U. S. Properties						
Total, U. S.	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
New York	76.1	75.3		70.3	78.7	78.4	69.9	58.2
Chicago	9.6	9.2		6.5	6.6	11.2	12.6	16.8
MBTA	6.1	7.0		12.7	6.3	2.9	7.2	10.5
SEPTA	3.9	3.4		0.4	3.9	3.3	4.9	4.0
PATH	2.3	3.2		8.5	2.4	2.0	2.5	2.4
Cleveland	0.6	0.7		1.4	0.9	1.0	1.2	3.0
Lindenwold	0.8	0.7		0.2	0.5	0.8	0.8	2.4
Shaker Heights	0.4	0.3	27.6		0.3	0.3	0.6	2.1
Newark	0.2	0.2	72.4		0.2	0.1	0.3	0.6

Table 6.13

SIZE INDICATORS FOR 1969, BY PROPERTY

Property	Total Revenue ($ thousands)	Operating Expenses ($ thousands)	Gross Operating Profit ($ thousands)	Gross Operating Deficit ($ thousands)	Revenue Passengers (millions)	Passenger Car-Miles (millions)	Active Passenger Cars	Total Miles of Single Track
New York	281,802	362,015		(80,213)	1,343.3	344.57	6,961	842
Chicago	45,044	43,940	1,104		103.1	45.62	1,155	243
MBTA	33,000	35,049		(2,049)	102.2	13.83	623	151
SEPTA	21,006	19,301	1,705		66.0	14.71	467	58
PATH	11,624	17,819		(6,195)	37.8	9.48	252	35
Cleveland	3,635	4,180		(545)	16.5	4.81	106	43
Lindenwold	2,822	3,654		(832)	6.0	2.93	75	34
Shaker Heights	1,815	1,680	135		5.0	1.22	55	30
Newark	914	859	55		3.8	.59	30	9
Total, U. S. Systems	401,662	488,497	2,999	(89,834)	1,683.7	437.76	9,724	1,445
			(86,835)					
Toronto	23,300	17,021	6,279		95.4	22.7	334	60
Montreal	17,753	14,510	3,243		66.4	19.35	369	33
		Percentage Distribution of U. S. Properties						
Total, U. S.	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
New York	70.2	74.1		89.3	79.8	78.7	71.6	58.2
Chicago	11.2	9.0	36.8		6.1	10.4	11.9	16.8
MBTA	8.2	7.1		2.3	6.1	3.2	6.4	10.5
SEPTA	5.2	4.0	56.9		3.9	3.4	4.8	4.0
PATH	2.8	3.6		6.9	2.2	2.2	2.6	2.4
Cleveland	0.9	0.9		0.6	1.0	1.1	1.1	3.0
Lindenwold	0.7	0.7		0.9	0.4	0.7	0.8	2.4
Shaker Heights	0.5	0.3	4.5		0.3	0.3	0.6	2.1
Newark	0.2	0.2	1.8		0.2	0.1	0.3	0.6

Table 6.14

SIZE INDICATORS FOR 1960, BY PROPERTY

Property	Total Revenue ($ thousands)	Operating Expenses ($ thousands)	Gross Operating Profit ($ thousands)	Gross Operating Deficit ($ thousands)	Revenue Passengers (millions)	Passenger Car-Miles (millions)	Active Passenger Cars	Total Miles of Single Track
New York	213,858	215,090		(1,232)	1,349.9	305.15	6,482	851
Chicago	29,709	29,817		(108)	112.9	44.63	1,220	204
MBTA	21,560	22,452		(892)	116.7	15.80	649	160
SEPTA	15,045	13,872	1,173		74.5	17.69	553	65
PATH	7,666	7,510	156		31.4	5.53	223	21
Cleveland	2,563	2,237	326		18.3	4.70	88	34
Shaker Heights	1,408	1,211	197		6.2	1.27	55	30
Newark	591[a]	639		(48)	4.0	.64	30	9
Total, U. S. Systems	292,400	292,828	1,852	(2,280)	1,713.9	395.41	9,300	1,374
			(428)					
Toronto	5,030	4,336	694		34.7	7.1	140	13
		Percentage Distribution of U. S. Properties						
Total, U. S.	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
New York	73.1	73.5		54.0	78.8	77.2	69.7	62.0
Chicago	10.2	10.2		4.7	6.6	11.3	13.1	14.8
MBTA	7.3	7.7		39.1	6.8	4.0	7.0	11.6
SEPTA	5.1	4.7	63.3		4.3	4.5	5.9	4.7
PATH	2.6	2.6	8.4		1.8	1.4	2.4	1.5
Cleveland	0.9	0.8	17.6		1.1	1.2	0.9	2.5
Shaker Heights	0.5	0.4	10.6		0.4	0.3	0.6	2.2
Newark	0.2	0.2		2.1	0.2	0.2	0.3	0.7

[a] Assumed to be the same as 1961.

Second, there have not been major changes in the sizes of U.S. properties from 1960 to 1970. Toronto has, of course, increased considerably. Montreal entered the scene in 1966, and the Lindenwold Line started operations in 1969.

Finally, it should be noted that a major change in "profitability" occurred from 1969 to 1970; for this reason, we have included 1969 in all subsequent analyses. In 1969, five of the nine U.S. firms had operating deficits, and New York accounted for 89 percent of the total deficit. The industry as a whole had a larger deficit in 1969 than in 1970, but this was almost entirely due to the New York system operations. In 1970, seven of the nine firms had deficits, but, because of the New York system's relative improvement, the industry as a whole showed a lower total deficit. This is a clear example of how industry figures that include New York can be misleading. Generally, the occurrence of operating deficits was more widespread in 1970 than in 1969, but the total figure showed an improvement.

To sum up, with few exceptions, the size relationships have been maintained from 1960 to 1970. New York is the largest system by a factor of 6 or 7 times Chicago, and Chicago is about two or three times the size of a group of five properties that are all about the same size. These, in turn, are two or three times the size of the remaining firms. The nature of the operations also differs. Shaker Heights and Lindenwold, for example, are long-line operations while Newark is a short-line operation. These size comparisons, and the fact that different technologies are involved, should be kept in mind when the remainder of this section is considered.

2. GENERAL TRENDS 1960 TO 1970

As indicated earlier, tables comparing individual operating statistics for the 1960 to 1970 period appear in Appendix VIB, but only certain general trends are considered here.

a. Industry-wide Changes

Even though the New York operation dominates industry-wide aggregates, the reader may nevertheless be interested in the overall changes that have taken place. Table 6.15 shows the changes in operations from 1960 to 1970 for the eight U. S. properties that existed in 1960. The Lindenwold Line and, of course, the Montreal and Toronto properties have been excluded from the totals.

In aggregative terms, the number of annual revenue passengers declined by 7.3 percent from 1960 to 1970. Total revenue, on the other hand, increased by 75 percent, reflecting fare increases. However, the increases in revenue were not as large as the increases in expenses. As a result, the industry as a whole shifted from a loss of $0.4 million in 1960 to a gross deficit of $80 million in 1970.

Table 6.15

CHANGES IN TOTAL U.S. OPERATIONS FROM 1960 TO 1970
(Excludes Lindenwold Line)

Operating Characteristics	1960	1970	Actual Change	Percent Change
Revenue Passengers (millions)	1,713.9	1,588.4	-125.5	-7.3
Total Revenue ($ millions)	292.4	510.9	218.5	74.7
Operating Expenses ($ millions)	292.8	591.1	298.3	101.9
Gross Profit (Deficit) ($ millions)	(0.4)	(80.2)	-79.8	
Passenger Car-Miles (millions)	395.4	455.5	60.1	15.2
Active Passenger Cars	9,300	9,833	555	5.7
Total Miles of Single Track	1,374	1,411	37	2.7

Despite the decrease in passengers, service levels appear to have increased. Annual passenger car-miles increased by 15 percent and the number of cars increased by 5.7 percent. Track mileage showed only a slight increase of 2.7 percent. Thus, the cost increases involve some increase in the levels of physical inputs as well as their associated prices.

b. Trends in Individual Property Operations

It is interesting that the aggregative figures do, in fact, reflect the general trends in individual property operations. Table 6.16 shows that six of the eight U. S. firms that existed in 1960 had declines in number of passengers ranging from -0.18 percent per

Table 6.16

AVERAGE RATES OF CHANGE PER YEAR IN REVENUE PASSENGERS, TOTAL REVENUE AND OPERATING EXPENSES, 1960 TO 1970

(Percent)

Property	Revenue Passengers	Total Revenue	Operating Expenses
New York	-0.29	2.07	2.88
Chicago	-0.18	2.00	2.11
MBTA	-0.37	1.76	2.42
SEPTA	-0.53	1.41	1.63
PATH	0.98	1.90	4.24
Cleveland	-0.75	1.36	2.91
Shaker Heights	-0.98	1.18	1.70
Newark[a]	0.27	2.93	1.88
Toronto	5.72	8.11	7.23

[a]For the 10 years 1961 through 1970.

Note: Rates of change should be interpreted as compounded rates; i.e., estimates of the parameter, b, in the equation

$$Y = a \cdot x^b$$

where Y is the variable, x (= 1, 2, ... n) denotes the order of years.

year for Chicago to -0.98 percent per year for Shaker Heights. PATH and Newark were the only properties to show increases. Note that Toronto experienced a 5.72 percent per year increase from 1960 to 1970, most of which occurred after 1965 (see Figure 6.4).

With respect to revenue versus expenses, all but one of the U.S. properties (Newark) showed a more rapid average increase in expenses than in revenue. The effect of this on Gross Profits and Operating Ratios is shown in Tables 6.17 and 6.18, respectively. The former table shows that in the early 1960s, revenues of the majority of the U. S. properties were covering operating expenses, but the gap narrowed until, by 1970, all but two had deficits. Newark's experience was the opposite. This property had a deficit in 1961, but enjoyed its highest profit in 1970. (Newark, incidentally, is the only privately owned property.) New York had a deficit during the entire period, and it has generally increased in magnitude. PATH and Cleveland show a similar pattern.

Table 6.18 shows that because expenses increased at a more rapid rate than revenues, virtually all of the operating ratios increased, and by 1970 all but a few had crossed the 1.0 threshold. Aside from Toronto and Montreal, the two smallest properties are the only ones whose operating ratios remained under 1.0.

It is clearly shown in Table 6.19 that some U. S. properties have reduced operating levels and these appear to be the same firms that have staved off deficits the longest, e.g., Newark, Shaker Heights, and SEPTA. The New York and Chicago systems increased their operations in the face of rising costs and declining ridership. A fare increase improved the New York system's operating ratio in 1970, but the general position of the three U. S. firms that have increased their car-miles seems to have deteriorated.

Thus, with few exceptions, the ability of the rail rapid transit properties to cover out-of-pocket expenses with revenues has decreased and, in fact, in 1970 the typical U. S. property had an operating deficit. But it must also be noted that the properties differed considerably in their capability to cover costs. This

Table 6.17

GROSS OPERATING PROFIT (DEFICIT) OF RAIL RAPID TRANSIT PROPERTIES, 1960 THROUGH 1970

(Thousands of Dollars)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	(1,232)	(6,653)	(9,608)	(22,936)	(28,984)	(24,487)	(36,578)	(29,509)	(64,966)	(80,213)	(56,569)
Chicago	(108)	(571)	365	10	(77)	(989)	(1,160)	104	569	1,104	(5,257)
MBTA	(892)	(324)	1,774	1,217	1,057	472	212	1,352	(235)	(2,049)	(10,200)
Toronto	694	447	296	(27)	674	701	458	2,375	3,488	6,279	5,852
SEPTA	1,173	1,960	1,241	1,032	1,766	2,049	2,089	1,800	1,655	1,705	(323)
Montreal							1,059	8,146	2,613	3,243	2,840
PATH	156	186	(821)	(2,021)	(3,149)	(5,019)	(5,137)	(5,657)	(6,308)	(6,195)	(6,840)
Cleveland	326	344	154	(135)	(323)	(277)	(435)	(310)	(384)	(545)	(1,128)
Lindenwold										(832)	(147)
Shaker Heights	197	155	167	124	68	42	28	17	38	135	34
Newark		(48)	(72)	(72)	(88)	(38)	7	16	1	55	89

Table 6-18

OPERATING RATIO, BY PROPERTY, 1960-1970

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	1.01	1.03	1.04	1.11	1.13	1.10	1.16	1.11	1.24	1.28	1.14
Chicago	1.00	1.02	.99	1.00	1.00	1.03	1.03	1.00	.99	.98	1.11
MBTA	1.04	1.01	.93	.95	.96	.98	.99	.95	1.01	1.06	1.32
Toronto	.86	.91	.94	1.00	.90	.90	.96	.84	.81	.73	.76
SEPTA	.92	.88	.92	.93	.89	.88	.88	.90	.91	.92	1.02
Montreal							.57	.62	.84	.82	.84
PATH	.98	.98	1.10	1.25	1.39	1.66	1.65	1.61	1.59	1.53	1.57
Cleveland	.87	.87	.94	1.05	1.12	1.10	1.16	1.11	1.13	1.15	1.34
Lindenwold										1.29	1.04
Shaker Heights	.86	.89	.89	.91	.95	.97	.98	.99	.98	.93	.98
Newark		1.08	1.13	1.13	1.16	1.06	.99	.98	1.00	.94	.92

Table 6.19

AVERAGE RATES OF CHANGE PER YEAR IN PASSENGER CAR-MILES, ACTIVE PASSENGER CARS, AND MILES OF SINGLE TRACK, 1960 THROUGH 1970

(Percent)

Property	Passenger Car-Miles	Active Passenger Cars	Miles of Single Track
New York	0.69	0.38	0.03
Chicago	0.39	-0.03	0.70
MBTA	-0.46	0.17	-0.19
SEPTA	-0.71	-0.35	-0.41
PATH	2.50	0.80	2.77
Cleveland	-0.17	1.26	1.11
Shaker Heights	-0.15	0.00	0.00
Newark[a]	-0.37	-0.34	0.00
Toronto	6.15	4.78	8.36

[a]For the 10 years 1961 through 1970.

Note: See note in Table 6.16.

implies that there may be some differences in performance characteristics--the subject of the next section.

3. COMPARISON OF PERFORMANCE RATIOS

Several "performance" ratios are used in the following analysis to compare the operations of the properties. Definitions of the ratios and what they are designed to measure appear in Table 6.20. Ideally, many measures could and should be used. Those used here can provide no more than a sketch of relative performance. The actual values of the ratios for the period 1960 through 1970 appear in Appendix VIB and should be examined at this point.

Table 6.20

PERFORMANCE RATIO DEFINITIONS

Performance Ratio	Definition	Measurement
Operating ratio	Operating expenses ÷ operating revenues	Ability to cover out-of-pocket expenses with revenues
Cost per car-mile	Operating expenses ÷ passenger car-miles	Cost of moving cars irrespective of whether or not passengers are on board
Cost per passenger	Operating expenses ÷ revenue passengers	Cost of moving passengers irrespective of the length of movement
Revenue per car-mile	Operating revenues ÷ passenger car-miles	Revenue production of rolling stock
Revenue per passenger	Operating revenues ÷ revenue passengers	Average fare per passenger trip
Passengers per car-mile	Revenue passenger ÷ passenger car-miles	Passenger boardings per car per mile
Passengers per car	Revenue passenger ÷ active passenger cars	Passenger boardings of cars irrespective of length of movement
Car-miles per car	Passenger car-mile ÷ active passenger cars	Car movement or "activity " of car

Table 6.21 presents the rankings of the ratios in 1969. Note that "adjusted" costs are used in the two ratios involving expenses. The adjustment is for substantial wage-rate differentials among the cities (see Appendix VIC). In addition to wage-rate differentials, there are important differences in employee benefits, payments for split-shift work schedules, etc., that have not been included in our "adjusted" costs. The rankings of the unadjusted cost ratios in Table 6.21 lead to approximately the same conclusions with respect to general ranking.

The rankings can be examined both horizontally and vertically. The horizontal ranking indicates where each property stood in 1969 with respect to the specific ratio. For example, Toronto had the lowest operating ratio (operating ratio is ranked lowest to highest, L-H), PATH had the highest. Toronto also had the lowest adjusted cost per car-mile, and MBTA the highest. MBTA, on the other hand, had the highest revenue-generating capability as reflected in revenue per car-mile (ranked highest to lowest, H-L) and passengers per car-mile.

The vertical rankings give a profile of the individual properties, and these are, perhaps, the most interesting. In 1969, New York had one of the highest operating ratios, yet it ranked next to the lowest in its cost per car-mile and next to the highest in passengers per car. Its inability to generate revenue was apparently the low fare. The property ranked last in revenue per passenger, which is ranked from highest fare to lowest (H-L). In 1969, therefore, New York could be characterized as a low-cost, high-passenger-density, low-fare system.

Now consider the Chicago property. Although it ranked sixth in terms of operating ratio, it still was able to cover operating expenses. It ranked fourth in cost per car-mile, tenth in passengers per car-mile and passengers per car, and next to highest in revenue per passenger. Chicago can be characterized as a moderate-cost, low-passenger-density, high-fare system.

Table 6.21

RANKINGS OF PERFORMANCE RATIOS BY RAIL RAPID TRANSIT PROPERTY, 1969

System	Operating Ratio, Actual	Performance Ratio									
		Operating Ratio (L-H)	Adjusted Cost per Car-Mile (L-H)	Adjusted Cost per Passenger (L-H)	Revenue per Car-Mile (H-L)	Revenue per Passenger (H-L)	Passengers per Car-Mile (H-L)	Passengers per Car (H-L)	Car-Miles per Car (H-L)	Unadjusted Cost per Car-Mile (L-H)	Unadjusted Cost per Passenger (L-H)
New York	1.29	9	2	3	10	11	7	2	3	5	5
Chicago	.98	6	4	10	7	2	10	10	5	4	9
MBTA	1.06	7	11	6	1	4	1	4	9	11	7
Toronto	.73	1	1	1	6	8	4	1	1	1	1
SEPTA	.92	3	7	6	4	4	3	7	8	7	6
Montreal	.84	2	2	4	9	7	8	3	2	1	2
PATH	1.53	11	9	9	5	6	6	6	7	10	10
Cleveland	1.15	8	5	5	11	10	8	5	4	3	4
Lindenwold	1.29	10	6	11	8	1	11	11	6	6	11
Shaker Heights	.93	4	10	8	3	3	5	9	10	8	7
Newark	.94	5	8	2	2	8	2	8	11	9	3

L-H = Lowest to highest.

H-L = Highest to lowest.

MBTA's operating ratio of 1.06 ranked seventh. MBTA has unusual characteristics, and it would be worthwhile to spend some time examining the tables in Appendix VIB to understand its relative behavior. MBTA's cost per car-mile is the highest of all systems. This high cost per car-mile is at least partially caused by low car use (MBTA ranks ninth in car-miles per car). Apparently, due to restricted running during nonpeak hours, MBTA is able to achieve the highest number of passengers and revenue per car-mile, even though revenue per passenger is moderate. Because of the restricted running, the number of passengers per car (per year) is moderate even though passengers per car-mile are the highest. Despite the fact that the cost per car-mile is the highest, MBTA's cost per passenger is moderate because of the large number of passengers per car-mile. MBTA can be characterized as a high-cost, high-passenger-density, moderately priced system.

Toronto stands out as a high-performance system. Its operating ratio was the lowest in 1969. It was the lowest-cost system and ranked highest in passengers per car and car movement. Its revenue per passenger was moderate. Toronto can be characterized as a low-cost, high-passenger-density, moderate-fare system.

The profiles of the other systems can be obtained in the same way. Tables 6.22 and 6.23 present similar rankings for 1970 and 1960, respectively, while Table 6.24 summarizes the rankings for all three years by property.

The main point brought out by these tables is that the profiles differ considerably and any policies addressed to their improvement must be tailored to individual characteristics. For example, in 1969, New York was a low-cost, high-passenger-density, high-car-movement system, but its fare was low. The latter was the primary reason for its very high operating deficit. A policy directed to decreasing costs would have yielded little return since it was already a low-cost system. MBTA, on the other hand, is a high-cost system, but passenger density is not a problem. Policies directed toward improving MBTA's performance should probably focus on the cost side.

Table 6.22

RANKINGS OF PERFORMANCE RATIOS BY RAIL RAPID TRANSIT PROPERTY, 1970

System	Operating Ratio, Actual	Performance Ratio									
		Operating Ratio (L-H)	Adjusted Cost per Car-Mile (L-H)	Adjusted Cost per Passenger (L-H)	Revenue per Car-Mile (H-L)	Revenue per Passenger (H-L)	Passengers per Car-Mile (H-L)	Passengers per Car (H-L)	Car-Miles per Car (H-L)	Unadjusted Cost per Car-Mile (L-H)	Unadjusted Cost per Passenger (L-H)
New York	1.14	8	4	4	7	5	8	2	2	6	6
Chicago	1.11	7	3	10	10	2	11	11	5	4	11
MBTA	1.32	9	11	7	1	5	1	6	11	11	8
Toronto	.76	1	1	1	8	10	3	1	1	1	1
SEPTA	1.02	5	7	6	4	4	4	7	8	7	5
Montreal	.82	2	2	2	9	9	7	3	3	2	2
PATH	1.57	11	9	8	5	5	5	4	7	10	9
Cleveland	1.34	10	5	5	11	11	9	8	6	3	4
Lindenwold	1.04	6	6	11	6	1	10	9	4	5	10
Shaker Heights	.98	4	10	9	3	3	6	10	10	8	7
Newark	.92	3	8	3	2	8	2	5	9	9	3

L-H = Lowest to highest.

H-L = Highest to lowest.

Table 6.23

RANKINGS OF PERFORMANCE RATIOS BY RAIL RAPID TRANSIT PROPERTY, 1960

System	Operating Ratio,	Performance Ratio									
		Operating Ratio (L-H)	Adjusted Cost per Car-Mile (L-H)	Adjusted Cost per Passenger (L-H)	Revenue per Car-Mile (H-L)	Revenue per Passenger (H-L)	Passengers per Car-Mile (H-L)	Passengers per Car (H-L)	Car-Miles per Car (H-L)	Unadjusted Cost per Car-Mile (L-H)	Unadjusted Cost per Passenger (L-H)
New York	1.01	7	2	2	7	6	6	2	3	4	3
Chicago	1.00	6	3	9	8	1	9	9	4	3	9
MBTA	1.04	8	9	5	2	5	1	4	7	9	5
Toronto	.86	1	4	2	6	7	4	1	2	2	2
SEPTA	.92	4	5	6	5	4	7	6	5	5	5
PATH	.98	5	8	7	1	2	3	5	6	8	8
Cleveland	.87	3	1	1	9	9	8	3	1	1	1
Shaker Heights	.86	1	6	7	3	3	5	8	8	6	7
Newark[a]	1.08	9	7	4	4	7	2	7	9	7	3

[a]Assumed to be the same as 1961.

L-H = Lowest to highest.

H-L = Highest to lowest.

Table 6.24

COMPARATIVE RANKINGS OF PERFORMANCE RATIOS BY RAIL RAPID TRANSIT PROPERTY, 1960, 1969, AND 1970

System	Performance Ratio							
	Operating Ratio (L-H)	Adjusted Cost per Car-Mile (L-H)	Adjusted Cost per Passenger (L-H)	Revenue per Car-Mile (H-L)	Revenue per Passenger (H-L)	Passengers per Car-Mile (H-L)	Passengers per Car (H-L)	Car-Miles per Car (H-L)
New York								
1960	7	2	2	7	6	6	2	3
1969	9	2	3	10	11	7	2	3
1970	8	4	4	7	5	8	2	2
Chicago								
1960	6	3	9	8	1	9	9	4
1969	6	4	10	7	2	10	10	5
1970	7	3	10	10	2	11	11	5
MBTA								
1960	8	9	5	2	5	1	4	7
1969	7	11	6	1	4	1	4	9
1970	9	11	7	1	5	1	6	11
Toronto								
1960	1	4	2	6	7	4	1	2
1969	1	1	1	6	8	4	1	1
1970	1	1	1	8	10	3	1	1
SEPTA								
1960	4	5	6	5	4	7	6	5
1969	3	7	6	4	4	3	7	8
1970	5	7	6	4	4	4	7	8
Montreal								
1960								
1969	2	2	4	9	7	8	3	2
1970	2	2	2	9	9	7	3	3
PATH								
1960	5	8	7	1	2	3	5	6
1969	11	9	9	5	6	6	6	7
1970	11	9	8	5	5	5	4	7
Cleveland								
1960	3	1	1	9	9	8	3	1
1969	8	5	5	11	10	8	5	4
1970	10	5	5	11	11	9	8	6
Lindenwold								
1960								
1969	10	6	11	8	1	11	11	6
1970	6	6	11	6	1	10	9	4
Shaker Heights								
1960	1	6	7	3	3	5	8	8
1969	4	10	8	3	3	5	9	10
1970	4	10	9	3	3	6	10	10
Newark[a]								
1960	9	7	4	4	7	2	7	9
1969	5	8	2	2	8	2	8	11
1970	3	8	3	2	8	2	5	9

[a]Assumed to be same as 1961.

L-H = Lowest to highest.
H-L = Highest to lowest.

Table 6.24 brings out the point that these profiles have remained relatively stable over the years. The New York system's costs have always been low. MBTA's, on the other hand, have always been high. The Chicago system's passenger density has always been low, and its fare has always been high. Apparently, policies directed toward improvement of the Chicago system must be focused on increasing the passenger-load factor. Hence, different management actions may be required for each property to improve its operating economics.

4. COST RELATIONSHIPS

The previous discussion has indicated that there are substantial differences in operating costs per car-mile.[1] This section examines the possibility of clear-cut patterns that may suggest explanations for differences. In the following, wage-rate-adjusted costs per car-mile are related first to total car-miles (per year) and then to car-miles per car (per year). The first comparison is concerned with whether or not unit costs are related to the size of the operation in terms of car-miles. The second is concerned with whether or not unit costs are related to utilization or movement per car.

Scatter diagrams rather than regression equations are used to show the relationships because the number of observations is too small to obtain valid statistical comparisons, and the purpose of the analysis is to determine the general patterns only. The values for the observations in the diagrams are given in Table 6.25

a. Unit Cost and Level of Output

Figure 6.12 presents the relationship of adjusted cost per car-mile to passenger car-miles for 1960, 1969, and 1970. Except for MBTA, the points have a downward sloping pattern that flattens out or

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1. The operating-cost concept excludes capital costs. Therefore, only variable costs are examined here.

Table 6.25

VALUES FOR SCATTER DIAGRAMS, FIGURES

Point Code	Property	Car-Miles (millions)			Car-Miles Per Car			Cost per Car-Mile: Actual			Cost per Car-Mile: Wage Rate Adjusted		
		1960	1969	1970	1960	1969	1970	1960	1969	1970	1960	1969	1970
1	New York	305.15	344.57	359.82	47.1	49.5	52.0	.70	1.05	1.24	.70	1.05	1.24
2	Chicago	44.63	45.62	51.49	36.6	39.5	41.3	.67	.96	1.06	.72	1.11	1.23
3	MBTA	15.80	13.83	13.65	24.3	24.2	21.0	1.42	2.53	3.06	1.51	2.97	3.59
4	Toronto	7.1	22.7	22.7	50.7	68.0		.61	.75	.82	.76	1.02	1.12
5	SEPTA	17.69	14.71	14.94	32.0	31.5	30.5	.78	1.31	1.38	.92	1.66	1.75
6	Montreal		19.35	18.37		52.4	49.8		.75	.84		1.05	1.17
7	PATH	5.53	9.48	9.25	24.8	37.6	36.6	1.36	1.88	2.04	1.36	1.88	2.04
8	Cleveland	4.70	4.81	4.56	53.4	45.4	39.0	.48	.87	.98	.57	1.21	1.37
9	Lindenwold		2.93	3.67		39.1	48.9		1.25	1.18		1.58	1.49
10	Shaker Heights	1.27	1.22	1.23	23.1	22.2	22.2	.95	1.38	1.53	1.12	1.92	2.13
11	Newark[a]	.64	.59	.60	21.3	19.7	20.0	1.00	1.45	1.64	1.14	1.75	1.98

[a] 1960 assumed to be same as 1961.

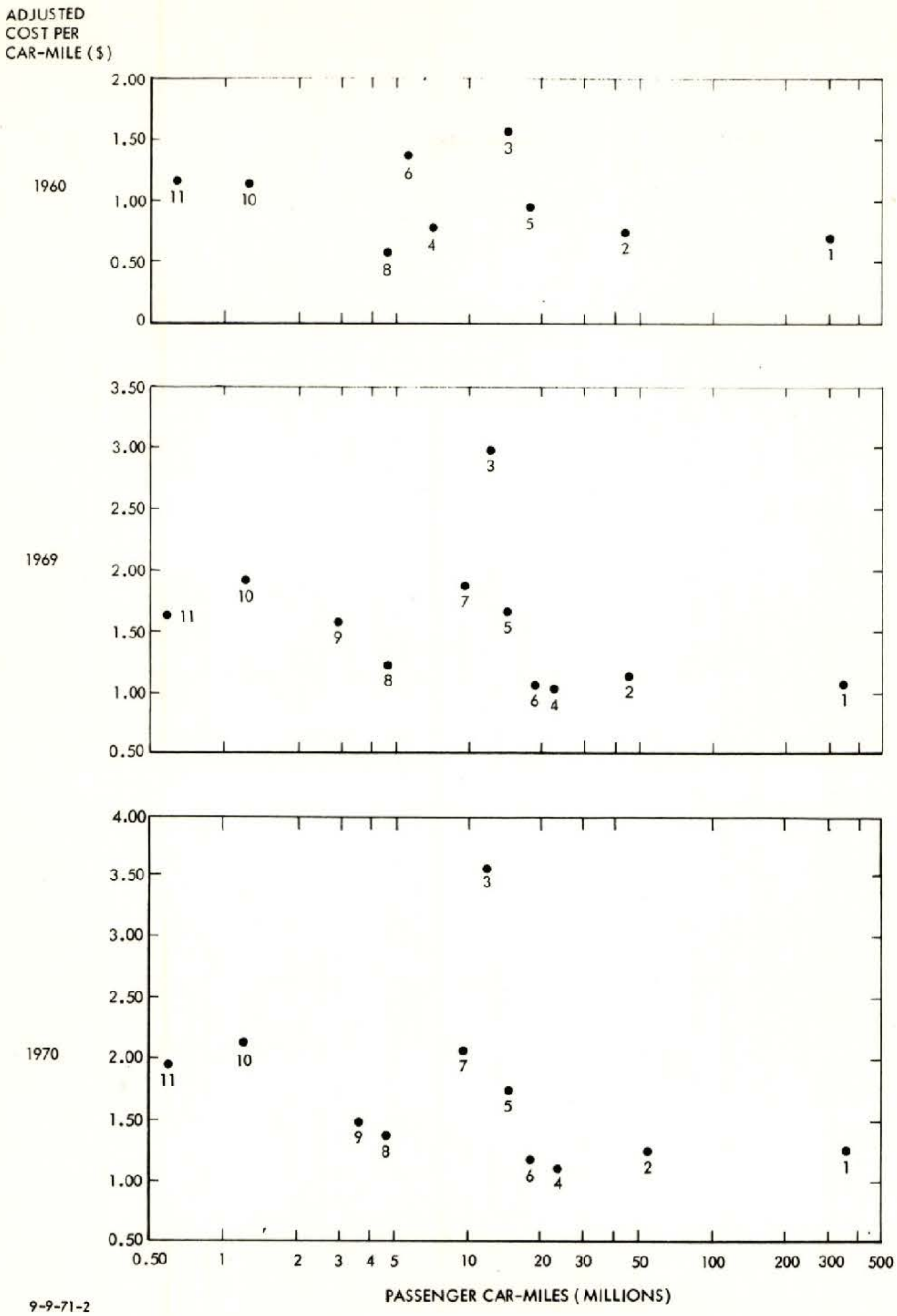

FIGURE 6.12 Cost per Car-Mile Related to Car-Miles, 1960, 1969, and 1970

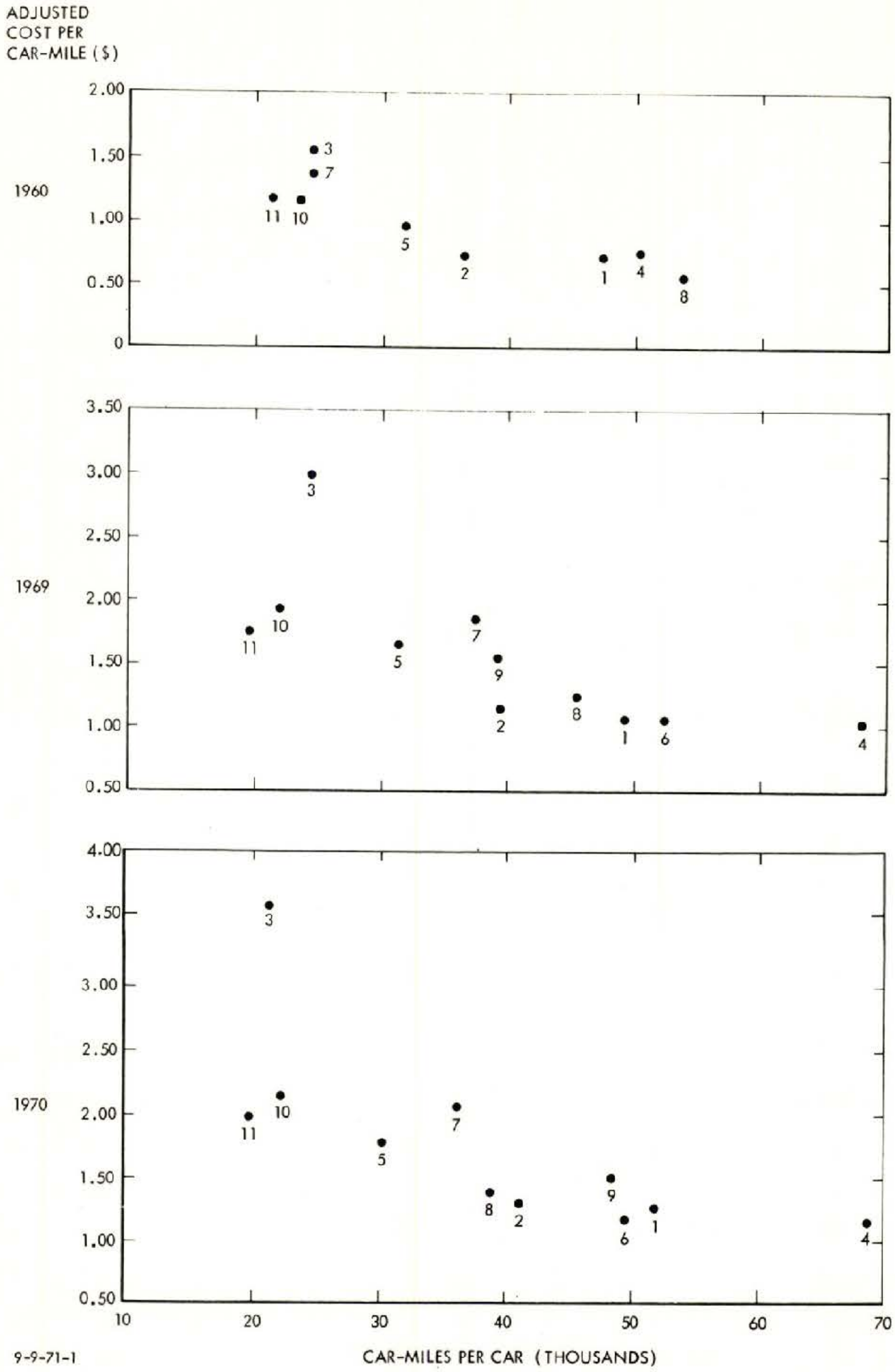

FIGURE 6.13 Cost per Car-Mile Related to Car-Miles per Active Car, 1960, 1969, and 1970

increases slightly after it reaches the output of the intermediate-sized firms.

In all three years there is an indications that, while very small operations tend to have higher unit cost, intermediate-sized operations can have unit costs as low, if not lower, than the largest operations. The least-cost position may, in fact, be at some intermediate level (see Cleveland, point 8, in 1960).

It is interesting to note that the unit cost of the Lindenwold Line (point 9) decreased from 1969 to 1970, whereas all others experienced increases. This suggests that the new line was still "shaking down" in 1969 and had not reached (and might still not have reached by the end of 1970) its least-cost position.

b. Unit Cost and Car Utilization

A strong relationship appears to hold between unit cost and car utilization. As can be seen in Figure 6.13, the points follow a downward-sloping pattern. This implies that the higher the car utilization, the lower the cost per car-mile. It is interesting that size has little to do with the relationship. If the car utilization of the large firms is low (e.g., MBTA, PATH, and SEPTA), their costs are higher. In all three years, the lowest cost per unit was associated with highest car utilization, and these were intermediate-sized properties. Cleveland (point 8) in 1960 was actually ranked eighth in size.

The consistency of the relationship suggests that car utilization is a better independent variable than size of output for estimating the unit cost of the firm. High car utilization implies that turn-around times are low, cars are moving rapidly, there is very little downtime, maintenance schedules are tight and being met, etc. All of which would indicate that both capital and labor are being used efficiently. Obviously, it would be better to have data on these more detailed aspects of the systems, but it is interesting that one variable seems to capture the overall effects.

Further work is necessary to establish the rationale behind these relationships.

Appendix VIA

BASIC INFORMATION CATEGORIES

Appendix VIA

BASIC INFORMATION CATEGORIES

Item	
	REVENUES
1.	Total Operating Revenue
2.	Passenger Revenue
3.	Freight Revenue
	EXPENSES
4.	Way and Structures (Excluding Depreciation)
5.	Equipment (Excluding Depreciation
6.	Power-Maintenance (Excluding Depreciation)
7.	Power - (Purchased-Generated)
8.	Conducting Transportation
9.	Wages of Trainmen
10.	General Miscellaneous
11.	Injuries and Damages
12.	Traffic
13.	Depreciation
14.	Operating Taxes
15	Total Operating Expenses
	STATISTICS
16.	Miles of 1st Main Track (December 31)
17.	Total Miles of Single Track (December 31)
18.	Number of Cars Owned (Total) (December 31)
19.	Passenger Cars Owned-Active (December 31)
20	Cars in Peak-Base Schedule
21	Number of Employees (Average)
22.	Car-Miles Operated (Total)
23.	Passenger Car-Miles
24.	Freight Miles
25.	Car Hours Operating (Total)
26.	Passenger Car Hours
27.	Freight Car Hours
28.	Total Passengers
29.	Revenue Passengers (Line Service)
30.	KW-hr. (D. C.) Consumed

Appendix VIB

COMPARISON OF OPERATING CHARACTERISTICS BY PROPERTY

Appendix VIB

COMPARISON OF OPERATING CHARACTERISTICS BY PROPERTY

The tables in this Appendix contain the same figures reported in Tables 6.1 through 6.11 in Section B. However, they are rearranged to allow easier comparisons of the properties.

Table 6B.1

TOTAL OPERATING REVENUE, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

(Thousands of Dollars)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	213,858	215,732	219,762	216,869	223,349	236,593	231,297	272,534	272,831	281,802	391,212
Chicago	29,709	29,853	32,077	31,086	31,324	31,990	33,290	35,603	38,452	45,044	49,348
MBTA	21,560	22,030	24,040	23,620	24,650	23,830	24,800	27,800	29,300	33,000	31,600
Toronto	5,030	4,990	4,950	5,550	6,600	6,870	11,680	15,030	18,320	23,300	24,400
SEPTA	15,045	16,542	15,886	14,797	16,109	16,883	17,612	18,461	19,364	21,006	20,305
Montreal							2,458	21,200	16,573	17,753	18,240
PATH	7,666	7,909	8,353	8,111	8,127	7,627	7,948	9,275	10,778	11,624	12,062
Cleveland	2,563	2,613	2,552	2,538	2,612	2,651	2,667	2,814	3,078	3,635	3,345
Lindenwold										2,822	4,195
Shaker Heights	1,408	1,430	1,481	1,449	1,455	1,452	1,499	1,535	1,685	1,815	1,908
Newark		591	552	554	541	637	659	676	745	914	1,077

Table 6B.2

TOTAL OPERATING EXPENSES LESS DEPRECIATION, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

(Thousands of Dollars)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	215,090	222,385	229,370	239,805	252,333	261,080	267,875	302,043	337,797	362,015	447,781
Chicago	29,817	30,424	31,712	31,076	31,401	32,979	34,450	35,499	37,883	43,940	54,605
MBTA	22,452	22,354	22,266	22,403	23,593	23,358	24,588	26,448	29,535	35,049	41,800
Toronto	4,336	4,543	4,654	5,577	5,926	6,169	11,221	12,655	14,833	17,021	18,548
SEPTA	13,872	14,582	14,645	13,765	14,343	14,834	15,523	16,661	17,709	19,301	20,628
Montreal							1,399	13,054	13,960	14,510	15,400
PATH	7,510	7,723	9,174	10,132	11,276	12,646	13,085	14,932	17,086	17,819	18,902
Cleveland	2,237	2,269	2,398	2,673	2,935	2,928	3,102	3,124	3,462	4,180	4,473
Lindenwold										3,654	4,342
Shaker Heights	1,211	1,275	1,314	1,325	1,387	1,409	1,471	1,518	1,648	1,680	1,874
Newark		639	624	626	629	675	652	660	744	859	988

Table 6B.3

REVENUE PASSENGERS, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970
(Millions)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	1,348.9	1,359.9	1,383.5	1,356.8	1,383.2	1,354.1	1,262.9	1,302.6	1,305.9	1,343.3	1,257.6
Chicago	112.9	110.1	114.1	111.1	111.2	114.6	117.6	120.7	110.8	103.1	105.6
MBTA	116.7	113.3	104.6	101.3	103.0	100.9	102.8	104.4	110.0	102.2	100.9
Toronto	34.7	33.0	32.9	36.5	38.1	39.7	67.1	75.8	89.2	95.4	98.5
SEPTA	74.5	76.6	72.6	61.6	67.1	66.0	68.4	68.5	70.1	66.0	62.7
Montreal							14.5	91.0	71.4	66.4	65.9
PATH	31.4	31.6	29.2	28.0	28.1	26.4	27.8	30.5	34.8	37.8	39.0
Cleveland	18.3	17.8	17.3	17.0	16.8	16.7	16.6	16.3	16.2	16.5	14.1
Lindenwold										6.0	8.7
Shaker Heights	6.2	6.0	5.8	5.7	5.5	5.5	5.4	5.3	5.2	5.0	4.8
Newark		4.0	3.7	3.7	3.5	3.4	3.5	3.5	3.3	3.8	3.7

Table 6B.4

TOTAL REVENUE PER REVENUE PASSENGER, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970
(Dollars)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	.16	.16	.16	.16	.16	.17	.18	.21	.21	.21	.31
Chicago	.26	.27	.28	.28	.28	.28	.28	.29	.35	.44	.47
MBTA	.18	.19	.22	.23	.24	.24	.24	.27	.27	.32	.31
Toronto	.15	.15	.15	.15	.17	.17	.17	.20	.21	.24	.25
SEPTA	.20	.22	.22	.24	.24	.26	.26	.27	.28	.32	.32
Montreal							.17	.23	.23	.27	.28
PATH	.24	.25	.29	.29	.29	.29	.29	.30	.31	.31	.31
Cleveland[a]	.14	.15	.15	.15	.16	.16	.16	.17	.19	.22	.24
Lindenwold										.47	.48
Shaker Heights	.23	.24	.26	.26	.26	.27	.28	.29	.32	.36	.40
Newark		.15	.15	.15	.16	.19	.19	.19	.23	.24	.29

[a] Total Revenue per Passenger

Table 6B.5

PASSENGER CAR-MILES, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970
(Millions of Car-Miles)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	305.15	300.82	304.14	306.09	314́.30	314.69	302.03	319.73	339.79	344.57	359.82
Chicago	44.63	44.19	43.91	43.82	43.86	44.17	45.44	45.08	44.79	45.62	51.49
MBTA	15.80	15.01	14.74	14.56	14.92	14.63	14.64	14.54	14.29	13.83	13.65
Toronto	7.1	7.0	7.0	9.0	9.5	9.3	17.8	16.4	20.5	22.7	22.7
SEPTA	17.52	16.77	16.28	14.92	15.38	14.78	14.80	14.78	14.62	14.57	14.79
Montreal							4.67	24.21	20.36	19.35	18.37
PATH	5.53	6.11	5.98	6.37	6.23	5.80	7.65	8.67	8.88	9.48	9.25
Cleveland	4.70	4.53	4.53	4.47	4.43	4.26	4.20	4.15	4.07	4.81	4.56
Lindenwold										2.93	3.67
Shaker Heights	1.27	1.27	1.25	1.23	1.25	1.25	1.24	1.23	1.24	1.22	1.23
Newark		.64	.63	.64	.61	.64	.61	.60	.59	.59	.60

Table 6B.6

ACTIVE PASSENGER CARS, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	6,482	6,601	6,516	6,559	6,655	6,707	6,969	6,958	7,080	6,961	6,924
Chicago	1,220	1,176	1,170	1,168	1,234	1,160	1,159	1,158	1,157	1,155	1,246
MBTA	649	636	618	650	643	642	642	642	623	623	718
Toronto	140	140	158	170	170	170	334	334	334	334	334
SEPTA	553	496	496	496	496	493	493	493	493	467	490
Montreal							324	324	324	369	369
PATH	223	223	212	211	211	213	215	253	253	252	252
Clevelan	88	88	88	88	88	88	88	108	.108	106	117
Lindenwold										75	75
Shaker Heights	55	55	55	55	55	55	55	55	55	55	55
Newark		30	30	30	30	30	30	30	30	30	26

Table 6B.7

TOTAL MILES OF SINGLE TRACK, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	837	841	841	841	841	841	841	846	847	842	842
Chicago	204	203	202	202	211	211	211	211	209	243	243
MBTA	150	158	152	151	151	151	151	151	151	151	151
Toronto	13	13	13	18	18	18	46	46	60	60	60
SEPTA	65	65	65	65	65	65	65	65	65	58	58
Montreal							27	33	33	33	33
PATH	21	21	21	21	21	21	21	34	34	35	35
Cleveland	34	34	34	34	34	34	34	34	43	43	43
Lindenwold										34	34
Shaker Heights	30	30	30	30	30	30	30	30	30	30	30
Newark	9	9	9	9	9	9	9	9	9	9	9

Table 6B.8

OPERATING COST[a] PER REVENUE PASSENGER, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970
(Dollars)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	.16	.16	.17	.18	.18	.19	.21	.23	.26	.27	.36
Chicago	.26	.28	.28	.28	.28	.29	.29	.29	.34	.43	.52
MBTA	.19	.20	.21	.22	.23	.23	.24	.25	.27	.34	.41
Toronto	.13	.14	.14	.15	.16	.16	.17	.17	.17	.18	.19
SEPTA	.19	.19	.20	.22	.21	.22	.23	.24	.25	.29	.33
Montreal							.10	.14	.20	.22	.23
PATH	.24	.24	.31	.36	.40	.48	.47	.49	.49	.47	.49
Cleveland	.12	.13	.14	.16	.18	.18	.19	.19	.21	.25	.32
Lindenwold										.60	.50
Shaker Heights	.20	.21	.23	.23	.25	.26	.27	.29	.32	.34	.39
Newark		.16	.17	.17	.18	.20	.18	.19	.23	.23	.27

[a] Total Expenses less Depreciation

Table 6B.9

OPERATING COST PER PASSENGER CAR-MILE, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	.70	.74	.75	.78	.80	.83	.89	.94	.99	1.05	1.24
Chicago	.67	.69	.72	.71	.72	.75	.76	.79	.85	.96	1.06
MBTA	1.42	1.48	1.51	1.54	1.58	1.60	1.68	1.82	2.07	2.53	3.06
Toronto	.61	.65	.67	.62	.63	.66	.63	.77	.72	.75	.82
SEPTA	.79	.87	.90	.92	.93	1.00	1.05	1.13	1.21	1.33	1.39
Montreal							.30	.54	.69	.75	.84
PATH	1.36	1.26	1.53	1.59	1.81	2.18	1.71	1.72	1.92	1.88	2.04
Cleveland	.48	.50	.53	.60	.66	.69	.74	.75	.85	.87	.98
Lindenwold										1.25	1.18
Shaker Heights	.95	1.01	1.05	1.08	1.11	1.13	1.19	1.23	1.33	1.38	1.53
Newark		1.00	1.00	1.00	1.03	1.06	1.07	1.10	1.27	1.45	1.64

Table 6B.10

REVENUE PER PASSENGER CAR-MILE, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	.70	.72	.72	.71	.71	.75	.77	.85	.80	.82	1.09
Chicago	.67	.68	.73	.71	.71	.72	.73	.79	.86	.99	.96
MBTA	1.36	1.47	1.63	1.62	1.65	1.63	1.69	1.91	2.05	2.38	2.31
Toronto	.71	.71	.71	.62	.70	.73	.66	.92	.89	1.03	1.07
SEPTA	.86	.99	.98	.99	1.05	1.14	1.19	1.25	1.32	1.44	1.37
Montreal							.53	.88	.81	.92	.99
PATH	1.39	1.29	1.40	1.27	1.30	1.32	1.04	1.07	1.21	1.23	1.30
Cleveland	.54	.58	.56	.57	.59	.62	.64	.68	..76	.76	.73
Lindenwold										.96	1.14
Shaker Heights	1.11	1.13	1.18	1.18	1.17	1.16	1.21	1.25	1.36	1.49	1.56
Newark		.92	.88	.87	.89	1.00	1.08	1.13	1.27	1.54	1.78

Table 6B.11

REVENUE PASSENGERS PER PASSENGER CAR-MILE, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	4.42	4.52	4.55	4.43	4.40	4.30	4.18	4.07	3.84	3.90	3.49
Chicago	2.53	2.49	2.60	2.53	2.54	2.59	2.59	2.68	2.47	2.26	2.05
MBTA	7.37	7.55	7.09	6.95	6.90	6.89	7.02	7.18	7.70	7.39	7.39
Toronto	4.91	4.70	4.73	4.07	4.02	4.25	3.77	4.62	4.34	4.21	4.34
SEPTA	4.25	4.57	4.46	4.13	4.36	4.47	4.63	4.63	4.79	4.53	4.24
Montreal							3.10	3.76	3.51	3.43	3.59
PATH	5.68	5.17	4.88	4.40	4 52	4.55	3.64	3.52	3.92	3.98	4.21
Cleveland	3.89	3.93	3.82	3.80	3.78	3.91	3.97	3.93	3.98	3.43	3.09
Lindenwold										2.06	2.36
Shaker Heights	4.85	4.77	4.62	4.59	4.45	4.39	4.35	4.28	4.21	4.08	3.94
Newark		6.19	5.91	5.84	5.73	5.41	5.78	5.82	5.61	6.42	6.10

Table 6B.12

ANNUAL REVENUE PASSENGERS PER ACTIVE PASSENGER CAR, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

(Thousands of Dollars)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	208.1	206.0	212.3	206.9	207.8	201.9	181.2	187.2	184.4	193.0	181.6
Chicago	92.6	93.6	97.5	95.1	90.1	98.8	101.4	104.3	95.8	89.2	84.8
MBTA	179.8	178.1	169.3	155.8	160.2	157.2	160.1	162.6	176.6	164.0	140.5
Toronto	247.6	235.7	208.1	214.7	223.9	233.7	200.9	226.9	267.1	285.7	294.9
SEPTA	134.7	154.4	146.4	124.2	135.4	133.9	138.8	138.9	142.2	141.4	127.0
Montreal							44.7	280.8	220.4	179.9	178.5
PATH	141.0	141.5	137.7	132.9	133.3	123.9	129.5	120.6	137.5	149.8	154.6
Cleveland	207.9	202.3	196.8	192.8	190.5	189.3	189.2	150.8	149.7	155.6	120.5
Lindenwold										80.6	115.4
Shaker Heights	112.4	109.8	105.1	102.7	100.7	99.6	97.8	95.8	94.5	90.5	87.8
Newark		131.8	123.5	123.7	116.0	114.8	118.0	116.0	109.3	126.7	141.9

Table 6B.13

ANNUAL PASSENGER CAR-MILES PER ACTIVE PASSENGER CAR, BY RAIL RAPID TRANSIT PROPERTY, 1960 THROUGH 1970

(Thousands)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	47.1	45.6	46.7	46.7	47.2	46.9	43.3	35.9	48.0	49.5	52.0
Chicago	36.6	37.6	37.5	37.5	35.5	38.1	39.2	38.9	38.7	39.5	41.3
MBTA	24.3	24.8	24.6	23.2	23.4	23.5	23.5	23.5	24.2	24.2	21.0
Toronto	50.4	50.1	44.0	52.8	55.7	54.7	53.3	49.2	61.5	68.0	68.0
SEPTA	31.7	33.8	32.8	30.1	31.0	30.0	30.0	30.0	29.7	31.2	30.2
Montreal							14.4	74.7	62.8	52.4	49.8
PATH	24.8	27.4	28.2	30.2	30.0	27.2	35.6	34.3	35.1	37.6	36.7
Cleveland	53.5	51.5	51.5	50.8	50.4	48.4	47.7	38.4	37.6	45.4	39.0
Lindenwold										39.1	48.9
Shaker Heights	23.2	23.0	22.7	22.4	22.7	22.7	22.5	22.4	22.5	22.2	22.2
Newark		21.3	20.9	21.2	20.3	21.2	20.4	19.9	19.5	19.8	23.3

Appendix VIC

ADJUSTMENT OF COSTS FOR WAGE DIFFERENTIALS

Appendix VIC

ADJUSTMENT OF COSTS FOR WAGE DIFFERENTIALS

The tables in this Appendix illustrate the procedure for adjusting cost (operating expenses) per car-mile and cost per passenger for differences in wage rates among the various cities. The wage rates are the maximum hourly rates for rail rapid transit motormen. It is assumed that wage rates for other classifications of rail rapid transit employees have the same relationships.

Table 6C.1 shows the wage rates as of July 1, 1968 and July 1, 1970. The information was obtained from different sources. Wage rates for Lindenwold and Shaker Heights were assumed to be the same as for SEPTA and Cleveland, respectively. Those of PATH were assumed to be the same as for New York. Note that the indexes show about the same relationship in each year. For this reason, the 1970 index was used to adjust both the 1969 and 1970 cost ratios. Each ratio was divided by the index for the property.

A similar procedure was used for 1960 (see Table 6C.3). Because wage rates were not available for Toronto, it was assumed that its rates bore the same relationship to those of U.S. systems as they did in 1970, i.e., slightly below the lowest U.S. figure.

In addition to wage-rate differentials, there are important differences in employee benefits, payments for split-shift work schedules, etc., that were not included in these adjustments.

Table 6C.1

ADJUSTMENT OF COST PER CAR-MILE FOR WAGE-RATE DIFFERENTIALS, 1969 AND 1970

Property	July 1, 1968		July 1, 1970		Cost per Car-Mile (dollars)			
					Actual		Adjusted	
	Wage Rate[a]	Index (New York = 1.0)	Wage Rate[b]	Index (New York = 1.0)	1969	1970	1969	1970
New York	4.21	1.0000	4.82	1.0000	1.05	1.24	1.05	1.24
Chicago	3.66	.8693	4.17	.8651	.96	1.06	1.11	1.23
MBTA	3.83	.9097	4.11	.8526	2.53	3.06	2.97	3.59
Toronto	3.00	.7125	3.53	.7323	.75	.82	1.02	1.12
SEPTA	3.26	.7743	3.81	.7904	1.31	1.38	1.66	1.75
Montreal	3.10	.7363	3.45	.7157	.75	.84	1.05	1.17
PATH	4.21	1.0000	4.82	1.0000	1.88	2.04	1.88	2.04
Cleveland	3.28	.7790	3.46	.7178	.87	.98	1.21	1.37
Lindenwold	3.26	.7743	3.81	.7904	1.25	1.18	1.58	1.49
Shaker Heights	3.28	.7790	3.46	.7178	1.38	1.53	1.92	2.13
Newark	3.66	.8693	4.00	.8298	1.45	1.64	1.75	1.98

Sources: a. U.S. Department of Labor, Union Wages and Hours: Local-Transit Operating Employees, July 1, 1968 (Bulletin No. 1620).

b. American Transit Association.

Table 6C.2

ADJUSTMENT OF COST PER PASSENGER FOR WAGE-RATE DIFFERENTIALS, 1969 AND 1970

Property	July 1, 1970 Index New York = 1.0	Actual Cost per Passenger (Dollars)		Adjusted Cost per Passenger (Dollars)	
		1969	1970	1969	1970
New York	1.0000	.27	.36	.27	.36
Chicago	.8651	.43	.52	.50	.60
MBTA	.8526	.34	.41	.40	.48
Toronto	.7323	.18	.19	.25	.26
SEPTA	.7904	.29	.33	.37	.42
Montreal	.7157	.22	.23	.31	.32
PATH	1.0000	.47	.49	.47	.49
Cleveland	.7178	.25	.32	.35	.45
Lindenwold	.7904	.60	.50	.76	.63
Shaker Heights	.7178	.34	.39	.47	.54
Newark	.8298	.23	.27	.28	.33

Table 6C.3

ADJUSTMENT OF COST PER CAR-MILE AND PER PASSENGER FOR DIFFERENTIAL WAGE RATES, 1960

Property	July 1, 1960		Cost per Car-Mile (Dollars)		Cost per Passenger (Dollars)	
	Wage Rate (dollars)	Index (N. Y. = 1.0)	Unadjusted	Adjusted	Unadjusted	Adjusted
New York	2.630	1.0000	.70	.70	.16	.16
Chicago	2.436	.9262	.67	.72	.26	.28
MBTA	2.478	.9422	1.42	1.51	.19	.20
Toronto		.8000[a]	.61	.76	.13	.16
SEPTA	2.230	.8479	.78	.92	.19	.22
PATH	2.630	1.0000	1.36	1.36	.24	.24
Cleveland	2.230	.8479	.48	.57	.12	.14
Shaker Heights	2.230	.8479	.95	1.12	.20	.24
Newark	2.300	.8745	1.00[b]	1.14	.16[b]	.18

[a]Assumed to bear about the same relationship to the New York system as in 1970.

[b]Assumed to be same as 1961.

Source of Wage Rates: U.S. Department of Labor, Union Wages and Hours: Local-Transit Operating Employees, July 1, 1960.

CHAPTER VII

U. S. COMMUTER RAILROAD OPERATIONS

by

Norman J. Asher

SUMMARY

Commuter railroads are railroads that have daily passenger service designed to haul passengers between cities, towns, and villages outside metropolitan areas and points within the areas. The service is usually oriented around the work trip.

An analysis of 14 of the 16 railroads in the United States that provide commuter service indicates that, in 1970, commuter passenger service was a money-losing operation. When income and expenses from all sources are considered, 12 of the 14 railroads registered net deficits. The overall deficit for the 14 railroads amounted to about $36 million. The aggregate operating deficit [1] amounted to $41 million (about $212 million expenses and $171 million revenues). Only 3 of the 14 companies achieved operating profits: Burlington Northern, Chicago Northwestern, and Illinois Central, all in the Chicago area.

The analysis of figures on revenue and cost per passenger-mile indicates that the various railroads incur operating deficits or profits for different reasons. Some railroads have both high revenue and costs per passenger-mile. Others have low revenue and high cost per passenger-mile. The three profitable railroads had the lowest unit costs but also below average revenue per passenger-mile.

These variations in the reasons for deficits imply that the remedies to the financial condition of the railroads are probably specific to the railroad. Some may require reductions in operating cost; while others may require stimulation on the revenue side. Still others may require improvements on both sides of the operation.

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1. Revenue from passenger operations minus operating expenses.

Trends in patronage from 1960 to 1970 are presented for the five cities having important commuter operations (New York, Chicago, Philadelphia, Boston, and San Francisco). After a drop from 142 million passengers in 1960 to 126 million in 1965, New York's patronage has remained stable at about the 126 to 128 million level. Chicago and Philadelphia have experienced increases in patronage. The former increased from 62 million in 1960 to 68 million in 1970. The latter increased from 24 million to 35 million over the same period. The ridership in Boston decreased from about 13 million to about 11 million, and in San Francisco from about 7 to about 6 million.

Interstate Commerce Commission data for the period 1964 to 1970 show that, in general, passengers, passenger revenue, and passenger-miles have increased over that period. The average trip length remained stable at about 22 miles. Nearly all railroads experienced an increase in revenue per passenger (average fare); the average increase for all railroads was about 20 percent over the 1964 to 1970 time period. Revenue per passenger-mile also increased at about the same rate.

A. INTRODUCTION

1. DEFINITION

Commuter railroad operations differ from rail rapid transit operations in several respects. First, the commuter operation is designed to haul passengers to and from cities, towns, and villages some distance outside large metropolitan areas. For this reason the trip length is somewhat longer (averaging about 22 miles) than for rail rapid transit operations. Second, the passenger cars used are usually heavier than those used by rapid transit. Third, the operations are run by railroad companies as part of their overall passenger and freight service. In terms of management, they are not regarded as part of the metropolitan rapid transit systems.

2. NATURE OF THE DATA

At the outset, it should be pointed out that reliable data in this field are difficult to find because commuter services are intermixed with the other railroad operations.

The "commuter" railroads carry not only "commuters" (passengers going to work in the morning and home in the evening) but other passengers as well (housewives on shopping trips, theater goers, etc.). The railroads report "commutation and multiple-ride passengers" to the Interstate Commerce Commission (ICC). These are passengers riding on commuter or multiple-ride tickets. However, many "commuter" railroad passengers pay regular fares, so that in many cases the actual number of commuter railroad passengers is greater than the ICC figures would indicate. The railroads appear to vary in this respect. In some cases, the ICC figures seem to be very nearly equal to the total number of passengers; in other cases they cover only about half the total passenger traffic.

Another problem arises where railroads provide commuter services to more than one city. Since railroads report to the ICC only on a system-wide basis, their commuter traffic must be allocated among cities when more than one city is served.

The actual cost of commuter service is also difficult to establish. The commuter services are generally intermixed with freight service and regular intercity passenger service. The allocation of total costs among these services is quite difficult and arbitrary.

Because of the problems noted above, we have attempted to locate many sources of data, correlate them, and present our best estimates of the actual figures for commuter railroad operations. The sources of the data are clearly indentified to facilitate further research.

3. ORGANIZATION OF THE SECTION

The remainder of this section is arranged into three subsections. Subsection B contains a detailed analysis of the financial operations of 14 commuter railroads for the year 1970. The data were provided by the Association of American Railroads (AAR). Subsection C presents "best estimates" of trends in commuter railroad patronage in the five cities in the United States with important levels of rail commuter service. The estimates were derived from a variety of sources, including the ICC. Finally, Subsection D contains an analysis of data on commuter railroad operations for the period 1964-1970. The data were provided by the ICC and have the advantage of consistency of definition.

Taken together, the three subsections provide a general idea of the nature and extent of the operations during the 1960-1970 time frame.

B. COMMUTER RAILROAD OPERATIONS IN 1970

1. NET INCOME

When all sources of revenue and expense are taken into consideration, commutation passenger service in 1970 was generally a money-losing operation. Table 7.1 shows that the aggregate deficit for 14 commuter railroads amounted to about $35.7 million and only 2 of the 14 registered a net profit.[1] The table also shows, however, that there was a great deal of variation in nonoperating revenue and in interest and depreciation charges.

2. NET OPERATING REVENUE

A better measure of the financial results of actual operations appears in Table 7.2. Here, operating expenses (which exclude depreciation and interest on equipment obligations) have been subtracted from revenue generated from commuter passengers. This yields net operating revenue. In addition, the "operating ratio" has been calculated by dividing operating expenses by commuter passenger revenue. Note that only three railroads--all of them serving the Chicago area--yielded a net operating profit in 1970. Moreover, the operating deficit for all 14 railroads was over $41 million.

3. REVENUE AND COST RATIOS

The relative performance of the railroads in terms of revenue and cost ratios is compared in Table 7.3. The first two columns

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1. Data for Penn Central and Pennsylvania-Reading Seashore Lines were not complete and are excluded from the analysis.

Table 7.1

SUMMARY OF COMMUTER RAILROAD OPERATIONS, BY RAILROAD, 1970
(All Figures in Thousands)

Railroad	Income				Expenses				Net Income	Commuter Passengers	Commuter Passenger Miles
	Total	Commuter Passenger Revenue	Revenue From State & Local Government	Other Income	Total	Operating Expenses	Interest on Equipment Obligations	Depreciation			
Boston and Maine	9,373	5,260	4,113	0	9,353	8,747	16	590	20	5,556	91,951
Burlington Northern	6,275	6,227	0	48	7,005	5,872	162	971	-730	9,726	173,654
Central of New Jersey	8,675	4,166	4,409	100	9,291	8,392	648	251	-616	6,516	123,758
Chicago, Milwaukee, St. Paul, and Pacific	4,968	4,956	0	12	5,955	5,194	218	543	-987	5,954	134,261
Chicago Northwestern	21,149	21,036	0	113	19,237	15,196	1,280	2,761	1,912	25,046	523,966
Chicago, Rock Island, and Pacific	4,289	4,264	0	25	5,824	5,132	283	409	-1,535	6,197	99,697
Chicago, South Shore, and South Bend	3,441	3,442	0	-1	5,238	5,092	0	146	-1,797	2,682	81,058
Erie Lackawanna	16,572	10,872	5,000	700	19,025	19,025	0	[a]	-2,453	15,839	325,217
Illinois Central	11,025	11,006	0	19	11,315	10,870	0	445	-290	18,785	310,241
Long Island	85,189	85,189	0	0	108,523	103,250	0	5,273	-23,334	70,069	1,760,614
Pittsburgh and Lake Erie	97	55	0	42	626	599	0	27	-529	69	1,497
Reading Company	13,716	9,016	4,700	0	16,473	15,183	717	573	-2,757	13,699	195,405
Southern Pacific	4,124	4,001	0	123	6,777	5,767	156	854	-2,653	5,826	144,429
Staten Island Rapid Transit	3,640	1,077	2,549	14	3,640	3,504	45	91	0	4,657	39,022
Total, 14 Railroads	192,533	170,567	20,771	1,195	228,282	211,823	3,525	12,934	-35,749	190,621	4,004,770

[a] Equipment is being retired and replaced by the State of New Jersey.

Source: Association of American Railroads.

Table 7.2

NET OPERATING REVENUE AND OPERATING RATIO, BY RAILROAD, 1970

(Dollar Figures in Thousands)

Railroad	Commuter Passenger Revenue	Operating Expenses[a]	Net Operating Revenue	Operating Ratio
Boston and Maine	5,260	8,747	-3,487	1.66
Burlington Northern	6,227	5,872	355	.94
Central of New Jersey	4,166	8,392	-4,226	2.01
Chicago, Milwaukee, St. Paul, and Pacific	4,956	5,194	-238	1.04
Chicago Northwestern	21,036	15,196	5,840	.72
Chicago, Rock Island, and Pacific	4,264	5,132	-868	1.20
Chicago, South Shore, and South Bend	3,442	5,092	-1,650	1.47
Erie Lackawanna	10,872	19,025	-8,153	1.74
Illinois Central	11,006	10,870	136	.98
Long Island	85,189	103,250	-18,061	1.21
Pittsburgh and Lake Erie	55	599	-544	10.89
Reading Company	9,016	15,183	-6,167	1.68
Southern Pacific	4,001	5,767	-1,766	1.44
Staten Island Rapid Transit	1,077	3,504	-2,427	3.25
Total, 14 Railroads	170,567	211,823	-41,256	1.24

[a] Excludes Depreciation and Interest on Equipment Obligations.

Table 7.3

SELECTED REVENUE AND COST RATIOS, BY RAILROAD, 1970

(All Figures in Dollars)

Railroad	Passenger Revenue Per Passenger	Operating Cost Per Passenger	Passenger Revenue Per Passenger-Mile	Operating Cost Per Passenger-Mile
Boston and Maine	.95	1.57	.0572	.0951
Burlington Northern	.64	.60	.0358	.0338
Central of New Jersey	.64	1.29	.0336	.0678
Chicago, Milwaukee, St.Paul, and Pacific	.83	.87	.0369	.0386
Chicago Northwestern	.84	.61	.0401	.0290
Chicago, Rock Island, and Pacific	.69	.83	.0427	.0514
Chicago, South Shore, and South Bend	1.28	1.90	.0424	.0628
Erie Lackawanna	.68	1.20	.0334	.0584
Illinois Central	.59	.58	.0354	.0350
Long Island	1.22	1.47	.0483	.0586
Pittsburgh and Lake Erie	.80	8.68	.0367	.4001
Reading Company	.66	1.11	.0461	.0777
Southern Pacific	.69	.99	.0277	.0399
Staten Island Rapid Transit	.23	.75	.0275	.0897
Average for 14 railroads	.89	1.11	.0425	.0528

indicate that there is considerable variation in passenger revenue per passenger (average fare) and even more variation in operating cost per passenger. These variations can be caused by differences in trip length, fare structure, relative efficiency, passenger load factor, and other aspects of the operation. Adjustment for trip length can be made by placing revenue and costs in terms of passenger-miles as shown in the last two columns of Table 7.3. Here it becomes clear that passenger revenue per passenger-mile is much more uniform than operating cost per passenger-mile. The former ranges from $.0275 to $.0572, with an average of $.0425. The range of the latter is $.0290 to $.4001 with an average of $.0528. Even without the Pittsburgh and Lake Erie Railroad, the range of cost per passenger-mile is much greater than that of passenger revenue per passenger-mile.

The two columns also indicate that the various railroads incur operating deficits or profits for different reasons. To give some illustrations: The Boston and Maine had the highest passenger revenue per passenger-mile ($.0572); however, the railroad's operating cost was next to the highest ($.0951). At $.0358, the Burlington Northern[2] had below average revenue per passenger-mile, but it managed to keep its cost per passenger-mile even lower($.0338) and was able to make a profit. The key to the Chicago Northwestern's success was obviously its low cost per passenger-mile ($.0290); for its revenue per passenger-mile ($.0401) was somewhat below the average for the group. Finally, the Southern Pacific had below average cost per passenger-mile ($.0399), but its revenue per passenger-mile ($.0277) was next to the lowest of the group and was not large enough to cover costs.

The illustrations imply that the remedies to the financial condition of the railroads are probably specific to the railroad.

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2. The Burlington Northern was formed in early 1971 by the merger of the Chicago, Burlington, and Quincy and the Great Northern. The commuter data reflects the Chicago-area commuter operations of the predecessor Chicago, Burlington and Quincy.

Some may require reductions in operating cost; while others may require stilmulation on the revenue side. Still others may require improvements in both the revenue and cost side of the operation.

4. DISTRIBUTION OF OPERATING EXPENSES

Tables 7.4 and 7.5 present the dollar and percentage distribution respectively, of operating expenses according to certain expense categories. Transportation Expense refers to all expenses having to do with the actual movement of people and equipment. Traffic Expense refers to expenses associated with setting fares, scheduling, ticketing, advertising, etc. The other categories are self-explanatory.

Table 7.5 shows that in 1970 Transportation Expense for the 14 railroads represented over 52 percent of Total Operating Expenses. Maintenance of Equipment and Maintenance of Way represent about 21 percent and 11 percent, respectively. There is considerable variation in the percentages for these three categories, and there does not appear to be a specific pattern associated with failure or success in obtaining operating profits. The three railroads that had operating profits for 1970--Burlington Northern , Chicago Northwestern, and Illinois-Central--have somewhat different distributions. Moreover, other railroads that had deficits have a variety of distributions, some of which are similar to the successful railroads.

Table 7.4

BREAKDOWN OF OPERATING EXPENSES, BY EXPENSE CATEGORY AND BY RAILROAD, 1970

(Thousands of Dollars)

Railroad	Total Operating Expenses	Trans-portation	Maintenance of Way	Maintenance of Equipment	Traffic	Non-Income Tax Payments	Other
Boston and Maine	8,747	5,076	435	1,961	34	1,071	170
Burlington Northern	5,872	3,295	575	950	114	581	357
Central of New Jersey	8,392	5,134	817	1,104	56	771	510
Chicago, Milwaukee, St. Paul, and Pacific	5,194	2,635	214	592	24	207	1,522
Chicago Northwestern	15,196	8,382	1,216	2,913	254	1,434	997
Chicago, Rock Island, and Pacific	5,132	2,799	299	1,188	36	491	319
Chicago, South Shore, and South Bend	5,092	2,140	672	737	60	409	1,074
Erie Lackawanna	19,025	9,010	3,090	5,205	62	a	1,658
Illinois Central	10,870	5,673	1,248	1,686	122	1,447	694
Long Island	103,250	52,578	13,230	24,420	338	6,022	6,662
Pittsburgh and Lake Erie	599	412	38	41	2	65	41
Reading Company	15,183	8,368	1,436	2,658	352	1,440	929
Southern Pacific	5,767	3,607	310	1,248	43	488	71
Staten Island Rapid Transit	3,504	1,634	282	584	11	748	245
Total, 14 Railroads	211,823	110,743	23,862	45,287	1,508	15,174	15,249

[a] Included in other categories.

Source: Association of American Railroads.

Table 7.5

PERCENTAGE DISTRIBUTION OF OPERATING EXPENSES, BY EXPENSE CATEGORY AND BY RAILROAD, 1970

Railroad	Total Operating Expenses	Transpor-tation	Mainte-nance of Way	Mainte-nance of Equipment	Traffic	Non-Income Tax Payments	Other
Boston and Maine	100.0	58.0	5.0	22.4	0.4	12.2	1.9
Burlington Northern	100.0	56.1	9.8	16.2	1.9	9.9	6.1
Central of New Jersey	100.0	61.2	9.7	13.2	0.7	9.2	6.1
Chicago, Milwaukee, St. Paul, and Pacific	100.0	50.7	4.1	11.4	0.5	4.0	29.3
Chicago Northwestern	100.0	55.2	8.0	19.2	1.7	9.4	6.6
Chicago, Rock Island, and Pacific	100.0	54.5	5.8	23.1	0.7	9.6	6.2
Chicago, South Shore, and South Bend	100.0	42.0	13.2	14.5	1.2	8.0	21.1
Erie Lackawanna	100.0	47.4	16.2	27.4	0.3	a	8.7
Illinois Central	100.0	52.2	11.5	15.5	1.1	13.3	6.4
Long Island	100.0	50.9	12.8	23.7	0.3	5.8	6.4
Pittsburgh and Lake Erie	100.0	68.8	6.3	6.8	0.3	10.9	6.8
Reading Company	100.0	55.1	9.5	17.5	2.3	9.5	6.1
Southern Pacific	100.0	62.5	5.4	21.6	0.7	8.5	1.2
Staten Island Rapid Transit	100.0	46.6	8.0	16.7	0.3	21.3	7.0
Total, 14 Railroads	100.0	52.3	11.3	21.4	0.7	7.2	7.2

[a] Included in other categories.

C. TRENDS IN PATRONAGE

In this subsection an attempt is made to provide "best estimates" of commuter railroad patronage for the period 1960-1970. The data are arranged by railroad according to the five major cities in the United States with important levels of rail commuter service. In descending order of number of passengers, they are: New York, Chicago, Philadelphia, Boston, and San Francisco. Some other cities, such as Washington, D.C, have limited commuter service but the volumes are far less than for the five cities noted above, and they have not been considered in this paper. The sources of the data are given in the tables presenting the details for each city. In addition, the ICC data of Table 7.11 and the Association of American Railroads data from Table 7.1 were used. Appendix VIIA discusses the problems of definition involved in deriving these "best estimates."

1. SUMMARY BY CITY

Table 7.6 summarizes the number of annual commuter rail passengers, by city, from 1960 to 1970. Total traffic declined about 6 percent from 1960 to 1965, and then increased so that by 1968 it was back to the 1960 level. From 1968 through 1970 it remained virtually constant. The drop in traffic from 1960 to 1965 was due almost entirely to the decrease in New York traffic. Since 1965, New York traffic has been quite constant, while traffic in Chicago and Philadelphia has increased.

2. NEW YORK CITY

Table 7.7 shows the breakdown of New York City passengers, by railroad. The Pennsylvania and New York Central railroads merged

Table 7.6

COMMUTER RAIL PASSENGERS BY CITY
(Annual Passengers in Millions)

City	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York	142	140	134	131	129	126	126	127	128	127	128
Chicago	62	62	60	60	61	62	64	67	70	72	68
Philadelphia	24	24	24	26	27	28	29	31	33	33	35
Boston	13	11	11	13	12	11	12	11	11	11	11
San Francisco	7	7	7	7	7	7	7	7	7	6	6
TOTAL	248	244	236	237	236	234	238	243	249	249	248

Source: Derived from data supplied by all available sources.

Table 7.7

NEW YORK CITY COMMUTER RAIL PASSENGERS BY RAILROAD
(Annual Passengers in Millions)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Central of New Jersey	6	6	6	6	6	6	6	6	6	6	6
Erie Lackawanna	16	16	15	15	14	14	13	13	14	15	16
Long Island	69	68	66	64	63	61	62	63	63	61	61
New York, New Haven & Hartford/Penn Central	21	21	19	19	19	18	18	18	18	18	18
New York Central/ Penn Central	22	22	21	20	20	20	20	20	20	20	20
Pennsylvania/ Penn Central	8	7	7	7	7	7	7	7	7	7	7
TOTAL	142	140	134	131	129	126	126	127	128	127	128

Sources:
1. Report prepared for the Committee on Interstate and Foreign Commerce, U.S. Senate, Commuter Transportation: A Study of Passenger Transportation in the New Jersey-New York-Connecticut Metropolitan Region with Particular Reference to Railroad Commutation. (Washington, D.C., 1961.)
2. New Jersey State Highway Department Division of Railroad Transportation, The Erie Lackawanna Railroad Company and Suburban Passenger Service in New Jersey. (March 1965.)
3. First National City Bank, Public Transportation in the New York Region. (New York, November.)
4. Metropolitan Transportation Authority, Annual Report. (New York, 1967.)
5. Donald S. Berry, et al, The Technology of Urban Transportation. (The Transportation Research Center, Northwestern University, 1963.)
6. Stanford Research Institute, U.S. Passenger Transportation: An Inventory of Resources and an Analysis of Capabilities of Surface Modes. (Menlo Park, California, March 1967.)

in February 1968, and the Penn Central took over the New York, New Haven, and Hartford on December 31, 1968. The number of passengers for the Penn Central is allocated to its original component railroads after their incorporation into the Penn Central.

Table 7.7 indicates that total number of passengers in New York City decreased significantly from 1960 to 1964 and since then has remained at about the same level. The number of passengers decreased from 1960 to 1970 on all railroads except the Central of New Jersey and the Erie and Lackawanna.

3. CHICAGO

Table 7.8 shows the breakdown of Chicago passengers by railroad. Total passengers declined slightly from 1960 through 1963, but then increased by about 20 percent through 1969, due in large part to the growth in passengers on the Chicago Northwestern. However, in 1970, the total number of passengers dropped again to approximately the 1967 level.

In addition to the six railroads listed in the table, the Pennsylvania; Norfolk and Western; and Gulf, Mobile and Ohio railroads carry small numbers of passengers on commuter lines into Chicago. However, they have been omitted because the volumes of passengers on these three lines are so small compared with the other Chicago commuter railroads.

4. PHILADELPHIA

Table 7.9 shows the breakdown of Philadelphia passengers by railroad. The Southeastern Pennsylvania Transportation Authority (SEPTA) provides subsidy payments to the two railroads to stimulate rail commuter service in the Philadelphia area. As a result of this subsidy program (started under the Passenger Service Improvement Corporation and administered by SEPTA since 1964) the number of passengers increased by almost 50 percent from 1960 to 1970. These data (except for 1970) are all taken from SEPTA annual reports and are believed to be of high quality.

Table 7.8

CHICAGO COMMUTER RAIL PASSENGERS BY RAILROAD
(Annual Passengers in Millions)

Railroad	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Chicago, Burlington & Quincy	9	9	9	9	9	9	9	9	10	10	10
Chicago, Milwaukee, St. Paul & Pacific	4	4	4	5	5	5	5	6	6	6	6
Chicago Northwestern	18	19	19	20	21	21	23	24	25	26	25
Chicago, Rock Island, and Pacific	7	7	7	6	6	6	6	6	6	7	6
Chicago, South Shore & South Bend	4	4	3	3	3	3	3	3	3	3	3
Illinois Central	20	19	18	17	17	18	18	19	20	20	18
TOTAL	62	62	60	60	61	62	64	67	70	72	68

Sources:
1. Institute for Rapid Transit, Rail Passenger Service in the Chicago Metropolitan Area. (Second Edition, December 1965.)
2. Southward Transit Area Coordination Study. Prepared for the Illinois Department of Public Works and Buildings in Cooperation with the Southward Transit Area Coordination Committee. (Chicago, December 1970.)
3. Chicago Area Transportation Study. Volume I Survey Findings, (December 1959); Volume II Data Projections, (July 1960.)
4. Automotive Safety Foundation, Urban Transit Development in Twenty Major Cities. (Washington, D. C., 1967.)
5. National Capital Transportation Agency, Office of Finance, United States Rapid Transit Systems. (Washington, D.C., October 1963.)
6. National Capital Transportation Agency, Office of Public Information and Community Services, United States Rapid Transit Systems. (Washington, D.C., September 1965.)
7. Donald S. Berry, et al, The Technology of Urban Transportation. (The Transportation Research Center, Northwestern University, 1963.)
8. Stanford Research Institute, U.S. Passenger Transportation: An Inventory of Resources and an Analysis of Capabilities of Surface Modes. (Menlo Park, California, March 1967.)

Table 7.9

PHILADELPHIA COMMUTER RAIL PASSENGERS BY RAILROAD
(Annual Passengers in Millions)

Railroad	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Pennsylvania/ Penn Central	14	14	14	15	16	17	18	18	20	20	21
Reading	10	10	10	11	11	11	11	13	13	13	14
TOTAL	24	24	24	26	27	28	29	31	33	33	35

Source: Southeastern Pennsylvania Transportation Authority, Annual Reports. (1964, 1965, 1966, 1967, 1968, 1969.)

5. BOSTON

The breakdown of Boston passengers, by railroad, appears in Table 7.10. The total number of passengers has declined somewhat from 1960 to 1970.

The report by the Boston Redevelopment Authority contains excellent data, by year, from 1960 through 1967. Unfortunately, the Authority does not plan to publish later editions of this report. Accordingly, the figures after 1967 were projected using ICC data. After 1967, the figures become progressively less accurate, but they should be fairly accurate over this relatively short extrapolation time period.

Table 7.10

BOSTON COMMUTER RAIL PASSENGERS BY RAILROAD
(Annual Passengers in Millions)

Railroad	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Boston & Maine	7	6	6	8	7	6	7	6	6	6	6
New York, New Haven, & Hartford/Penn Central	5	4	4	4	4	4	4	4	4	4	4
New York Central/ Penn Central	1	1	1	1	1	1	1	1	1	1	1
TOTAL	13	11	11	13	12	11	12	11	11	11	11

Sources: 1. 1960-1967, Boston Redevelopment Authority, Transportation Facts for the Boston Region, 1968/1969 Edition. (Boston, August 1968.)

2. 1968-1970, Interstate Commerce Commission.

6. SAN FRANCISCO

All of the commuter rail passengers to San Francisco are carried by one railroad, the Southern Pacific. Therefore, the figures in Table 7.6 are for that railroad and are not repeated here. Note that through 1968 the (rounded) figures were constant at 7 million passengers per year, but the 1969 and 1970 levels were at 6 million.

The following are the sources for the San Francisco data:

1. Stanford Research Institute, U.S. Passenger Transportation: An Inventory of Resources and an Analysis of Capabilities of Surface Modes. (Menlo Park, California, March 1967.)

2. Automotive Safety Foundation, Urban Transit Development in Twenty Major Cities. (Washington, D.C. 1967.)

3. Wolfgang S. Homburger, Urban Mass Transit Planning. Institute of Transportation and Traffic Engineering, University of California. (Berkeley, California, 1967.)

D. OPERATING TRENDS 1964-1970

The remainder of this section presents commuter rail operating data provided by the Interstate Commerce Commission. The figures have the advantage of consistency, but there are some problems of definition, as discussed below.

1. NATURE OF THE DATA

The railroads report to the ICC three items of information on "commutation and multiple ride passengers": number of revenue passengers carried, passenger revenue, and number of revenue passenger-miles. Note that all these data pertain to passengers riding on commuter or multiple-ride tickets. However, many "commuter" railroad passengers pay regular fares, so that, in many cases, the actual number of commuter railroad passengers is greater than the ICC figures would indicate. The railroads appear to vary in this respect. In some cases, the ICC figures seem to be very nearly equal to the total number of passengers; in other cases they cover only about half the total passenger traffic. Accordingly, the ICC figures differ from those of Section B, which were obtained from the AAR, and those of Section C, which are "best estimate" traffic figures based on all available sources.

The basic data are reported on ICC Form OS-B. Unfortunately, data prior to 1964 were not available.

2. REVENUE PASSENGERS

Table 7.11 shows the trend in commuter revenue passengers for each railroad and the total for all railroads. There is little uniformity in the trend of number of passengers among the railroads; on some railroads, commuter passenger traffic increased

Table 7.11

ANNUAL COMMUTER RAIL REVENUE PASSENGERS
(Millions)

Railroad	1964	1965	1966	1967	1968	1969	1970
Boston & Maine	4.6	3.9	3.6	3.9	3.8	3.6	3.8
Central of New Jersey	4.1	3.9	3.5	3.6	3.5	3.9	4.0
Chicago, Burlington, Quincy	9.2	8.8	9.2	9.4	9.6	9.7	9.7
Chicago, Milwaukee, St. Paul & Pacific	4.8	5.0	5.2	5.6	5.9	6.0	6.0
Chicago Northwestern	20.5	21.4	22.7	24.3	25.0	25.7	25.4
Chicago, Rock Island & Pacific	6.0	5.7	5.8	6.2	6.5	6.6	6.2
Erie Lackawanna	11.2	10.8	10.5	10.0	11.1	12.0	12.5
Illinois Central	16.9	18.1	18.2	19.2	20.4	20.2	18.3
Long Island	55.0	53.8	55.0	55.7	55.1	53.3	53.5
New York, New Haven & Hartford	13.7	13.2	13.1	13.2	13.1	-	-
New York Central	16.1	16.0	16.4	16.8[a]	-	-	-
Pennsylvania/Penn Central	19.0	18.8	19.2	18.8	36.5	54.0	54.0
Reading Company	5.8	5.7	5.4	5.7	5.9	6.1	6.2
Southern Pacific	5.9	5.9	5.9	5.8	5.4	5.4	5.2
Total, All Railroads	192.8	190.9	193.7	198.1	201.9	206.6	204.6

a. Estimated.

Source: Derived from data supplied by the Interstate Commerce Commission.

Table 7.12

ANNUAL COMMUTER RAIL PASSENGER REVENUE
(Millions of Dollars)

Railroad	1964	1965	1966	1967	1968	1969	1970
Boston & Maine	2.7	2.4	2.4	2.6	2.9	3.0	3.3
Central of New Jersey	3.4	3.2	2.9	2.4	2.1	2.3	2.4
Chicago, Burlington, Quincy	4.6	4.8	5.0	5.2	5.7	5.9	6.1[a]
Chicago, Milwaukee, St. Paul, & Pacific	3.7	3.9	4.0	4.3	4.7	5.0	4.9
Chicago Northwestern	14.6	15.2	16.1	17.1	18.4	19.4	20.2
Chicago, Rock Island, & Pacific	3.6	3.8	3.8	4.1	4.3	4.5	4.2
Erie Lackawanna	7.4	7.2	7.0	6.8	7.5	8.2	8.6
Illinois Central	8.4	8.9	8.8	9.4	10.0	10.1	10.5
Long Island	42.0	43.7	45.0	46.0	50.0	50.2	56.4
New York, New Haven, & Hartford	12.8	12.5	12.7	12.9	13.2	-	-
New York Central	12.3	12.8	13.3	13.8[a]	-	-	-
Pennsylvania/Penn Central	11.5	11.4	11.7	12.3	27.5	45.4	47.3
Reading Company	2.6	2.6	2.9	3.1	3.3	3.6	3.8
Southern Pacific	2.8	2.8	2.8	2.9	3.1	3.1	3.1
Total, All Railroads	132.4	135.2	138.4	142.9	152.2	160.7	170.8

a. Estimated.

Source: Derived from data supplied by the Interstate Commerce Commission.

while on others it decreased. The total for the 14 railroads increased about 6 percent from 1964 to 1970.

3. PASSENGER REVENUE

Table 7.12 shows the trend in commuter passenger revenue for each railroad and the total for all railroads. Passenger revenue increased on all railroads except the Central of New Jersey. The total for the 14 railroads increased by 29 percent from 1964 to 1970.

4. REVENUE PASSENGER-MILES

Table 7.13 shows the trend in commuter passenger-miles for each railroad and the total for all railroads. As in the case of revenue passengers, there is little uniformity in the trend of passenger-miles among the railroads. The total for the 14 railroads increased about 9 percent from 1964 to 1970.

5. AVERAGE TRIP LENGTH PER PASSENGER

Table 7.14 shows the trend in average trip length per passenger for each railroad, and the weighted average for all railroads. The trip length figure has remained fairly constant for most of the railroads. The figure for the Penn Central increased after the merger with the New York Central and the take-over of the New York, New Haven, and Hartford. The Central of New Jersey evidently dropped some of its longer runs since its miles per passenger dropped significantly. Over this period, the miles per passenger varied from a minimum of 14 for the Reading to a maximum of 28 for the Central of New Jersey. The weighted average for all railroads remained constant at about 22 miles.

6. REVENUE PER PASSENGER

Table 7.15 shows the trend in revenue per passenger for each railroad, and the weighted average for all railroads. This figure

Table 7.13

ANNUAL COMMUTER RAIL REVENUE PASSENGER-MILES
(Millions)

Railroad	1964	1965	1966	1967	1968	1969	1970
Boston & Maine	85.2	65.5	63.2	66.4	64.1	62.2	64.3
Central of New Jersey	114.6	109.9	98.2	83.1	76.0	84.0	86.8
Chicago, Burlington, Quincy	156.4	150.7	157.3	161.9	165.0	168.4	171.8[a]
Chicago, Milwaukee, St. Paul, & Pacific	108.8	113.5	119.2	126.7	132.9	135.4	134.2
Chicago Northwestern	437.0	453.0	485.0	509.9	517.4	534.9	524.0
Chicago, Rock Island, & Pacific	90.3	86.1	87.9	95.1	99.4	103.1	99.6
Erie Lackawanna	275.2	215.3	212.0	205.3	228.4	247.1	261.9
Illinois Central	260.8	283.4	284.0	296.5	319.0	321.5	310.2
Long Island	1,368.8	1,349.3	1,379.4	1,411.5	1,406.7	1,379.4	1,383.2
New York, New Haven, & Hartford	355.1	347.2	349.3	351.8	352.6	-	-
New York Central	335.7	335.4	344.0	352.6[a]	-	-	-
Pennsylvania/Penn Central	365.2	358.1	362.7	382.5	770.7	1,260.1	1,308.1
Reading Company	82.1	79.0	76.3	80.4	85.2	87.1	88.1
Southern Pacific	143.6	144.6	142.5	141.0	134.0	132.1	126.6
Total, All Railroads	4,178.8	4,091.0	4,161.0	4,264.7	4,350.4	4,515.2	4,558.8

a. Estimated.

Source: Derived from data supplied by the Interstate Commerce Commission.

Table 7.14

AVERAGE TRIP LENGTH PER COMMUTER RAIL PASSENGER
(Miles)

Railroad	1964	1965	1966	1967	1968	1969	1970
Boston & Maine	18.5	16.8	17.4	17.1	17.0	17.1	17.1
Central of New Jersey	27.7	28.0	28.1	23.4	21.5	21.5	21.6
Chicago, Burlington, Quincy	17.0	17.2	17.2	17.2	17.2	17.4	17.6[a]
Chicago, Milwaukee, St. Paul, & Pacific	22.7	22.8	22.9	22.7	22.4	22.4	22.6
Chicago Northwestern	21.3	21.2	21.3	21.0	20.7	20.8	20.6
Chicago, Rock Island, & Pacific	15.1	15.1	15.2	15.4	15.4	15.5	16.1
Erie Lackawanna	24.7	19.9	20.3	20.5	20.5	20.6	21.0
Illinois Central	15.5	15.6	15.6	15.4	15.6	15.9	17.0
Long Island	24.9	25.1	25.1	25.3	25.5	25.9	25.9
New York, New Haven, & Hartford	25.9	26.4	26.7	26.7	26.9	-	-
New York Central	20.8	21.0	21.0	21.0[a]	-	-	-
Pennsylvania/Penn Central	19.2	19.0	18.9	20.4	21.1	23.3	24.2
Reading Company	14.2	13.8	14.1	14.1	14.3	14.3	14.3
Southern Pacific	24.4	24.4	24.2	24.4	24.7	24.5	24.5
Weighted Average, All Railroads	21.7	21.4	21.5	21.6	21.6	21.9	22.3

a. Estimated.

Source: Derived from data supplied by the Interstate Commerce Commission.

Table 7.15

COMMUTER RAIL REVENUE PER PASSENGER
(Dollars)

Railroad	1964	1965	1966	1967	1968	1969	1970
Boston & Maine	.59	.61	.66	.67	.77	.83	.88
Central of New Jersey	.82	.81	.83	.68	.59	.59	.60
Chicago, Burlington, Quincy	.50	.55	.55	.55	.59	.61	.63[a]
Chicago, Milwaukee, St. Paul, & Pacific	.77	.78	.77	.77	.79	.83	.82
Chicago Northwestern	.71	.71	.71	.70	.74	.75	.79
Chicago, Rock Island, & Pacific	.60	.66	.66	.66	.67	.68	.68
Erie Lackawanna	.66	.67	.67	.68	.67	.68	.69
Illinois Central	.50	.49	.48	.49	.49	.50	.57
Long Island	.76	.81	.82	.83	.90	.94	1.05
New York, New Haven, & Hartford	.93	.95	.97	.98	1.01	-	-
New York Central	.76	.80	.81	.82[a]	-	-	-
Pennsylvania/Penn Central	.60	.61	.61	.66	.75	.84	.88
Reading Company	.45	.45	.53	.54	.56	.59	.62
Southern Pacific	.48	.47	.48	.50	.57	.57	.60
Weighted Average, All Railroads	.69	.71	.71	.72	.75	.78	.83

a. Estimated.

Source: Derived from data supplied by the Interstate Commerce Commission.

Table 7.16

REVENUE PER COMMUTER RAIL PASSENGER-MILE
(Dollars)

Railroad	1964	1965	1966	1967	1968	1969	1970
Boston & Maine	.032	.037	.038	.039	.045	.048	.051
Central of New Jersey	.030	.029	.030	.029	.028	.027	.028
Chicago, Burlington, Quincy	.029	.032	.032	.032	.035	.035	.035[a]
Chicago, Milwaukee, St. Paul, & Pacific	.034	.034	.034	.034	.035	.037	.037
Chicago Northwestern	.033	.034	.033	.034	.036	.036	.039
Chicago, Rock Island, & Pacific	.040	.044	.043	.043	.043	.044	.042
Erie & Lackawanna	.027	.033	.033	.033	.033	.033	.033
Illinois Central	.032	.031	.031	.032	.031	.031	.034
Long Island	.031	.032	.033	.033	.035	.036	.041
New York, New Haven, & Hartford	.036	.036	.036	.037	.037	-	-
New York Central	.037	.038	.039	.039	-	-	-
Pennsylvania/Penn Central	.031	.032	.032	.032	.036	.036	.036
Reading Company	.032	.033	.038	.039	.039	.041	.043
Southern Pacific	.019	.019	.020	.021	.023	.023	.024
Weighted Average, All Railroads	.032	.033	.033	.033	.035	.036	.037

a. Estimated.

Source: Derived from data supplied by the Interstate Commerce Commission.

represents the average fare paid by those passengers riding on commuter or multiple-ride tickets. The regular fares paid by other passengers are somewhat higher, so that the average fare for all passengers would be slightly higher than the figures in the table. Between 1964 and 1970, the revenue per passenger increased on all railroads except the Central of New Jersey. In 1970 the revenue per passenger varied from a low of $.47 on the Reading to a high of $1.05 on the Long Island. The weighted average for all railroads increased from $.69 in 1964 to $.83 in 1970.

7. REVENUE PER PASSENGER-MILE

Table 7.16 shows the trend in revenue per passenger-mile for each railroad, and the weighted average for all railroads. As discussed in the previous paragraph, the average revenue per passenger-mile for all passengers would be slightly higher. Over this period of time the revenue per passenger-mile has increased on all railroads, again with the exception of the Central of New Jersey. In 1970 the revenue per passenger-mile varied from a low of 2.4 cents on the Southern Pacific to a high of 5.1 cents on the Boston and Maine. The weighted average for all railroads increased from 3.2 cents in 1964 to 3.7 cents in 1970.

APPENDIX VIIA

VARIOUS DEFINITIONS OF PASSENGER TRAFFIC

The literature on commuter rail operations defines passenger traffic in several ways. To make matters worse, it is often not clear just which definition is being used. All the results in Section C are presented in terms of total passengers annually; i.e., number of individual fares collected (or tickets punched) during a year. In arriving at these annual figures it was often necessary to convert from other definitions of numbers of passengers. The most often used measures of passenger traffic are:

1. Weekday peak hour (AM) inbound only
2. Weekday peak period (7 AM to 10 AM) inbound only
3. Weekday all day, inbound only
4. Weekday all day, inbound plus outbound
5. Annually, inbound plus outbound

The numerical relationships among these definitions vary by city and by individual rail lines within a city. Where actual relationships are available, they should of course be used. However, where they are not available, it is necessary to use "ball park" conversion factors. The following are representative numerical relationships, based upon empirical data, from the sources cited in Section VII for these various definitions using the numbers associated with the definitions above:

Definition 2 = 1.5 x Definition 1

Definition 3 = 1.5 x Definition 2

Definition 4 = 2 x Definition 3

Definition 5 = 300 x Definition 4

With these relationships, one can convert from any definition to any other definition. For example, if we know that 5,000 passengers arrive downtown on a railroad during the peak hour of a weekday morning, the number of passengers annually can be estimated as follows:

$$5{,}000 \times 1.5 \times 1.5 \times 2 \times 300 = 6{,}700{,}000$$

PART FOUR

URBAN TAXICAB TRANSIT

CAHPTER VIII

CHARACTERISTICS OF THE URBAN TAXICAB TRANSIT INDUSTRY

by

John Wells
Fred Selover

SUMMARY

In aggregate terms, taxicabs in urban areas transport more people than rail rapid transit systems and over one-half as many as bus transit systems. More revenue is generated by taxicab operations than the combined total of other mass-transit operations. In some urban communities, the taxicab is the only form of urban public transit.

Taxicabs are used mostly by housewives and white collar workers, particularly in the professional and managerial categories. Most riders are white, of working age, and their rides are either to home or to work. However, significant percentages of riders fall outside these categories. Service and household workers often ride cabs to noncentral area destinations, and there is substantial (26 percent) ridership by students and unemployed, retired, and incapacitated persons.

In terms of numbers, the taxicab industry is dominated by small fleets (two or more taxicabs under one ownership) and owner/operators. There are about 7,200 fleet operations in the United States operating in about 3,300 "communities" or regulatory jurisdictions.

This paper is devoted primarily to the development of a profile, as of 1970, of taxicab operations. Numerous statistics are presented that provide information on costs and revenue-generating activities.

A. INTRODUCTION

Although the taxicab is not regarded as a form of urban mass transit, it is a public transit vehicle that plays an important role in moving people within urban areas. The distinguishing feature of the taxicab is that it is the only public transit form that simulates the features of the private automobile. Moreover, the taxicab operation is demand-activated rather than scheduled. A person can telephone for taxicab service, and (assuming that the taxicab operation is well-run) within a few minutes receive comfortable door-to-door service similar to that provided by an automobile. Moreover, he does not have to drive or park the vehicle! Because of this service, taxicabs are used extensively by businessmen, housewives, the old, the handicapped, the young, out-of-town visitors, and others who cannot or do not wish to drive, or who have no automobile available to them and need the door-to-door service that scheduled mass transit vehicles do not provide.

Clearly, the taxicab is an important mode of urban travel; yet relatively little is known about taxicab operations and the taxicab industry. The purpose of this paper is to present and analyze statistical information that has been provided by the International Taxicab Association. The paper is descriptive and relatively free of technical analyses since our objective is to present data for others to consider.

B. TAXICAB INDUSTRY CHARACTERISTICS

1. RELATIVE SIZE AND PERFORMANCE

a. Overall Size

According to the International Taxicab Association, there are about 7,200 fleet operations in the United States and more individual operations. These fleets operate in about 3,300 communities and, in many cases, are the only form of public transportation available.[1] Moreover, in several respects the taxicab transit industry is larger than the bus, trolley coach, and rapid rail passenger transport industry combined (see Table 8.1). First, the industry operates about three times as many vehicles for twice as many revenue vehicle miles. Second, in 1970, passenger revenues in the taxicab industry amounted to $2,221 million, or about 600 million more than the combined total revenue of the bus and rail industries. Finally, taxicabs move far more passengers than rail rapid transit and over one-half as many as bus transit.

b. Employment Level Trends

Trends in employment indicate that the taxicab industry is increasing in importance. The annual average employment level in the taxicab industry declined from 121,000 persons in 1960 to 109,000 in 1966 (see Table 8.2), but from 1967 to 1970, the level stabilized at about 111,000. In contrast, employment in other local and suburban transit has continued a downward drift over the period until there were 18,000 fewer employees in 1970 than in 1960.

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1. These "communities" are actually "jurisdictions" within which taxicabs are franchised to operate under specific fare structures and/or operating regulations. These terms are used interchangeably throughout this paper.

Table 8.1

SELECTED URBAN TRANSPORTATION ANNUAL STATISTICS, 1970

	All Modes	Taxicab	Bus, Rail, and Trolley Coach: Total	Bus	Rail[a]	Trolley Coach	Commuter Rail[b]
Revenue Passengers (Millions)	8,557	2,378	5,932	4,058	1,746	128	247
Percent of all-mode total	100.0	27.8	69.3	47.4	20.4	1.5	2.9
Passenger Revenue (Millions of Dollars)	4,065	2,221	1,639	1,194	415	30	205
Percent of all-mode total	100.0	54.6	40.3	29.4	10.2	0.7	5.0
Revenue miles traveled (Millions)	-	3,417	1,884	1,409	441	33	d
Number of vehicles (Thousands)	-	170	62	50	11	1	d
Average employment level (Thousands)[c]	-	111	138	d	d	d	d

[a]Includes elevated and subway rail rapid transit, grade-separated surface rail, and streetcar operations.

[b]Urban passenger rail service provided by railroad companies.

[c]Taxicab employment believed to be underestimated.

[d]Not available.

Source: For bus, rail, and trolley coach data: American Transit Association, 1970-71 Transit Fact Book.

For taxicab data: International Taxicab Association, American Automobile Association, Bureau of Labor Statistics, Employment and Earnings, United States 1909-70 (Bulletin 1312-7). Employment figures are believed to be understated.

For commuter rail: Interstate Commerce Commission, commuter railroad companies and several independent studies.

Table 8.2

ANNUAL AVERAGE EMPLOYMENT LEVELS IN THE URBAN PASSENGER TRANSIT INDUSTRY 1960-1970
(Thousands)

Year	Taxicab	Other Local and Suburban Transit
1960	120.7	156.4
1961	114.3	151.8
1962	112.5	149.1
1963	111.9	147.2
1964	109.5	144.8
1965	109.5	145.0
1966	109.2	144.3
1967	111.3	146.1
1968	111.2	143.6
1969	111.3	140.9
1970	111.3	138.0

Source: Compiled from information presented in Appendix VIIIA.

Table 8.3

INDEXES OF PUBLIC TRANSIT FARES
ANNUAL AVERAGE 1964-1970

Year	Basic Indexes[a]			Converted to 1965 = 100			
	All Public Transit[b] 1957-1959	Local Transit[c] 1957-59 = 100	Taxicabs Dec. 1963 = 100	All Public Transit	Local Transit	Taxicab	Consumer Price Index
1964	119.0	122.8	101.9	98.0	97.9	97.5	98.3
1965	121.4	125.4	104.5	100.0	100.0	100.0	100.0
1966	125.8	130.9	109.9	103.6	104.4	105.2	102.9
1967	132.1	140.2	116.7	108.8	111.8	111.7	105.8
1968	138.2	148.2	121.7	113.8	118.2	116.5	110.3
1969	148.9	160.4	126.7	122.7	127.9	121.2	116.2
1970	169.5	188.6	134.2	139.6	150.4	128.4	123.1

a. Sources: U.S. Department of Labor, Bureau of Labor Statistics, Handbook of Labor Statistics, 1968, Table 108, p. 250, and February issues of Monthly Labor Review, 1969, 1970, 1971.

b. Includes airline, intercity rail, intercity bus, as well as urban transit.
c. Bus and rail rapid transit.

It is important to recognize that the figures in Table 8.2 are average annual employment levels derived by averaging monthly employment levels reported to the Bureau of Labor Statistics. The figures do not show how many individuals were actually employed during the year.[1] Unfortunately, official figures on employment turnover in the industry are not available, but it is well known that the industry employs many part-time and temporary workers, especially during periods of economic recession. Employee turnover rates of three to six times the average monthly level of employment are not uncommon for individual companies. Moreover, until recently, most companies experienced driver shortages of as much as 20 percent, even though unemployment rates have been averaging around 5 percent. This means that many firms have not been able to fully utilize their taxicab fleets, and this in turn has constrained passenger movement and attendant revenues.

c. General Trends in Fares 1965 through 1970

Table 8.3 presents information regarding the relative growth of public transit fares. The right section of the table indicates that taxicab fares have increased 28.4 percent from 1965 to 1970 as compared with 50.4 percent in other local transit and 39.6 percent for the overall public transit industry. Note that, up to 1968, taxicab and other local transit moved virtually in parallel, but in 1969 and 1970 local transit fares increased sharply.[2] Both indexes have increased more rapidly than the consumer price index, but the disparity is much greater for local transit.

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1. The International Taxicab Association estimates that the industry employs over 600,000 persons annually.

2. The effects of this disparity in fares should be analyzed carefully. One would expect that, as taxicab fares become relatively more attractive, people will shift from the scheduled mass transit vehicles (bus and rail rapid transit) to the more convenient and comfortable demand-response vehicles. Unfortunately, sufficient data are not yet available to allow such an analysis.

2. TAXICAB RIDER CHARACTERISTICS

Data on taxicab rider characteristics are somewhat sparse, but three major studies conducted in the Chicago, Pittsburgh, and New York areas seem to give consistent results, as discussed below.

a. Taxicab Trip Destinations

Beimborn's analysis of the 1956 Chicago Area Transportation Study (see Table 8.4) shows that over 50 percent of the taxicab trips were to home or to work, with the former being the largest category. Trips to the central area were about equally divided between home, work, and personal business destinations; but trips to the noncentral area were predominantly home destinations, and social-recreation and personal business were about the same order of magnitude.

Table 8.4

PERCENT OF TAXICAB TRIPS IN CHICAGO AREA
BY TRIP PURPOSE, 1956

Trip Purpose	Taxi to Central Area	Taxi to Noncentral Area	All Taxi
Home	27.9	52.9	42.4
Work	23.2	6.4	13.4
Shop	4.2	2.3	3.1
School	0.4	1.1	0.8
Social-recreation	13.6	18.5	16.5
Eat meal	7.1	1.6	3.9
Personal business	23.6	17.2	19.9
Total	100.0	100.0	100.0

Source: Edward A. Beimborn, "Characteristics of Taxicab Usage," Highway Research Record, Number 250, 1968, p. 86. Data are derived from the 1956 Chicago Area Transportation Study.

A more recent (February 1969) study of the Tri-State area around New York City shows approximately the same ridership characteristics as in the Chicago study.[1] In the Tri-State area, about 60 percent of the taxicab ridership was either to home or to work, and a somewhat larger percentage (approximately 36 percent) were home trips. Home and work trips in the Manhattan area were about evenly divided, which suggests that trips outside this area were largely oriented to home destinations. In the overall Tri-State area, social-recreation accounted for about 12 percent of the trips and personal business for about 17 percent.

Thus, home, work, social-recreation, and personal business are the predominant trips in both studies. Stated another way, shopping, school, and meal trips are relatively unimportant as trip destinations.

b. Occupational Characteristics

Housewives accounted for most of the trips to the central and noncentral area of Chicago (see Table 8.5), but there is a considerable difference in the overall trip distribution among various occupations. In the central area, 32.3 percent of the trips were made by housewives. In the noncentral area, 54.2 percent were made by housewives, but non-white-collar workers, particularly service workers, made a larger proportion of the remaining trips.

A predominance of taxicab use by housewives was also noted by S. Rosenbloom in an analysis of the 1963 Pittsburgh Area Transportation Study (see Table 8.6). According to Rosenbloom, 60 percent of all taxicab trips were made by housewives, students, and unemployed, retired, or incapacitated persons. Housewives accounted for 34 percent of the total. (Note that 6.8 percent of the trips are not accounted for.)

The Chicago figures for the noncentral area suggest that family income may play an important role in taxicab ridership. Housewife

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1. Tri-State Transportation Commission, Regional Profile: Who Rides Taxis? Vol. I, No. 11, February 1969. The figures given below are estimated from a graph on page 3 of that document. From this point on, this study will be called the "Tri-State study."

Table 8.5

TAXICAB PERSON-TRIPS IN THE CHICAGO AREA
BY OCCUPATIONAL GROUPS, 1956

Occupational Group	Destination: Central Area		Destination: Noncentral Area		Destination: All Areas		Percent (exclusive of housewives)	Proportion of Population
	Trips	Percent	Trips	Percent	Trips	Percent		
Professional and technical	8,749	20.7	6,855	11.8	15,604	15.6	28.2	12.1
Farmers	0	0.0	0	0.0	0	0.0	X	X
Managers, etc.	7,425	17.6	3,712	6.4	11,237	11.1	20.2	9.0
Clerical	3,796	9.0	4,981	8.5	8,777	8.8	15.8	20.5
Sales workers	5,235	12.5	2,734	4.7	7,969	7.9	14.4	7.9
Operatives	1,143	2.7	2,000	3.4	3,143	3.1	5.7	20.3
Private household workers	97	0.2	918	1.6	1,015	1.0	1.8	1.4
Craftsmen, foremen	935	2.2	977	1.7	1,912	1.9	3.5	15.4
Service workers	1,015	2.4	3,924	6.7	4,939	4.9	9.0	8.8
Laborers	153	0.4	570	1.0	723	0.7	1.3	4.6
Housewives	13,586	32.3	31,607	54.2	45,193	45.0	X	X
Total	42,166	100.0	58,340	100.0	100,506	100.0	100.0	100.0

Source: See Table 8.4.

Table 8.6

TAXI PASSENGER TRIPS BY OCCUPATION OF THE TRIPMAKER: PITTSBURGH, 1963

Occupational Group	Percent of Total Trips
Housewives, Students, Unemployed, Retired, or Incapacitated	60.0
Professional, Technical, Kindred Workers	9.0
Managers, Officials, Proprietors	8.9
Service Workers	5.0
Sales Workers	4.6
Craftsmen, Foremen, Kindred Workers	3.0
Private Household Workers	1.3
Laborers, Farm Workers	1.2
Operatives, Kindred Workers	0.2
Other	6.8
Total	100.0

Source: S. Rosenbloom, "Characteristics of Taxicab Supply and Demand in Selected Metropolitan Areas," (Santa Barbara, California: General Research Corporation, October 1967), p. 25. Data were derived from the Pittsburgh Area Transportation Study, 1963.

Table 8.7

PERCENTAGE DISTRIBUTION OF TAXICAB PERSON-TRIPS IN TRI-STATE AREA, 1969, AND IN CHICAGO, 1956, BY OCCUPATIONAL GROUPS

Occupational Group	Tri-State Area 1969[a]	Chicago Area 1956[b]
Professional and Technical	26.5	28.2
Managers	21.8	20.2
Clerical	18.7	15.8
Sales	15.4	14.4
Services	7.1	9.0
Craftsmen	5.2	3.5
Operatives	3.4	5.7
Private Household	1.0	1.8
Laborers	0.0	1.3
Total	100.0	100.0

a. Figures from Tri-State Area Study.
b. Excludes housewives and farmers, see Table 8.5.

ridership in noncentral areas is very high and it is likely that the fares of the service and household workers are often paid by employers. The Tri-State Study shows that there is a much higher use of taxicabs by high-income groups.[1]

Table 8.7 presents an interesting comparison which excludes housewives from the occupational groups. Note that the distributions among occupations are similar for the Tri-State and Chicago areas despite the time and space differentials. As would be expected, the concentration is in the white-collar groups, particularly the professional and managerial occupations.

c. Personal Characteristics

In terms of the total area, the Chicago and Pittsburgh area studies have very similar profiles (see Table 8.8). Taxicab ridership is predominantly female (59 to 61 percent), but the Chicago data show that this is probably true only for the noncentral area destinations which, it will be recalled, are predominantly home trips.

Table 8.8

PERSONAL CHARACTERISTICS OF TAXICAB RIDERS IN CHICAGO, 1956, AND PITTSBURGH, 1963

Characteristic	Chicago			Pittsburgh
	All Trips	Central Area Destination	Noncentral Destination	All Trips
Sex				
Male	41.2%	52.5%	32.9%	39.0%
Female	58.8	47.5	67.1	61.0
Race				
White	90.2	95.7	86.1	a.
Nonwhite	9.8	4.3	13.9	a.
Drivers				
Female				
Drivers	28.8	39.5	22.4	24.8
Nondrivers	71.2	60.5	76.6	75.2
Male				
Drivers	68.1	80.4	53.8	51.8
Nondrivers	31.9	19.6	46.2	48.2

a. Not available
Source: See Table 8.5.

1. Ibid., p. 1.

In 1956, only about 10 percent of the ridership in Chicago was black, but there was a considerable variation between the central and noncentral areas. This is consistent with the observation made earlier that a greater proportion of household and service workers, a high proportion of whom are probably nonwhite, ride taxicabs in the noncentral area.

In both Chicago and Pittsburgh, well over 70 percent of the female riders were nondrivers. Pittsburgh had a greater proportion of male nondrivers than Chicago for all trips, but the destination pattern was comparable to Chicago's noncentral area.

With respect to the age of taxicab riders, Beimborn reports that in Chicago 78.6 percent of all taxicab rides were taken by persons 30 or older, although this group constituted only 51.8 percent of the population; the percentage difference is even more pronounced in the central area.[1] Similar results are reported in the Tri-State study which shows that 68 percent of all taxicab trips are made by persons in the 25 to 64 age group, and this group constitutes only 47 percent of the Tri-State area population.

To summarize, three studies appear to give strikingly similar results, even though there are significant time and space differentials. It is not surprising that taxicabs are ridden mostly by housewives (family income probably well above average), and white-collar workers, particularly in the professional and managerial categories. Most riders are white, of working age, and their rides are either to home or to work. On the other hand, significant percentages fall outside these categories. Service and household workers often ride cabs to noncentral area destinations, and the Pittsburgh Area Transportation Study indicated substantial ridership (26 percent) by students and unemployed, retired, and incapacitated persons.

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1. Beimborn, _op_. _cit_., p. 93.

3. THE SUPPLY OF TAXICAB SERVICES

A gross measure of the supply of taxicab services is the number of taxicabs per 1,000 population. These figures are presented in Tables 8.9 through 8.12. Some words of explanation are necessary before the tables can be analyzed.

Table 8.9

SELECTED SUMMARY MEASURES OF TAXICAB SERVICES, 1970
(Sample of 741 Communities)

Statistic	First Quartile	Median	Third Quartile	Range
Licenses in community	14	26	56	1 to 11,754
Population served (thousands)	30	47	88	2 to 7,867
Licenses per 1,000 population	.364	.568	.900	.03 to 11.13

Total number Licenses in Sample 77,064[a]
Total Population in Sample (000) 83,130[a]
Licenses per 1,000 population .927

a. Includes some overlapping of jurisdictions, therefore, the mean licenses per 1,000 is overstated.

Source: See Appendix VIII B and Table 8.10.

The International Taxicab Association reports licensing and fare information for 741 "jurisdictions" in the United States. These jurisdictions are communities or sets of communities in which individual taxicab companies are franchised to operate under specified fare structures and operating regulations. The population figures in Tables 8.9 through 8.12 represent estimates of the population served by the taxicabs in the jurisdictions (called "communities" in the tables). In most cases, these figures were obtained from the 1970 census. In a few cases where a jurisdiction overlaps two or more census areas, the population served in the jurisdiction was estimated by the taxicab operators. For example, the population served in the Van Nuys jurisdiction includes several surrounding areas and should not be construed as indicating the official census figure.

Table 8.10

DISTRIBUTION OF TAXICAB LICENSES PER 1,000 POPULATION IN 1970
(Sample of 741 Communities)

Licenses per 1,000 Population	Number of Communities	Percent of Total
Under .2	72	9.72
.2 and under .4	150	20.24
.4 and under .6	168	22.67
.6 and under .8	116	15.65
.8 and under 1.0	70	9.45
1.0 and under 1.2	61	8.23
1.2 and under 1.4	24	3.24
1.4 and under 1.6	20	2.70
1.6 and under 1.8	10	1.35
1.8 and under 2.0	14	1.89
2.0 and over	36	4.86
Total	741	100.00

First Quartile (Q1) = .3636
Median = .5682
Third Quartile (Q3) = .9000
Range = .0300 - 11.1257

Table 8.11

CUMULATIVE DISTRIBUTION OF TAXICAB LICENSES
PER 1,000 POPULATION, 1970
(Sample of 741 Communities)

Licenses per 1,000 Population	Number of Communities	Cumulative Percent of Total
Under .2	72	9.72
Under .4	222	29.96
Under .6	390	52.63
Under .8	506	68.29
Under 1.0	576	77.73
Under 1.2	637	85.96
Unerr 1.4	661	89.20
Under 1.6	681	91.90
Under 1.8	691	93.25
Under 2.0	705	95.14
Under 12.1	741	100.00

Table 8.12

TAXICAB LICENSES PER 1,000 POPULATION ORDERED ACCORDING TO POPULATION OF JURISDICTION SERVED
(1970 Population 500,000 or more)

City	Population Served (Thousands)	Licenses	Licenses per 1,000 Population
New York	7,867	11,754	1.49
Chicago	3,366	4,600	1.37
Los Angeles	2,816	1,024	.37
Philadelphia	1,948	1,750	.90
Detroit	1,511	1,358	.90
Houston	1,232	473	.38
Baltimore	905	1,151	1.27
Dallas	844	507	.60
Van Nuys[a]	790	50	.06
Washington	764	8,500	11.13
Cleveland	750	560	.75
Indianapolis	744	482	.65
San Francisco	715	756	1.06
Milwaukee	713	423	.59
San Diego	696	304	.44
San Antonio	654	518	.79
Boston	641	1,575	2.46
Memphis	623	400	.64
St. Louis	622	1,267	2.04
New Orleans	593	1,500	2.53
Phoenix	581	95	.16
Columbus	539	351	.65
Seattle	530	316	.59
Jacksonville	528	270	.51
San Gabriel	525	52	.10
Pittsburgh	520	550	1.06
Denver	514	317	.62
Kansas City	507	542	1.07

a. Includes parts of surrounding communities.

In other words, the population figures should be regarded as the International Taxicab Association's best estimates of population served by corresponding number of taxicabs (licenses)--not as official estimates of the community's population.

As Table 8.9 indicates, a very large number of small jurisdictions are served by taxicabs. The median size of jurisdiction, in terms of population, is 47,000, and 75 percent of the jurisdictions have populations of 88,000 or less (the third quartile). The median number of licenses per 1,000 population is .568, or slightly over one taxicab for every 2,000 persons.

The mean number of licenses per 1,000 is .927. This is considerably larger than the median and indicates the influence of some extremely high ratios in big cities as well as a slight degree of double counting because of overlapping jurisdictions.

The more detailed distributions appear in Tables 8.10 and 8.11. These tables show that the main concentration is between .2 and .8 licenses per 1,000 population, but there are, indeed, a few communities with very high ratios. Nearly 5 percent have two taxicabs or more per 1,000 population, and about 23 percent have one or more.

In Table 8.12, the ratios for jurisdictions with populations of 500,000 or more are presented. New York and Chicago have ratios well over 1.0, but Los Angeles is well below the median at .37. There are both high and low ratios within this range of populations.

Although larger cities tend to have higher-than-average ratios, a better explanation appears to be the geographical location and age of the cities. New cities in the West and Southwest appear to have low ratios. Older cities in the East and those with tourist attractions appear to have high ratios. However, there are enough exceptions to this to suggest that the actual explanation of the variation is quite complex.[1]

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1. S. Rosenbloom has related licenses per 1,000 population to several indices of city economic activity and found relatively little correlation. See S. Rosenbloom op. cit., Section III. Rosenbloom argues that constraints on the number of licenses permitted has an important bearing on the ratios.

Special note should be taken of the Washington ratio of 11.13. This is one of a few cities that has virtually free entry into the taxicab business. A very large number of the taxicabs are driven only a few hours per day by their owners, if at all. If all ratios were converted to "full-time equivalents," Washington's figure would be more in line with the others. In fact, this conversion would undoubtedly account for a great deal of the variation in the ratios.

4. TAXICAB OPERATIONS

a. Organizational Characteristics

Although several types of companies exist in the taxicab industry, it is convenient to consider taxicabs in terms of the relationship between drivers and vehicles. In this context, taxicabs are either fleet or owner/operator cabs. Fleets hire drivers who are compensated by some form of incentive system, whereas owner/operators are private entrepreneurs who may have different incentives and motivations than the fleet drivers.

A fleet may exist in any of several organizational forms (partnership, corporation, etc.). The essential element of a fleet is that it consists of more than one passenger vehicle, rather than individual cabs, and is considered as the entity. Fleets typically provide maintenance and repair facilities as well as dispatching service; however, these services are sometimes provided by a separate enterprise, an association, or a management company.

Some taxicab "companies" act as dispatching services only. This type of company negotiates with the local government agency for the location of taxicab stands, advertises, and provides dispatching service for a fee. Individual owner/operators or fleets may use the service provided by this type of company. The owner/operator benefits from group advertising and dispatching. The small fleet owner limits his capital investment by buying a service that he may not be able to support as part of his own fleet. Because some communities limit taxicabs to radio operation, the availability of this dispatching service on a contract basis from this type of company, or from a relatively large fleet, enables the taxicabs of private owner/operators to function effectively.

The association or management company is composed of owner/operators or fleets. These associations are organized for many reasons. They enable the owner/operator to purchase insurance, fuel, oil, maintenance and other goods or services at lower prices than they would be able to obtain as individuals. In some areas, associations provide dispatching service for their member owner/operators or fleets. One major function of associations is to represent the membership in negotiations with local government agencies.

b. Nature of Regulation

The regulation of the taxicab industry is primarily a local government activity. The government activity or agency interacts with associations, fleets, and owner/operators in regard to the taxicabs on the street. Fleets or owner/operators may negotiate directly with the local government, or they may conduct the negotiations through an association. The owner/operator who buys dispatching service from a fleet usually negotiates through the fleet. Matters for negotiation typically include (1) rate of fare, (2) number of taxicabs, (3) insurance requirements, (4) licensing of drivers, and (5) mode of operation.

The rate of fare is a particularly critical item for taxicab operators. Revenue must exceed expenses if the company is to stay in business. The rate of fare is generally expressed in terms of "flag drop" and a certain number of dollars for each additional mile or fraction thereof. For example, the fare may be expressed as 50 cents for the first fifth of a mile (flag drop) plus 10 cents for each additional fifth of a mile. Because of heavy traffic congestion in many urban areas, most taxi meters in these areas now include a "live clock". The live clock automatically records the time the driver is delayed (not moving) because of traffic or other factors and adds the cost of this waiting to the cost derived from the distance factor. Typically, waiting-time rates range from $3.00 to $6.00 per hour, computed in increments of 1.0, 1.5, or 2.0 minutes. This waiting-time or traffic-delay factor may add 20 percent or more to the basic fare in dense urban areas such as New York City or Chicago. In effect, the traffic delay factor is a form of differential fare, with the actual fare being greater in heavy traffic. Another significant fare factor concerns trips outside franchised or normal operation areas. These fares are normally assessed at a flat rate to specific destinations or a specified rate per mile, with the fare reflecting the fact that these are typically one-way trips (no revenue on return portion).

Most communities limit the number of taxicabs that are allowed to operate in a given area. The basis for this limitation is generally a "Public Convenience and Necessity Clause" which, typically, is stated as follows:

> Licenses shall be issued for public convenience and necessity and the safety of existing vehicular and pedestrian traffic requiring such limitations. Public hearing shall be held to determine if additional licenses should be granted to meet the demand for service.[1]

A few cities, e.g., New York, have specific limits on the number of licenses, and a few, e.g., Washington, D.C., have unlimited licenses. Most jurisdictions, however, issue licenses on the basis of convenience and necessity.

Another item of concern to local governments is personal injury and property damage insurance for the taxicab companies. Although the minimum insurance requirements vary from community to community, typical coverage amounts to $100,000/$300,000 bodily injury plus $10,000 property damage. The taxicab company may purchase the required coverage from an insurance company or they may deposit securities as a guarantee of self-insurance. In most areas, the insurance rate is based on prior experience, or there is a flat rate plus a variable amount which is dependent upon claims during the

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1. Statement provided by the International Taxicab Association.

coverage period. Normally, the individual owner/operator pays a somewhat higher fee for comparable insurance coverage than a fleet, because the insurance company is unable to spread the risk over a large number of vehicles.

Local governments also license taxicab drivers, usually for the purpose of screening those with criminal records or poor driving records. Although temporary licenses are frequently issued within a few days of application, permanent licenses are typically withheld until a fingerprint check has been made and the driving record investigated.

Local governments are also concerned with the mode of operation of taxicabs. In a dense urban area such as New York City or Chicago, taxicabs may "cruise" the streets seeking passengers at random. With experience, a cab driver learns where he is most likely to find passengers at different times of the day. In the suburban areas, however, customers are widely distributed and cruising is not as productive. Moreover, residents of suburban areas do not want taxicabs cruising the residential neighborhoods. For these and other reasons, taxicabs in suburban areas normally are notified by radio of specific telephone requests.

For the cruise mode, the primary path is from the garage to cruise. The cruise mode continues until the cab finds a passenger for a revenue trip. At the end of the trip the cab immediately returns to the cruise mode in search of another passenger. At the end of the work day the driver switches to the off mode, cruises to the garage or, if necessary, into service and then to the garage. At any point the driver has the option of going into the "off" mode. This often makes it difficult for dispatchers to locate drivers and vehicles and is one of the main problems in maintaining a high level of productivity.[1]

In the radio mode, the driver usually cruises from the garage to a taxi stand where he waits for a radio call. When a telephone

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1. Much research has been conducted to develop automatic vehicle-location devices that will alleviate this problem.

request for a taxi comes in to the dispatcher, the nearest stand is identified and a radio call is put out for the first cab at the stand. The first cab responds, is given the location of the pick-up, and cruises to meet the customer. If there are no cabs at the stand nearest the customer, a radio call is put out to the next nearest stand. After the revenue trip, the cab cruises to a stand to await another radio call. As in the case of the cruise mode, the driver may go to the "off" mode at any time.

Although many suburban areas prohibit cruising, drivers in suburban areas are usually more productive if they use the taxi stand and the radio. Taxi stands on public property are typically provided by the local government at no cost to the taxi company and may be used by all cabs licensed to operate in the area. Exclusive use of stands at locations such as airports or train stations typically includes some form of compensation to the government for the exclusive license.

c. Operating Statistics

Turning now to the detailed operating aspects of the taxicab business, sample data on taxicab operations provided by the International Taxicab Association shows reasonably consistent results, regardless of the size of the operation or of the sample. A sample of 194 communities or "jurisdictions" in 1969 indicates that taxicabs carry about 1.6 passengers per trip for an average trip length of 4.5 miles (see Table 8.13).[1] Typically, they carry about 14,000 passengers per year and drive their cabs 40,000 miles for an average of .35 passengers per total vehicle-mile.[2]

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1. Trip mileage includes all mileage associated with the pickup and delivery of the passenger to his destination. This includes so-called "dead-head" mileage from the cab stand to the pickup point and from the destination to the nearest stand.

2. The fact that the arithmetic means and medians of the ratios are very close, even though there is high positive skewness in the original distributions, suggests relative uniformity of operations, regardless of locality.

Smaller samples of about 25 fleet operations give similar results but they tend to be more indicative of the larger fleet operations.[1] Item 18 in Table 8.14 shows that there were from 1.3 to 1.4 passengers per trip and that trip lengths ranged from 5.62 to 6.10 miles per trip (item 12). Paid miles per trip average about 50 percent of total miles per trip, or from $2.90 to $3.20.

The figures in Table 8.14 present a rather extensive profile of the nature of taxicab operations. In 1970, cab receipts ran about $.31 per mile and $.65 per paid mile. Each trip generated about $2.00 of revenue, and each shift $37.00 (averaging nine hours per driver). Operators paid about 44 percent of the revenue to drivers in the form of commissions. Of a total revenue of about $4.10 per man-hour, about $1.85 per man hour was paid out in the form of commissions. This usually did not include fringe benefits paid to drivers.

Cabs were driven about 115 miles per day or about 12 miles per man-hour. The former figure represents about 42,000 miles per 365-day year, which is consistent with the figures presented in Table 8.13.

An interesting figure is item 17, the percentage of trips originating from phone orders. These averaged about 86 percent, an indication that relatively little revenue is generated from "cruising." It is also interesting that the values for all items shown fluctuate within narrow margins during the year, i.e., they show little seasonal variation.

Table 8.15 shows trends in receipts and miles traveled per trip for the same sample of companies. From 1965 to 1970, receipts per trip increased 63.4 percent, but receipts per mile traveled increased only 37.5 percent, because the number of miles traveled per trip increased substantially (19.7 percent).

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1. The sample has broad geographic coverage; see Appendix VIIID.

Table 8.13

SELECTED ANNUAL STATISTICS ON TAXICAB OPERATIONS IN 194 COMMUNITIES, 1969
(Based on Annual Data)

Per Fleet	Arithme-tic Mean	First Quartile	Median	Third Quartile	Range
Size of Operation					
Number of Licenses	211	10	20	57	1 to 11,779
Annual Passengers Carried (000)	2,956	155	322	880	3 to 200,000
Total Miles Traveled (000)	8,501	433	893	2,500	9 to 700,000
Total Trips (000)	1,871	100	219	550	1 to 180,000
Operating Characteristics					
Passengers per mile traveled	.348	.267	.355	.429	.103 to 1.499
Passengers per trip	1.580	1.260	1.500	1.766	.667 to 6.227
Passengers per license (1,000 per year)	14.0	9.5	13.7	16.9	2.2 to 66.7
Miles traveled per license (1,000 per year)	40.2	33.3	40.1	50.0	6.0 to 106.2
Miles traveled per trip	4.543	3.620	4.670	5.767	1.3 to 13.7

Source: International Taxicab Association.

Table 8.14

MEDIANS OF SELECTED RATIOS DESCRIBING TAXICAB OPERATIONS, BY MONTH, 1970

Item #	Ratio	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Range During Year
	Cab Receipts ($)													
02	per mile	.31	.31	.32	.31	.32	.31	.30	.31	.31	.32	.32	.31	.30- .32
03	per paid mile	.66	.66	.65	.65	.66	.65	.66	.65	.64	.64	.64	.64	.64- .66
04	per man hour-total	4.13	4.12	4.24	4.34	4.39	4.13	4.13	4.18	4.24	4.17	4.29	3.89	3.89- 4.39
05	driver commission	1.78	1.83	1.88	1.90	2.05	1.93	1.79	1.75	1.91	1.88	1.88	1.81	1.75- 2.05
	percent of total	43.10	44.42	44.34	43.78	46.70	46.73	43.34	41.87	45.05	45.08	43.82	46.53	41.87- 46.73
06	per trip	1.97	1.90	1.86	1.98	1.95	1.95	1.95	1.94	2.04	2.06	2.06	1.99	1.86- 2.06
07	per shift	37.16	37.65	36.98	37.04	38.71	38.18	39.29	37.81	38.84	36.06	36.65	35.75	35.75- 39.29
	Cab Mileage													
10	per cab owned per day	120.00	112.00	129.50	118.00	112.00	109.20	106.70	101.70	106.00	106.70	112.00	108.60	101.70-129.50
11	per man hour	11.70	11.80	12.30	12.05	12.10	12.10	12.05	12.30	12.20	12.30	12.10	12.10	11.70- 12.30
12	per trip-total	5.90	5.70	5.62	5.90	5.70	5.90	5.85	5.90	5.90	5.80	6.00	6.10	5.62- 6.10
13	paid miles	2.90	2.90	3.00	2.95	3.00	3.00	2.95	3.00	3.00	3.00	3.00	3.20	2.90- 3.20
14	percent of total	52.00	50.85	51.00	52.00	51.00	50.00	49.45	49.00	50.60	51.50	50.00	46.70	46.70- 52.00
15	per gallon of gas	10.35	10.30	10.60	10.60	11.20	11.50	11.45	11.35	11.20	11.15	10.70	10.60	10.30- 11.50
	Trips													
16	per man hour	2.10	2.20	2.20	2.15	2.20	2.20	2.15	2.25	2.10	2.10	2.10	2.15	2.10- 2.25
17	percent from phone orders	87.50	83.10	82.00	82.50	84.00	84.00	88.15	88.00	82.90	87.00	83.20	90.00	82.00- 90.00
18	passengers per trip	1.35	1.35	1.35	1.40	1.35	1.40	1.30	1.30	1.30	1.30	1.35	1.40	1.30- 1.40
	Other													
08	hours per shift	9.00	9.00	9.00	8.75	9.00	9.00	9.00	9.00	8.80	8.75	8.50	8.50	8.50- 9.00
09	phone orders per shift	15.20	15.00	15.55	15.15	16.50	15.95	16.45	16.30	15.60	15.40	14.85	15.10	14.85- 16.50

Source: International Taxicab Association, Cab Research Report: Monthly Digest of Cab Operations. See Appendix VIII D for companies in the sample.

d. Operating Costs

A recent survey of 50 fleet operators in New York City, involving 5,426 cabs, provides a breakdown of taxicab operating costs in that area (see Table 8.16). In 1970, total expenses, including depreciation and interest, exceeded revenues by 4.5 percent. Total operating expenses were 94.2 percent of revenues.[1] Driver cost represented 59.5 percent of total revenue, 56.9 percent of total expenses, and 63.1 percent of total operating expenses.

Some cost information on a per-mile basis is also available from ITA for a sample of 27 fleets outside New York City (see Table 8.17). Unfortunately, all of the categories were not reported, but it is possible to make some comparisons with the New York data. First, total expenses as a percent of total revenue averaged 88.9 percent, a considerably better profit picture than for New York. Depreciation charges as a percent of revenue at 5.2 percent were slightly less than the 6.2 percent for the 27 companies, but there was a considerable difference in driver costs. These are 49.1 and 59.5 percent for the sample of 27 companies and New York companies, respectively. In fact, if the New York cab companies had the same percentage for driver costs, their total expenses would be well below revenues. All of the other cost items are of about the same magnitude, but slightly higher for New York.

A rough check on the credibility of the taxicab per-mile costs can be made by comparing them with similar private automobile costs published by the Bureau of Public Roads (see Table 8.18). The automobile costs are based upon the assumption that the owner will operate his car 100,000 miles over a 10-year period. As Table 8.18 shows, taxicab depreciation costs per mile are lower (because taxis are driven farther), but maintenance costs are higher. Generally, cab companies have maintenance facilities and try to drive their taxicabs at least 200,000 miles before replacing them.

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1. This compares with 94.4 percent for bus transit in 1969. See Section III, Table 3.5.

Table 8.15

AVERAGE (ARITHMETIC MEAN)
RECEIPTS PER MILE TRAVELED, RECEIPTS PER TRIP, AND
MILES TRAVELED PER TRIP FOR A SAMPLE OF TAXICAB COMPANIES
1965 to 1970

Year	Number of Companies Reporting	Receipts per Mile Traveled (Dollars)	Receipts per Trip	Miles Traveled per Trip
1965	14	.24	1.34	5.59
1966	16	.25	1.53	6.02
1967	16	.27	1.53	5.75
1968	21	.31	1.92	6.19
1969	21	.33	2.10	6.50
1970*	21	.33	2.19	6.69
INDEXES 1965 = 100				
1965		100.0	100.0	100.0
1966		104.2	114.2	107.7
1967		112.5	114.2	102.9
1968		129.2	143.3	110.7
1969		137.5	156.7	116.3
1970		137.5	163.4	119.7

Source: International Taxicab Association. See Appendix VIIID for the list of companies in the sample.

Table 8.16

FARE REVENUES AND COST AGGREGATES FOR 50 TAXICAB FLEETS (5,426 CABS) IN NEW YORK CITY, YEAR ENDING JUNE 30, 1970

Revenue or Cost Classification	Dollar Amount	Percent of Gross Fare Revenue	Percent of Total Expenses	Percent of Total Operating Expenses
Gross Fare Revenue	132,619,182	100.0		
Total Expenses	138,572,162	104.5	100.0	
Depreciation	8,598,836	6.5	6.2	
Interest	4,992,000	3.8	3.6	
Total Operating Expenses	124,981,326	94.2	90.2	100.0
Driver Cost	78,884,077	59.5	56.9	63.1
Vehicle Operation	11,600,814	8.7	8.4	9.3
Maintenance	8,607,143	6.5	6.2	6.9
Garage	4,401,485	3.3	3.2	3.5
Public Liability (insurance)[a]	9,919,353	7.5	7.2	7.9
General and Administrative	11,568,454	8.7	8.3	9.3

a. Most companies are self-insured.

Note: The 5,426 taxicabs represent about 80 percent of the fleet cabs in New York City.

Source: Price Waterhouse and Co. Financial Survey of New York City Taxicab Industry, October 1970.

Table 8.17

SELECTED COST ITEMS FOR 27 TAXICAB FLEET OPERATIONS, 1970

Revenue or Cost Classification	Median Value per Mile	Percent of Total Receipts	Percent of Total Expenses
Cab Receipts	.3172	100.0	
Total Expenses	.2821	88.9	100.0
Depreciation	.0166	5.2	5.9
Interest	a	a	a
Total Operating Expenses	a	a	a
Driver cost	.1556	49.1	55.2
Vehicle Operation	.0250[b]	7.9[b]	8.8[b]
Tires	.0029	0.9	1.0
Gasoline	.0221	7.0	7.8
Maintenance	.0197[b]	6.2[b]	7.0[b]
Labor	.0112	3.5	4.0
Parts	.0085	2.7	3.0
Garage	a	a	a
Public Liability (insurance)[b]	.0160	5.0	5.7
General and Administrative	a	a	a

a. Not available.
b. Assumed to be sum of two subitems.

Note: The sample comprises 27 individual companies covering a wide geographical distribution (see Appendix XIII D). New York companies are not included.

Source: International Taxicab Association, Cab Research Report: Composite Report on Operating Costs.

Table 8.18

SELECTED PRIVATE AUTOMOBILE AND TAXICAB PER-MILE OPERATING COSTS, 1970
(Figures are in cents per mile)

Cost Item	Private Automobile	Taxicab
Depreciation	3.19	1.67
Repairs, maintenance, and accessories	1.55	1.97
Replacement tires	.39[a]	.29
Gasoline and oil	2.69	2.21
Insurance	1.72	1.60

a. Excludes taxes.

Source of Automobile Data: E.M. Cope and C.L. Gauthier, "Cost of Operating an Automobile," Bureau of Public Roads: February 1970.

Replacement tires, gasoline, and oil costs are slightly lower for taxicabs, since cab companies can obtain discounts through volume buying. The lower insurance cost for taxicabs, however, is rather surprising. One explanation may be that most companies in the sample self-insure, and thus realize some economies.

In any case, the taxicab per-mile costs appear to be reasonably in line with private automobile costs obtained from the independent analysis of the Bureau of Public Roads.

Appendix VIIIA

DETERMINATION OF VALUES FOR TABLES 1 AND 2

APPENDIX VIIIA

DETERMINATION OF VALUES FOR TABLES 1 AND 2

VALUES FOR TABLE 8.1

Table 8A.1 presents the model used in estimating the values for the taxicab industry which are presented in Table 8.1. With the exception of the number of taxicabs, the parameter estimates (items 2, 4, 6, and 8) are obtained from the sample information provided by the International Taxicab Association (ITA) and presented in the specified tables in the paper.

The number of taxicabs used in the table represents what appears to be a reasonable estimate based upon a number of sources and methods of calculation. In early 1970, the International Taxicab Industry reported that there were 152,400 taxicabs operating in fleets or associations in the United States. This information was based upon figures reported by the Association's membership. Extrapolation of figures from another source (see Table 8A.2) shows about 175,000 taxicabs in fleets. Finally, Table 8.9 in the paper shows that the mean number of licenses per 1,000 population is .927. Because there is a small degree of double counting of jurisdictions, assume this figure is about .9. In 1970 there were about 193 million people living in nonfarm areas that are served by taxicabs.[1] The application of .9 per 1,000 to this figure yields an estimate of 173,700 taxicabs. It appears that the ITA estimate is somewhat low, and the number chosen for the calculations in Table 8A.1 (170,000) seems reasonable.

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1. The Bureau of Census reports a 1970 total of 203 million persons in the United States, 9.7 million of whom are on farms. Bureau of Census series, P-23, No. 42.

Table 8A.1

CALCULATION OF VALUES FOR TABLE 8.1

Item	Value
1. Estimated number of taxicabs in the U.S., 1970	170,000
2. Vehicle miles traveled per cab per year (see Table 8.13)	40,200
3. Estimated total cab miles traveled in 1970 (millions)	6,834
4. Paid mile factor (see Table 8.14)	x.50
5. Estimated total revenue-miles traveled (millions)	3,417
6. Revenue per paid mile in 1970 (see Table 8.14)	x.65
7. Estimated total revenue (millions)	2,221
8. Passengers per mile (see Table 8.13)	.348
9. Total passengers (millions), Item 8 x Item 3	2,378

Table 8A.2

TAXICABS IN FLEETS, 1966 TO 1970

Year	Number of Taxicabs (thousands)
1966	142
1967	146
1968	153
1969	169
1970	175[a]

a. Estimated from trend line.

Source: Automobile Manufacturers Association, *Automobile Facts and Figures* (1967, 1968, 1969, and 1970 issues).

Employment Estimates (Table 8.2)

Table 8A.3 presents estimates of urban transit employment from two sources, the Bureau of Labor Statistics (BLS) and the American Transit Association (ATA). The former is the only known official source of figures on taxicab employment. Note that for the BLS, total urban transit employment is computed by deducting Intercity and Rural Highway transit employment from total local and interurban passenger transit employment. Then, taxicab employment is subtracted to obtain nontaxicab employment. Except for a small number representing nonlocal transit employees mixed in with charter service employees and terminal and service facility employees, this nontaxicab employment figure should be comparable to the ATA figures. However, the ATA figures do not include school bus employees, and compare conceptually with SIC 411, Local and Suburban Transit.

In fact, the BLS figures severely underestimate employment in local and suburban transit. A reasonably accurate "rule of thumb" is that there are about 1.75 bus transit employees for every bus in the United States. Since there are about 50,000 active buses, this means that there are about 87,500 employees in bus operations alone, exclusive of school bus operations. For these reasons, the ATA figures have been used in Table 8.2. We suspect that the number of taxicab employees is also understated, but it is used here for lack of an alternative.

Table 8A.3

EMPLOYMENT IN URBAN TRANSIT, 1960 TO 1970
(Annual averages of monthly employment on a given day in mid-month)

Item	1970	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
Total Local and Interurban Passenger Transit (SIC 41)	284.5	282.3	281.5	279.4	270.5	268.8	266.9	269.2	270.7	276.9	284.4
Less: Intercity and Rural Highway Transit (SIC 413)	43.2	43.1	43.2	43.8	41.9	41.8	42.1	40.8	41.3	40.9	40.5
Equals: Total Urban Transit[a]	241.3	239.2	238.3	235.6	228.6	227.0	224.8	228.4	229.4	236.0	234.9
Less: Taxicab operations (SIC 412)	111.3	111.3	111.2	111.3	109.2	109.5	109.5	111.9	112.5	114.3	120.7
Equals: Nontaxicab Urban Transit	130.0	127.9	127.1	124.3	119.4	117.5	115.3	116.5	116.9	121.7	123.2
Local and Suburban Transit (SIC 411)	76.4	73.6	77.1	78.4	77.7	78.1	79.3	83.8	86.6	93.3	95.5
School Buses (SIC 415)[b]	c.	46.4	41.8	38.4	35.6	31.3	28.3	c.	c.	c.	c.
Charter Service (SIC 414)[b] / Terminal and Service Facilities (SIC 417)[b]	c.	7.1	7.2	6.7	6.0	6.0	6.1	5.3	c.	c.	c.
Total of SIC 411, 415, 414, 417	c.	127.1	126.1	123.5	119.3	115.5	112.9	-	-	-	-
Statistical discrepancy	c.	0.8	1.0	0.8	0.1	2.0	2.4				
American Transit Association Estimates of nontaxicab urban transit	138.0	140.9	143.6	146.1	144.3	145.0	144.8	147.2	149.1	151.8	156.4

a. Includes some nonlocal activities in SIC 414 and 417.

b. As of March of the given year.

c. Not available.

Source: U.S. Bureau of Labor Statistics, Employment and Earnings, United States, 1909-70 (Bulletin 1312-7).

Appendix VIIIB

APPENDIX VIIIB

The tables in this Appendix comprise distributions of the basic data used in determining the values in Tables 8.9, 8.10, and 8.11 in this paper. The reader is reminded that the term "community" is synonymous with the jurisdiction in which the taxicab licenses are issued and where fares and operations are regulated. The population figures are estimates of the population served by the licensees in the jurisdiction and correspond to 1970 census figures, except where jurisdictions overlap. Where jurisdictions do overlap, the population-served figures were provided by the operators. The degree of overlap is believed to be very small.

The International Taxicab Association is the source of all data in this Appendix.

Table 8B.1

DISTRIBUTION OF TAXICAB LICENSES ISSUED, 1970
(Sample of 741 Communities)

Number of Licenses	Number of Communities	Percent of Total
Under 10	115	15.52
10 and under 20	160	21.59
20 and under 30	132	17.81
30 and under 40	68	9.18
40 and under 50	51	6.88
50 and under 60	39	5.26
60 and under 70	27	3.64
70 and under 80	17	2.29
80 and under 90	13	1.75
90 and under 100	11	1.48
100 and under 200	45	6.07
200 and under 300	30	4.05
300 and under 400	6	.81
400 and under 500	4	.54
500 and under 1,000	12	1.62
1,000 and under 10,000	10	1.35
10,000 and over	1	.13
Total	741	100.00

First Quartile (Q1) = 14
Median = 26
Third Quartile (Q3) = 56
Range = 1 to 11,754

Source: International Taxicab Association

Table 8B.2

CUMULATIVE DISTRIBUTION OF TAXICAB LICENSES ISSUED, 1970
(Sample of 741 Communities)

Number of Licenses	Number of Communities	Cumulative Percent of Total
Under 10	115	15.52
Under 20	275	37.11
Under 30	407	54.93
Under 40	475	64.10
Under 50	526	70.99
Under 60	565	76.25
Under 70	592	79.89
Under 80	609	82.19
Under 90	622	83.94
Under 100	633	85.43
Under 200	678	91.50
Under 300	708	95.55
Under 400	714	96.36
Under 500	718	96.90
Under 1,000	730	98.52
Under 10,000	740	99.87
Under 11,755	741	100.00

Table 8B.3

DISTRIBUTION OF POPULATION SERVED BY TAXICAB FLEETS, 1970
(Sample of 741 Communities)

Population (Thousands)	Number of Communities	Percent of Total
Under 10	30	4.05
10 and under 20	48	6.48
20 and under 30	103	13.90
30 and under 40	134	18.08
40 and under 50	59	7.96
50 and under 60	72	9.72
60 and under 70	48	6.48
70 and under 80	35	4.72
80 and under 90	32	4.32
90 and under 100	23	3.10
100 and under 200	89	12.01
200 and under 300	17	2.29
300 and under 400	16	2.16
400 and under 500	7	.94
500 and under 1,000	22	2.97
1,000 and over	6	.81
Total	741	100.00

First Quartile (Q1) = 30
Median = 47
Third Quartile (Q2) = 88
Range = 2 to 7,867

Table 8B.4

CUMULATIVE DISTRIBUTION POPULATION SERVED BY TAXICAB FLEETS, 1970
(Sample of 741 Communities)

Population (Thousands)	Number of Communities	Cumulative Percent of Total
Under 10	30	4.05
Under 20	78	10.53
Under 30	181	24.43
Under 40	315	42.51
Under 50	374	50.47
Under 60	446	60.19
Under 70	494	66.67
Under 80	529	71.39
Under 90	561	75.71
Under 100	584	78.81
Under 200	673	90.82
Under 300	690	93.12
Under 400	706	95.28
Under 500	713	96.22
Under 1,000	735	99.19
Under 7,868	741	100.00

Appendix VIIIC

APPENDIX VIIIC

This Appendix presents the basic data underlying the summary statistics presented in Table 8.13 of the text. The International Taxicab Association is the source of all data.

The term "community" is synonymous with the "jurisdiction" which issues the licenses and regulates the taxicab fares and operations.

Table 8C.1

DISTRIBUTION OF TAXICAB LICENSES ISSUED, 1969
(Sample of 194 Communities)

Number of Licenses	Number of Communities	Percent of Total
Under 10	39	20.10
10 and under 20	45	23.20
20 and under 30	30	15.46
30 and under 40	18	9.28
40 and under 50	7	3.61
50 and under 60	7	3.61
60 and under 70	2	1.03
70 and under 80	4	2.06
80 and under 90	2	1.03
90 and under 100	0	0.00
100 and under 200	14	7.22
200 and under 300	9	4.64
300 and under 400	5	2.58
400 and under 500	3	1.55
500 and under 1,000	3	1.55
1,000 and under 10,000	5	2.58
10,000 and over	1	.52
Total	194	100.00

First Quartile (Q1) = 10
Median = 20
Third Quartile (Q3) = 57
Range = 1 to 11,779

Table 8C.2

CUMULATIVE DISTRIBUTION OF TAXICAB LICENSES, ISSUED 1969
(Sample of 194 Communities)

Number of Licenses	Number of Communities	Cumulative Percent of Total
Under 10	39	20.10
Under 20	84	43.30
Under 30	114	58.76
Under 40	132	68.04
Under 50	139	71.65
Under 60	146	75.26
Under 70	148	76.29
Under 80	152	78.35
Under 90	154	79.38
Under 100	154	79.38
Under 200	168	86.60
Under 300	177	91.24
Under 400	182	93.81
Under 500	185	95.36
Under 1,000	188	96.91
Under 10,000	193	99.48
Under 11,780	194	100.00

Table 8C.3

DISTRIBUTION OF ANNUAL TAXICAB PASSENGERS PER COMMUNITY, 1969
(Sample of 194 Communities)

Annual Taxicab Passengers (Thousands)	Number of Communities	Percent of Total
Under 100	31	15.98
100 and under 200	29	14.95
200 and under 300	26	13.40
300 and under 400	23	11.86
400 and under 500	10	5.15
500 and under 600	11	5.67
600 and under 700	5	2.58
700 and under 800	6	3.09
800 and under 900	5	2.58
900 and under 1,000	4	2.06
1,000 and under 2,000	14	7.22
2,000 and under 3,000	13	6.70
3,000 and under 4,000	4	2.06
4,000 and under 5,000	3	1.55
5,000 and under 10,000	4	2.06
10,000 and under 50,000	5	2.58
50,000 and over	1	.52
Total	194	100.00

First Quartile (Q1) = 155
Median = 322
Third Quartile (Q3) = 880
Range = 3 to 300,000

Table 8C.4

CUMULATIVE DISTRIBUTION OF ANNUAL TAXICAB PASSENGERS PER COMMUNITY, 1969
(Sample of 194 Communities)

Passengers Carried (Thousands)	Number of Communities	Cumulative Percent of Total
Under 100	31	15.98
Under 200	60	30.93
Under 300	86	44.33
Under 400	109	56.19
Under 500	119	61.34
Under 600	130	67.01
Under 700	135	69.59
Under 800	141	72.68
Under 900	146	75.26
Under 1,000	150	77.32
Under 2,000	164	84.54
Under 3,000	177	91.24
Under 4,000	181	93.30
Under 5,000	184	94.85
Under 10,000	188	96.91
Under 50,000	193	99.48
Under 300,000	194	100.00

Table 8C.5

DISTRIBUTION OF ANNUAL TAXICAB MILES TRAVELED
PER COMMUNITY, 1969
(Sample of 194 Communities)

Annual Miles Traveled (Thousands)	Number of Communities	Percent of Total
Under 100	2	1.03
100 and under 200	12	6.19
200 and under 300	14	7.22
300 and under 400	17	8.76
400 and under 500	14	7.22
500 and under 600	11	5.67
600 and under 700	5	2.58
700 and under 800	11	5.67
800 and under 900	12	6.19
900 and under 1,000	4	2.06
1,000 and under 2,500	43	22.16
2,500 and under 5,000	16	8.25
5,000 and under 10,000	13	6.70
10,000 and under 100,000	17	8.76
100,000 and over	3	1.55
Total	194	100.00

First Quartile (Q1) = 433
Median = 893
Third Quartile (Q3) = 2,500
Range = 9 to 700,000

Table 8C.6

CUMULATIVE DISTRIBUTION OF ANNUAL TAXICAB MILES TRAVELED PER COMMUNITY, 1969
(Sample of 194 Communities)

Annual Miles Traveled (Thousands)	Number of Communities	Cumulative Percent of Total
Under 100	2	1.03
Under 200	14	7.22
Under 300	28	14.43
Under 400	45	23.20
Under 500	59	30.41
Under 600	70	36.08
Under 700	75	38.66
Under 800	86	44.33
Under 900	98	50.52
Under 1,000	102	52.58
Under 2,500	145	74.74
Under 5,000	161	82.99
Under 10,000	174	89.69
Under 100,000	191	98.45
Under 700,000	194	100.00

Table 8C.7

DISTRIBUTION OF ANNUAL TAXICAB TRIPS PER COMMUNITY, 1969
(Sample of 194 Communities)

Annual Trips (Thousands)	Number of Communities	Percent of Total
Under 100	48	24.74
100 and under 200	40	20.62
200 and under 300	29	14.95
300 and under 400	15	7.73
400 and under 500	9	4.64
500 and under 600	9	4.64
600 and under 700	6	3.09
700 and under 800	1	.52
800 and under 900	6	3.09
900 and under 1,000	1	.52
1,000 and under 2,000	13	6.70
2,000 and under 10,000	13	6.70
10,000 and over	4	2.06
Total	194	100.00

First Quartile (Q1) = 100
Median = 219
Third Quartile (Q3) = 550
Range = 1 to 180,000

Table 8C.8

CUMULATIVE DISTRIBUTION OF ANNUAL TAXICAB TRIPS PER COMMUNITY, 1969
(Sample of 194 Communities)

Total Trips (Thousands)	Number of Communities	Cumulative Percent of Total
Under 100	48	24.74
Under 200	88	45.36
Under 300	117	60.31
Under 400	132	68.04
Under 500	141	72.68
Under 600	150	77.32
Under 700	156	80.41
Under 800	157	80.93
Under 900	163	84.02
Under 1,000	164	84.54
Under 2,000	177	91.24
Under 10,000	190	97.94
Under 180,000	194	100.00

Table 8C.9

DISTRIBUTION OF PASSENGERS PER TAXICAB MILE TRAVELED, 1969
(Sample of 194 Communities)

Passengers Per Mile Traveled	Number of Communities	Percent of Total
Under .1	3	1.55
.1 and under .2	22	11.34
.2 and under .3	45	23.20
.3 and under .4	67	34.54
.4 and under .5	25	12.89
.5 and under .6	13	6.70
.6 and under .7	7	3.61
.7 and under .8	4	2.06
.8 and under .9	1	.52
.9 and under 1.0	1	.52
1.0 and over	6	3.09
Total	194	100.00

First Quartile (Q1) = .267
Median = .355
Third Quartile (Q3) = .429
Range = .019 to 1.499

Table 8C.10

CUMULATIVE DISTRIBUTION OF PASSENGERS
PER TAXICAB MILE TRAVELED, 1969
(Sample of 194 Communities)

Passengers Per Mile Traveled	Number of Communities	Cumulative Percent of Total
Under .1	3	1.55
Under .2	25	12.89
Under .3	70	36.08
Under .4	137	70.62
Under .5	162	83.51
Under .6	175	90.21
Under .7	182	93.81
Under .8	186	95.88
Under .9	187	96.39
Under 1.0	188	96.91
Under 2.5	194	100.00

Table 8C.11

DISTRIBUTION OF PASSENGERS PER TAXICAB TRIP, 1969
(Sample of 194 Communities)

Passengers per Trip	Number of Communities	Percent of Total
Under 1.0	3	1.55
1.0 and under 1.2	34	17.53
1.2 and under 1.4	40	20.62
1.4 and under 1.6	35	18.04
1.6 and under 1.8	35	18.04
1.8 and under 2.0	6	3.09
2.0 and under 2.2	19	9.79
2.2 and under 2.4	4	2.06
2.4 and under 2.6	4	2.06
2.6 and under 2.8	2	1.03
2.8 and under 3.0	0	0.00
3.0 and over	12	6.19
Total	194	100.00

First Quartile (Q1) = 1.260
Median = 1.500
Third Quartile (Q3) = 1.766
Range = .125 to 20.000

Table 8C.12

CUMULATIVE DISTRIBUTION OF PASSENGERS PER TAXICAB TRIP, 1969
(Sample of 194 Communities)

Passengers per Trip	Number of Communities	Cumulative Percent of Total
Under 1.0	3	1.55
Under 1.2	37	19.07
Under 1.4	77	39.69
Under 1.6	112	57.73
Under 1.8	147	75.77
Under 2.0	153	78.87
Under 2.2	172	88.66
Under 2.4	176	90.72
Under 2.6	180	92.78
Under 2.8	182	93.81
Under 3.0	182	93.81
Under 21.0	194	100.00

Table 8C.13

DISTRIBUTION OF ANNUAL PASSENGERS PER TAXICAB LICENSE, 1969
(Sample of 194 Communities)

Annual Passengers per License	Number of Communities	Percent of Total
Under 6,000	13	6.70
6,000 and under 8,000	14	7.22
8,000 and under 10,000	23	11.86
10,000 and under 12,000	28	14.43
12,000 and under 14,000	21	10.82
14,000 and under 16,000	28	14.43
16,000 and under 18,000	23	11.86
18,000 and under 20,000	10	5.15
20,000 and under 30,000	22	11.34
30,000 and under 40,000	5	2.58
40,000 and under 50,000	3	1.55
50,000 and over	4	2.06
Total	194	100.00

First Quartile (Q1) = 9,529
Median = 13,719
Third Quartile (Q3) = 16,931
Range = 1,000 to 66,667

Table 8C.14

CUMULATIVE DISTRIBUTION OF ANNUAL PASSENGERS
PER TAXICAB LICENSE, 1969
(Sample of 194 Communities)

Passengers per License	Number of Communities	Cumulative Percent of Total
Under 6,000	13	6.70
Under 8,000	27	13.92
Under 10,000	50	25.77
Under 12,000	78	40.21
Under 14,000	99	51.03
Under 16,000	127	65.46
Under 18,000	150	77.32
Under 20,000	160	82.47
Under 30,000	182	93.81
Under 40,000	187	96.39
Under 50,000	190	97.94
Under 66,667	194	100.00

Table 8C.15

DISTRIBUTION OF ANNUAL MILES TRAVELED PER TAXICAB LICENSE, 1969
(Sample of 194 Communities)

Annual Miles Traveled per License	Number of Communities	Percent of Total
Under 10,000	4	2.06
10,000 and under 20,000	6	3.09
20,000 and under 30,000	21	10.82
30,000 and under 35,000	29	14.95
35,000 and under 40,000	35	18.04
40,000 and under 45,000	24	12.37
45,000 and under 50,000	23	11.86
50,000 and under 55,000	21	10.82
55,000 and under 60,000	9	4.64
60,000 and under 70,000	7	3.61
70,000 and under 80,000	7	3.61
80,000 and over	8	4.12
Total	194	100.00

First Quartile (Q1) = 33,333
Median = 40,152
Third Quartile (Q3) = 50,000
Range = 6,042 to 106,250

Table 8C.16

CUMULATIVE DISTRIBUTION OF ANNUAL MILES
TRAVELED PER TAXICAB LICENSE, 1969
(Sample of 194 Communities)

Miles Traveled per License	Number of Communities	Cumulative Percent of Total
Under 10,000	4	2.06
Under 20,000	10	5.15
Under 30,000	31	15.98
Under 35,000	60	30.93
Under 40,000	95	48.97
Under 45,000	119	61.34
Under 50,000	142	73.20
Under 55,000	163	84.02
Under 60,000	172	88.66
Under 70,000	179	92.27
Under 80,000	186	95.88
Under 106,251 ·	194	100.00

Table 8C.17

DISTRIBUTION OF MILES TRAVELED PER TAXICAB TRIP, 1969
(Sample of 194 Communities)

Miles Traveled per Trip	Number of Communities	Percent of Total
Under 2	3	1.55
2 and under 3	19	9.79
3 and under 4	47	24.23
4 and under 5	56	28.87
5 and under 6	30	15.46
6 and under 7	17	8.76
7 and under 8	5	2.58
8 and under 9	4	2.06
9 and under 10	3	1.55
10 and under 20	6	3.09
20 and over	4	2.06
Total	194	100.00

First Quartile (Q1) = 3.620
Median = 4.670
Third Quartile (Q3) = 5.767
Range = .400 to 109.589

Table 8C.18

CUMULATIVE DISTRIBUTION OF MILES TRAVELED PER TAXICAB TRIP, 1969
(Sample of 194 Communities)

Miles Traveled per Trip	Number of Communities	Cumulative Percent of Total
Under 2	3	1.55
Under 3	22	11.34
Under 4	69	35.57
Under 5	125	64.43
Under 6	155	79.90
Under 7	172	88.66
Under 8	177	91.24
Under 9	181	93.30
Under 10	184	94.85
Under 20	190	97.94
Under 111	194	100.00

Appendix VIIID

CITIES REPRESENTED BY SAMPLE OF 27 TAXICAB FIRMS

APPENDIX VIIID

CITIES REPRESENTED BY SAMPLE OF 27 TAXICAB FIRMS

Below are the cities represented by the sample of 27 taxicab firms used in generating the data in Tables 8.14, 8.15, and 8.17. Except where indicated, each city is represented by a single firm.

Arlington Heights, Illinois
Bethel Park, Pennsylvania
Binghampton, New York
Cincinnati, Ohio
Denver, Colorado
Des Moines, Iowa
El Monte, California
Indianapolis, Indiana
Los Angeles, California
Louisville, Kentucky (3 firms)
Medford, Oregon
Mesa, Arizona
Milwaukee, Wisconsin (2 firms)
Oakland, California
Omaha, Nebraska
Palm Springs, California
Phoenix, Arizona
Pomona, California
Saginaw, Michigan
St. Charles, Missouri
San Francisco, California
San Jose, California
Terre Haute, Indiana
Van Nuys, California

PART FIVE

EXTERNAL EFFECTS OF URBAN TRANSIT OPERATIONS

CHAPTER IX

SOME AIR POLLUTION, ACCIDENT, AND NOISE FACTORS DUE TO MASS TRANSIT SYSTEMS

by

Murray Kamrass

A. INTRODUCTION

One of the tools that has been developed within DOT for evaluating alternative transportation plans is a computer model called the TRANS model (Ref. 1). This model, which is continuously being refined, is capable of accepting inputs that describe transportation external costs.[1] If the inputs can be expressed in monetary terms, then they are so used. However, if they cannot be so expressed, then they are expressed in other terms that will at least permit consideration and acknowledgment of the trade-offs that are made by the selection of specific transportation systems.

This chapter presents some data that can be used in the TRANS model for evaluating transportation system external costs. Three types of external-cost data are presented--air pollution, accidents, and noise--each in a separate section. The first two types are treated as though they add linearly to the general cost level in an area. In the case of air pollution, for example, operation of a bus or an electric-powered transit vehicle superimposes pollution components on the general level of pollution that derives from other sources, including automobiles, manufacturing, heating, and power generation. The data are presented on a vehicle-mile basis. Because the public transit displacement of automobile vehicle miles can be represented in the TRANS model, these public transit pollution data will permit the calculation of transportation-caused pollution in a particular community.

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1. External costs are social costs not accounted for in the cost-pricing system of the operation. Specifically, we are referring to air and noise pollution and accident costs that have not yet been fully allocated within urban transportation systems and imply a general discomfort to the community.

Similarly, only public transit accident data are presented. For an examination of transportation accident rates from the community viewpoint, these must be superimposed on the total number of accidents, including automobile accidents. The TRANS model does this on a per-vehicle-mile or passenger-mile basis and, to the first order, represents the case where public transit is substituted for the private automobile. However, there are possible interactions here that might become significant if the proportion of public to private transit changes greatly, but we have no data on hand that would permit the evaluation of these interactions.

We have treated noise somewhat differently than the other two external effects factors because noise effects cannot be added linearly. To deal with transportation noise in a community, it is desirable to start with a basic background level that is usually due primarily to automobile traffic. This basic level is increased by the presence of larger vehicles, particularly trucks. Even if trucks comprise as little as 5 percent of the vehicles, they will dominate the average noise level. In such a circumstance, buses will add little measurable noise. However, if there are no trucks, then buses might increase the average noise level, depending on their proportion to the total traffic.

All of the data presented here apply to the national situation, and local situations are likely to be different. We have attempted to indicate the sources and magnitudes of the errors involved in using these data for specific localities. Although it may be necessary to use these data at times, greater accuracy can be obtained by collecting the appropriate information for specific urban areas. The method we have used can readily be used for calculating such specific cases.

B. MASS TRANSPORTATION AIR POLLUTION FACTORS

The purpose of this section is to present some factors that can be used in the TRANS model (Ref. 1) to represent air pollution due to mass transit facilities. This section deals with only two kinds of pollution sources--electric generators used to power electric railways and diesel engines used to power transit buses. Consideration is given only to commonly recognized pollutants. Only emissions are considered and not the level of pollution that might result.

The figures presented are based upon averages that are considered applicable to the nation as a whole. However, for any particular urban area they are likely to be in error, although they may be useful for rough calculations. The methods of calculation and the assumptions that were used in deriving these factors are discussed below. The calculated factors can be easily corrected if better or more specific information becomes available.

1. ELECTRIC RAIL TRANSIT

Electric energy for the operation of rail transit systems is supplied by generating stations using either fossil fuel, nuclear fuel, or water power as primary energy sources. Fossil fuel currently provides about 82 percent of all the power generated in the United States. Nuclear fuel provides less than 2 percent, and water power contributes about 16 percent (Ref. 2). Because neither nuclear nor water power systems create pollutants of the type we are discussing here, we shall confine our discussion to fossil fuel power plants. We note, however, that the proportion of power generated by nuclear plants is increasing and that the net air polluting emissions per unit of electrical energy generated are likely to be reduced in the future.

The basic formula for relating stationary fossil fuel power plant emissions to vehicle (rail car) miles is:

$$Q = \frac{E_i}{K} T$$

where: Q = lbs of emissions per car-mile

E_i = stack emissions of constituent i in lb/unit of fuel

K = energy output of the plant in KWH per unit of fuel

T = transit energy used in KWH/car mile

Fuel units: coal = 1 ton

gas = 1000 standard cubic feet

oil = 1 U.S. gallon (approx. 7.45 lb.)

Each of the factors in the formula is variable, depending on the location. E is primarily a function of the fuel used (gas, oil, coal), and it varies somewhat with the specific kind of coal or oil, which depends in turn on the economics of the fuel supply and the age of the power plant.

K, the power output of the plant per unit of fuel, depends on the plant's efficiency which might vary, depending on the age of the plant, from about 15 percent to 33 percent or better (some modern plants are approaching an efficiency of 40 percent).

Finally T, the transit energy used, is a function of the transit system characteristics.

The tabulation below contains the basic values that were used in the calculations shown in Table 9-1:

	Coal	Gas	Oil
Fuel Unit	1 ton	1000 cubic ft	1 gallon
Energy of Combustion (BTU/unit)	26×10^6	10^6	140×10^3
Heat Rate (BTU/KWH)	10,000	10,000	10,000
KWH/unit	2600	100	14

The energy of combustion used in the calculation is an assumed approximate value that depends on the specific kind of fuel (gas, oil or coal) being used. In general, the range of combustion energy is within 5 percent of the values shown in Table 9.1. The heat rate is a measure of the thermal efficiency of the power plant. We used a value of 10,000 BTU/KWH. Some of the more efficient plants have achieved values of more than 9000; the national average in 1965 was about 10,500 (Ref. 3). Thus, the error in this quantity, when applied to a specific local situation, might be about 10 percent.

The stack emissions given for each fuel are taken from Ref. 4. They represent the results of various tests for which we do not have the data and therefore cannot estimate the accuracy. A major factor in the emissions of coal and oil is the sulfur content, which can vary considerably. In the case of coal, the general range of sulfur content is from about 1 percent to about 5 percent (Ref. 5). Since the sulfur oxide emissions are proportional to the amount of sulfur in the fuel, the local situation should be determined for more accuracy. For the results presented in Table 9.1, we have used a value of 2 percent.

The sulfur content of oil varies from essentially zero to something over 2 percent. About two-thirds of all the oil produced in the United States in 1966 had a sulfur content of less than 0.5 percent, and only about 8 percent had sulfur content in excess of 2 percent (Ref. 6). However, the low sulfur content of U.S. oil is offset by the larger proportion of high sulfur oil from the Middle East and South America. In 1966 the weighted average sulfur content of oil used in the United States was 0.67 percent, a decline from the 0.73 percent level in 1955. In Table 9.1 we have used a value of 0.5 for the sulfur content of oil, but it is obvious that a specific local situation may be different.

The ash content of coal is also highly variable; the general range is from 4 percent to 15 percent (Ref. 5). We have assumed 10 percent for this calculation.

The factors that determine the consumption of energy by rail systems include acceleration rates, frequency of stations on the routes, and the weight of the cars. Table 9.2 presents annual energy consumption in kilowatt hours and average energy consumption in

Table 9.1

CALCULATIONS AND AIR POLLUTION EMISSION FACTORS FOR RAIL TRANSIT POWER

Fuel Type	Coal			Gas			Oil		
Stack Gas Emissions	lb/Unit	lb/1000 KWH	lb[a]/1000 car miles	lb/Unit	lb/1000 KWH	lb[a]/1000 car miles	lb/Unit	lb/1000 KWH	lb[a]/1000 car miles
Aldehydes	0.005	.0019	0.010	0.001	0.01	.053	0.0006	0.043	0.23
Carbon Monoxide	0.5	0.19	1.00	neg.	---	---	0.00004	0.0029	0.015
Hydrocarbons	0.2	.077	0.41	neg.	---	---	0.0032	0.23	1.2
Oxides of Nitrogen	20	7.7	41	0.390	3.9	21	0.104	7.4	39
Oxides of Sulfur	38S	2.9[b]	15.4	0.0004	0.004	0.021	0.160S	5.7[c]	30
Particulate	16A	61[d]	32.3	0.015	0.15	0.80	0.010	.71	3.8

a. Assumes 5.3 KWH/car mile.
b. Assumes 2 percent sulfur (S = fuel sulfur content in percent).
c. Assumes 0.5 percent sulfur.
d. Assumes 10 percent ash (A = fuel ash content in percent).

Table 9.2

ENERGY CONSUMPTION OF RAPID TRANSIT SYSTEMS

Measure	Cleve-land	Toronto	Phila-delphia	Chicago	New York	1960 Sum of Five	1960[a] ATA Total	1970[b] ATA Total
Annual Car Miles (Millions)	4.703	7.053	10.20	44.63	305.6	372.2	465.7	440.8
Annual Energy Used (Million KWH)	17	36	60	203	1,660	1,976	2,491	2,418
Average Energy (KWH/car mile)	3.6	5.1	5.9	4.5	5.4	5.3	5.3	5.5

a. ATA data include surface railway.
b. 1970 data are preliminary.

Sources: A. S. Lang and R. M. Soberman, Urban Rail Transit: Its Economics and Technology, MIT Press, Cambridge, Mass. and '70-'71 Transit Fact Book, American Transit Association, Washington, D.C.

kilowatt hours per car mile. It will be noted that there is a significant variability among these systems with Cleveland consuming only 60 percent of the car-mile energy used in Philadelphia. The difference is attributed to the relatively low station frequency of the Cleveland system and the high weight of the Philadelphia cars.

Since 1960, there has been an emphasis on the development of air-conditioned cars that would tend to increase power consumption. This development, however, is offset by the development of lighter-weight cars that require less power to operate. Some of this new equipment incorporates dynamic braking that returns significant amounts of energy to the system when the train is braked to a stop. The data between 1960 and 1970 provided by the ATA (Ref. 8) for all systems indicate little change in the average energy consumed per car mile but this may reflect these offsetting factors. In the calculation shown in Table 9.1 we have used an average value of 5.3 KWH/car mile. This figure is largely determined by the gigantic New York system, and the error in using it for other cities can be deduced from Table 9.2.

2. DIESEL BUSES

This subsection provides factors that represent the contributions of buses to area pollution. The data are applicable to 45- to 50-passenger city buses powered by two-stroke cycle diesel engines that have no emission controls. Minibuses, which are likely to have gasoline engines, are not represented in these data.

The basic equation for specifying emissions is the following:

$$Q_i = \Sigma q_{ij} T_j$$

where

- Q = quantity of emission in lb/hour or standard cubic feet/hour (SCFH)
- q = emission quantity per hour in operating mode j
- i denotes emission type
- j denotes vehicle operating mode.
- T_j = proportion of time in operating mode j

The data sources typically specify four operating modes: (1) idle (2) acceleration (3) cruise (steady) and (4) deceleration. However, these modes are not standardized by speed, load, or rate. Therefore, the tests are not truly comparable, and they cannot be precisely related to any specified driving pattern. The one set of data that comes closest to this is provided by Ref. 9. The data in Tables 9.3 and 9.4 are taken from this reference. Table 9.3 shows the performance of three buses, A, B, C, selected as typical buses from the fleet of the Chicago Transit Authority. They are all 45-passenger coaches equipped with two-cycle diesel engines having a displacement of 426 cubic inches. The mileage since major overhaul on the three buses ranged from 126,000 to 217,000 miles.

Table 9.4 shows three typical motor coach driving patterns for three different cities (unidentified). The patterns are based on rush-hour and off-hour operation in both downtown and residential areas. Table 9.5 presents a comparison of diesel bus exhaust emission data from several reference sources (Refs. 9, 10, 11, and 12). The variations shown in the table could be due to differences among the vehicles as well as variations in the methods of testing. The information available was insufficient to evaluate the methodologies. Therefore, we have chosen to present in Table 9.6 the range of the data and two sets of calculated data. One set (GM) was originally presented in Ref. 9, based on the City A driving pattern and the average emissions of the three buses tested. The second set is also based on the City A driving pattern but uses the midrange values of emissions from all the references shown in Table 9.5. These calculations can be readily modified for other driving patterns and other vehicle emission data that might become available.

Also shown in Table 9.6 are the emissions that would result from buses cruising on expressways where traffic moves freely. Although the cruising speeds were generally not specified in the references, they are probably in the 35 to 50 mile-per-hour range.

Table 9.3

EXHAUST COMPONENTS OF DIESEL COACHES[a]

Operating Condition	Vehicle	Exhaust Flow SCFM	Carbon Monoxide Volume (Percent)	Carbon Monoxide SCFH	Hydrocarbons Volume (Percent)	Hydrocarbons Lb/Hr	Nitrogen Oxide PPM	Nitrogen Oxide SCFH	Formaldehyde PPM	Formaldehyde SCFH
Idle	A	98	0.0	0.0	0.047	0.363	60	0.353	6	0.035
	B	95	0.0	0.0	0.017	0.132	50	0.285	4	0.023
	C	159	0.0	0.0	0.053	0.633	68	0.648	17	0.162
	Average	117	0.0	0.0	0.039	0.376	59	0.429	9	0.073
Accelerate	A	447	0.0	0.0	0.018	0.550	827	22.2	7	0.188
	B	461	0.1	27.7	0.023	0.833	863	23.9	6	0.166
	C	529	0.05	15.9	0.021	0.677	856	27.2	37	1.173
	Average	479	0.05	14.5	0.021	0.683	849	24.4	17	0.509
Cruise	A	395	0.0	0.0	0.013	0.478	310	7.35	4	0.095
	B	279	0.0	0.0	0.000	0.000	224	3.73	19	0.318
	C	360	0.0	0.0	0.015	0.423	178	3.85	9	0.195
	Average	345	0.0	0.0	0.009	0.300	237	4.98	11	0.203
Decelerate	A	350	0.0	0.0	0.061	2.00	40	0.840	7	0.147
	B	238	0.0	0.0	0.000	0.0	42	0.600	10	0.143
	C	318	0.0	0.0	0.038	38.7	9	0.171	70	1.335
	Average	302	0.0	0.0	0.033	37.1	30	0.537	29	0.541

a. Applies to 45 passenger coaches with 426 cubic inch, two-cycle diesel engines. Mileage since major overhaul 126,000-217,000.

Source: M.A. Elliott, et al. "Composition of Exhaust Gases from Diesel, Gasoline, and Propane-powered Motor Coaches." Journal of APCA, Vol. 5, August 1955.

Table 9.4

TYPICAL MOTOR COACH DRIVING PATTERN[a]

City	Percent of Time Spent				
	Idle	Accelerate	Cruise	Decelerate	Stop
A	35	15	30	15	5
B	25	20	30	25	---
C	30	15	40	15	---

a. Driving patterns are based on rush-hour and off-hour operation in both downtown and residential areas.

Source: M. A. Elliott, et al. "Composition of Exhaust Gases from Diesel, Gasoline, and Propane-powered Motor Coaches." Journal of APCA, Vol. 5, August 1955.

Table 9.5

EXHAUST COMPONENTS OF DIESEL COACHES

Condition	Reference	Carbon Monoxide SCFH	Hydro-carbon Lb/Hr	Oxides of Nitrogen SCFH	Formal-dehyde SCFH
Idle	9	0	0.376	0.429	0.073
	10	2.10	0.386	1.51	---
	11	---	---	---	0.122
	12	2.10	0.290	---	0.049
Approx.	Midpoint	1.05	0.338	0.982	0.081
Accelerate	9	14.5	0.683	24.4	0.509
	10	29.0	1.523	17.9	---
	11	27.6	---	---	0.927
	12	5.80	0.979	---	0.778
Approx.	Midpoint	17.4	1.038	21.2	0.718
Cruise	9	0	0.300	4.98	0.203
	10	6.20	2.01	8.22	---
	11	0	---	---	0.203
	12	20.7	0.668	---	0.425
Approx.	Midpoint	13.4	1.165	6.60	0.314
Decelerate	9	0	0.96	0.537	0.541
	10	5.4	1.52	2.62	---
	11	---	---	---	---
	12	3.6	1.46	---	0.187
Approx.	Midpoint	4.5	1.25	1.61	0.374

Table 9.6

DIESEL COACH HOURLY EMISSIONS

Elements of Driving Pattern	Carbon Monoxide CFH		Hydrocarbon Lb/Hr		Formaldehyde CFH		Oxides of Nitrogen CFH		City A Pattern Percent of Time
	GM[a]	All	GM	All	GM	All	GM	All	
Idle	0	1.05	0.376	0.34	0.073	0.081	0.429	0.98	35
Accelerate	14.5	17.4	0.683	1.04	0.509	0.72	24.4	21	15
Cruise	0	13.4	0.300	1.16	0.203	0.31	4.98	6.6	30
Decelerate	0	4.5	0.96	1.25	0.541	0.37	0.531	1.6	15
Stop	--	--	--	--	--	--	--	--	5
Total Emissions in City A pattern	2	7.7	0.47	0.81	0.24	0.28	5.4	5.7	
Freeway (Cruise) Emissions	0	13.4	0.300	1.16	0.203	0.31	4.98	6.6	

a. GM data are from Ref. 9 and are in SCFH (except hydrocarbon). Other volumetric data are not standardized.

C. ACCIDENT FACTORS FOR THE EVALUATION OF URBAN MASS TRANSPORTATION SYSTEMS

One of the factors that can be used for the evaluation of transportation systems is their safety or accident rate. The TRANS model (Ref. 1) can accept accident rates as nonmonetary factors or, by establishing some average cost for accidents, the model can include accident costs if this is desired. This section presents accident rates for urban bus and subway systems. The data are taken from Ref. 13 and apply to the calendar year 1968 unless otherwise specified.

1. BUS ACCIDENT RATES

Three bases appear useful in evaluating transportation safety; vehicle miles, passenger miles, and passenger trips. For buses, the data known are the number of passengers and operating mileages. The length of the average ride has been estimated as 2.5 miles on buses and trolleys, 2.75 miles on surface railroad. Passenger accident and traffic accident data for 1967 and 1968 have been calculated using ATA data (Ref. 15) and are presented in Table 9.7. Fatalities and fatality rates are shown in Table 9.8, the basic data for which are taken from Ref. 14. These figures do not include subway data.

2. SUBWAY ACCIDENT RATES

Within the United States, there are at least eleven rail rapid transit systems in operation, and new ones are under construction. This section presents accident data on three of the subway systems in New York, Boston, and Philadelphia.

The size of these three subway systems varies considerably. New York has by far the largest subway system, carrying six times as

Table 9.7

OPERATING ACCIDENT RATES FOR INTRACITY MOTOR BUSES

Traffic Accident Rates Per One Million Miles Operated	1967	1968
Total Traffic Accidents	78.47	77.68
Collision with Pedestrian	2.68	2.61
Collision with Company Vehicle	1.85	1.69
Collision with Other Motor Vehicle	68.04	67.69
Collision with Fixed or Other Object	5.90	5.69
Passenger Accident Rates Per One Million Passengers Carried		
Total Passenger Accidents	5.81	5.47
Boarding (excludes door accidents)	0.64	0.54
Alighting (excludes door accidents)	1.22	1.03
Caught/Struck by Doors	0.70	0.70
Accidents on Board	3.25	3.19

Sources: Harriet Biddle and Murray Kamrass, The Use of Accident Data for Evaluating the Safety of Urban Transportation, Note N-742(R), Institute for Defense Analyses, Arlington, Virginia, August 1970; and Comparative Operating Accident Rates for Calendar Year 1967-1968, Report No. 58, ATA Accident Data Exchange, American Transit Association, March 1969.

Table 9.8

FATALITIES FOR THE TRANSIT INDUSTRY, 1968[a]

Category	Number of Fatalities	Per Million Vehicle Miles[c]	Per Million Passenger Miles[d]	Per Million Passenger Trips
Passengers[b]	15	0.098	0.001	.003
Non Passengers	135	0.880	0.009	.023
Total	150	0.980	0.010	.026

a. Includes surface rail and trolley coach, but predominantly motor buses.
b. Passengers--5,981 million
c. Vehicle Miles--1,533 million.
d. Passenger Miles--15,000 million (approximately 2.5 miles average ride).

Source: American Transit Association, Estimates of Fatalities... Transit Industry, Calendar Year 1968, Washington, D.C., April 24, 1969.

many passengers and traveling eight times as many car miles as Boston, the second largest system. Boston carries 1.8 times as many passengers and travels three times as many car miles as Philadelphia. Table 9.9 indicates the relative size of the three systems as well as the total number of accidents for the year 1968.

In order to compare the number of accidents of the three subways by cause, accidents were grouped in several categories as shown in Table 9.9. There seem to be significant differences in the rates, part of which can be attributed to the use of different criteria by the three transit authorities in categorizing accidents. For example, Boston categorized much of its data as Miscellaneous Collisions. Philadelphia divided Miscellaneous Accidents into Miscellaneous Transportation and Miscellaneous Station Accidents, and New York had six categories of Miscellaneous Accidents. Hence, the category "Traffic Accidents" is not consistent among the three systems, but the other categories seem to be generally consistent, so that there are some real differences in the accident rates of each system.

The original data showing the various breakdowns used by the subway authorities are given in Ref. 13. Most subway passenger accidents occur in the station rather than on the train. The largest single category of accident cause is stairways and escalators in all three systems.

The death rate of passengers is very low when they are on board, boarding, or alighting from the train. However, a significant number of deaths result from a category of accident called "fall or jumped to tracks." For example, in 1968 the three subway systems examined had 240 passenger deaths (Ref. 16), nearly all of which are attributed to this cause. The three systems produced over 400 million car miles, most of these in New York. If we use the New York system average of 22 passengers per car, then the three subways produced a total of 8.8 billion passenger miles in 1968. The passenger death rate then is 0.027 per million passenger miles. Because there is a clear possibility that a significant number of these incidents may be willful, it is questionable whether the system should be charged with such fatalities.

Table 9.9

RELATIVE SIZE, SUBWAY ACCIDENTS, AND ACCIDENT RATES
FOR NEW YORK, BOSTON, PHILADELPHIA SUBWAY SYSTEMS, 1968

Items	New York	Boston	Phila.	Total
Relative Size				
Passengers (Millions)	1,324	194	108	1,626
Million Car Miles	343.4	42.6	14.7	400.7
Million Passenger Miles[a]	7,550	937	323	8,810
Accidents	10,355	1,219	1,465	13,039
Per Million Passengers	7.8	6.3	13.6	8.0
Per Million Car Miles	30.2	28.6	100	32.5
Per Million Passenger Miles	1.4	1.3	4.5	1.5
Passenger Accidents in Station[b]	6,504	367	1,080	7,951
Per Million Passengers	4.9	1.9	10.0	4.9
Per Million Car Miles	18.9	8.6	73.5	19.8
Per Million Passenger Miles	0.86	0.39	3.3	0.90
Passenger Accidents on Board[c]	3,617	187	2.68	4,072
Per Million Passengers	2.7	1.0	2.5	2.5
Per Million Car Miles	10.5	4.4	18.2	10.2
Per Million Passenger Miles	0.48	0.20	0.83	0.46
Traffic Accidents[d]	234	665	117	1,016
Per Million Passengers	0.2	3.4	1.1	0.6
Per Million Car Miles	0.7	15.6	8.0	2.5
Per Million Passenger Miles	0.03	0.71	0.36	0.12
Passenger Deaths	---	---	---	240
Per Million Passengers				0.15
Per Million Car Miles				0.6
Per Million Passenger Miles				0.027

a. Assumes 22 passengers per car.
b. Includes miscellaneous for New York.
c. Includes boarding and alighting.
d. Includes miscellaneous collisions for Boston.

3. SUMMARY AND CAVEATS

Table 9.10 presents a summary of the transit accident rate data that are computed in Ref. 13. We suggest consideration of the following caveats in using these data to make comparisons between modes: (1) Buses operating on city streets tend to have high accident rates. This is a result of their sharing streets with pedestrians and other vehicles. Buses on exclusive roadways would probably have much better accident records. (2) Subways have many accidents that are associated with their stations rather than with their train operations. It is easy to call such incidents passenger accidents because it is reasonable to assume that nearly everyone in a subway station is a passenger. However, bus accidents are designated as passenger accidents only if the passenger is involved while alighting, boarding, or riding on the bus. Except for these kinds of accidents we have seen no data that designates "passenger accidents" at bus stops and terminals. Therefore, it is likely that the bus passenger accident rate is understated compared to the subway passenger accident rate. (3) As we have already noted, significant numbers of the subway passenger accidents may be willful.

Table 9.10

COMPARATIVE ACCIDENT RATES FOR BUSES AND SUBWAYS[a]
1968

Category	Per Million Vehicle Miles		Per Million Passenger Miles		Per Million Passenger Trips	
	Bus	Subway	Bus	Subway	Bus	Subway
Accidents						
Total		32.5		1.5		8.0
Traffic	77.68	2.5		0.12		0.6
Passenger		30.0		1.4	5.47	7.4
Deaths						
Total	1.00	0.6[b]	0.010	.027[b]	0.026	0.15[b]
Traffic	0.90	0[b]	0.009	0[b]	0.023	0[b]
Passenger	0.10	0.6	0.001	.027	0.003	0.15

a. Subway rates are based on combined New York, Boston, and Philadelphia data.
b. This assumes that all deaths in the subway system are passengers. Actually, some may be employees.

D. HIGHWAY TRANSPORTATION NOISE

This section provides data that can be used for the evaluation of transportation noise. The data presented are limited to vehicle noise that occurs when traffic is flowing at constant speed--the kind of background noise common to most urban areas in the daytime. However, the data do not include local noise increments caused by accelerations, climbing hills, and braking. Rail noise data also are not included.

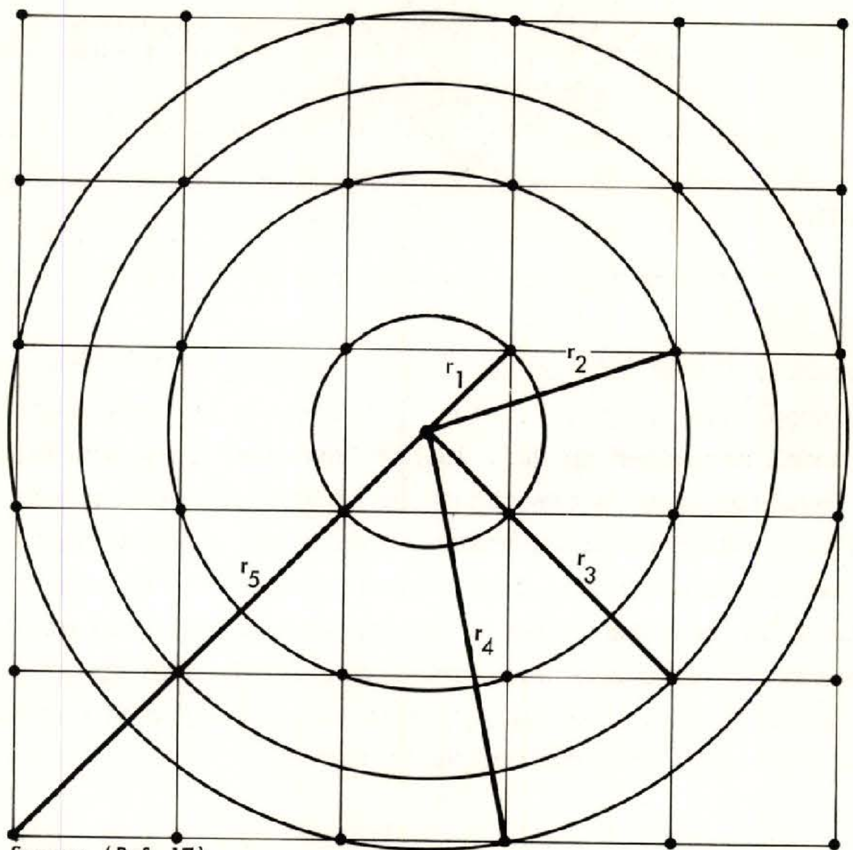
1. GENERAL MODEL

Several approaches can be taken to modeling community noise levels. One of these is described by Thiessen in Ref. 17. In this model a grid of noise sources is superimposed on a community having a circular boundary of radius r_4. (See Figure 9.1). All noise sources radiate q watts per unit area at unit distance. The intensity of sound at midpoints of each grid rectangle can be calculated approximately by

$$I = \frac{7q}{r_i^2} \log n$$

where n = the number of sources. The results of this calculation must be decreased by 15 db to account for the effects of shielding caused by buildings.

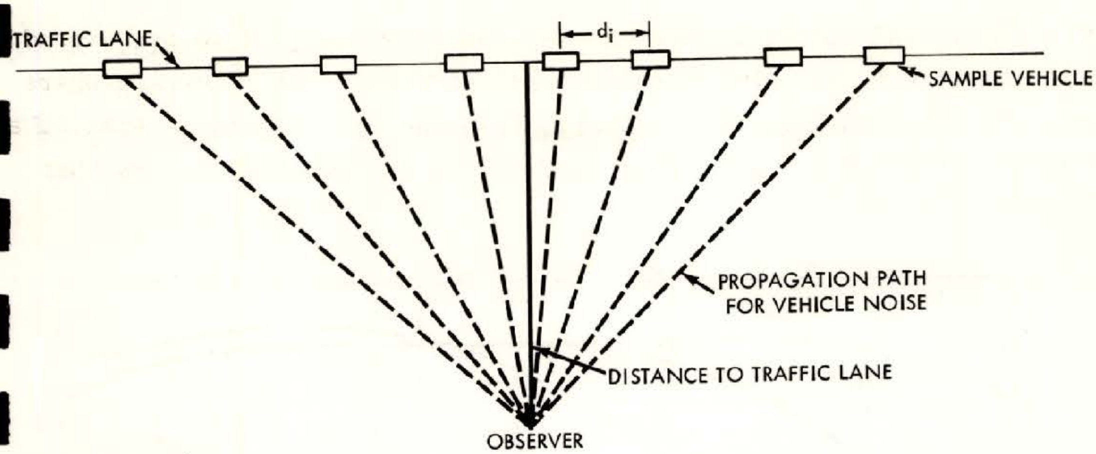
Thiessen shows that this model can be used to calculate the general background level of traffic noise in a community. However, the model is limited to use away from concentrated sources (such as freeways and noisy factories). The model seems simple enough to be useful for determining some generalized effects, such as the influence of changing the size of an area, the effects of traffic density on background noise, and the effects of individual sources on background noise. For example, Thiessen's paper shows that in a situation where heavy trucks constitute only 5 percent of the vehicles in an area, the trucks contribute more to the average level of background noise than all the other vehicles.



Source: (Ref. 17)
P3-29-71-1

FIGURE 9.1 Community Background Noise Model

A model which seems more useful for planning and predicting purposes is presented in Ref. 18. The geometric basis of the model is shown in Figure 9.2, which represents a set of noise sources arrayed along a straight line. If the noise emission of each source is known, then the total noise received by the observer can be calculated. The paper presents a single noise spectrum for automobiles



Source: (Ref. 18)
P3-29-71-2

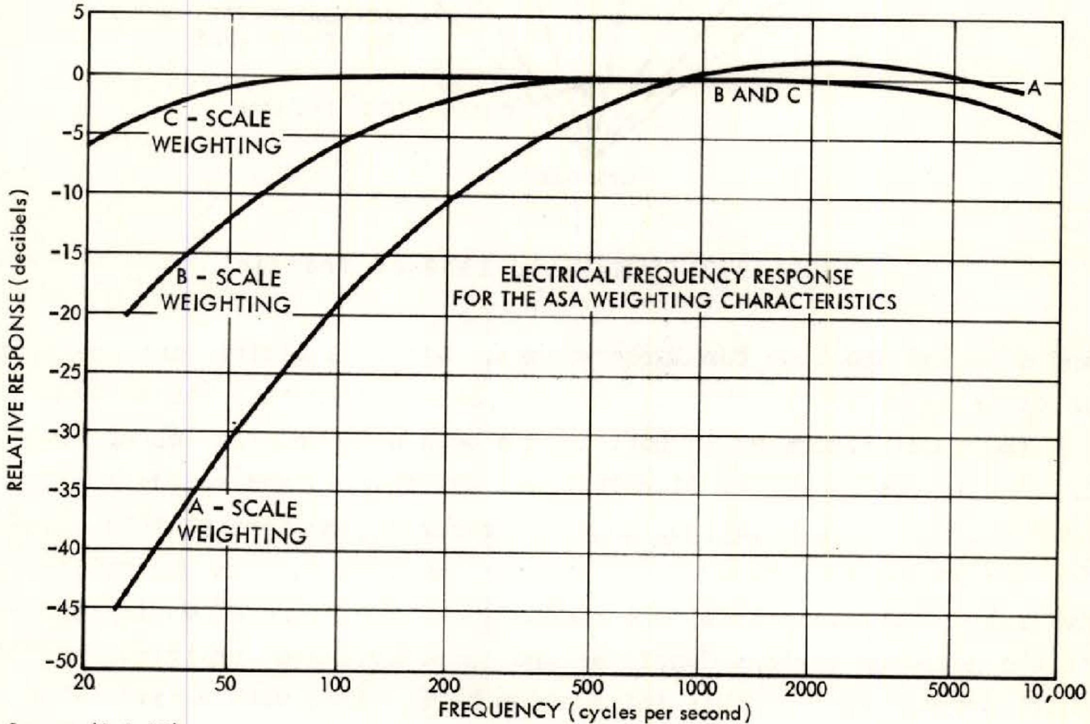
FIGURE 9.2 Simulated Lane of Traffic

and a second spectrum for large trucks. Although a different spectrum level is suggested for buses, none is presented in this report.

The model described in Ref. 18 has been used in a series of simulations involving random distributions of vehicles and speeds. However, for the simulations that are reported, uniform vehicle spacing was used. No estimate of the error involved in this choice is available. The results of the simulations have produced estimates of the noise of various densities and compositions of traffic. We shall present some of this information here, along with estimates of the effects of potential modifying factors.

2. MEASURES OF NOISE

Numerous investigations have been undertaken to define acoustic measures that reflect loudness, noisiness, or annoyance. These investigations have resulted in the definition of such measures as dBA (decibels on the A-scale), Phons, Sones, Speech Interference Level, Noys, and Perceived Noise Level (PNdB). Theoretically, loudness and noisiness are not the same. However whenever real noises (as opposed to laboratory-generated noises) are compared in terms of loudness (dBA) and noisiness (PNdB) the correlations are generally very high. The dBA is a physical measure of noise in decibels. A special weighting of the noise is used, such that the low frequencies are weighted less than the high frequencies. This weighting is shown in Figure 9.3, taken from Ref. 19.



Source: (Ref. 19)
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FIGURE 9.3 Frequency-Response Characteristics in the American Standard for Sound-Level Meters, S1.4, 1961

The C-scale shown in Fig. 9.3 is an unweighted scale used to measure the purely physical level called the sound pressure level of a sound. The B and A scales are weighted to approximate the frequency response of the human ear at values of the sound pressure level below 85 and 55 dB, respectively. By measuring a particular sound with all three scales, it is possible to make an approximate analysis of spectral content without a frequency analyzer.

Although the A-scale weighting was intended to provide an approximation of human perception of loudness at generally low sound levels, it correlates highly with measures of annoyance associated with transportation noise and is often used for this purpose when more elaborate instrumentation is not available.

3. VEHICLE SOURCE NOISES

Traffic noise at any point is the sum of the noises reaching that point from individual vehicles. The contribution of each vehicle depends on the speed of the vehicle, the kind of vehicle, road characteristics, and the distance between the point and the vehicle. It also varies with the operating condition of the vehicle, acceleration, cruise, deceleration, or hill climbing. For our purposes, we consider all vehicles to be cruising at constant speed.

The major noise sources for individual vehicles are their engines, exhausts, and tires. Depending on the speed, one or the other of these sources tends to predominate. However, in the case of trucks, tire noise is never great enough to predominate unless the vehicle is coasting. We have no data that would indicate whether this is also true of buses. In spite of the variation of predominant noise source with speed, the overall spectrum of automobile noise is relatively smooth and can be represented with good accuracy by the dBA through the entire speed range. Ref. 18 gives the following equation for the level of auto noise:

$$L = 50 - 20 \log_{10} d + 30 \log_{10} v$$

where

L = overall noise level in dBA

d = distance to the observer in feet

v = speed of the auto in miles per hour.

The same reference also shows that trucks and automobiles tend to have a similar noise spectrum, although that of trucks is higher by about 15 dB. This reference presents no data for buses. However, Ref. 22 has indicated that, except for acceleration, urban diesel bus noise is about the same as that of gasoline engine trucks, typically about seven dBA higher than automobile noise. Thus, a bus produces approximately the noise equivalent of about five automobiles, while a truck produces the noise equivalent of about 30 automobiles. This comparison, however, applies to individual vehicles and not to a stream of traffic.

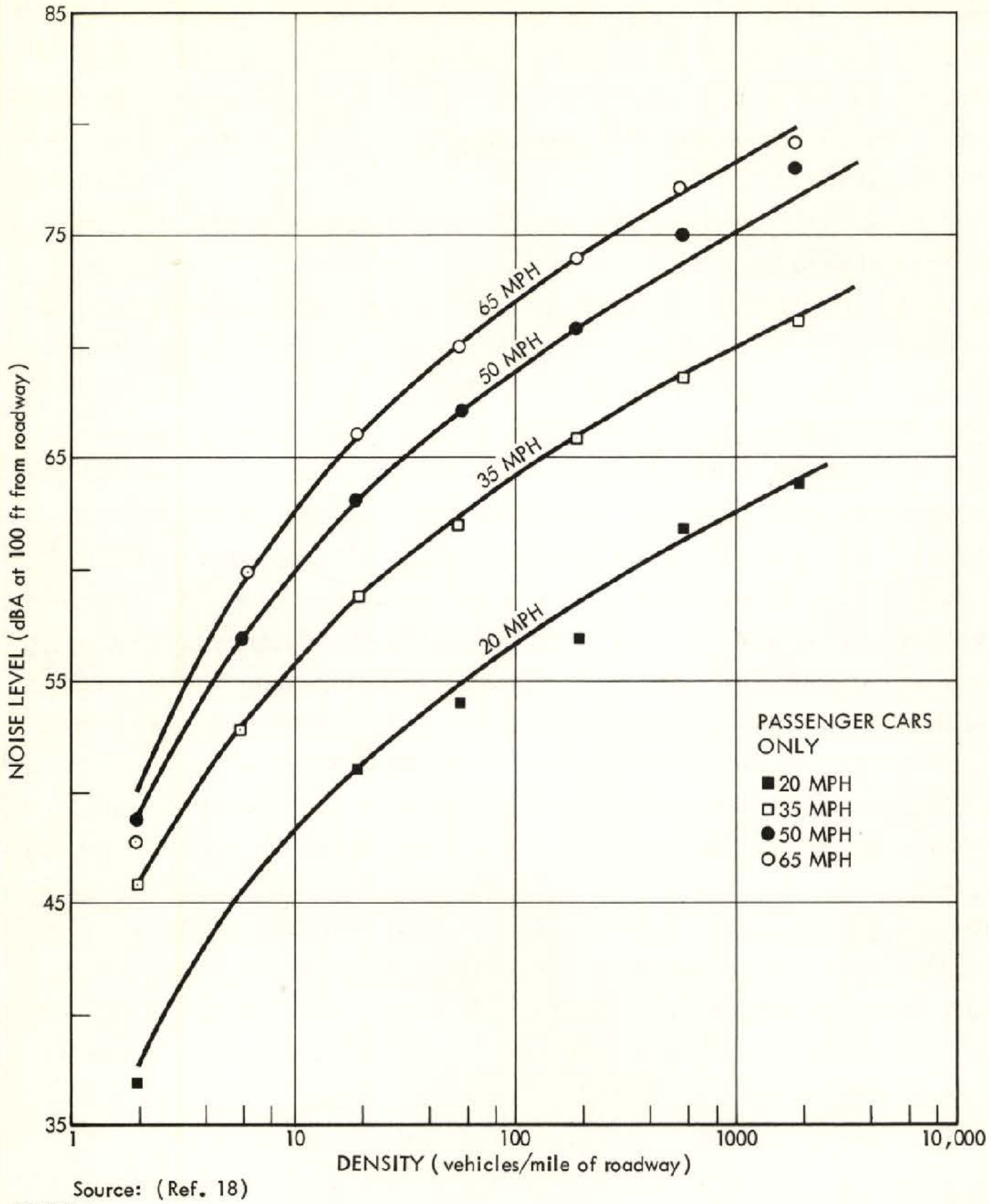
4. TRAFFIC NOISE

Using their model, the authors of Ref. 18 simulated various traffic conditions to determine typical values of traffic noise. These data are shown in Figure 9.4. This figure presents curves for estimating mean noise level in dBA, 100 feet from a lane of automobile traffic, as a function of vehicle speed and roadway density.

The values shown in Figure 9.4 are the mean values of fluctuating quantities. Reference 18 indicates that the standard deviations of these quantities are variable, depending on the density of traffic, the distance from the roadway, and the proportion of trucks. The smallest fluctuations, perhaps 0.1 dBA standard deviation, occur with the highest density, all-automobile condition at the greatest distance (1500 vehicles per mile of roadway at 1000 feet.) The highest fluctuations in the range tested are about six dBA standard deviation at 100 feet which occurs when the density is 15 vehicles per mile of roadway and at least 5 percent trucks. With the same flow density but no trucks, the standard deviation is about three dB at 100 feet.

The values shown in Figure 9.4 should be corrected for the following factors:

<u>Distance</u>: Figure 9.4 shows results for a position 100 feet from the line of traffic. An increase in distance decreases the average noise level with approximately the first power of distance. For 300 feet the mean noise level can be estimated by subtracting about six dBA, and for 1000 feet the mean noise level can be estimated by subtracting 15 dBA.



Source: (Ref. 18)
P 3-29-71-4

FIGURE 9.4 Curves for Estimation of Mean Noise Level in dbA at 100-Ft Distance from a Lane (or Single-Lane-Equivalent) of Passenger Car Traffic, for Four Speeds

Presence of Other Vehicles: If trucks or buses are included in the vehicle mix, the amount of noise is increased as shown in Table 9.11. If both buses and trucks are included, the truck data apply until there are about 5 times as many buses as trucks. Note, however, that the bus information is rough and is based on little data.

Multiple-Lane Roadway: If a multiple-lane roadway is involved, a single pseudolane is considered, and all vehicles are assumed to be at the distance associated with the pseudolane. The pseudolane distance is defined by its displacement away from the nearest lane in lane widths as seen in Table 9.12.

Highway Configuration: The difference in noise emanating from a highway in a cut and a highway at grade level ranges from nothing at about 30 feet to about seven dBA less for the depressed highway at about 400 feet from the centerline of the lane. (See Figure 9.5). At distances less than 30 feet, the noise level will be higher for the cut than for the on-grade roadway. An elevated highway is five to ten dBA less noisy than the on-grade highway for locations within 200 feet, but beyond 400 feet the noise levels of the two configurations are the same.

Shielding: The effect of shielding due to buildings, hills, etc. is to reduce the calculated noise 10 to 20 dBA, according to Ref. 23.

Vehicle Operations: The data above apply to freely flowing traffic moving at constant speed. If accelerations or steep hill climbing are present additional noise will occur, but we have no estimate of its magnitude.

Table 9.11

EFFECTS OF ADDING TRUCKS OR BUSES TO VEHICLE MIX

Percentage of Trucks in Traffic	Percentage of Buses in Traffic	Additional dBA
0	0	0
2.5	12	1
5	25	2
10	a.	4
20	a.	8

a. Not considered.

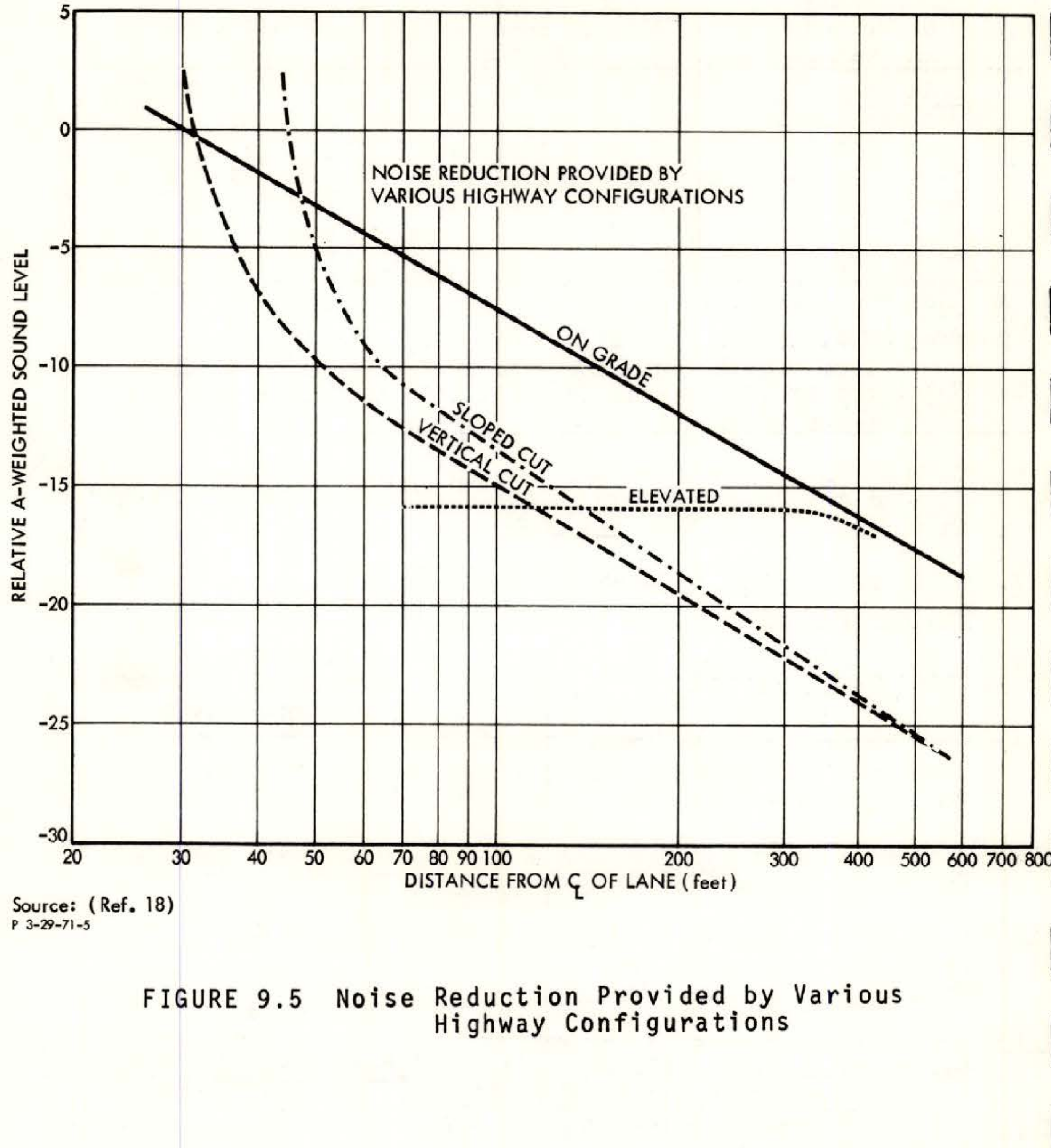
Source: M.A. Elliott, et al. "Composition of Exhaust Gases from Diesel, Gasoline, and Propane-powered Motor Coaches." Journal of APCA, Vol. 5, August 1955 (except buses).

Table 9.12

PSEUDOLANE LOCATION

Number of Lanes	Displacement Away From Nearest Lane, In Lane Widths
2	1.4
3	1.7
4	2.0
5	2.2
6	2.5
7	2.7
8	2.8

Source: William J. Galloway et al. Highway Noise Measurement, Simulation and Mixed Reactions. National Cooperative Highway Research Program Report 78. Highway Research Board, 1969.



Source: (Ref. 18)
P 3-29-71-5

FIGURE 9.5 Noise Reduction Provided by Various Highway Configurations

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