STUDY OF PUBLIC TRANSPORTATION FARE POLICY

Prepared for

OFFICE OF THE SECRETARY
U.S. DEPARTMENT OF TRANSPORTATION

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA •

DECEMBER 1976

Prepared by

PMM&Co. PEAT, MARWICK, MITCHELL & CO.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Study of Public Transportation Fare Policy		5. Report Date December 1976 6. Performing Organization Code 289-51864-30,40
7. Author(s) Paul Dygert, James Holec, Donald Hill		8. Performing Organization Report No.
9. Performing Organization Name and Address Peat, Marwick, Mitchell & Co. 1025 Connecticut Avenue, N.W. Washington, D.C. 20036		10. Work Unit No. (TRAIS) 11. Contract or Grant No. DOT-OS-50134
12. Sponsoring Agency Name and Address U.S. Department of Transportation Office of the Secretary 400 Seventh Street, S.W. Washington, D.C. 20590		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

This study was sponsored by and performed jointly for Office of the Secretary and Urban Mass Transportation Administration.

16. Abstract

The factors which affect transit fare policy can be grouped into three categories: institutional, demand, and pricing rationale. Institutional factors include fare trends, types of fares, fare collection techniques, and the role and objectives of the various groups involved in procing transit. Demand factors are concerned especially with the responsiveness of transit users and potential users to changes in fares, in transit service characteristics, and in the perceived price of urban automobile trips. Pricing rationale or cost factors are concerned particularly with the cost characteristics of the production of transit services. This report identifies the issues with which any fare policy must deal, and presents information that will aid individual transit operators to resolve those issues in their own operations.

17. Key Words	18. Distribution Statement
Institutional, demand, pricing factors, fare and service elasticities, transit management strategies, new DOT policies.	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

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INTRODUCTION

1. PURPOSE AND APPROACH

PURPOSE OF THE STUDY

This report documents the results of a study of factors which affect the formulation of transit fare policy. The study has been concerned both with technical and policy questions, and is intended to provide those interested in transit fare policy with synthesis of the ideas and data which are relevant to the development of that policy.

The purpose of the study has been to provide an organized review and synthesis of a large body of existing information and to show the relevance of that information for transit fare policy. Only a limited attempt has been made to develop additional empirical data. There are two major reasons why this approach has been taken. First, it was known that a good deal of information already existed, but that this information needed to be organized and directed in a way that would make it more useful to transit operators and others responsible for making fare policy decisions. Second, many of the most important issues in transit fare policy concern new markets and new marketing strategies. Most of the information that could be extracted from additional empirical studies would provide little information beyond that which already exists, and would be largely irrelevant to the new markets and the innovative marketing strategies. For these reasons, the new empirical research undertaken in this study has been limited in obtaining data on commuter clubs, paratransit, and special transit services which were considered to be particularly relevant as examples of innovative services.

APPROACH

The approach to the study has involved five major steps. These include:

- search for information;
- synthesis of market information;
- identification of promising alternatives;

- implications of alternative fare policies for other policies and programs; and

- suggestions for further research.

Information Search

One task of the study was to identify, organize, and present the available information which affects transit fare policy. The main pieces of relevant information include:

- a description of the institutional structure within which transit systems operate and fare policies must be formulated;

- an identification of the market segments which lend themselves to different levels and service qualities;

- an identification of the responsiveness of transit ridership to change in fare levels and service quality, and to changes in the cost of automobile travel;

- an analysis of the various elements of transit cost and the related arguments for transit subsidy; and

- an analysis of fare collection techniques, with particular emphasis on the relation between fare collection and feasible fare structures.

Synthesis of Market Information

A second task of the study was to provide a synthesis of the market segment and fare and service elasticity data so that the fare policy alternatives available to transit management are readily apparent. Data on the responsiveness of transit ridership to fare and service changes are organized in such a way that the management of any particular transit system can readily identify whether data relevant to their fare policy decisions exist. In many cases, sufficient data are simply not available, particularly where one seeks fare and service responsiveness data for particular market segments. Often, it has been necessary to use aggregate market data as an approximation of the likely results in specific markets.

Identification of Promising Alternatives

A third task has been to draw together the synthesis of market information, information on fare collection systems, transit cost information, and knowledge of the institutional environment of urban public transportation to identify promising alternative fare policies. Although the choice of a particular fare policy will also depend on local conditions as seen by transit management and boards of directors, some generally promising alternative policies are identified.

A fourth task of the study has been to identify the implications of alternative fare policies for other public policies and programs. The policies and programs most likely to interact with transit fare policy decisions include programs for transit capital and operating assistance, urban highway development programs, pollution control, energy conservation, transportation system management programs, and the like.

Research Requirements

A final task of the study has been to identify the areas in which further research is required. Discussions of research requirements have been included at the ends of the chapters on demand analysis and on cost.

2. STRUCTURE OF THE STUDY

This section sets out the main components and structure of the analyses which accomplish the study tasks outlined in the previous section. The six chapters of this report on the study are summarized below and depicted in flow-diagram form in Figure 1.

CHAPTER I. INSTITUTIONAL SETTING

This chapter contains a concise description and analysis of the institutional setting within which transit fare and service policy decisions are made. In addition to a description and analysis of the direct participants in fare policy decisions, the institutional analysis considers the effect of highway agencies and of automobile operating and parking costs on transit fare policy decisions. The institutional analysis is particularly concerned with various participants (users, operators, transit labor, and governments) who affect transit costs and who have either direct or indirect roles to play in determining transit fare policy.

CHAPTER II. FARE STRUCTURE AND COLLECTION TECHNIQUES

This chapter provides a history of transit fares and fare collection techniques that have either been used or have been proposed for use. An analysis is also made of the relationship between fare structures and the collection systems required to implement them.

CHAPTER III. ANALYSIS OF FARE AND SERVICE ELASTICITIES

Demand elasticities constitute the central issues in determining the best levels and structure of transit fares and service characteristics to be provided for particular market segments. The main purpose of this chapter is to assemble and organize the available information in the transportation literature on elasticities with respect to fare, service characteristics, and auto cost. The chapter synthesizes the fare and service elasticities and market segment information to present a comprehensive picture of the influence of changes in fare levels and structures, and of alternative combinations of transit service characteristics on transit ridership in various market segments. The available information on the cross elasticities of transit ridership with respect to the cost of automobile trips is also integrated into the analysis.

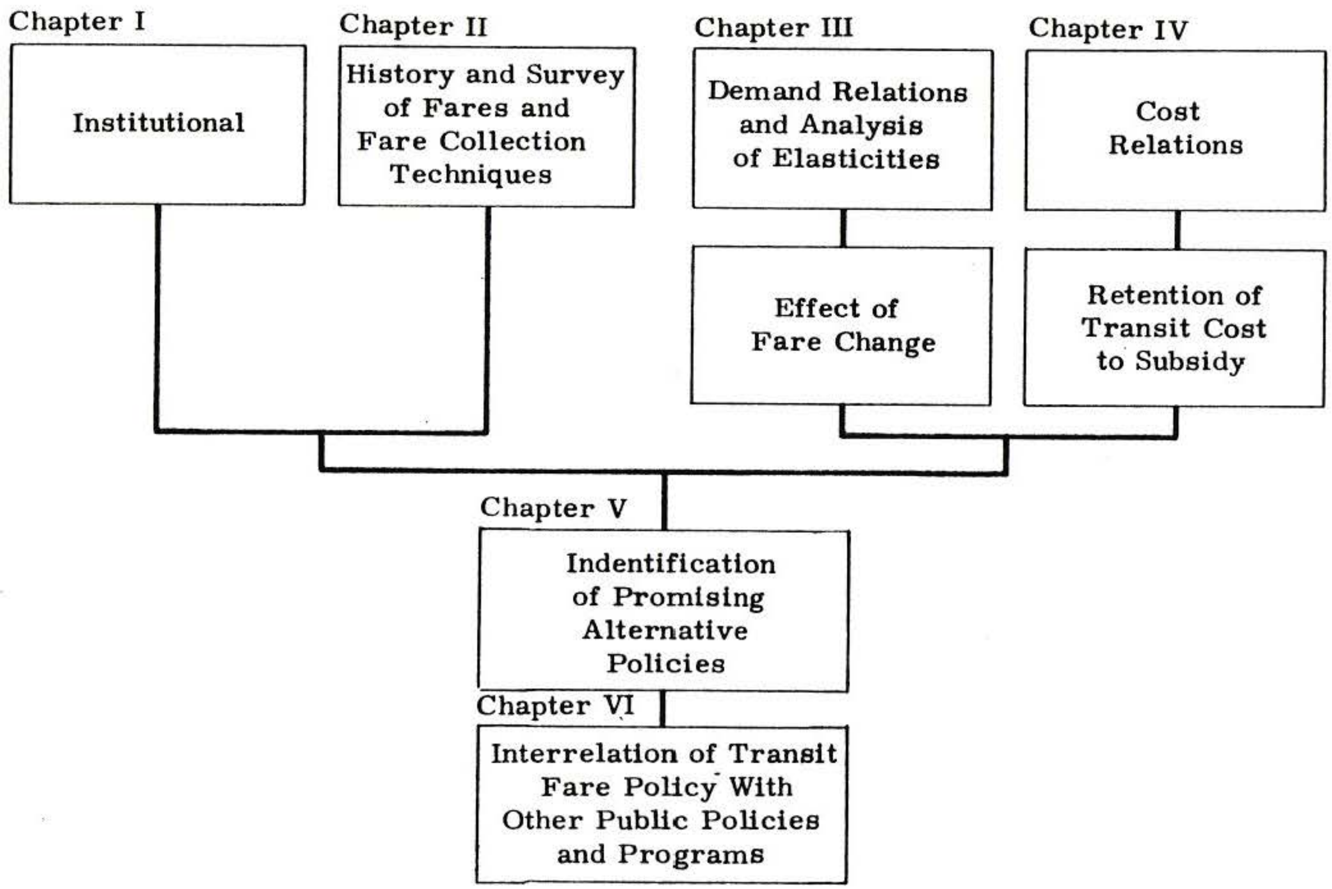

FIGURE 1: STRUCTURE OF THE REPORT

CHAPTER IV. TRANSIT COST FUNCTIONS, FARES, AND SUBSIDIES

The purpose of this chapter is to provide an analytical and empirical description of the cost structures of urban public transportation as they relate to questions of fare level and structure. The chapter reports on analyses of transit cost patterns. In addition, the analysis is concerned with economic justifications for subsidies based on such social benefits as pollution and congestion reduction and redistribution of income.

CHAPTER V. IDENTIFICATION OF PROMISING ALTERNATIVE POLICIES

This chapter suggests some alternative fare policies which appear to hold promise for increasing transit ridership and for reducing deficits. The alternatives take particular account of the market segments with the greatest probability of responding positively to improvements in transit service characteristics, thus allowing increases in fares and revenues.

CHAPTER VI. INTERRELATIONS WITH FEDERAL POLICIES AND PROGRAMS

This chapter deals with the interrelations between alternative transit fare policies and federal policies and programs. The main policy areas of interest include: (1) transit capital assistance; (2) transit operating assistance; (3) urban highway development; (4) transportation system management (TSM); (5) pollution control; and (6) energy conservation.

CHAPTER I
INSTITUTIONAL SETTING

1. INTRODUCTION

This chapter identifies and analyzes those institutional factors which have influenced, and will continue to influence, the development of transit and of transit fare policy. The ideas in this chapter are developed in four sections.

Section 2 of this chapter traces the main aspects of the historical development of urban mass transportation, particularly as they affect, or have been affected by transit fare policy. Of particular interest is the change in transit from profitable undertakings in the private sector to publicly operated undertakings with large and increasing deficits. The reasons for this change will be detailed in Section 2, but there are two main causes to consider throughout. One clear cause has been competition from the automobile, and the change in residential development patterns effected by automobiles and trucks. Another cause has been the apparent reluctance of transit management to modify the characteristics and the prices of the services it provides.

Section 3 of this chapter suggests alternative economic rationales for transit fares. Fares need not, of course, be based on any economic rationale. Nonetheless, fare policy is essentially an economic issue, and it is desirable to consider the alternative economic rationales which are relevant to fare policy.

A major theme developed in Section 4 concerns the roles played by the different groups who participate either formally or informally in setting fare policy for transit systems. The section considers the ways in which the various participatory groups, and other more general factors, influence transit fare policy. In addition to the main participatory groups, including transit users, government, and transit labor, there are two more general sets of economic forces affecting transit fare policy. These include:

. General economic conditions, which affect price trends, labor costs, and the income levels of transit riders. These factors are wholly outside the control of transit management.

- Automobile facilities investment and price policy. These can have a significant effect on transit ridership and fares. Investment and pricing decisions for urban highways and parking facilities have kept the perceived cost of automobile travel into urban areas relatively low, and transit has not been able to compete, even with large Government subsidies.

2. HISTORY OF URBAN MASS TRANSIT

EARLY HISTORY OF URBAN MASS TRANSIT

The early history of urban mass transportation dates from at least 1827 when the first commercial operation began in New York City with horse-drawn vehicles.[1] After the electric motor was introduced in 1888, several cities constructed surface rail lines, while New York, Boston, and Chicago constructed elevated or subway lines.

These early systems were expected not only to provide public transportation services, but also to produce financial returns for the investors. The monopoly status of transit firms was created by the issuance of franchises giving exclusive rights in certain routes. In return for this protection, transit firms submitted through regulatory processes to local and state control over their fares, route structures, and sometimes even over their financing. Government regulation, aimed at protecting the public from the potential negative effects of monopoly, has continued throughout the development of urban mass transit and exists today over the private and some of the public transit firms.

At the start of the twentieth century, the urban mass transit industry converted to electric-powered vehicles. As many of the transit firms were able to sell some of their excess electrical generating capacity to industrial and other users, the electrical generating activities of the transit firms often became large and more profitable than the mass transportation operations. Holding companies were formed to acquire the utilities. It is estimated that if both direct and indirect control are counted, by 1931 approximately 50 percent of the transit firms, carrying more than 80 percent of all revenue passengers, were controlled by the holding companies.[2]

At the turn of the century, it was evident that transit systems were in financial trouble. In a document, Special Reports--Street and Electric

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[1] For early transit history, see Lewis M. Schneider, Marketing Urban Mass Transit: A Comparative Study of Management Strategies (Boston: Graduate School of Business, Harvard University Press, 1965).

[2] Richard J. Solomon and Arthur Saltzman, History of Transit and Innovative Systems (Cambridge, Mass.: Massachusetts Institute of Technology, Urban Systems Laboratory, March 1971), p. 1-15.

Railways 1902, the U. S. Bureau of the Census warned of impending problems caused by high construction costs, long rides at low fares, the concentration of destinations in downtown areas, traffic peaking, and the expectation of population shifts to outlying areas. Already the policy of low fares was becoming a problem.

By the end of World War I, the automobile had become an established mode of transportation. Contemporaneously, the Great Depression further damaged the transit industry. Patronage declined sharply during the Depression years, and financing became increasingly difficult. The shortage of financing limited the modernization of electric streetcars, and bus service began to develop.

Transit financing problems were further exacerbated when the Public Utilities Holding Company Act of 1935 forced separation of utilities from transit companies, and the latter lost their primary source of capital funds. Meanwhile, rising costs could not be met by increased fares because of the limits of franchises and pressure from political regulatory sources. Actual transit fares remained relatively constant up to the advent of World War II: the average transit fare was 7.1 cents in 1924, and 6.7 cents 16 years later, despite rising costs.[1]

As utilities withdrew from the transit business and transit systems began to convert from electric traction vehicles to motor buses, vehicle and parts suppliers moved to fill the capital void caused by the utility companies divesting themselves of transit operations. Participation of these suppliers in transit occurred through indirect ownership of transit firms via transit holding companies: transit firms were subject to ownership by non-transit interests. In 1947, the Justice Department sought injunctions against National City Lines, the largest transit holding company, and other suppliers for violating the anti-trust laws. Transit organizations were again deprived of capital funds for modernization and innovation.

The declining economic condition of transit companies continued until the early 1940s. With the onset of World War II, transit experienced a temporary resurgence, due largely to the lack of automobile production and severe limitations on available gasoline and rubber tires.

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[1] Wilfred Owen, The Metropolitan Transportation Problem (Washington: The Brookings Institution, 1956), p. 90.

POST WORLD WAR II EXPERIENCE

From the end of World War II through 1973, the urban mass transit industry experienced a continual decline in activity despite increases in population and real income. The reasons for this decline are well-known and include such factors as increasing affluence and automobile ownership, growing suburbanization, and widespread highway construction. Only from 1973 through 1975 has there been any indication of a possible reversal of the declining trend, with the reversal caused largely by rising gasoline costs, constraints on the availability of gasoline, and perhaps by sustained efforts of local, state, and Federal governments to maintain and improve the quality of transit service.

Some of the more significant transit industry trends from 1945 through 1975 are shown in Table I.1. The decrease in demand for transit services is indicated by the decline in revenue passengers by some 72.3 percent from 1945 to 1972; in the last three years, however, the number of revenue passengers has increased 7.1 percent. Changes in population and revenue passengers for the period 1945 through 1975 are graphically displayed in Figure I.1. Vehicle miles operated, which provides a measure of the amount of transit service offered, decreased by some 46.0 percent from 1945 through 1972, and then increased some 13.3 percent from 1972 through 1975. The historical record of vehicle miles operated by bus, trolley, and rail systems is shown in Figure I.2.

In addition to cutting service, the transit industry reacted to the declining market and revenues by raising fares. Average fares for all transit modes increased from 6.92 cents in 1945, to 32.10 cents by 1975, an increase of 364 percent. Figure I.3 shows the trends in average fares from 1945 through 1974 for all transit modes combined, and for bus, light rail, heavy rail, and trolley coach, individually. The leveling off of average fare in recent years is a result of, among other factors, rising fare levels for heavy rail and declining bus fares.

Generally rising fares have caused operating revenues to increase despite declining passenger volume. From 1945 through 1975, operating revenues rose some 45.1 percent. Contemporaneously, however, operating expenses rose by some 231.3 percent, so that net operating income declined from a surplus of $313 million in 1945 to a deficit of $1.5 billion in 1975. The trends in operating revenue and operating expenses in the period 1945 through 1974 are shown in Figure I.4. Much of the increase in operating cost is due to wage increases. Over recent years, payroll has accounted for 68 to 70

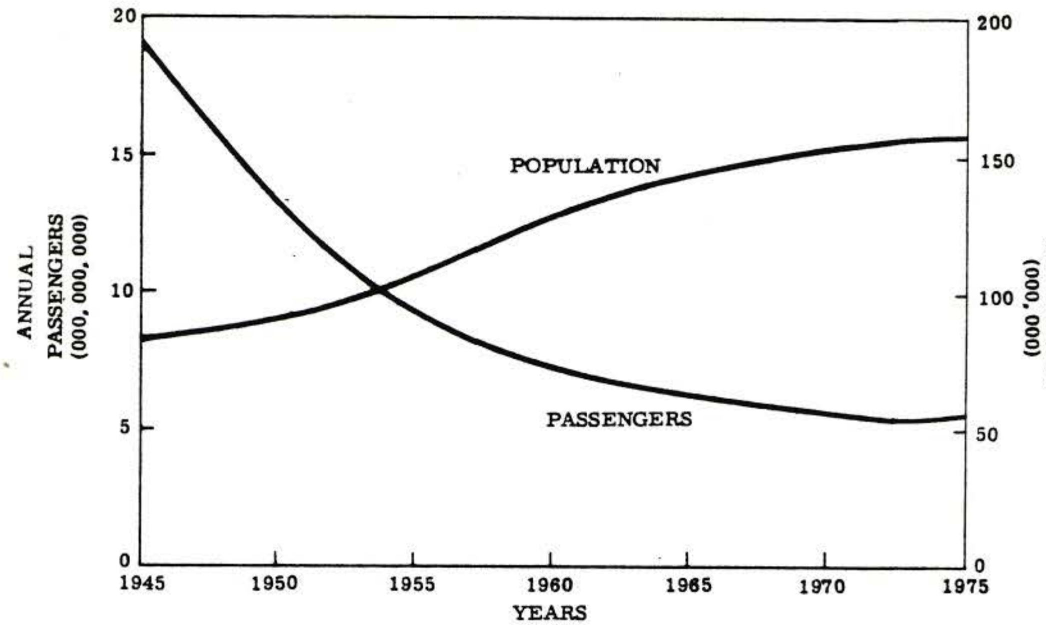
TABLE I.1

TRENDS IN URBAN MASS TRANSIT
1945-1975

Calendar Year	Revenue Passengers (000,000)	Annual Change (%)	Vehicle Miles Operated (000,000)	Annual Change (%)	Average Fare (cents)	Annual Change (%)	Operating Revenue ($000,000)	Annual Change (%)	Operating Expenses ($000,000)	Annual Change (%)	Operating Expense/ Vehicle Mile ($)	Annual Change (%)	Net Operating Revenue (Loss) ($000,000)	Annual Change (%)
1945	18,982		3,254		6.92		1,380		1,067		.33		313	
		-7		-2		8		1		4		5		-15
1950	13,845		3,008		10.02		1,452		1,297		.43		155	
		-9		-4		8		*		*		4		-1
1955	9,189		2,448		14.79		1,426		1,277		.52		149	
		-4		-3		3		*		*		3		-5
1960	7,521		2,143		17.75		1,407		1,290		.60		117	
		-2		-1		2		1		1		3		-11
1965	6,798		2,008		19.71		1,444		1,374		.68		70	
		-3		-1		7		3		7		8		-29
1970	5,932		1,883		27.63		1,707		1,892		1.00		(184)	
		-7		-2		8		2		8		11		-63
1971	5,497		1,846		29.78		1,741		2,040		1.11		(300)	
		-4		-5		6		*		4		9		-33
1972	5,253		1,756		31.42		1,729		2,128		1.21		(400)	
		1		4		1		4		14		9		-56
1973	5,294		1,835		31.80		1,798		2,420		1.32		(622)	
		6		3		*		6		28		23		-87
1974	5,606		1,888		31.76		1,940		3,102		1.63		(1,163)	
		*		5		1		3		14		9		-32
1975	5,626		1,990		32.10		2,002		3,535		1.77		(1,533)	
Average Annual Change 1945-1975		-4		-2		-5		1		4		6		-6

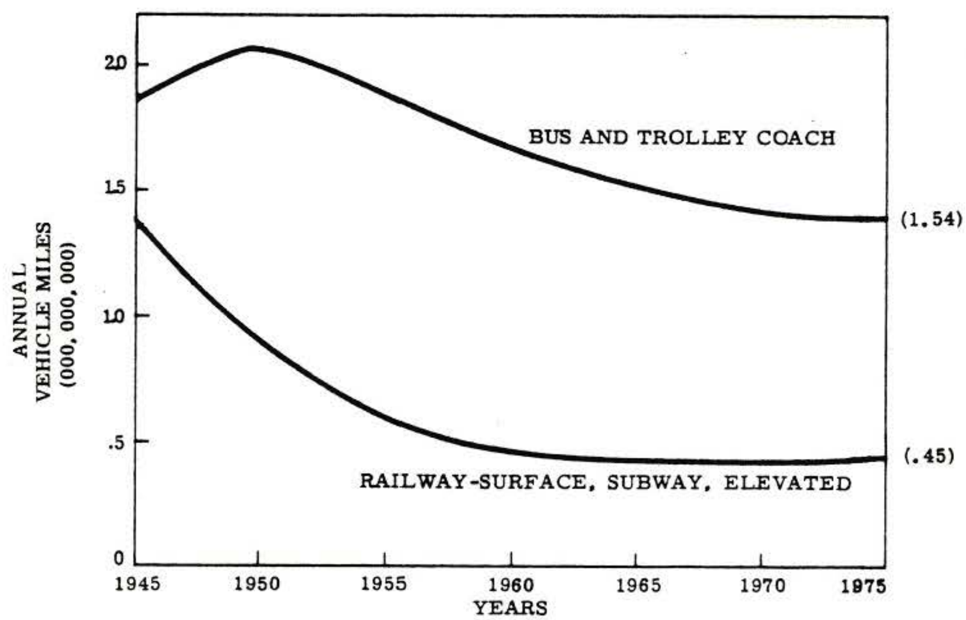
*Less than 1 percent.

Source: '75-'76 Transit Fact Book (Washington, D.C.: American Public Transit Association, March 1976).



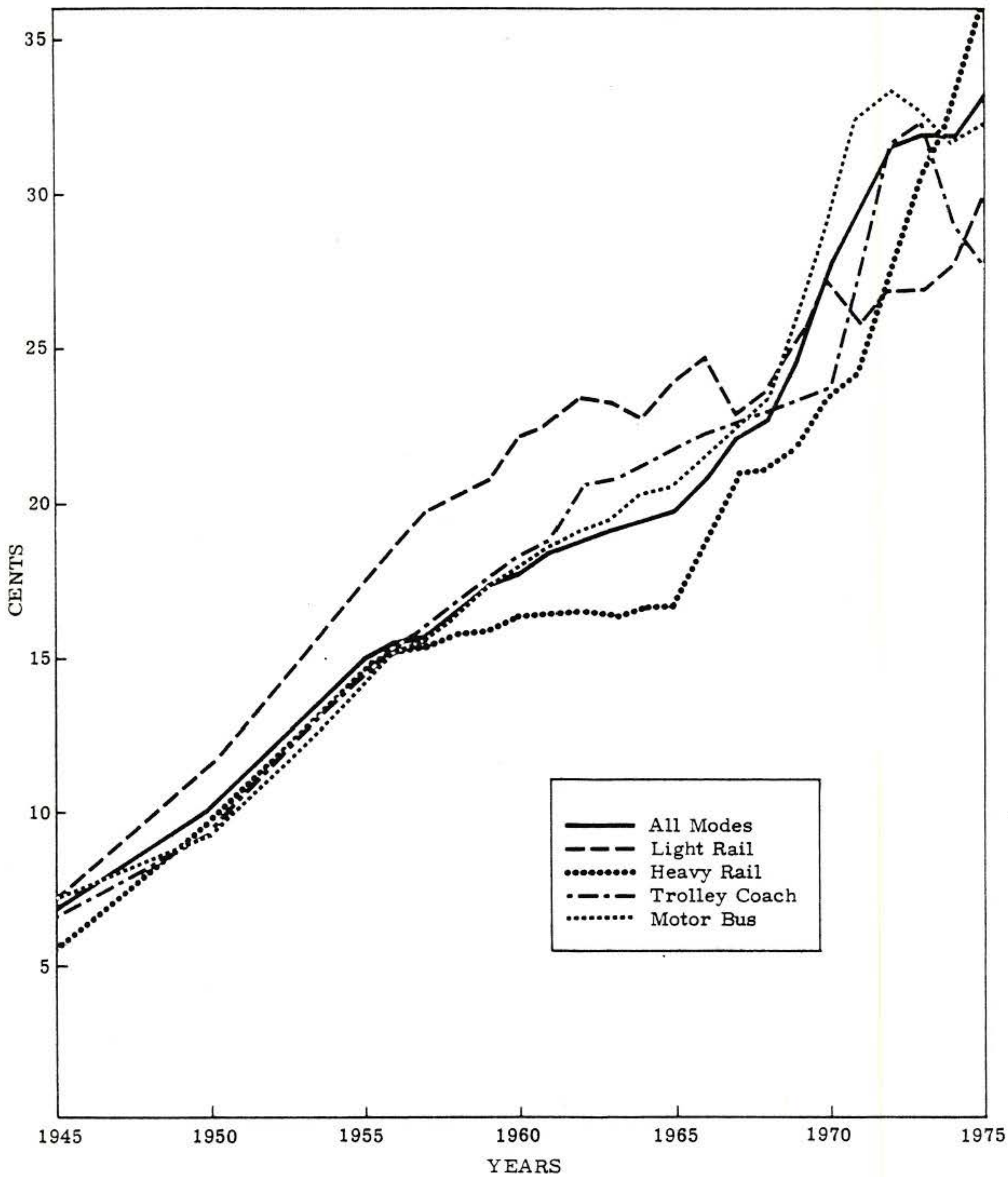
Source: '74-'75 Transit Fact Book (Washington: American Public Transit Association, March 1976).

FIGURE I.1: URBAN POPULATION AND REVENUE PASSENGERS, 1945-1975



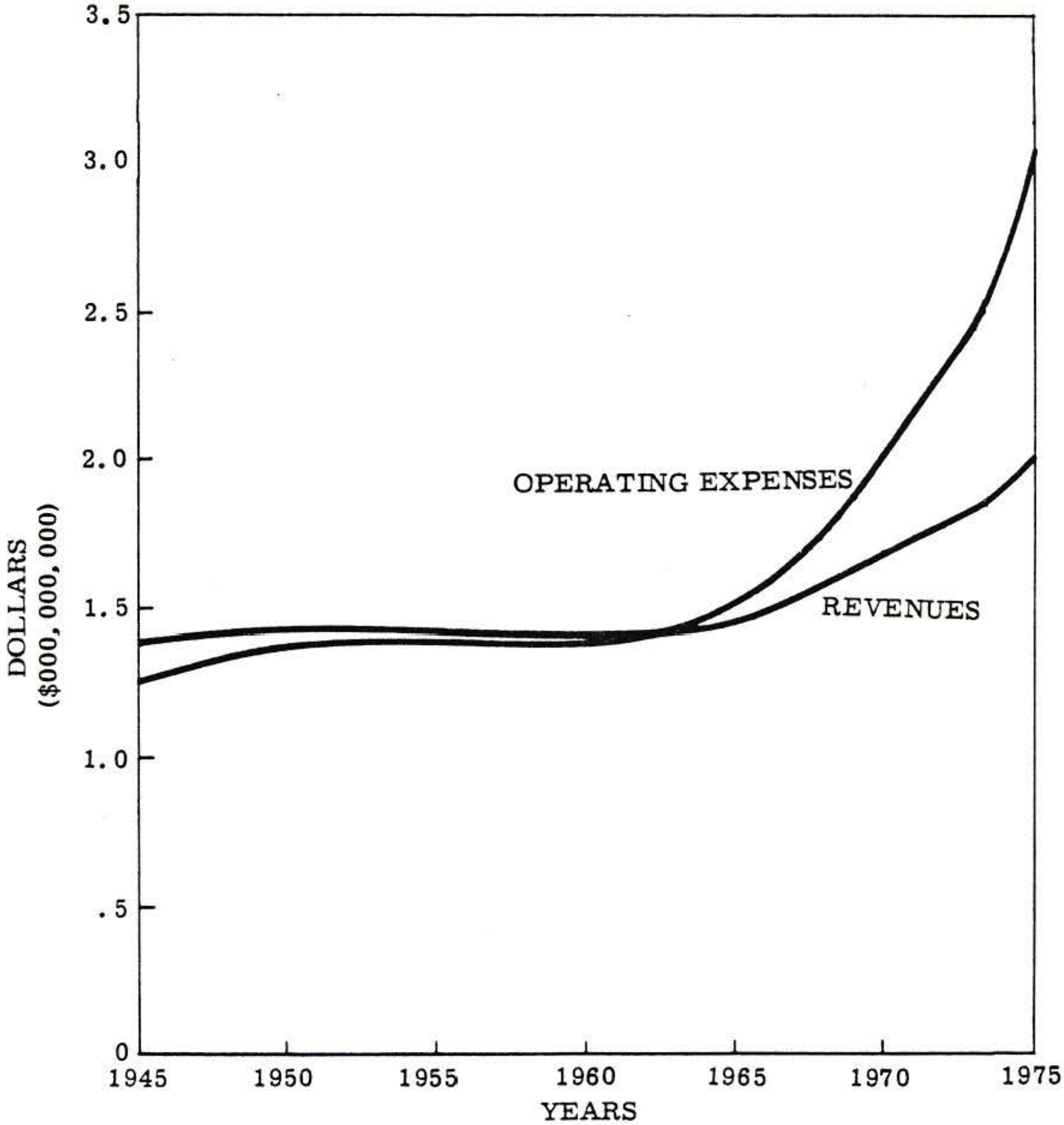
Source: '75-'76 Transit Fact Book (Washington: American Public Transit Association, March 1976).

FIGURE I.2: VEHICLE MILES OPERATED, 1945-1975



Source: '75-'76 Transit Fact Book (Washington: American Public Transit Association, 1976).

FIGURE I.3: TRENDS IN AVERAGE FARES, 1945-1975



Source: <u>'75-'76 Transit Fact Book</u> (Washington: American Public Transit Association, March 1976).

FIGURE I.4: TRANSIT REVENUES AND OPERATING EXPENSES, 1945-1975 percent of transit operating expenses. Figure I. 5 shows the relation between employment and transit payroll for the period 1945 through 1975. Over this period, the average salary per employee has increased from $2,600 to $14,000. This increase represents an annual gain of about 5.8 percent. From 1966 through 1975, however, the average annual gain has been about 8.2 percent.

Revenue passengers per employee have dropped from 78,000 in 1945 to 35,000 in 1975, while revenue vehicle miles per employee have remained relatively constant. Thus, while labor productivity in vehicle miles has remained fairly constant, labor productivity expressed in number of passengers transported has dropped significantly.

As cost rose and patronage fell in the post-World War II period, transit firms fought for existence. More than 200 transit firms disappeared from existence in the first two decades following the War as public pressure resulted in accelerated public takeover of urban transit systems in the 1960s.[1] The number of publicly owned transit systems increased from 36 in 1948 to 333 by 1975.[2]

AUTOMOBILE COMPETITION

It can plausibly be argued that public transportation largely lost its market to the automobile. Some of the data and issues relevant to that argument are discussed below because they relate directly to transit fare policy.

Table I. 2 presents some selected statistics concerning the growth of specific automobile and highway supply statistics for the period 1925 through 1973. Items I and II in Table I. 2 are national totals, whereas items III and IV are for municipal areas.

Highway motor fuel use increased 12.7 times over the 48 years from 1925 through 1973. Over the same period, automobile registrations increased 5.8 times and bus registrations 17.5 times.

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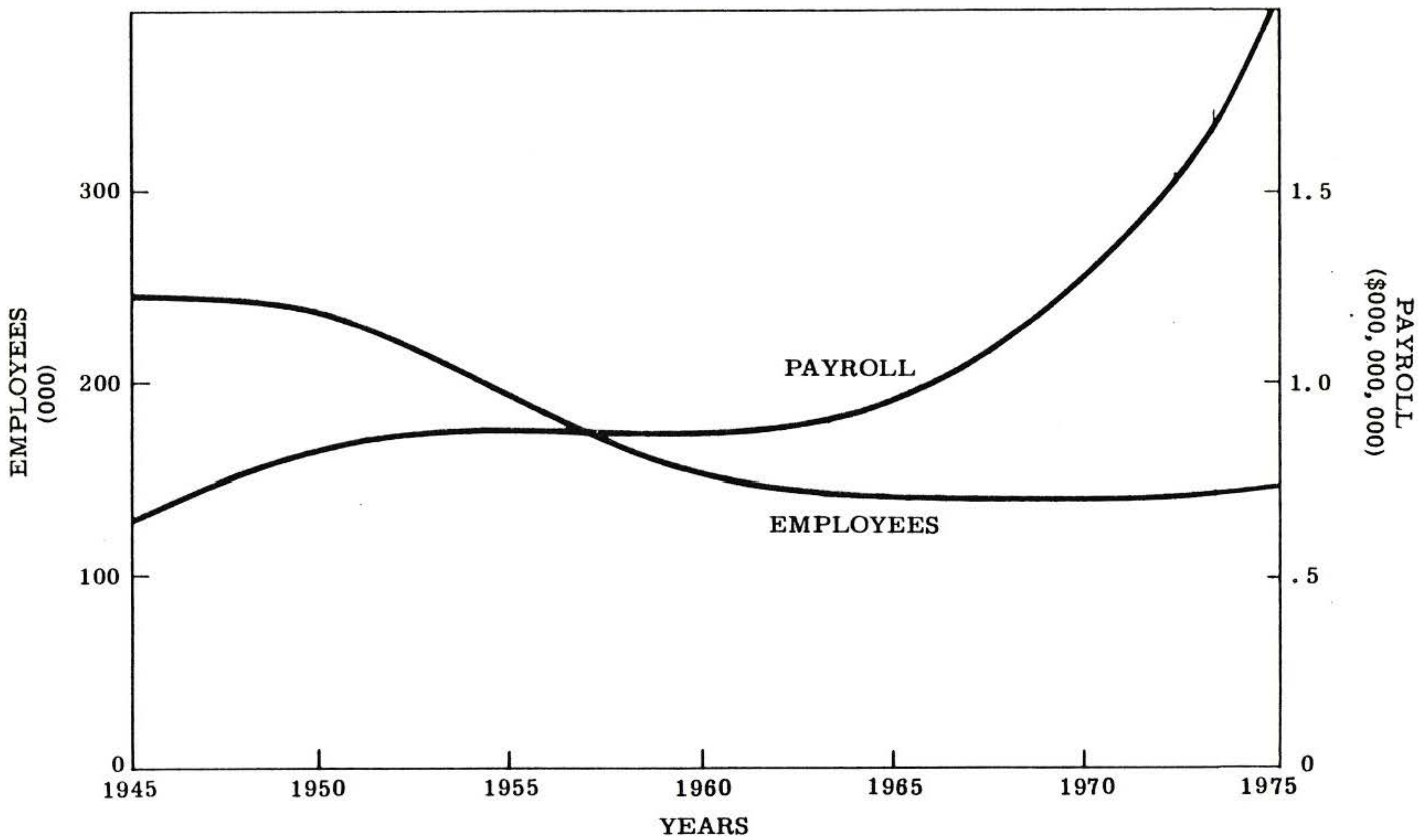
[1] George M. Smerk, Urban Mass Transportation: A Dozen Years of Federal Policy (Bloomington, Indiana: University of Indiana Press, 1974), p. 11.

[2] Op. cit., p. 141; and American Public Transit Association, '75-'76 Transit Fact Book (Washington: American Public Transit Association, 1976), p. 25.



Source: <u>'75-'76 Transit Fact Book</u> (Washington: American Public Transit Association, March 1976).

FIGURE I.5: TRANSIT EMPLOYEES AND TRANSIT PAYROLL, 1945-1975

TABLE I. 2

SELECTED AUTOMOBILE AND HIGHWAY SUPPLY DATA, 1925-1973

	YEARS										
	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1973
I. Highway Motor Fuel Use											
Amount (Billions of gallons)	8.7	14.7	16.3	22.0	19.1	35.7	47.7	57.9	71.1	92.3	110.5
Percentage change by period	-	69.0	10.9	35.0	-0.13	86.9	33.6	21.4	22.8	29.8	19.7
II. Motor Vehicle Registration											
Automobile											
Number (Millions)	17.5	23.0	22.6	27.5	25.8	40.3	52.1	61.7	75.3	89.3	101.8
Percentage change by period	-	31.4	-1.7	21.7	-6.2	56.2	29.3	22.0	22.0	18.6	14.0
Buses											
Number (Thousands)	24.3	40.5	59.0	101.1	162.1	223.7	255.2	272.1	314.3	379.0	425.5
Percentage change by period	-	66.7	45.7	71.3	60.3	38.0	14.1	6.6	15.5	20.6	12.3
III. Municipal Roads and Streets											
Amount (Thousands of miles)	240[a]	250[a]	278	297	307	323	373	430	506	561	631
Percentage change by period	-	4.2	-	6.8	3.4	5.2	15.5	15.3	17.7	10.9	12.5
IV. Automobile Vehicle Miles of Travel (Urban)											
Amount (Billions)	-	-	109.3[b]	129.1	109.5	182.5	233.6	284.8	356.7	494.5	592.2
Percentage change by period	-	-	-	18.1	15.2	66.7	28.0	21.9	25.2	38.6	19.8

Notes: a/ city streets only
b/ 1936 datum

Sources: 1925-1965: U. S. Department of Transportation, Federal Highway Administration, Highway Statistics, Summary to 1965 (Washington: GPO, 1967), Tables MF221, MV201, M200, and VM-201.

1970: _____, Highway Statistics, 1970 (Washington: GPO, n. d.), Tables MF-21, MV-1, M-1, and VM-1.

1973: _____, Highway Statistics, 1973 (Washington: GPO, n. d.), Tables MF-21, MV-1, M-1, and VM-1.

From 1935 through 1973, mileage in municipal roads and streets increased 2.3 times and from 1936 through 1973 automobile vehicle miles of travel (VMT) increased 5.4 times.

Average annual percentage increases in each of these five items are:

. highway motor fuel use	5.4 percent
. automobile registrations	3.7 percent
. bus registrations	6.6 percent
. municipal street and road mileage	2.2 percent
. urban automobile VMT	4.7 percent

A key factor which permitted the automobile to gain dominance over public transportation for the intra-city movement of persons was the dispersion of residences from the inner city to the suburbs. Although the automobile was a primary factor allowing residential dispersion, it could not have been a major cause of the dispersion of manufacturing activity which ultimately caused the decline of the inner city. The decline in personal transportation costs attributable to the automobile caused some dispersion of population; but the lower cost also increased the relative attractiveness of the core as a place of employment,[1] and reduced the relative attractiveness of suburban areas. One may conclude that the improvement to personal transportation brought about by the automobile did not cause the dispersion of manufacturing firms to satellite areas.

Instead, the outward movement of manufacturing activity was caused by the reduction in the cost of intra-city goods movement brought about by the truck.[2] Dispersion of manufacturing concentration in the urban core probably had a more distinct competitive effect on the ability of

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[1] Gerald S. Goldstein and Leon N. Moses, "Air Pollution, the Clean Air Act, and the Spatial Structure of Urban Areas," unpublished paper (Evanston: Northwestern University, Department of Economics and Center for Urban Affairs, n.d.).

[2] Leon Moses and Harold F. Williamson, Jr., "The Location of Economic Activity in Cities," American Economic Review, LVII (1967), 211-22.

public transportation to survive economically than did the dispersion of residences, and consequently population, caused by the automobile. Dispersion of the economic activity from the city center eliminated the high density employment core that radial transit routes could serve efficiently. It was not the dispersion of residential areas caused by the automobile as much as the dispersion of high density employment cores that gave the automobile a competitive advantage over public transportation early in the twentieth century.

In 1905, there were 1,400 private and commercial trucks registered in the United States. By 1965, this number had increased to 14 million, a ten-thousand-fold increase. By 1973, the number of private and commercial truck registrations had increased another 50 percent to 22.2 million. Comparing truck registrations with the data in Table I.2, private and commercial registrations increased from 2.2 million in 1925 to 22.2 million by 1973, an increase of more than 10 times.[1]

The point here is that the decline of public transportation was caused not only by preference for the automobile and by the changing residential patterns that the automobile permitted, but predominantly by the changing spatial patterns of employment caused by the truck and the increased efficiency in the intra-city movement of goods. Public transportation could not, or at least did not, attempt to compete with the automobile in providing service to dispersed employment centers.

This analysis suggests several points about the effect of automobile competition on transit fare policy. First, it indicates that the automobile did not cause the most significant shifts in urban spatial structure; the truck did. Accordingly, limitations on the automobile would not, by themselves, reverse the trends in spatial structure. Second, lowering the price of public transportation will not make it competitive with the automobile because, for the most part, public transportation is not designed to serve the diversity of origins and destinations that are required of a modern urban transportation system. Third, emphasis needs to be placed on service and flexibility rather than on price in order that public transportation compete and provide a service in the urban community. To a large degree, public transportation systems--bus or rail--are still being designed to serve the nineteenth century core-dominated city which has passed, or is rapidly passing, out of existence. If public transportation is to provide service within the

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[1] U.S. Department of Transportation, Federal Highway Administration, Highway Statistics, Summary to 1965; Highway Statistics, 1970; and Highway Statistics, 1973 (Washington: GPO).

spatial form of the contemporary city, it must have flexibility in service characteristics which are more comparable to the automobile than are current versions of public transportation. Manipulation of service prices alone will not help much: what is needed is manipulation of the service characteristics to meet market needs.

3. PRICING RATIONALES

Transit fares may be set based on three alternative pricing rationales. The first of these pricing rationales has as its objective the proper allocation of production resources to transit service; the strategy for achieving this objective is to set fares based on the incremental (or marginal) cost to provide an additional increment of transit service.

The argument for pricing any good or service at incremental cost is quite straightforward. The incremental cost of the next larger amount of output reflects the value of the resources used in its production. If the additional output cannot be sold for at least its incremental cost, there is a presumption that the output is not worth the value of the resources used to produce it, and those resources should be allocated to a more valuable use.[1]

The second pricing rationale has as its objective the maximization of transit fare box revenue. The strategy for achieving this objective is to offer different transit services to different market segments at differentiated fares based on the value users place on the services. This is essentially the point of market segmentation: to determine what transit services users or potential users in different markets want and are willing to pay for, and to provide those services at fares which are equal to the valuation users place on them.

Finally, the third pricing rationale, has as its objective, the maximization of social benefits derived from increased transit use (including reduced air pollution, congestion, and energy consumption). The strategy for achieving this objective is to set transit fares below marginal cost, specifically at the point below marginal cost that will encourage the supply and use of transit services at a socially desired level. The essence of this pricing rationale is that transit subsidies should be provided in situations where it is evident that subsidies could help to achieve some real social benefit.

Each of these alternative pricing rationales can best be illustrated and explained by referring to Figure I. 6 which shows hypothetical supply and demand functions for a transit firm. In this figure, the number of transit trips taken in a given period, say a week, is measured on the horizontal axis. Fare and cost for these trips are measured in dollars along the

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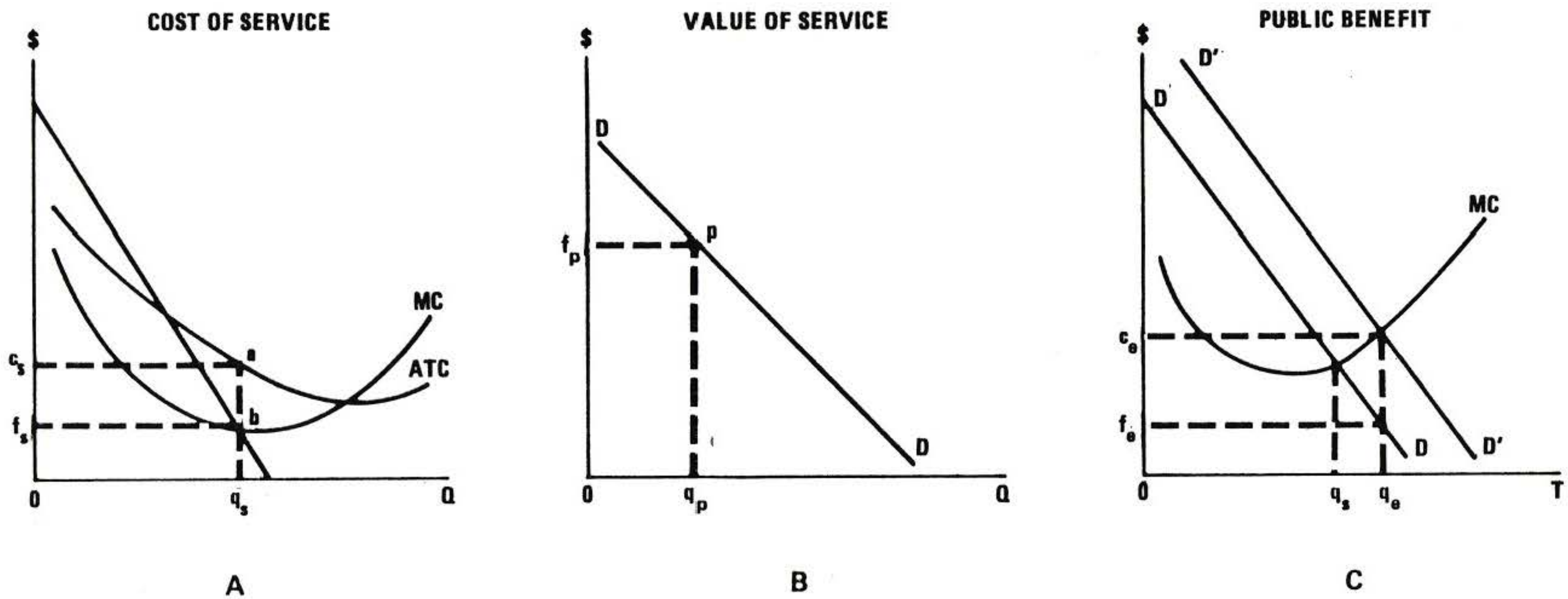
[1]For a discussion of pricing at cost, and particularly at marginal cost, see Chapter IV, Section 3, and the references therein.



Q = Transit Trips per Week

FIGURE I.6: ALTERNATIVE TRANSIT PRICING RATIONALES vertical axis. The implications of these pricing rationales are discussed below with the strategies considered in the following order:

- fares based on incremental or marginal cost;
- fares based on the incremental value of the service to passengers; and
- fares reflecting the incremental benefits of transit use to society as a whole.

COST-BASED FARES

There are two measures of unit cost which are frequently used in economic analysis. One measure is average total cost (ATC), which is the total cost divided by the number of units produced. Average cost of the illustrative transit firm is the ATC curve in Figure I. 6a. The other measure of unit cost is incremental (or marginal) cost. Marginal cost is the change in total cost resulting from producing one additional unit of output. Incremental cost is a more operational notion and means the change in total cost resulting from producing the next larger possible increment of output (which may be sub-- stantially greater than one unit). The following discussion uses the notion of incremental cost. The incremental cost curve of the illustrative transit firm in Figure I. 6A is the MC curve.

The cost curves shown in Figure I. 6 are short-run curves, which means that the size of the transit firm (principally the number of vehicles, the size of the maintenance facilities, and the number of employees under contract) is fixed so that costs which can vary with the level of output are mainly fuel consumption, labor hours, and that portion of maintenance which is proportional to miles or hours of operation. These variable costs are the short-run incremental costs which constitute the firm's supply curve because it shows the prices at which the transit firm can supply successive increments of output. All other costs are irrelevant to the short-run supply decision because they are already committed and cannot be avoided by reducing the amount of vehicle miles produced.

Incremental cost of transit will usually be much less than the average total cost of accommodating the additional passengers because a share of the capital costs will be included in the average cost, but it will not be included in incremental cost. Thus, fares which are equal to the incremental cost will be less than average cost and will cause deficits.

Referring to the illustration in Figure I. 6A, if the transit fare was set at incremental cost, it would equal $0f_s$, and $0q_s$ transit trips would be demanded and supplied. The average cost of transit trips is shown by the ATC curve. If q_s trips are produced and sold, the average cost of a trip will be $0c_s$. Total cost is given by the area $q_s\ ac_s\ 0$ and total revenue $q_s\ bf_s\ 0$. The loss on each trip would equal ab $(=0c_s - 0f_s)$ and the total weekly loss would be given by the area $f_s\ bac_s$. This loss would have to be offset by subsidies if the transit firm were to continue providing $0q_s$ trips per week.

VALUE-OF-SERVICE FARES

A second approach to transit fares considers only the demand for transit services, and disregards costs altogether. In this approach, fares would be set at levels which correspond to the incremental (or marginal) benefit of the service being priced. A demand curve, such as curve DD in Figure I. 6B can be interpreted as a marginal benefit curve in the following way.

Consider point p on the demand curve, DD. This point implies that q_p trips (say 10,000) will be taken during the week if the fare were f_p (say, $1.00 per trip). This means that persons for whom a trip is worth at least a dollar will probably take one or more trips during the week, and no one will make any trips which are worth less than a dollar to them. Then the value of the last trip taken, or the value of the marginal trip, is just $1.00. Each point along the DD curve can be given a similar interpretation, so demand curve can be interpreted as a marginal value curve.

Two sets of situations can be identified in which value-based pricing is an operationally useful approach to transit fare policy. Probably the most important situation is one in which different services are offered in different market segments at different fares. This is essentially the point of market segmentation: to determine what transit services users or potential users in different markets want and are willing to pay for, and to provide those services at fares which are equal to the valuation users place on them.

A second situation for marginal benefit pricing occurs in instances in which a decision has been made to provide a minimum frequency of service. Since, from an economic viewpoint, it makes no sense to provide unused capacity, the economically justified fare is the highest non-negative fare which will cause the entire capacity to be utilized. Such a fare could, of course, be zero. From the viewpoint of the transit firm, this fare would meet the objective of providing maximum service to the community. From a financial viewpoint, however, the fare to charge under these assumed conditions is the one which maximizes revenue.

PUBLIC BENEFIT FARES

A third approach takes account of incremental benefit to non-users as well as to users in establishing a fare policy. This approach would imply fares below the levels indicated by either cost-of-service or value-of-service rationales discussed above if a governmental body believed that transit offered social benefits in addition to private benefits. In that case, a governmental entity could, through regulation or subsidy, influence the transit firm to reduce its fares and increase the level of service supplied to raise transit demand to the socially desired level. The notion of social benefits includes the following:

- Transit provides several benefits to the public. These benefits, including reduced pollution, energy consumption, and congestion; improved and revitalized downtown land use and the like, accrue to everyone in the community regardless of their use of, or contribution to, transit. No one in the community would demand transit service separately for these purposes since benefits are not proportional to contributions.

- Certain groups in society that are more dependent on transit such as the young, poor, elderly, or handicapped, would demand more transit if they could afford those services; and the public in general would benefit from the improved travel opportunites of these groups.

In both instances, if the demand and supply of transit were left to the workings of the private market, an insufficient quantity of transit service would be produced to provide those benefits. Through regulating and subsidizing reduced fare levels, government can affect the provisions of transit service, since transit firms facing increased demand for the lower priced service would increase supply and, correspondingly, increase the provision of social benefits.

If social benefits exist, they would be added to private benefits to determine the total benefits of a particular level of transit services. In Figure I. 6C private benefits are, as before, given by the demand curve, DD. Social benefits would be added to private benefits, and graphically would have the effect of raising the demand curve from DD to, say, D^1D^1. The volume of weekly transit trips would now be q_e. At this point, the total incremental benefits (private and social) would equal the incremental cost per trip, which would be $0c_e$. The necessary equivalent revenue would be composed of a fare component, $0f_e$ and a public service component, $f_e\ c_e$.

4. INFLUENCE OF PARTICIPATING GROUPS ON FARE POLICY

The purpose of the following discussion is to identify the groups that are likely to influence transit fare policy decisions, and indicate the fare objectives of those groups. The discussion also identifies the general sets of economic forces which affect the various groups. The discussion is essentially conceptual rather than empirical. It is suggested as a way to visualize the groups which are likely to affect fare policy decisions, identify the objectives of those groups, and analyze the effects of the objectives on fare policy decisions.[1]

STRUCTURE OF THE ORGANIZATION

An organization can be defined to include an extended set of roles. In common terms, a transit organization would be thought to include the board of directors, management and its staff, and employees. The more extended organization model[2] suggests that any organization comprises three general groups of participants: owners, customers, and suppliers. This conception of the organization is useful for the analysis of transit policy decisions because of the important role that transit users and certain suppliers, particularly those who supply transit labor and capital financing, have in pricing and output decisions of the transit firm.

Each of the three groups is defined by the role that it plays in the organization; that is, by its contributions and rewards. If an individual or agency makes more than one kind of contribution, it will fall into more than one group. The three groups are defined as follows:

- Owners contribute equity and receive a return on that equity as a reward.

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[1]The analysis is similar to, and has been influenced by Benjamin Ward, "Majority Voting and Alternative Forms of Public Enterprise," in Julius Margolis (ed.) The Public Economy of Urban Communities (Washington: Resources for the Future, Inc., 1964), pp. 112-26.

[2]See James G. March and Herbert A. Simon, Organizations (New York: John Wiley, 1958), pp. 83-111.

- Customers supply the resources, usually money, that allow the organization to function; and, in turn, they receive some of the output of the organization.

- Suppliers contribute a broad range of goods and services, which include transit labor, managerial talent, capital financing (debt), or other goods or services in return for a monetary reward.

Application of this model to urban transit suggests a set of relationships like those depicted in Figure I. 7. Although transit managements and their boards of directors are, in most instances, immediately responsible for transit fare policy decisions, their decisions are immediately affected by a number of groups, each with its own objectives for fare policy. These groups include government at all levels; transit users; transit labor; and others, including employers, merchants, welfare agencies, school districts, and others with special demands for transit services. The general public or taxpayer is also included in the "other" group for reasons to be discussed.

In addition to the groups which directly influence transit fare policy decisions, there are two generalized sets of economic factors which come into play, and function through the direct participants. These factors are shown in the top two boxes on Figure I. 7. The set of factors designated "Highway Development, Pricing, and Operational Policies" comprise the set of policies which affect the cost of automobile trips. Included are highway and street investment policies; public policies concerning the provision of parking facilities; and pricing policies for streets, roads, and parking facilities. These policies affect the out-of-pocket cost of choosing automobile trips rather than transit trips, as well as the time cost of both automobile and bus trips. Also included in this set of factors are the policies generally included in the transportation system management (TSM) programs. To the extent that the operational policies promulgated under these TSM programs change the relative dollar and time costs of automobile and bus trips, they will affect transit fare policy.

The other general set of influences on transit fare policy is "General Economic Trends." Particularly important are economic trends which affect the general cost of living because these will affect labor costs, which comprise some 75 to 85 percent of transit operating costs.

Another general economic factor which can have an explicit, if indirect effect on transit fare policy is gasoline price and availability.

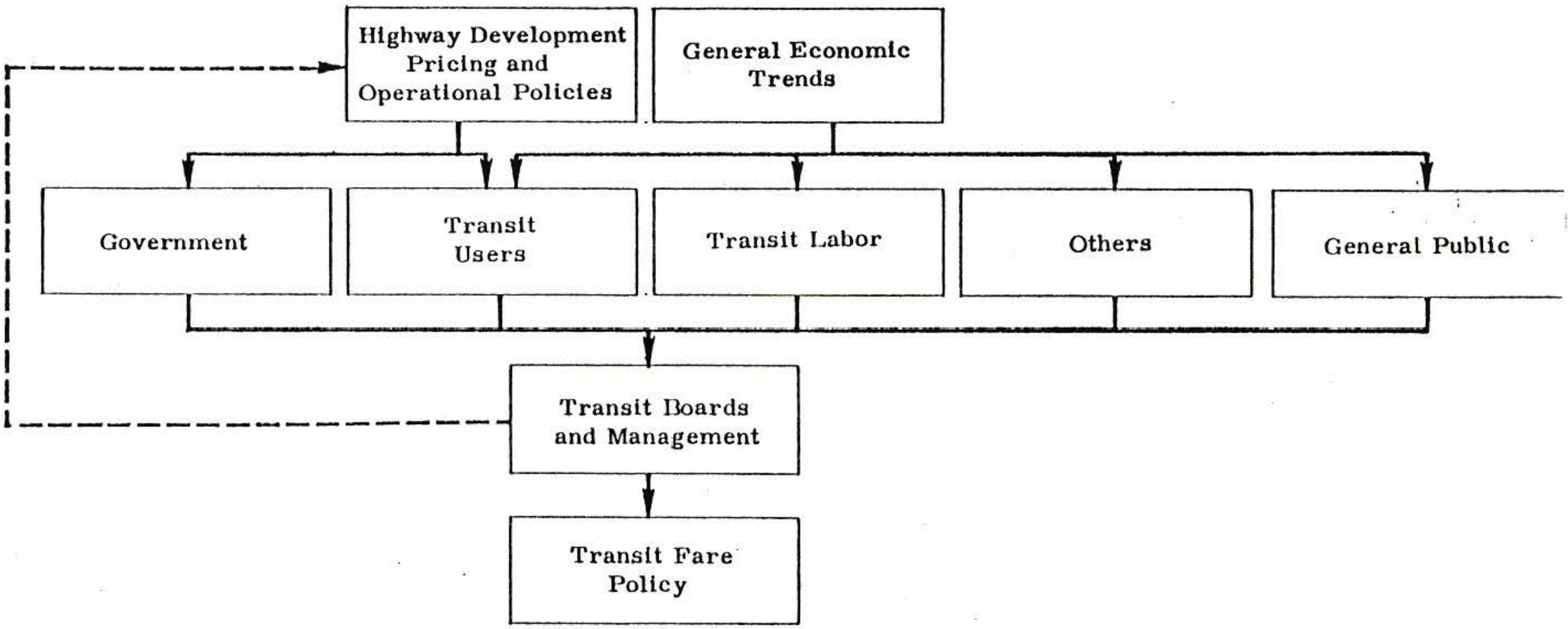

FIGURE I. 7: INFLUENCE ON TRANSIT FARE POLICY

Experience during the 1974 fuel shortage indicated gasoline availability to be a more important determinant of relative automobile and transit usage than is gasoline cost.[1] In the long run, however, gasoline price would also be expected to have some effect on relative automobile and transit usage and on transit fare policy. The effects of gasoline price and availability are expected to operate predominantly through decisions made by the transit user.

Concern for the quality of the environment, particularly air quality and energy conservation, can also have long term effects on transit usage and on fare policy. Although it will be argued in Chapter IV that attempts to improve air quality and energy conservation through manipulation of transit variables have not been particularly successful, this is largely because the attempts have not been very successful in achieving a major mode shift to transit. If, however, large numbers of persons were to take air quality and energy conservation improvements seriously and shift to the use of transit, substantial improvements would occur, and there would be marked implications for transit fare policy.

It is evident from Figure I. 7 that the effects of general economic conditions, or of policies affecting the use of the automobile, all work through the direct participants in the extended transit organization. The nature and objectives of each of the participants in the organization are discussed in the next subsection.

OBJECTIVES OF PARTICIPATING GROUPS

The fares resulting from a transit firm using one or more of the three pricing rationales can now be examined. The preferences of each group in the transit firm's institutional environment for fares based on one of the alternative pricing rationales are given in Table I. 3. The table has been constructed so that the first column shows each group having a potentially major role in transit fare policy decisions. The objectives of each group are indicated in the second column. The third column identifies the particular role that each group would usually play in the extended transit organization. The fourth column indicates the pricing rationale each group is likely to use, and the last column in the table indicates the set of fare policy objectives that each group would advocate.

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[1] Cf. Robert L. Peskin, Joseph L. Schofer, and Peter R. Stopher, <u>Immediate Impact of Gasoline Shortages on Urban Travel Behavior</u> (Washington: U. S. Department of Transportation, Federal Highway Administration, 1975), p. 45 ff.

TABLE I-3: GROUPS THAT INFLUENCE FARE POLICY DECISIONS

GROUP	OBJECTIVE FOR URBAN MASS TRANSIT	ROLE IN PRICING	PRICING RATIONALE	PRICING OBJECTIVE
Transit Management	. maximize ridership, subject to financial constraints	. make pricing decisions . implement pricing decisions	. public benefit . value of service for high income users	. price low relative to competition to attract riders . offer special services at compensatory fares to attract riders . maintain or increase subsidies to relax financial constraints . provide convenient fare collection
Government	. ensure existence of public benefits provided by transit subject to constraints on subsidy payments	. finance portion of transit costs through subsidy . exert control over transit pricing and service decisions to varying degrees through the regulatory and financing processes . control roads, parking restrictions, and other factors which influence the alternative mode, the automobile	. public benefit . value of service for specific markets	. minimize subsidy payments . price low to achieve social objectives for transit . offer special services at compensatory fares to attract riders and reduce deficit . minimize competition from underpriced automobile trips
Transit Users	. obtain better transportation services or lower costs than are available from competing modes	. pay fares . demand specific transit services . participate in fare hearings or deliberations	. public benefit . value of service	. maintain low fares . offer special services at compensatory fares to meet customer needs . provide convenient fare collection
Transit Labor	. growing labor force . increasing wages	. increase transit costs through wage demands	. public benefit . value of service	. maintain stabilized fares . offer special services at compensatory fares . maintain or increase subsidies
Others: Merchants	. achieve high accessibility for potential customers	. advocate reduced fares to and within commercial area . subsidize lower fares	. value of service	. maintain low fares . maintain large subsidies . provide some subsidy for special service out of increased sales resulting from that service
Employers	. achieve transit accessibility to work for employees	. provide subsidies to employees . support transit through prepayment plans and organization of company buspools, in some areas	. value of service	. maintain low fares . maintain large subsidies . provide some subsidy for special services which reduce costs
Sponsor Groups (school boards, welfare organizations)	. secure mobility opportunities at low cost	. advocate and lobby for special reduced fares . subsidize reduced fares, in some areas	. value of service	. maintain low fares . maintain large subsidies
General Public	. good service . minimize subsidy	. vote funds . lobby for lower taxes	. cost of service . value of service	. maintain low subsidies

Transit Management

The term "transit management" is used here to mean the group that makes policy decisions for the transit agency, and includes the manager, senior staff, and board of the transit agency. From observation of transit management decisions, particularly decisions to expand service and stabilize fares in the face of increasing deficits, the main objective of transit management appears to be to maximize ridership, subject to financial constraints. This objective is analogous to the objective of private firms to maximize sales or market share subject to financial constraints.

The role of transit management in fare policy is to decide the policy of the firm, based on its own research and taking account of the influences exerted by other participants in the extended organization. Once the fare policy has been decided, it is the responsibility of transit management to implement the decision.

The fare policy objectives that transit management would be expected to advocate would be to:

. maintain relatively low fares to attract and retain transit ridership;

. offer special services at compensatory fares to attract ridership, although accomplishment of this objective requires a more comprehensive marketing effort than what transit firms have typically engaged in;

. maintain or increase subsidies to further relax financial constraints; and

. provide convenient fare collection systems, including a prepaid alternative to maximize the ease of using transit.

To comprise these objectives, transit management may be expected to adopt a pricing rationale that emphasizes the public benefits aspects of transit services to maintain high and expanding levels of subsidies. They may, however, also adopt a value of service pricing rationale for high income market segments in which offering special services at compensatory fares, accompanied with an adequate marketing program, could increase transit ridership and the level and quality of service provided to the community. It should also have some effect on reducing transit deficits.

The emphasis of transit management on the public benefits rationale for transit pricing has largely been a result of transit managements having developed as operating organizations, oriented toward supplying transit services. Transit management has not, until recently, been much concerned with marketing.

The absence of marketing effort in transit firms was documented by Schneider over a decade ago.[1] In his study, Schneider defined marketing to encompass market research, product planning, pricing, and promotion. He examined the way in which transit firms have marketed mass transportation and concluded that most firms lacked an integrated marketing orientation and that the transit firm's organizational structure generally lacked a separate and formal marketing department. He argued further that transit marketing strategies were characterized by poor product planning; unwillingness to invest in market research and extensive promotion; failure to integrate product planning and pricing to create a high-quality, high-priced service for the affluent part of the transit market; and failure to recognize and market to differential segments of the urban travel market.[2]

For about ten years, the transit industry showed no major change in the attitudes observed by Schneider. Although more firms have become aware of marketing, they view it primarily as active sales promotion aimed at increasing the use of transit services as they exist.[3] A follow-up on Schneider's work showed increased evidence of the existence of marketing departments and marketing plans, but most of the plans concentrated on transit promotion.[4] Mundy interviewed persons in 41 transit systems. Formal marketing departments exist in 18 of the firms, and most of the chief marketing officers are considered members of top management. Approximately one-third of the transit systems surveyed had developed at least a minimal marketing plan, but most of the plans concentrated only on promotion.

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[1] Schneider, op. cit., p. 33.

[2] Ibid., pp. 173-4.

[3] Richard R. Reed, Market Segmentation Development for Public Transportation, U.S. Department of Transportation Report No. UMTA-CA-11-0008-73-6 (Springfield, Va.: National Technical Information Service, 1973), p. 6.

[4] Ray A. Mundy, Marketing Urban Mass Transit - 1973, U.S. Department of Transportation Report No. UMTA-PA-11-0010-74-1 (Springfield, Va.: National Technical Information Service, 1974).

Currently, however, efforts of the Urban Mass Transportation Administration (UMTA), coordinated with the American Public Transit Administration (APTA) show promise for increasing transit management's concern with the full range of marketing activities including market research, product planning by market segment, promotion and advertising, information aids, and others.[1] Building on the best current marketing ideas, UMTA is in the process of having a marketing manual produced that should provide transit managements with the basis for significant new efforts in transit marketing in the next few years.

Government

The transit objectives of government are to ensure the provision of public transportation services to obtain public benefits, such as pollution and congestion reduction; to conserve energy; and to provide mobility to low income persons and to persons for whom the automobile is not an option. At the same time, however, government has the objective of maintaining control over the subsidy payments made to achieve the first set of objectives.

In achieving these objectives, governments have roles of customer, supplier, and owner. Government functions in the role of customer in expressing public demands for services which have public benefits. Government pays for these services in the form of subsidies, particularly in subsidizing students, the elderly, the handicapped, and others. Government also functions as a supplier in several ways. It supplies financing; but it also supplies some important services, such as regulatory control and coordination of transit with other modes of urban transportation. Finally, government functions in the role of owner for most of the large transit systems.

The fare policy objectives that government would be expected to advocate would be to:

- minimize subsidy payments;
- set fares at low levels to achieve the social objectives and provide the social benefits of transit;

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[1] See especially, U.S. Department of Transportation, Urban Mass Transportation Administration, Transit Marketing Management Handbook, "Pricing" (April 1976), "Marketing Plan" (April 1976), and "Marketing Organization" (November 1975) (Washington: U.S. Department of Transportation).

- offer special services at compensatory fares to reduce deficits and subsidy requirements; and

- minimize competition from underpriced automobile trips through coordination of transit with auto services and by taxing automobile trips where appropriate.

To accomplish these objectives, government would also be expected to adopt pricing rationales that emphasize the public benefits aspects of transit services and the value of special services to particular market segments.

Transit Users

Transit users, or customers, are probably the key participants in the determination of transit fare policy. Users participate in fare decisions in at least two ways: through their choice to accept or reject transit services at the offered fares, and through their participation in fare hearings before transit boards of directors or regulatory agencies.

Although passengers, as individuals or in groups, can undoubtedly be effective in fare hearings, they can exercise their vote for fare and service characteristics more effectively through the market. If current and potential transit riders are presented with a range of service options and fares, along with adequate information, they will decide which combinations of fares and service characteristics are worthwhile to them.

Transit users have quite straightforward objectives: to obtain better transportation services at lower costs than are available from competing modes. In seeking these objectives, transit users function in three roles: they demand transit services, pay fares for these services, and participate in fare hearings and other fare deliberations. To achieve their objectives, transit users would be expected to advocate a fare policy that would maintain low fares; provide special services at compensatory fares to meet the needs of current and potential users in particular market segments; and provide convenient fare collection techniques, including simple means for fare prepayment.

The pricing rationale that transit users are most likely to adopt is some combination of value of service and public benefit pricing. The public benefit rationale would help to maintain low fares through large subsidies. It will be shown subsequently that transit users are more interested in (responsive to) changes in the quality of service than they are to changes in fares. One would expect, therefore, that users would place a relatively heavy emphasis on the provision of high quality services designed to meet the needs of specific market segments, even if these services require higher fares.

Transit Labor

Transit labor costs are currently the largest single transit operating expense (some 80 percent of total expense).[1] Moreover, since labor contracts with transit organizations generally include cost-of-living provisions, it is expected that this cost element will continue to increase at least as rapidly as the increase in the cost of living index. As a result, transit firms face continually rising costs which must be met despite intentions to stabilize fares.

Viewed in terms of the organization model, labor is a supplier which contributes a specific set of productive services in exchange for a monetary reward. Since labor constitutes such a large proportion of total cost, and because the cost-of-living provisions of most labor contracts make it virtually an automatically increasing cost, labor constitutes an important pressure on transit firms in their attempts to achieve financial equilibrium. Although financial equilibrium is maintained by many sources in addition to fares, fare policy is an important element in the total financial resources of a transit firm.

The main objectives of the labor participants in the extended transit organization are a stable and growing labor force, and increasing wages. The main role that labor plays in transit fare policy is to increase transit costs through wage demands and to maintain a stable labor force through limiting the amount of substitution of capital for labor that transit management can accomplish.

From these points of view, labor would advocate a fare policy that would comprise the following elements:

. maintain stablilized fares to achieve high ridership and high employment;

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[1]Edward Hall Leicester and F. Houston Wynn, Analysis of Alternative Bus Fare Structures, Report No. WMATA-TTS-1974-17 (Springfield, Va.: National Technical Information Service, 1974), p. 9; for 1975, see American Public Transit Association, '75-'76 Transit Fact Book (Washington: American Public Transit Association, 1976), pp. 28 and 38.

- offer special services at compensatory fares, again for the purpose of maintaining high levels of service; and

- maintain or increase subsidies to allow both increases in levels of service and in wages.

One would therefore expect labor, like transit users, to place emphasis on value of service and public benefits rationales for transit pricing. Also, labor might be expected to support differential pricing for peak and off-peak periods as this could have several benefits from their point of view. It would increase revenue during peak periods, maintain relatively higher levels of ridership during off-peaks, and maintain a more constant ridership volume throughout the day, which will at least partially alleviate the split-shift problem.

Other Groups

There are three other special groups indicated in the bottom section of Table I. 3 that may, on occasion, play roles in determining some aspects of transit fare policy.

Merchants

One of the special groups is merchants, who are interested in high accessibility for potential customers. For downtown merchants, accessibility has often meant adequate transit service; whereas for the suburban merchant, accessibility has required the provision of extensive parking. There is increasing interest, however, in providing transit services to high traffic-generating suburban centers.

Merchants currently contribute to transit through direct promotional subsidies, through validation of consumer transit tickets, and by advocating greater attention to public transportation. Increased accessibility to and mobility within the downtown area for potential shoppers would be expected to increase the value of downtown commercial property. At least part of this increase would, in principle, be taxed for support of increased transit service. This additional tax revenue could be used to subsidize fares.

The role of merchants has often been to advocate low fares, particularly during off-peak times when there is excess capacity and when shoppers are more likely to travel. Merchants also subsidize fares on occasion. In general, merchants may be expected to advocate low, subsidized fares, or special services at compensatory fares. An example of special services might be services to suburban shopping centers.

Employers

The objective of employers for transit is to achieve transit accessibility for workers. This increased accessibility can have three beneficial effects:

- increase the size of labor pool;
- reduce the workers' cost of transportation to work, permitting a lower wage while leaving the worker with the same income net of transportation costs; and
- reduce parking requirements and their associated costs.

All three of these effects will tend to reduce employers' costs. The cost savings will be available to pay a portion of the costs of the transit service through some form of subsidy. Employers may also provide free transit tickets to employees, analogous to the free parking which employers sometimes provide. Several employers in Pittsburgh, for example, buy transit permits and sell the permits to employees at reduced rates. Employers also contribute to transit support through subsidy of special bus service for their employees. An example is the bus service provided to the National Geographic Society Bindery Plant in Gaithersburg, Maryland, from Washington, D.C., a distance of more than 20 miles. The National Geographic Society subsidizes the service for 580 riders at a cost of approximately $170 per passenger per year, a price the Society pays in lieu of providing parking for these riders and having to find low-income, low-skilled workers in the suburbs.[1]

The transit fare policy one might expect employers to advocate would be to maintain low fares, to provide large subsidies, and to provide some subsidy for special services which reduce cost.

Sponsor Groups

This last group includes schools, welfare organizations, and the like. The objective of these groups is to achieve mobility for their constituents at a low cost. Their main roles in fare policy decisions are to advocate or lobby for low fares, and to subsidize fares for the persons they represent from their own sources of income. The fare policy that they would be expected to advocate would be for low fares and large subsidies. The pricing rationale that they represent is almost entirely for social benefit pricing for their constituents.

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[1] Solomon and Saltzman, op. cit., pp. 3-26.

General Public

The general public is taking increasing interest in transit fare policy because of the increasing deficits and tax financed subsidies that have been occurring over the past several years. Since much of the general public uses transit infrequently, it is becoming increasingly concerned about the tax costs of transit subsidies and the problematic nature of the benefits received. The general public may then be expected to hold objectives of good service and minimum subsidy, which implies cost of service or value of service pricing rationales.

CHAPTER II
FARE STRUCTURE AND COLLECTION TECHNIQUES

1. INTRODUCTION

This chapter surveys transit fare structures and fare collection techniques that have been used, or have been proposed for use. The main purpose of the chapter is to provide a background of the historical development of fares as a point of departure for suggestions on alternative new fare structures.

Before proceeding, definitions of some basic terms will be useful.

- Flat fare is a single boarding fare which is independent of the distance traveled.

- Stage Fare is a distance-based fare with the charge dependent on the number of stops intervening between the embarking and debarking stops of a trip.

- Zone fare is also a distance-based fare, and is a simplification of the stage fare. The zone fare uses zones or service areas about a common point (usually the central business district) with fares increasing each time a zone line is crossed.

- Transfer is an additional fee or entire new fare charged for changing vehicles as part of a single trip. Typically, a transfer is a date and time stamped ticket that shows that a basic fare has been paid, and for which there may or may not be an additional charge.

All fares are some variant or combination of flat or distance-based fares. The complexity of a particular fare will depend on the objectives of the transit firm and on the feasibility of assessing and collecting a complex fare.

2. RECENT FARE PATTERNS AND TRENDS

FARE PATTERNS

The most recent comprehensive compilation of transportation data and plans is the 1974 National Transportation Study (1974 NTS).[1] In a recent study of transit needs and financing,[2] PMM&Co. used the 1974 NTS data plus specific fare information from the American Public Transit Association (APTA), to analyze the fare patterns and trends for transit operations in 36 representative urbanized areas in four population groups. This section largely summarizes that analysis, which included the following urbanized areas:

More than 2 million population (8 areas)

New York	Detroit
Chicago	Cleveland
Los Angeles	Boston
Philadelphia (SEPTA)	San Francisco (BART) (MUNI)

500, 000 to 2 million population (17 areas)

Baltimore	San Diego
Houston	Seattle
Jacksonville	Buffalo
Columbus (Ohio)	Cincinnati
Portland (Oregon)	Denver
Rochester	Indianapolis
Miami	St. Louis
Dayton	New Orleans
	Pittsburgh

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[1] The results of the study are reported in U.S. Department of Transportation, 1974 National Transportation Report (Washington: U.S. Department of Transportation, 1975).

[2] U.S. Department of Transportation, A Study of Urban Mass Transportation Needs and Financing (Washington, D.C.: U.S. Department of Transportation, 1974) pp. V-1 - V-19.

250,000 to 500,000 population (6 areas)	
Flint	Honolulu
Grand Rapids	El Paso
Tacoma	Richmond
50,000 to 250,000 population (5 areas)	
Fort Wayne	Raleigh
Peoria	Corpus Christi
	Madison

Six of the eight urbanized areas included in the population group of more than 2 million inhabitants operate rail as well as bus transit systems. Of the 25 urbanized areas with populations of more than 500,000 inhabitants, 17 had zone fares (or some combination of zone and flat fares) in 1972, and eight had flat fares. The 11 urbanized areas with populations from 50,000 to 500,000 have bus systems only, of which seven had flat fares in 1972 and the remaining four had zone fares.

An analysis of fare structure, including transfers, by population group, is given in Table II.1. Historically, transfer fares have accounted for from 2 percent to 11 percent of total base fare revenue.

Distributions of average fare level by fare type are shown in Table II.2. The majority of the 36 urbanized areas analyzed set their basic adult cash fare between 25 cents and 40 cents in 1972. The highest fare charged any child or student in the 36 areas in 1972 was 34 cents. The senior citizen fare in the majority of the 36 areas was less than 30 cents in 1972. Six areas offered free fares to senior citizens, while two areas charged senior citizens a fare of between 45 cents and 50 cents. Nine of the smaller urbanized areas provided fare discounts in 1972 through multiple-journey tickets--the typical discount was on the order of 2 cents to 4 cents per ride. Larger urbanized areas which offer a multiple-journey ticket plan normally do so at full cash fare. Nine of the areas sold passes on permits which would yield discounts if used a sufficient number of times during the period for which they are valid.

FARE POLICY TRENDS

Fares for the 36 selected urbanized areas for the period from 1958/61 (depending on the availability of data) to 1976 are given in Table II.3.

TABLE II. 1

BREAKDOWN OF FARE STRUCTURES BY POPULATION GROUP[1]
(36 Urbanized Areas)

<u>More than 2 million population (8 urbanized areas)</u>

- 6 areas have existing bus/rail systems.
- 2 areas have bus-only systems.
- 3 areas have essentially flat fare[2] (one gives free transfer, one requires new fare for transfer, one gives free transfer for rapid rail but requires 10 cents for surface transfer).
- 3 areas have zone fare (2 give free transfer, one requires 5 cents for transfer).
- Detroit has combination of flat fare on some routes and zone fare on others--requires 5 cents for transfer.
- San Francisco (MUNI) has flat fare and free transfer; BART has stage fare structure.

<u>500, 000 to 2 million population (17 urbanized areas)</u>

- All 17 areas have bus-only systems.
- 5 areas have flat fare (2 give free transfer, one requires 5 cents for transfer, one requires new fare for transfer, and one requires 5 cents for the first transfer but gives the second transfer free).

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[1]All information as of 1972. Information obtained from transit operator statistics submitted to the American Transit Association.

[2]The analysis was conducted on the basis of transit operator properties; where other modes or systems (such as commuter rail in Chicago) are involved, other fare structures (including zone and stage fares) may be applied.

TABLE II. 1 (Continued)

- 12 areas have zone fare (5 give free transfer, 2 require new fare for transfer, 3 require 5 cents for transfer, one requires 10 cents for transfer, and one requires 5 cents for the first transfer but gives the second transfer free).

250, 000 to 500, 000 population (6 urbanized areas)

- all 6 areas have bus-only systems.
- 4 areas have flat fare (2 give free transfer and 2 require 10 cents for transfer).
- 2 areas have zone fare (one gives free transfer and one requires 5 cents for transfer).

50, 000 to 250, 000 population (5 urbanized areas)

- all 5 areas have bus-only systems.
- 3 areas have flat fare (one gives free transfer, one requires 5 cents for transfer, and one requires 10 cents for transfer).
- 2 areas have zone fare (both give free transfer).

Source: U.S. Department of Transportation, A Study of Urban Mass Transportation Needs and Financing, op. cit., pp. V-8 and V-9.

TABLE II. 2

FARE LEVEL BY FARE TYPE
(36 Urbanized Areas)

Type of Fare Offered by Urbanized Area

Fare (cents)	Basic Adult	Senior Citizen	Student	Child
0-24	3	16*	26	24
25-29	10	11	7	7
30-34	5	3	3	5
35-39	8	1		
40-44	5	3		
45-49	3	1		
50	2	1		
Total Number of Areas Analyzed	36	36	36	36

Note: All information as of 1972. Information obtained from transit operator statistics submitted to the American Transit Association.

* Six transit firms offer senior citizens free fare.

Source: U.S. Department of Transportation, A Study of Urban Mass Transportation Needs and Financing, op. cit., p. V-10.

TABLE II.3

BASIC ADULT CASH FARES, 1958-1975, AND REVENUE-TO-COST RATIO, 1974 (36 Urbanized Areas)

Urbanized Area	Adult Fares (cents)[1,2] 1958	1970	Changes between 1970-1973	Changes between 1973-1975	1975 Revenue-to-Cost Ratio[3]
More than 2 million population (8 areas)					
New York	15	30	35	50	.69
Chicago	25	45	-	-	.71
Los Angeles	25 (1961)	30	-	25	.53
Philadelphia (SEPTA)	22 (1960)	30	35	-	.61
Detroit	20	40	-	-	.61[4]
Cleveland	20	45	50	25	.83
San Francisco (MUNI)	15	25	-	-	NA
(BART)			30 to $1.25	-	NA
Boston	20	25	-	-	.33
500,000 to 2 million population (17 areas)					
Baltimore	25	30	-	35	.81
Houston	22	45	-	40	.82
Jacksonville	20 (1959)	30	25	-	.68
Columbus (Ohio)	25 (1961)	35	40	-	.81
Portland (Oregon)	25	35	-	-	.42
Rochester	20	25	40	50	.80
Miami	20	30	-	-	.72
Dayton	15	35	40	-	.75
San Diego	20	40	25	35	.42
Seattle	20	25	20	-	1.09
Buffalo	25 (1960)	35	45	40	NA
Cincinnati	25	50	25	-	.50
Denver	15	40	35	-	.48
Indianapolis	20 (1960)	40	50	-	NA
St. Louis	25	45	25	-	.47
New Orleans	10 (1960)	25	-	30	.48
Pittsburgh	25	35	40	50	.50
250,000 to 500,000 population (6 areas)					
Flint	25	35	-	-	NA
Grand Rapids	25	35	-	-	NA
Tacoma	25	25	-	-	.44
Honolulu	20 (1960)	20	25	-	NA
El Paso	10	10	20	25	1.07
Richmond	15	25	30	-	NA
50,000 to 250,000 population (5 areas)					
Fort Wayne	25	35	-	-	NA
Peoria	20	40	-	-	NA
Raleigh	15	30	-	-	.88
Corpus Christi	20	25	-	-	.66
Madison	15 (1960)	25	-	-	.62

[1] Zone, express, and transfer fares are not indicated.

[2] Fare data are taken from transit operator statistics reported to the American Public Transit Association.

[3] Operating revenue and operating cost data are taken from American Public Transit Association, Transit Operating Report for Calendar/Fiscal Year 1974.

[4] City Transit Division.

NA Not Available

During this period, fares typically increased, doubling in many of the urbanized areas. By 1970, many of the 36 areas had stabilized fares; fares in Tacoma have not increased since 1958.

From 1970 to 1972/73, 12 of the 36 cities increased their fares while five reduced fares. The largest reduction was 50 percent in Cincinnati, from 50 cents to 25 cents. From 1972/73 to 1975, seven cities increased fares while four cities reduced fares. The largest reduction was 50 percent in Cleveland, from 50 cents to 25 cents, while the largest increase was 43 percent in New York, from 35 cents to 50 cents.

A policy of fare stabilization since 1970 implies that farebox revenues will cover a decreasing percentage of operating and maintenance costs as these costs rise. The ratio of revenues to costs for the 36 areas for 1974 are also shown in Table II. 3. Only two areas had revenue-to-cost ratios that exceeded 1.0; that is, only two of the 36 urbanized areas had revenues that exceeded operating and maintenance costs.

The data in Table II. 4 show that the revenue-to-cost ratio for the nation was 0.85 in 1972, and was the same for the nine largest urbanized areas in the nation. Thus it is evident that farebox revenues are falling short of covering operating and maintenance costs by a significant amount.

The 1974 NTS data reported by the states for the 1990 Plans were analyzed and compared with the 1972 average fares and revenue-to-cost ratios (see Table II. 4). These data, in effect, constitute an aggregate of the individual plans and forecasts prepared by the states in cooperation with urban planning agencies and local transportation officials. The average fare for the nation is not expected to increase from 34 cents in 1972 if the fare policies reported by the states are, in fact, followed. The average fare for the nine largest urbanized areas would increase from 35 cents in 1972 to 42 cents in 1990 (expressed in relative 1971 dollars). This suggests that, at the time data for the 1974 NTS were obtained, urbanized areas as a whole planned to pursue a policy of fare stabilization well into the future. Although the 1974 NTS data indicate that some large urbanized areas plan to increase their fares, a number of transit operators in these areas indicated their desire to stabilize fares.[1]

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[1] Based on discussions between Department of Transportation representatives and several transit operators, March-April 1974.

TABLE II. 4

COMPARISON OF 1972 AND 1990 NTS AVERAGE FARE, REVENUE, OPERATING COSTS, AND REVENUE-TO-COST RATIO*

	Average Fare# (cents)		Revenue Minus Operating Costs [Deficit ($ billion)]		Revenue-to-cost Ratio@	
	1972	1990	1972	1990	1972	1990
Total Nation	34	34	-0.4	-2.5	0.85	0.65
Nine Largest** Urbanized Areas	35	42	-0.3	-1.9	0.85	0.63
Rest of Nation	33	24	-0.1	-0.6	0.83	0.71

*All figures expressed in terms of 1971 constant dollars.

#Average fare is calculated as NTS reported revenue divided by annual unlinked trips.

@NTS revenue divided by NTS operating (annual) costs.

**New York, Boston, Philadelphia, Chicago, Cleveland, Detroit, Los Angeles, San Francisco, Washington, D.C.

Source: U.S. Department of Transportation, <u>A Study of Urban Mass Transportation Needs and Financing</u>, op. cit., p. V-15.

The rest of the nation plans to reduce average fares from 33 cents to 24 cents, which would cancel out the proposed increases for the nine largest urbanized areas.

Stabilization of fares is a reversal of a post World War II trend, as shown in Table II. 5. From 1949 to 1970, national average fares for bus, rail, and commuter rail increased at a rate 3 percent greater than the Consumer Price Index (CPI).[1] In contrast, for 1972 to 1990, average bus fares are expected to decline relative to the CPI, while average fares for rail and commuter rail would increase, but at an annual relative rate between 1.3 percent and 1.4 percent.

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[1] 1974 National Transportation Study, Manual II, Volume I - Procedures, U.S. Department of Transportation, October 1972.

TABLE II. 5

ANNUAL PERCENTAGE CHANGE IN AVERAGE FARES
AND OPERATING AND MAINTENANCE COSTS*

(Historical Trend Compared With 1972-1990 Data
Reported in the 1974 National Transportation Study)

	Average Fare			Operating and Maintenance Costs Per Vehicle Hour		
	Bus	Rail	Commuter Rail	Bus	Rail	Commuter Rail
Historical Trend 1949-1970, National Aggregate#	3.0	3.0	3.0	2.4	2.7	2.7
National Urbanized Area Total, 1972-1990 (1972 NTS)	-.1	1.3	1.4	2.7	4.0	6.7

*All figures relative to the Consumer Price Index.

#From 1974 National Transportation Study, Manual II, Volume I - Procedures, U.S. Department of Transportation October 1972.

Source: U.S. Department of Transportation, A Study of Urban Mass Transportation Needs and Financing, op. cit., p. V-17.

3. TYPES OF FARES

FLAT FARES

The flat fare was particularly workable and popular when mass transportation served only limited-length routes in central cities.[1] Approximately one-half the North American transit firms reporting fare data to the American Public Transit Association are currently using flat fares. In the last 5 years, several transit firms have simplified their fare structure to offer flat fares.

The major advantages of flat fares are that they are simple and convenient to understand and use. A major disadvantage is that the flat fare offers the same price for trips with different costs and with different values to the transit user. Under a flat fare system, the same price is charged for a long trip from an affluent suburb during a heavily congested rush-hour as is charged for a short trip from a low income ghetto when there is no congestion and the transit system has excess capacity. This is a very high price to pay for the simplicity of the flat-fare system. The flat fare thus tends to discriminate against the inner-city user and discourages off-peak neighborhood trips which could utilize excess capacity. If the flat fare were set so low as to not discourage short, inner-city trips it would undercharge passengers who are willing to pay more for longer trips.

From both a cost and a value of service point of view, the flat fare is most appropriate for service with similar trip lengths, usually in small networks. Currently, the flat fare is used in city centers, or city portions of metropolitan areas, with surcharges for trips beyond the center area. Used in this way, the flat fare is simply part of a zone fare structure (see the description of zone fares, below) with a very large central zone.

FREE FARE

The free fare is the extreme case of the flat fare. The user is charged nothing for the trip, and all of the costs are paid from non-user sources. Like the flat fare, free fare has the advantage of

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[1]Alan M. Voorhees & Associates, Inc., Short-Range Transit Planning (Springfield, Va: National Technical Information Service, July, 1973), p. III-6.

simplicity and the disadvantage of missed opportunities to charge passengers for transit services.

A major objective of free fare is to achieve increased transit ridership and all of the benefits of mobility, reduced congestion, reduced pollution, and the like that are expected to occur as a result of the shift from automobiles to transit. The same shift, and the same benefits, could be achieved at positive and, perhaps in some cases, substantial fares as long as those fares did not exceed the value of the transit trip, as seen by the individual rider. A carefully segmented market with fares differentiated to reflect market valuations of the services offered would achieve at least as much mode shift to transit as would free fares, and would generate a positive revenue.

Most of the existing free fare services are not systemwide. They are provided for a particular place, time, or group of passengers. This point will be discussed in the context of fare differentiation.

The free fare service in the City of Commerce, California, is the only example of a totally free transit system in the United States. It was instituted in 1962, and is paid for by a sales tax on manufacturing. The system is used chiefly by housewives, senior citizens, and students. It serves approximately 7 to 8 percent of the population daily, compared to a national average of less than 4 percent for towns of this size.[1] The results of the experiment in Commerce probably have limited applicability to other areas because of the combination of a small population (10,500 persons), demographic characteristics (70 percent Mexican-American population with near poverty incomes), and the relatively large industrial base (1,500 corporations).

A second free-fare experiment worth some discussion is the city-wide experiment in Rome, Italy. There was a certain obvious logic to abolishing fares on the Rome system since most of the 1,900 buses were two-man operations and the forecast of revenues for 1973 would only be sufficient to cover fare collection costs. There were two free-fare experimental periods: nine days from December 30, 1971 through January 7, 1972; and a 60-day period, May 2, 1972 through June 30, 1972. In the second case, a service change of a 1.1-mile, two-way reserved bus lane was also introduced.

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[1] Michael A. Kemp, Reduced Fare and Fare-Free Urban Transit Services--Some Case Studies (Washington, D.C.: The Urban Institute, July, 1974), p. 31.

In the first experiment, there was only one "normal" day since the experimental period spanned the New Year and school holiday. For the period as a whole, there was a 44.2 percent increase in ridership over the same period in the previous year; but for the one normal day there was only an 18.4 percent increase in ridership. A survey of transit riders showed the effects of free fare to be nominal. Some 68.1 percent of the persons surveyed indicated that they "would have used public transit in any case";[1] whereas only 1.7 percent indicated that "had I to pay for my ticket I would have used the car."[2] An additional 19.9 percent indicated that they "couldn't arrange to go by car."[3] One must conclude that free fare did very little to divert modal choice to transit.

In the second experiment, fares were free during the peak hours only in an attempt to reduce peak hour automobile use. Again, the growth in transit ridership was small, only 11.4 percent. In addition, 50 percent of the respondents to a survey of automobile drivers indicated that they "would not cease to use their private car for any reason."[4] The results of the reserved bus lanes were considered successful because they produced a 10 percent increase in speed and a 26 percent ridership increase.[5]

DIFFERENTIATED FARES

There are two economic bases for differentiating transit fares; that is, for charging different prices to different persons. Either the cost and character of service provided to different persons varies and one wishes to reflect these differences in the prices charged; or the value of the service differs, and one wishes to set fares to reflect these differences. The rest of this section concerns fares with various approaches to fare differentiation.

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[1]Kemp, op. cit., Table 4, p. 16.

[2]Ibid.

[3]Ibid.

[4]Ibid., p. 17.

[5]Ibid.

Distance-Based Fares

Fares which vary with distance traveled may have either a cost or a value rationale. A long trip is both more costly to the transit supplier and more valuable to the transit user than is a short trip.

Fares which vary with distance would typically include a basic charge for boarding the vehicle, and an incremental charge which would depend on the distance traveled. Distance-based fares are handled operationally by either stage- or zone-collection systems. In a stage system, each route is divided into stages, or route segments, with a fare increment being charged for each stage or combination of stages traversed by the user. The stage fare is most appropriate on routes with a few designated stops, or where an automatic fare collection system eases the collection of differential fares. A stage system is in operation on the BART system in the San Francisco area, where a fare is computed for each origin-destination pair used by a rider.

The more common approach to the distance-based fares is the zone system, in which the area served by the transit system is subdivided into zones, with the fare increased each time a zone boundary is crossed. Operationally, the zone fare system involves charging a passenger a base fare, plus an incremental fare for each zone boundary crossed. There are several ways to design a zone-fare system, some of which are shown in Figure II.1.

Fare zones are defined for an area by tessellating the area with a geometric pattern. Geometric forms commonly used include grids, concentric circles, segmented concentric circles, or hexagonal patterns. In most instances, the precise geometric forms are modified to conform to geographic features or jurisdictional boundaries. When concentric circles are used, and there are a significant number of cross-town trips, the circles can be segmented by lines radiating from the city center.

Using any of these patterns, the fare system can be a centrally oriented or a moving-zone system. In the former, the base fare is assigned to the central zone, with increments added to the base fare for trips ending or originating outside the central zone. In a moving-zone system, the base fare is paid for by trips within the zone of origin, with incremental fares paid for trips beyond the origin zone.

The primary disadvantage of the zone system is that, because it is only an approximation of distance relations, it can charge a passenger making a short trip which crosses a zone line a higher fare than

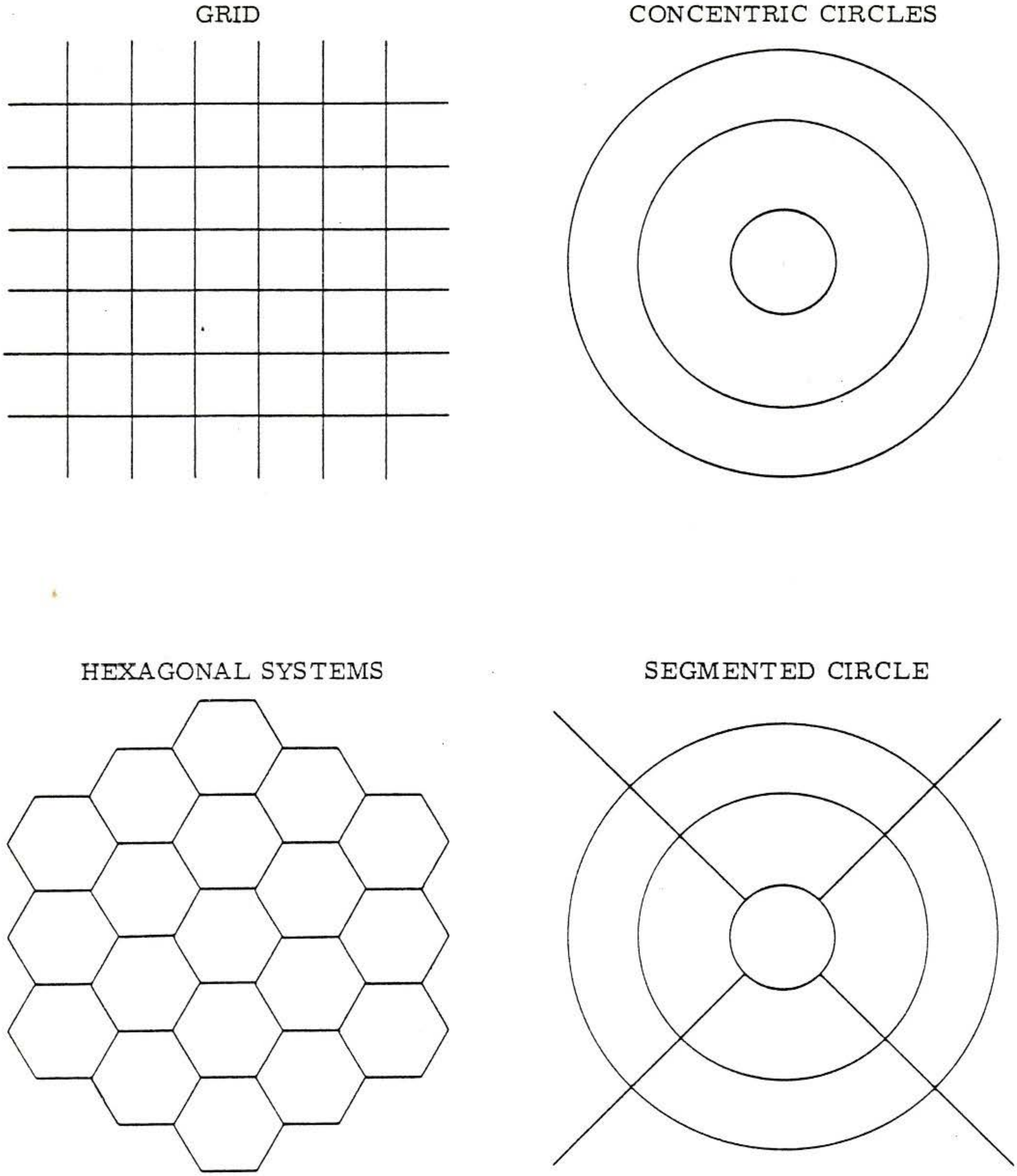

FIGURE II. 1: ZONAL FARE SYSTEM

a passenger making a long trip within a zone. Overlapping zonal boundaries can partially rectify this problem, but will complicate the fare-collection system. Problems of handling zone-fare collection systems will be discussed in the following section on fare collection systems.

Time Differentiated Fares

There are several reasons for charging fares differentiated by time of day, although some of the arguments supporting this differentiation are conflicting. The basic economic argument for time differentiated fares rests on cost differences. Transit systems acquire most of their capital stock--buses; or rights-of-way, trackage, rolling stock, and so forth--to accommodate peak loads that occur during the morning and evening rush hours. The cost of this equipment has been incurred to provide services to the peak period users, and should be charged to those users. In addition, there are congestion costs experienced directly by transit users as a result of crowding and reduced comfort during peak hour trips. Since, under congested conditions, each additional transit user imposes some additional crowding and discomfort on others, it is sometimes argued that the fare charged should also reflect this incremental cost. Moreover, since the incremental cost of serving a non-peak period is very small compared to the cost of providing for peak period demand, the price of an off-peak trip should be less than the price for a peak period trip.

A peak/off-peak pricing differential can also be justified by differences in the value of the service. Persons who ride transit during peak periods typically have different transit requirements than do off-peak riders and are generally less responsive to changes in transit fares. The peak period transit rider is typically making a trip to or from work. In the short run, he may be expected to continue using transit even at a higher fare because he cannot forego the trip, and the available alternative, principally an auto trip on congested highways, may be relatively unattractive. In the long run, however, the higher transit fare may cause him to change his residence or work location for one which does not require a work trip by transit. One would expect, then, that the long-run responsiveness of peak period transit riders to fare increases would be greater than the short-run response.

Examples of transit systems which offer systemwide off-peak fare reductions are given in Table II. 6. Most of the off-peak discounts are offered to the elderly; these fares will be discussed in the context of reduced fares for special groups. Off-peak discounts occur for midday

TABLE II. 6

TRANSIT SYSTEMS OFFERING OFF-PEAK FARES

TRANSIT ORGANIZATION	LOCATION	DESCRIPTION OF SERVICE	SPECIAL FARE	REGULAR FARE
South Coast Area Transit	Ventura, Calif.	Passes for unlimited weekend travel	$2.00/weekend $1.50/Sunday	$.20
Massachusetts Bay Transportation Authority	Boston, Mass.	Reduced fares 10 a.m. to 2 p.m. and all day Sunday	$.10, $.25/ride	$.25, $.30
Toronto Transit Commission	Toronto, Ontario, Canada	Sunday/Holiday Family Pass	$1.00/family/day	$.40
Port Authority of Allegheny County	Pittsburgh, Pa.	Sunday/Holiday Pass	$1.75/weekend	$.40
Regional Transportation District	Denver, Colo.	Off-Peak Fare	$.25/ride	$.35
Tri-County Metropolitan Transportation District	Portland, Ore.	Sunday/Holiday Pass	$1.00/day	$.35
A C Transit	Oakland, Calif.	Sunday/Holiday Pass	$.60/day	$.25
British Columbia Hydro & Power Authority	Vancouver, British Columbia, Canada	Sunday/Holiday Pass	$.50/day	$.25
Metro Regional Transit Authority	Akron, Ohio	10 a.m. to 2 p.m.	$.25	$.35
Municipal Transit System	St. Petersburg, Fla.	Sunday/Holiday Fare	$.75/day	$.25
Western Reserve Transit Authority	Youngstown, Ohio	Shoppers' Special, 9 a.m. to 3 p.m.	$.25/ride $.60/day	$.50 $.25
Tacoma Transit System	Tacoma, Wash.	Sunday Pass Downtown Shop-Around Pass, to be used before 3:30 p.m.	$.25/day	$.25
Erie Metropolitan Transit Authority	Erie, Pa.	10 a.m. to 2 p.m., after 6 p.m., Sundays and Holidays	$.20/ride	$.30
Mercer County Improvement Authority	Trenton, N.J.	10 a.m. to 2 p.m., after 6 p.m., Sundays	$.15/ride	$.30
Canton Regional Transit Authority	Canton, Ohio	10 a.m. to 2 p.m.	$.20/ride	$.30
City Transit Authority	Billings, Mont.	Saturdays	$.10/ride	$.25
New York City Metropolitan Transportation Authority	New York, New York	Sundays	Round trip for the price of one way	$.50

Source: Fare data reported to the American Public Transit Association.

periods (often oriented toward the downtown or neighborhood shopper), for evenings, or for weekend/holiday travel.

One example of daytime off-peak fare reduction is the Massachusetts Bay Transportation Authority's (MBTA) "dime time" which extends from 10 a.m. to 2 p.m. The fare on the rail system during this period is reduced from 25 cents to 10 cents (from 50 cents to 25 cents on one line). Another example of an off-peak reduction is the Sunday reduced fare offered in New York City by the New York City Metropolitan Transportation Authority (MTA), where two rides are offered for the price of one on bus, rail, and commuter services to, from, and within the city. Any passenger purchasing a transit token on Sunday receives a coupon permitting free entry through the station gate for a return trip. On commuter lines, a passenger receives a round-trip ticket for a one-way fare. On buses, the passenger receives a return-trip ticket in return for a full fare. Theaters, restaurants, and other potential destinations have promoted the reduced fares by offering discounts to holders of the Sunday special fare tickets.

VALUE-BASED FARES

A value-based fare is set at or close to the maximum an individual would be willing to pay for a service, rather than at the cost of supplying the service. A value-based fare has two distinctly different kinds of applications:

(1) In cases in which a decision has been made to supply a fixed amount of service, the appropriate fare is the highest non-negative fare that can be charged and still utilize the full capacity supplied. The cost of the service is irrelevant for determining the fare since a decision has already been made to supply the service.

(2) In cases where special services are being considered, the fare criterion should be the same as in the previous case, but the service should be supplied only if the revenue generated at that fare exceeds the incremental cost of supplying the service. Vehicles should be supplied in the service as long as the incremental revenue is at least as great as the incremental cost of the last vehicle supplied. It is this latter application which is considered here.

Fares for Special Origins and Destinations

Examples of transit services for special origins or destinations are listed in Table II. 7. Included are services to special sports events, recreation areas, and other special destinations. These services are typically provided from one or several points in a metropolitan area to a single destination. Examples of services designed and priced for special origin-destination combinations are given in Table II. 8.

Subscription bus service and buspools offer further examples of specific origin/destination combinations especially designed and priced to meet specific patronage needs. The subscription service and buspools provide some indication of the successes possible with special services and fares. Two examples of successful subscription bus services[1] are the Peoria Premium Special, which has a specific destination, and the Murraysville bus club service, which has a specific origin:

- The Peoria Premium Special (initiated in Peoria, Illinois, in 1964 with UMTA demonstration funds) offered home-to-work subscription service. Most of the buses served the Caterpillar Tractor plant. Schedules matched workshift times for plant and office workers. For an average trip distance of 3.5 miles, the average fare was 23 cents and payment was made monthly. The majority of the plant-destined routes became self-sufficient.

- In Murraysville, a suburb of Pittsburgh, Pennsylvania, local citizens organized a bus club service in 1974 and contracted with the Allegheny County Port Authority to provide the service on a 20-mile route between Murraysville and Pittsburgh. The fare was $40 per month, with the club members collectively specifying the arrival and departure times and the bus routing.

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[1] For other examples of buspools, see Kiran U. Bhatt, "Subscription Buses and Car Pools," in Ronald F. Kirby, et al., Para-Transit: Neglected Options for Urban Mobility (Washington: The Urban Institute, n. d.), Chap. 11; Richard J. Solomon and Arthur Saltzman, History of Transit and Innovative Systems (Cambridge, Mass.: Massachusetts Institute of Technology, Urban Systems Laboratory, 1971), Chap. 3; and Alan M. Voorhees and Associates, Inc., Buspools (Washington; U.S. Department of Transportation, 1974).

TABLE II. 7

EXAMPLES OF TRANSIT SYSTEMS OFFERING SPECIAL ORIGIN/DESTINATION SERVICE

TRANSIT ORGANIZATION	LOCATION	DESCRIPTION OF SERVICE	SPECIAL FARE	REGULAR FARE
Cleveland Transit System	Cleveland, Ohio	Airport Service	$.75/ride	$.50
Washington Metropolitan Area Transit Authority	Washington, D.C.	Service to Lorton Reformatory	$1.25	$.40
San Francisco Municipal Railway	San Francisco, Calif.	Ball Park Express	$.50/ride	$.25
Niagara Frontier Transit Metro System	Buffalo, N.Y.	Football Special	$1.00/ride	$.40
Southwestern Ohio Regional Transit Authority	Cincinnati, Ohio	Club Flyer-Neighborhood Service	$12.00/month plus $.10/ride	$.25
A C Transit	Oakland, Calif.	Sports Events	$1.00-$1.50/ride	$.25
CNY Centro, Inc.	Syracuse, N.Y.	State Fair Service	$.50/ride	$.35
Calgary Transit System	Calgary, Alberta, Canada	Pennant Express	$.35/ride	$.30
Central Pinellas Transit Authority	Clearwater, Fla.	Sunday and Holiday Bus to Clearwater Beach	$.10	$.25

Source: Fare data reported to the American Public Transit Association.

TABLE II. 8

EXAMPLES OF TRANSIT SYSTEMS
OFFERING EXPRESS SERVICE AT SPECIAL FARES

TRANSIT ORGANIZATION	LOCATION	DESCRIPTION OF SERVICE	SPECIAL FARE	REGULAR FARE
New York City Transit Authority	New York, N.Y.			
Queens/Bronx Surface Division		Special rush-hour express bus service, Mon.-Fri., between Queens and Manhattan.	$1.00	$.35
Staten Island Surface Division		Special rush-hour express bus service, Mon.-Fri., between Staten Island and Brooklyn,	$.50	$.35
		Wall St.-City Hall,	$1.00	$.35
		Midtown Manhattan	$1.00	$.35
Manhattan and Bronx Surface Transit Operating Authority	New York, N.Y.	Special rush-hour express bus service, Mon.-Fri.	$1.00	$.35
Washington Metropolitan Area Transit Authority	Washington, D.C.	Capital Hill Exp.	$.75	$.40
		DC-Maryland Exp.	$.55	$.40
San Francisco Municipal Railway	San Francisco, Calif.	Express Service	$.30	$.25
Southwest Ohio Regional Transit Authority	Cincinnati, Ohio	Freeway Flyer	$.30	$.25
Regional Transportation District	Denver, Colo.	Express	$.50	$.35
Metro Area Transit	Omaha, Neb.	Express	$.45	$.40
Luzerne County Transportation Authority	Wilkes-Barre, Pa.	Express	$.35	$.25

Source: Fare data reported to the American Public Transit Association.

Special Fares for Services within Limited Areas

Service within limited and usually high density areas can be specially priced to reflect the difference in costs or value of the service. An example of this service is the central business district loop service which offers circulation throughout the central business district at reduced fares. The low fares reflect both the low cost due to the limited route length and high density of use, and the relatively low incremental value of a trip to the individual passenger. The service may also yield some public benefits by reducing downtown congestion and pollution, and by increasing downtown accessibility. The service is a good example of the appropriateness of the flat fare for uniform length trips.

Several examples of systems offering reduced downtown rates are given in Table II. 9. Some downtown loop services use special vehicles, such as the downtown minibus operated by the Washington Metropolitan Area Transit Authority. The Magic Carpet Service in Seattle is free to all passengers travelling within the 105-block district in the city center encompassing the government, financial, and retail business districts. The Seattle service was funded by a $64,000 city appropriation. Following institution of the service and free fare, ridership in the free zone tripled, traffic volume downtown decreased approximately two percent, and retail sales in the central business district (CBD) showed an increase, largely during the noon hour.[1]

Reduced Fares for Special Groups

Several transit firms have reduced fares for certain groups--the elderly, handicapped, poor, school children, and college students. The reductions have come primarily in response to pressures from the public, who believe that reduced fares for these groups provide public benefits through an increased opportunity for them to travel. Fares for each of these groups are discussed below.

Senior Citizen Fares

As of April 1975, 44 percent of the transit systems in North America reporting fare data to APTA offer reduced or free fares for the elderly. Prevalence of such fares is expected to be increased by the provision in the National Mass Transportation Assistance Act of 1974 which makes off-peak half fares for the elderly and handicapped a condition for transit capital and operating subsidies.

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[1] U.S. Department of Transportation, Transit Marketing Handbook (Washington: Department of Transportation, 1975), p. 42.

TABLE II. 9

EXAMPLES OF TRANSIT SYSTEMS OFFERING SPECIALLY PRICED DOWNTOWN LOOP SERVICE

TRANSIT ORGANIZATION	LOCATION	DESCRIPTION OF SERVICE	SPECIAL FARE	REGULAR FARE
Department of Street Railways	Detroit, Mich.	Downtown loop area	$.20	$.40
Rapid Transit Lines, Inc.	Houston, Tex.	Service in CBD	$.15	$.45
Cleveland Transit System	Cleveland, Ohio	Downtown loop	$.25	$.50
Washington Metropolitan Area Transit Authority	Washington, D.C.	Downtowner minibus	$.10, $.25	$.40
Southwest Ohio Regional Transit Authority	Cincinnati, Ohio	Downtown Circulator	$.10	$.25
Metro Transit	Seattle, Wash.	Service in CBD	Free	$.20
Regional Transportation District	Denver, Colo.	Downtown	$.10	$.35
Tri-County Metropolitan Transportation District	Portland, Ore.	CBD shopper	$.10	$.35
Citran	Fort Worth, Tex.	CBD zone	Free	$.35
Metro Area Transit	Omaha, Neb.	Downtowner	$.25	$.40
Wichita Metro Transit Authority	Wichita, Kan.	Downtown Shuttle	$.10	$.30
Ottawa-Carleton Regional Transit Commission	Ottawa-Carleton, Canada	Ottawa-Hull Loop	$.25	$.30
Rhode Island Public Transit Authority	Providence, R.I.	Short rides within one-half mile of downtown	$.20	$.35
Jacksonville Transportation Authority	Jacksonville, Fla.	Spirit Special--downtown shuttle	$.10	$.25
Calgary Transit System	Calgary, Alberta, Canada	Downtown shuttle bus	$.15	$.30
Municipal Transit System	St. Petersburg, Fla.	Three CBD routes	$.15	$.25

Source: Fare data reported to the American Public Transit Association.

Special fares for the elderly include reduced or free fares, and the provision of special tickets, tokens, or multiple trip passes at reduced rates. These fares are frequently restricted to off-peak periods on weekdays and use all day on Saturdays, Sundays, and holidays. The fares are generally limited to persons aged 65 or older, although some programs allow inclusion of women at age 62, and in a few cases, maximum permissible income is specified.

The objectives of special senior citizen fares include:

. providing increased mobility opportunities to the aged who are often unable to drive;

. providing mobility at reduced rates since the aged are often living on small incomes;

. increasing off-peak capacity utilization; and

. increasing peak-period bus speeds through reduced peak-period number of elderly boardings.

Response to reduced fares for the elderly, where it has been measured, has varied from little noticeable change in ridership and peak-to-off-peak switches to large-scale patronage increases. For example, a 23 percent increase in patronage occurred in Albuquerque as a result of a 30 cent to 20 cent (33.3 percent) reduction in fares; a 20 percent increase occurred in South Bend as a result of a 50 percent cut in fares.[1]

Several transit systems do not receive increased public subsidies to reimburse them for reduced fares for the elderly, implying that other riders in the system subsidize the elderly. Some systems, however, do receive additional governmental subsidies to specifically cover the elderly-regular fare differential, to cover a contractually agreed upon amount (based, in some cases, on passenger estimates), or as part of the overall subsidy of the transit operating deficit. Government subsidies can come from local (from city general funds or revenue sharing), county, or state funds. Pennsylvania subsidizes trips for the elderly from the state lottery fund; New Jersey finances senior citizen fares from the general fund.

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[1] American Transit Association, Senior Citizens Data for Individual Transit Systems (Washington: American Transit Association, 1972).

A transit firm implementing reduced fares for the elderly must consider the most appropriate way to identify the elderly as eligible for the fares and to collect the reduced fares from them. Both of these considerations are discussed below.

Identification. At some point in the collection process, the elderly have to be identified as being eligible for reduced fares. Several systems use existing documents, like Medicare cards, social security cards, or driver's licenses as identification and issue special identification only to elderly persons without these documents. Other transit systems, preferring to ensure that the reduced fares are used only by qualified residents, issue special IDs, often with photographs, to all potential elderly passengers to limit misuse of the system. The latter method improves accountability since the number of potential riders is known, but it is inconvenient for each elderly rider to apply for the ID. Some systems use banks as distribution outlets for identification cards with a commission paid to the banks for each card issued.

Collection. To take advantage of reduced fares, the elderly may be required either to prepurchase tickets, tokens, or passes or to show identification upon boarding. The former method involves additional administrative costs for the transit firm, inconvenience for the elderly, and lends itself to cheating. Prepayment, however, provides an accurate accounting of the number of elderly trips, aids in securing trip reimbursement, and permits speedier boarding. Collecting fares at boarding is more convenient for the elderly rider and is more likely to reduce cheating, but it slows the collection process and reduces accounting accuracy for the number of elderly trips.

Fares for the Blind and Handicapped

Fares for the blind and handicapped are often provided in the same manner as those for the elderly. As of April 1975, 38 North American transit systems reporting fare data to APTA provided special fares for the blind and handicapped. An increase in the number of reduced fares for the handicapped is expected as a result of the provision in the National Mass Transportation Assistance Act of 1974 for off-peak half price fares for the elderly and handicapped. Special fares for the blind and handicapped may take the form of fare reductions, free fares, or passes. The forms of identification required may be an identification card or, in the case of the blind, a white cane or seeing eye dog. Occasionally, the blind person must be accompanied by a non-blind fare-paying passenger who is charged a reduced fare.

Fares for Welfare Recipients

Reduced fares for welfare recipients are not widespread. In Omaha, welfare recipients pay reduced fares through purchase of 100-trip ticket books. In Detroit, transportation for welfare recipients is provided in the form of a welfare allowance by a social agency. To encourage low-income ridership, the Port Authority of Allegheny County (Pittsburgh) offers a 10 cent special loop bus in the model cities area and 10 cents off the regular fare for regular bus service through the model cities area.

Special Fares for Students and Children

Several states require transit systems to have reduced fares for students. A large number of systems accommodate students through the use of reduced fares, special tickets or tokens, and passes. The fares are generally confined to weekdays and daylight hours and are available to those who attend elementary through high school and, sometimes, those up to a specific age. Other restrictions often include distance of residents from school. Implementation of these special fares involves many of the same problems experienced by systems with special elderly fares--identification and collection. Identification is usually required for reduced student fares and is provided free or for a nominal price.

Arguments against reduced student fares note that, in cases where the transit system is not reimbursed for the reduction, low-income riders may have to subsidize school children from families which can more easily afford the transit trip. In many cases, reimbursement comes from school districts or city or state governments. In general, reimbursement occurs at a specified rate per student.

Special fares for children, other than student fares, are provided by some transit systems. These fares are generally free for the very young (up to 5 years) and reduced for children up to a specified age (generally 12) or a specified height.

Fares for College Students

In many college communities, students receive reduced or free fares. In some cases, these fare reductions are subsidized by the students. Examples of special fares for students include the following:

- At the University of Massachusetts at Amherst, a fleet of buses managed and operated by the students provides free transportation service throughout the campus and through the surrounding town to designated apartment complexes. The system, originally supported by student fees matched by state funds, has been expanded upon the receipt of a $475,000 18-month UMTA demonstration grant. The system has been intended to reduce campus congestion and air pollution and ease the parking problem on campus; it has been coordinated with a campus policy of increasing the cost of a campus parking space and limiting the spaces. The coordinated bus/parking approach was one factor which encouraged UMTA to make the grant.

- At the University of California at Santa Cruz, the students voted to impose a special fee of $10.50 per student on the student body at registration to subsidize free bus service for students. The students receive free bus service by showing their student ID on boarding.

- In Peoria, Illinois, free tickets are provided to new residents and freshman at a local college to encourage transit ridership.

Commuter Fares

The commuters represent another group in the transit firm's market which receives special transit services at special fares. Many of the special service and price packages for commuters have already been discussed under the topic of special origin/destination services; that is, express and buspool services, which are priced according to the value-based rationale. An interesting array of commuter fares and other price incentives offered by the Port Authority of Allegheny County is shown in Table II.10.

Promotional Fares

Promotional fares are reduced or free fares offered for a limited time to serve as a promotion tool. The objective of promotional fares is to attract riders to the system through a temporary low price in order to acquaint riders with the transit system, a new part of the system, or, perhaps, a special destination. It is hoped that, as a patron realizes the value of the service or destination, he will be willing to

TABLE II. 10

SPECIAL PRICE PACKAGES OFFERED TO COMMUTERS BY THE PORT AUTHORITY OF ALLEGHENY COUNTY

DESCRIPTION OF SERVICE	SPECIAL FARE	REGULAR ONE-TRIP FARE
Reduced weekly permit	$2.60/week	$.40
Reduced monthly permit	$10.00/month	$.40
Reduced annual permit	$100.00/year	$.40
Ten trip tickets in outer zones for 49 Red Flyer Express and other multi-zone routes	$4.05	$.45 (express)
Early Bird Special (before 7 a.m.)	$.25	$.40
Wild Card Bus (one morning trip daily)	Free	$.40
Stop-over transfer for one hour	$.10	

OTHER PROVISIONS

Payroll deduction and annual subscription programs

Credit Card charge for permit purchases

Free outlying parking
(3,600 spaces)

20-Trip downtowner zone ticket for close-in park-n-ride parking for $4.00
(2,000 spaces)

Sources: "A Price Package for Every Rider's Pocketbook," Port Authority of Allegheny County, June 6, 1975 and "Fare Reports," American Public Transit Association, December, 1973.

pay more to ride the system. Examples of such promotions include the following:

. Hartford's nickel day (Sept. 20, 1973) for shoppers was run in conjunction with downtown merchants who offered special bargains. The results showed increases in downtown sales from 10-40 percent as new shoppers were lured downtown.

. The Central New York Regional Transportation Authority's one month of free rides, which was offered when it took over the Auburn Transit Company bus service in April 1973. The promotion attracted almost four times more passengers than rode the system under the Auburn Transit Company.

The effects of promotion fares on long-term transit ridership have not been studied to determine whether they have achieved their long-term objective of attracting new riders to transit.

4. FARE COLLECTION TECHNIQUES

The following discussion identifies the major fare collection techniques currently used in the transit industry. The main purpose of the discussion is to show the close relation between fare collection techniques and feasible fare structures and fare policies. The discussion is not intended as a detailed and comprehensive analysis of fare collecting techniques as these are available in the references cited.

Determining the appropriate set of fare collection techniques is important for the transit firm because of the several roles that fare collection plays in affecting the following aspects of transit service.

Fare policy is affected because collection systems make certain types of fares workable and preclude the use of other types of fares. Moreover, collection techniques partially affect the types of discounts, prepayments, and promotional techniques that a transit firm can implement.

The quality of service is affected by fare collection techniques by affecting the ease and speed of ingress to and egress from the vehicle, the need to make special arrangements to pay fares, and the dwell times at stops and the resulting schedule reliability.

The fare collection techniques will affect the simplicity and cost of the collection devices, the amount of customer interaction required with the driver, and the need for fare collection personnel, particularly for rail systems.

The ease with which revenue and passenger records are maintained will be affected by fare collection systems, which are largely depended on to perform these functions.

The importance of fare collection is emphasized by Lovelock:

> Although important, cost is not the principal determinant of modal choice for upper and middle income groups. In competing with the private automobile, the emphasis should be on the convenience associated with fare payment, recognizing that this requires a flexible approach to pricing strategy. Offering a choice of alternative ways in which payments can be made--reflecting the varying

needs of different trip-takers--it is anticipated (sic) to have an important impact on consumer perceptions of the cost, convenience and simplicity of transit ridership.[1]

Several fare collection techniques are examined below with regard to their effects on fare and service policy. The discussion includes:

- on-board collection techniques;
- prepayment plans; and
- automatic fare collection.

ON-BOARD FARE COLLECTION TECHNIQUES

In its simplest form, the fare collection process involves the passenger giving the required fare to the driver of the vehicle, or to a station attendant in the case of rail system. The introduction of the farebox has eased the driver's job. London Transport experience has shown, however, that with the institution of the farebox, driver accountability and transfer revenue declined as drivers became less likely to check the amount deposited and tip the farebox tray for each fare deposit.[2]

Exact Fare

Of the 204 transit firms reporting fare collection data to APTA, 116 reported having some form of exact fare requirement. Under this system, the bus driver carries neither change for fares nor the key to the locked farebox. The passenger deposits exact fare or a token or ticket-token purchased elsewhere in the farebox. Eighty-four of the 116 systems with exact fare requirements reported the use of script systems, under which the passenger without exact fare receives paper script worth the amount paid in excess of the fare and redeemable at designated transit offices or by mail.

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[1]Christopher Lovelock, Consumer Oriented Approaches to Marketing Urban Transit, U.S. Department of Transportation, UMTA- CA-11-008-73-3 (Springfield, Va.: National Technical Information Service, 1974), pp. 269-70.

[2]Edward Hall Leicester and F. Houston Wynn, Analysis of Alternative Bus Fare Structures, Report No. WMAA-TTS-1974-17 (Springfield, Va.: National Technical Information Service, 1974), p. 10.

The exact fare requirement for buses was first instituted in the United States in June 1968 by the D.C. Transit Company following the murder of a bus driver. The system was begun to reduce robberies: the Washington, D.C. system had experienced approximately 500 bus robberies in the year prior to the change to exact fare.[1] In addition to improving safety for drivers, the exact fare system yields several other advantages. Bus service is quicker and safer for the passenger with fewer stack-ups at busy stops as the driver no longer makes change and drives at the same time. The problems in recruiting bus drivers have been reduced. Finally, there have been several financial returns to the bus companies. In addition to savings from reduced robberies (D.C. Transit lost $38,000 to robbers during 1967 and the first half of 1968),[2] bus transit companies realized the returns from investing the money otherwise needed for making change--requirements of $300,000 per day in Washington, D.C., and $200,000 per day in Pittsburgh prior to instituting exact fare.[3]

Zone Charge

The introduction of a zone system complicates the fare collection process since each passenger trip must be monitored to assure that the full amount is collected. A ticketless zone system puts passengers on their honor, subject to the memory of the driver, since each passenger must declare a destination upon boarding and depositing appropriate fare. Alternatively, each time a zone boundary is crossed, the driver could collect a zone increment from each passenger--a system which is quite cumbersome to employ and inconvenient to the passenger.

Most transit systems with zone fares use some form of ticket to identify the origin of the passenger or the destination paid for. The ticket is surrendered at the end of the ride with an additional fare, if necessary. The ticket can be issued by the driver, but a remote machine speeds the boarding process.

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[1] "Exact Fares Cut Robbery in Buses in Major Cities," New York Times, August 31, 1969.

[2] "Exact-Fare Plan Costly to 1 in 6 Riders," Washington Post, September 17, 1968.

[3] "Exact Fare Only, Please," Business Week, August 31, 1968.

Pay/Leave Collection

Under this technique, the passenger pays the driver upon leaving the vehicle. The technique is most appropriate for a zone system and assumes a common origin for each passenger (for example, downtown) unless the passenger has obtained a zone check upon boarding to indicate otherwise. The advantages of the technique are that it would speed up the boarding process in congested boarding areas, and any delays from fare collection occur when passengers are on-board, a benefit in inclement weather. A disadvantage of the technique is the opportunity for passengers to ride and then claim no funds on departing.

This technique can be even more complicated, such as the pay-enter/pay-leave system in Cleveland, with appropriate charges for each different enter-exit combination. A disadvantage of this system, besides its complexity, is the need for the passenger to interact with the driver both upon entering and exiting from the system.

Transfers

Transfers are paper checks given to the passenger to permit switching from the initial vehicle of a trip to another vehicle as part of the same trip. They provide second and subsequent legs of a trip at reduced or free fare. Transfers are generally used for switching between buses or between bus and rail. They usually have a time limit to assure their use for a single, continuous trip.

Transfers lend themselves to some abuse and revenue loss when passengers give them to other passengers or violate the transfer regulations. Some systems charge a fee for transfers to try to limit abuses and to gain additional revenue. Of the 167 systems reporting the use of transfer systems to APTA, 97 offer free transfers with the rest charging fees ranging from one cent to fifteen cents. The tendency to charge for transfers has been declining as systems prefer not to penalize the passenger whose desired origin-destination combination fails to match the system design.

Transfers generally are printed with the time and origin of issue to try to eliminate fraud. Transfers can indicate time of issue by the way the paper is manually torn from the transfer-holder. Alternatively, for bus or off-bus locations, electromechanical dispensers can print the time on the transfer, giving the rider and the operator no excuse for misreading.

PREPAYMENT PLANS

Prepayment involves the passenger's paying in advance for a ticket, token, pass, or other right to ride transit. Prepayment indicators can be unrestricted or can be specialized for certain groups, places, times of day or week, or special services. Prepayment has the disadvantage of requiring the passenger to make a special trip to purchase the prepayment indicators and also involves extra costs to the transit firm for printing and administration. In some cases, when prepayment indicators are sold at banks, stores, and other designated places in addition to transit offices, the transit firm offers reimbursement for the administration expenses. Prepayment indicators can also be sold through the mail. The advantages of prepayment are numerous.

- Prepayment is convenient for the passenger, who no longer must bother with exact change on exact-change-requiring systems.

- Prepayment speeds up the fare collection process by eliminating payment and, if necessary, special identification, as part of the boarding process.

- Prepayment would make transit more competitive with the automobile. The use of prepaid monthly bus tickets would be comparable to the use of credit cards, monthly parking tickets, etc., which separate payments of auto-related expenses from individual trip decisions.

- Prepayment permits differentiation of fares for different groups using the same service.

- Prepayment can secure passenger commitment to different kinds of special services like special commuter or school buses.

- Prepayment can serve as a promotion device when combined with discounts.

- Prepayment can encourage participation by subsidizing organizations which purchase the appropriate prepayment indicators and resell or give them to their patrons.

- Prepayment can aid recordkeeping for accounting and/or subsidy purposes.

Several kinds of prepayment are discussed below.

Tokens and Ticket-Tokens

Tokens and ticket-tokens (tickets used as tokens) are deposited in the farebox in place of the fare. Tokens, discs accepted in lieu of cash, are most appropriate for flat fares. Tickets can be sold in denominations and presented in quantity for a ride whose fare varies with trip length.

Fifty-two transit firms reported offering undiscounted ticket-tokens, according to APTA. Forty-four other firms reported generalized reductions for tokens and ticket-tokens ranging from 4 to 20 percent of the regular fare, with purchase in specified bulk often required to receive the discount.

Although some experience with prepayment in the U.S. and abroad suggests passenger's unwillingness to trouble themselves with prepayment, experience in Washington, D.C., has shown that a significant proportion of bus passengers are willing to purchase undiscounted prepaid tickets and tokens. In January 1974, one-fifth of all weekday passengers, excluding school and commuter ticketholders, used 40-cent token-tickets. When all passengers are included, the proportion rises to about one-fourth.[1]

Another example from Washington, D.C., shows how the use of tickets aids the subsidy process. The city subsidizes 30 cents of each student's 40 cent ride to and from school. The student pays 10 cent per ride and deposits a school ticket in the farebox. Every week, the tickets for students are placed in bags and weighed with the weight of the tickets in the bags used as the basis for determining the subsidy.

Passes

Transit passes allow the bearer to receive multiple transit rides. Passes are issued for specific times of day periods (weekends or a particular month), destinations, and groups (elderly, students, families) and may be used for a limited or unlimited number of trips. Passes offering discounts are useful ways to encourage capacity utilization in off-peak periods, as with unlimited weekend passes, or to implement fare reductions for specific groups which need identification on the transit vehicle.

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[1]Leicester and Wynn, p. 14.

Passes may or may not be transferable. If they are not, the passes must be inspected by the driver which may be time-consuming and present a greater opportunity for misuse than transfers and passes. Passes may require no additional payment upon boarding, or they may require an extra cash fee for each ride to reduce usage violations, or for crossing zone boundaries (passes requiring additional fees are often called permits). Passes used for a limited number of trips may require cancellation.

Passes are one way to identify members of a special group for subsidy purposes, as with the use of the senior citizen card in Albany. To reimburse the bus system for reduced elderly fares, each county in the Albany area contributes a subsidy based on the number of cards issued by the county to its residents multiplied by the average number of rides per card user, with the latter information obtained through mail surveys supplemented by bus head counts.

Club Subscriptions

Club subscription is one way to secure prepayment for a special type of service, limited to only its subscribers. Certain commuter services and school buses are examples of situations where subscription is used. An example is the Cincinnati Club Flyer, a commuter service with assured seats operated over three routes during the rush hour. Members pay $12.00 for the monthly permit card and ten cents per ride. The commuters are billed monthly for the service and send their card in the mail.

AUTOMATED FARE COLLECTION

Automated fare collection devices range in complexity from simple coin-operated turnstiles to complex electronic systems that can compute varied fares and read magnetically-encoded tickets. Along with the collection of fares, an automated fare collection system can provide numerous benefits, including:

- easier collection of distance-based fares by automating the process of computing alternative fares for trips of different distances;
- faster passenger entry to the transit system;
- reduced opportunity for fare collection fraud; and
- continuous data collection about different aspects of system operations.

Although all of these benefits could accrue to both bus and rail systems, one of the primary advantages to rail systems of automated fare collection is the cost savings resulting from the reduction in numbers of fare collection and monitoring personnel. One of the primary advantages to bus systems is the use of more accurate distance-based fares permitted by an automatic collection system. To date, most automatic fare collection systems have been installed on rail systems because of the potential personnel cost savings, the relatively smaller number of automatic fare collection devices per passenger which would have to be installed, and the problem of reliability of devices on buses. The following discussion briefly discusses the main issues in using automated collection devices for rail and bus installations.

<u>Rail</u>

Rail automated fare collection systems have been successful in reducing fare collection costs on many systems. For example, 8 percent of the operating expenses on the high-speed Port Authority Transit Corporation (PATCO) line between Philadelphia, Pa., and Lindenwold, N.J., are estimated to relate to fare collection, compared with 20 to 30 percent of the expenses normally attributed to conventional manually-operated fare collection systems.[1]

There is substantial variation among the automated fare collection systems currently used on rail transit systems.[2] The simplest device is the turnstile, operated by either cash or a transit token. A more complicated version of this single-trip collection system is used by the Montreal Metro where the automated fare collection system accepts tickets or punched rail/bus transfers.

More complicated automated fare collection systems accept magnetically-encoded tickets prepaid for more than one trip, sometimes applicable to distance-based fare systems. On systems which use such collection devices, passengers can purchase multiple-trip or stored-value tickets, usually coded with such information as time and day of travel, number of trips allowed or total value of travel purchased, and route code. The passenger inserts the ticket into the entry gate to gain

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[1] J. William Vigrass, "PATCO's Experience With Unmanned Stations and an Automatic Fare Collection System," presented at the American Transit Association Rail Transit Conference, April 13, 1972, p. 4.

[2] Peter Wood, <u>Automated Fare Collection</u> (Washington, D.C.: The MITRE Corporation, October 1972).

acceptance to the transit system. The gate checks the validity of the ticket and admits the passenger to the system (or denies the passenger access if the ticket is invalid). The passenger repeats the validity check when exiting from the system. At the time of entrance or exit, the value of a trip is deducted from the ticket.

The most elaborate automated fare collection system currently in operation in the U.S. is the one installed on the San Francisco Bay Area's BART system, where passengers are charged according to a relatively complex fare structure based on distance traveled and scheduled travel speed. The passenger buys a ticket which is inserted into the gate when the passenger enters the system. At the destination, the system deducts the fare for the trip from the value of the ticket and either returns the ticket to the user and permits exit, retains the ticket if its value is exhausted, or rejects it for insufficient value (in which case the value of the ticket must be increased at an Addfare machine).

Implementation of an automated fare collection system for rail transit involves several considerations:

- Will the system work? One of the most troublesome parts of the automatic fare collection system has been the ticket vending machinery which often accompanies the automatic fare collection gate. For example, during the initial stage of the PATCO system, an average of one-quarter of the 58 ticket vendors were out of service sometime during a typical weekday.[1] Such problems are important to the success of such a system because they cause passenger inconvenience and affect passenger attitude toward the system.

- How can special reduced fares be incorporated into the system? In New York City, since the transit system accepts only tokens, half-fare passengers (i.e., the elderly or return-trip Sunday riders) gain access to the system through a gate opened by an agent. In Montreal, students and children can buy special tickets and use them on the nonautomatic turnstile next to the station agent's booth. Since BART's gates can handle only a single-fare table, BART intends to sell special tickets at a reduced rate by mail and over-the-counter.

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[1] Vigrass, op. cit., p. 5.

- How do automated fare collection systems permit intermodal transfer? Chicago Transit Authority rapid transit travelers, for example, pay an additional ten cents upon entering the system to get a transfer which, when validated on leaving the system, permits free travel on a connecting bus. No transit fee is charged for riding on another rapid transit line and, if riding the second rapid transit leg requires leaving the station, a free paper transfer is issued at the station exit.

  A Montreal bus passenger connecting with the Metro can request a free transfer permitting entry to the Metro within ninety minutes after issue. The transfer is inserted into the entry gate of the Metro system and checked automatically for validity.

- Will labor constraints interfere with adopting such a system? Port Authority Trans Hudson (PATH) system handled such a transition successfully in changing from a token to an exact change turnstile system which resulted in the elimination of jobs for several people formerly involved in issuing and handling the tokens for the system. PATH agreed that no employees would lose their jobs because of the adoption of the new collection system; employment would be reduced only by attrition, retirement, or promotion.

- Does the layout of the system lend itself to the passenger control necessary for an automated fare system; that is, does it have closed entrances and exits? Lack of suitable layout is one reason automated fare collection is generally easier to install on newer systems. For example, of the 197 stations on the Reading and Pennsylvania commuter lines in the Philadelphia region, 142 would have to be rebuilt and the others would have to be adapted to provide the necessary control for automated fare collection; the total cost of modification is estimated at twelve million dollars.[1]

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[1]C. William Hamilton and Frederick A. Koomanoff, "Automatic Fare Collection Systems," Papers--Eighth Annual Meeting, "Man and Transportation" (Montreal: Transportation Research Forum, September 6-9, 1967) p. 232.

Bus

Automated fare collection systems for buses are still in the developmental stage, with little implementation to date. Although such systems offer bus operations the opportunity to develop more elaborate fare structures, such as distance-based fares, the adoption of automated devices on buses has been discouraged by the lack of clear cost savings from the elimination of employees as has been the case for rail systems. The impetus for the adoption of automatic fare collection systems on buses must come from two sources:

- the cost savings realized when the entire system of collecting and processing bus fares is automated and human errors in processing bus fares and potential for theft are minimized, or

- the increased coordination of rail and bus systems with the latter often acting in feeder capacity: for example, WMATA is planning a fare system in which the cost of feeder bus service would be deducted from the transit fare with ultimate use of prepaid magnetic tickets on the buses.

Automated devices for buses would have to be low-cost and compact to be installed on every vehicle. Examples of simple devices include the coin or token-operated turnstile on the San Juan buses and the ticket-issuing machine on buses in Turin, Italy. A more complicated example is the system used to collect the graduated fares on the London Transport double-decker bus system. On these buses, two streams of passengers board simultaneously. If a passenger has exact change, he uses the automated fare collection system, which involves pushing a button to select one of the three fares, paying the fare in the coin slots, and taking a ticket to release the turnstile. The driver issues tickets manually to those passengers without exact change. This collection system is based on the honor system, with traveling inspectors ensuring that passengers are carrying valid tickets.

5. FINDINGS

Three main points emerge from the foregoing discussion. These points deserve reemphasis here since they are fundamental to much of the remainder of the analysis.

First, there is a great variety of fare structures, special fares, and promotional fares that have been used or that could be used. It is also evident, however, that the question of fare structure has not been approached and analyzed in a very systematic fashion by most transit firms. In recent years, too, there has been a trend away from complex fare structures and toward more simple, flat fares.

Second, it appears that the desirable direction for fare policy for a transit firm is to increase rather than decrease the range of types of fares it uses. The next two chapters directly address the question of user responsiveness to alternative fare and service combinations. The point is already beginning to emerge, however, that combinations of particular fare and service characteristics directed toward particular markets may have promise for increasing ridership and revenue. The effectiveness of specific fare and service combinations clearly depends on how responsive transit users are to these two aspects of a transit ride. That question is dealt with in detail in the following two chapters.

Third, the effective and efficient use of complex fare structures depends on the development of technically and economically feasible fare collection systems. To some degree, systems of prepaid passes can be used effectively to differentiate markets and to charge different fares in those separate markets. More generally, however, sophisticated systems of fares will require complex and sophisticated fare collection devices. Devices have yet to be developed that are sufficiently inexpensive and reliable that they can be installed in buses.

CHAPTER III
ELASTICITY OF DEMAND FOR PUBLIC TRANSPORTATION

1. INTRODUCTION

OVERVIEW OF THE CHAPTER

Before changing the fare or some other element of a transit service, the transit manager will want to know what effect the change will have on ridership, costs, revenue, and the quality of the service. Planners and public officials will also want to know the consequences of any of their proposed actions intended to generate additional demand for the transit service, increase the revenue from it, lower the cost of providing it, or use it to achieve some objective unrelated or only indirectly related to transportation. Many mathematical models have been developed to explain or predict the demand for public transportation, but they are often not very useful to transit managers, urban planners, and public officials. Some of these models may be too expensive to calibrate and use, requiring large quantities of data and automatic data processing. The data needed to calibrate them may be unavailable or too costly to obtain. More importantly, the models may not indicate the effects of the changes or actions being considered because they do not incorporate all of the factors that influence the demand for public transportation. Until an inexpensive, widely usable model is developed, there is a need for a simple measure which summarizes the relation between the demand for transit and some causal variable, but which is also practical enough to give transit managers, planners, and public officials some helpful guidance and valid answers. Demand elasticity is one such measure.

This chapter summarizes the findings of previous research on the elasticity of the demand for public transportation. It begins by reviewing the concept of elasticity, defining the term, describing its properties, and discussing its usefulness and limitations. This review is followed by a discussion of the problems of measuring demand elasticities for transit services, and methods for solving these problems.

The remainder of the chapter deals with the results of previous attempts to estimate transit demand elasticities. The discussion is primarily concerned with conventional, fixed-route, fixed-schedule bus systems and rail transit systems. This portion of the chapter begins by presenting estimates of elasticity of demand with respect to changes in the fare. These estimates are given first for the aggregate transit market and then for different segments of the market, defined by different characteristics of the riders, trip purpose, and time of day.

Estimates of demand elasticities for changes in the quality of the transit service are examined next and compared with values of elasticity for changes in the fare to determine which type of change is likely to have a greater effect on ridership and revenue. Changes in the cost and time of travel by automobile are then analyzed for their effect on the use of public transit. The chapter concludes by presenting the very few estimates that have been made of demand elasticities for other forms of public transportation besides fixed-route, fixed-schedule bus service and rail transit. The implications of the findings reported in this chapter are noted throughout the discussion.

DEFINITION OF TERMS

Elasticity is the proportional change in the amount of a good purchased resulting from the proportional change in some causal variable. The amount purchased at a specific price is defined as the demand and, in the case of public transportation, is usually expressed as the number of passengers carried over a certain period. The causal variable could be any one of many. For public transportation, the variables include fare, headway or elapsed time between two successive transit vehicles, the amount of time a passenger spends waiting for a vehicle, the amount of time a passenger actually spends in the vehicle, the passenger's income, cost of traveling by some other mode of transportation, the time required to travel by an alternate mode, and many other variables.

Often, the name of the causal variable is included in the term for the elasticity. Thus, fare elasticity or price elasticity is sometimes used when describing the effect of changes in the fare. Likewise, travel time elasticity indicates that the causal variable is the amount of time a passenger spends in the transit vehicle, while income elasticity indicates that the passenger's income is the causal variable.

The term cross elasticity denotes the relation between the demand for a good and a change in some characteristic of a substitute or alternate good. An example of cross elasticity is the ratio of the proportional change in the demand for a transit service to the proportional change in the cost of traveling by automobile.

To make the concept of elasticity clearer, consider the following example. Suppose the fare of a local bus service is lowered from a flat 35 cents to 25 cents, a decrease of 28.6 percent. Suppose further that this reduction in the fare causes the average daily ridership to change from 1,000 passengers to 1,150, an increase of 15 percent. The elasticity of the demand to the change in price is -0.52, computed by dividing the proportional increase in the demand, 15 percent, by the proportional decrease in the fare, 28.6 percent. The minus sign simply indicates that the direction of the change in the fare is opposite to the direction of the change in the ridership. Since the elasticity was found by computing the ratio of two percentages, it is a dimensionless number, meaning that its value does not depend on the units used for measuring demand and price.

The demand for an economic good is inelastic, unit elastic, or elastic to changes in a particular causal variable depending on whether the absolute value (the value disregarding sign) of the demand elasticity is less than, equal to, or greater than 1.0, respectively. An elasticity less than 1.0, indicating inelastic demand, means that a proportional change in the causal variable produces a smaller proportional change in the demand, whereas an elasticity greater than 1.0, signifying elastic demand, means that a proportional change in the causal variable produces a larger proportional change in the demand. In the foregoing example, the demand for the local bus service is inelastic to the change in the fare, since the 28.6 percent decrease in the fare induces only a 15 percent increase in ridership. The larger the numerical (absolute) magnitude of the demand elasticity for a particular causal variable, the more sensitive is the demand to changes in that variable.

A more precise term for the form of elasticity calculated in the above example is arc elasticity.[1] Another name for arc elasticity is shrinkage ratio, a term commonly used by the transit industry. Shrinkage ratio has a more narrow definition than arc elasticity, since it is normally used to mean the percent loss in ridership for every 1-percent increase in the fare. Because of this narrower meaning and negative connotation, the broader term arc elasticity will be used in this chapter.

There is another form of elasticity, called point elasticity. More abstract than arc elasticity, it is defined as the limit of the ratio of the proportional change in the demand to the proportional change in

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[1]Kemp gives a different definition of arc elasticity, defining it as a ratio of differences in logarithms. If the value of the causal variable is changed from X_1 to X_2, and the demand subsequently changes from D_1 to D_2, the arc elasticity, as defined by Kemp is $\frac{\log D_1 - \log D_2}{\log X_1 - \log X_2}$.

See: Michael A. Kemp, "Some Evidence of Transit Demand Elasticities," Transportation, Vol. 2, No. 1, April 1973, p. 27.

the causal variable as the latter change becomes infinitesimal.[1] Although arc elasticity can be computed for changes of any size in the causal variable, point elasticity can be computed only for an infinitesimal change. Arc elasticity is the same as point elasticity only for changes in the causal variable that are extremely small. Through the mathematics of calculus, the point elasticity of the demand can be calculated for any particular value of the causal variable, if the mathematical relation between the demand and the causal variable is known. Point elasticity can be interpreted as the sensitivity of the demand to the slightest change in a causal at some particular value of that variable.

There are other important differences between these two forms of elasticity. These are noted in the following subsections on the variability of elasticity and the relation between price elasticity and revenue. Because of these differences, estimates of point elasticity should be clearly distinguished from estimates of arc elasticity. In this chapter, all estimated values of elasticity will be designated as being either point or arc elasticities.

VARIABILITY OF ELASTICITY

The elasticity of the demand for any particular product or service is defined at a specific value of the causal variable but is not necessarily constant as the variable changes. Point and arc elasticities are likely to vary over the range of values of the causal variable and are also likely to depend on the values of other attributes of the good as well as the attributes of substitutes. Arc elasticity may also vary by the amount and direction of a change in the causal variable. Any single value of elasticity, therefore, does not provide complete information about the characteristics of the demand for a particular good.

To show how arc and point elasticities change over the range of values of a causal variable, assume that the demand for bus service is related to the fare in a simple, linear fashion when all other causal

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[1]More precisely, point elasticity is defined in terms of the partial derivative of the demand with respect to the causal variable. If the demand, D, is related to a causal variable, X, by some mathematical function, the point elasticity for any particular value of X is defined as $\frac{\partial D}{\partial X} \cdot \frac{X}{D}$, where $\frac{\partial D}{\partial X}$ is the partial derivative of the demand with respect to the causal variable, and D is the magnitude of the demand for the particular value of X.

variables are held constant. An example of this kind of relation is shown in Figure IV.1. The point price elasticity, E_p, for any particular fare, F, in this case is:

$$E_p = \frac{-5.0F}{D},$$

where D is the demand in average passengers per day for the given fare.[1] For example, when the fare is 10 cents, the demand is 625 passengers per day and the absolute value of the point price elasticity is 0.08.[2] At a fare of 35 cents, the demand drops to 500 passengers per day, and the absolute value of the point price elasticity increases to 0.35. The magnitude of the point price elasticity continues to rise, reaching 1.00 at a fare of 67.5 cents, indicating that the demand for bus service is becoming more sensitive to changes in the fare as the fare becomes larger. Below the fare of 67.5 cents, the demand is inelastic, while above this critical fare, the demand is elastic.

The magnitude of the arc price elasticity likewise depends on the size of the fare. If the fare is increased 20 percent from 25 to 30 cents, the average daily ridership drops from 550 to 525 passengers, a decrease of 4.55 percent. These changes result in an arc price elasticity of -0.23. If, however, the fare is raised another 5 cents from 30 to 35 cents, an increase of 16.7 percent, the demand decreases by 4.8 percent, yielding an arc price elasticity of -0.29. In this hypothetical case, the absolute value of the arc price elasticity changes in the same manner as the point elasticity, becoming larger as the size of the fare increases, indicating that the demand is more sensitive to changes in higher fares.

In the preceding examples, the relation between the demand and the fare was assumed to be linear when all other causal variables are held constant. If, however, the relation is:

$$D = 1000F^{-0.3},$$

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[1] The mathematical relation between the demand and the fare in this hypothetical case is D = 675 - 5.0F. By definition, the point price elasticity is $\frac{\partial D}{\partial F} \cdot \frac{F}{D}$, the product of the partial derivative of the demand with respect to the fare and the ratio of the fare to the demand. The partial derivative of the above linear relation is simply -5.0.

[2] The actual value is -0.08.

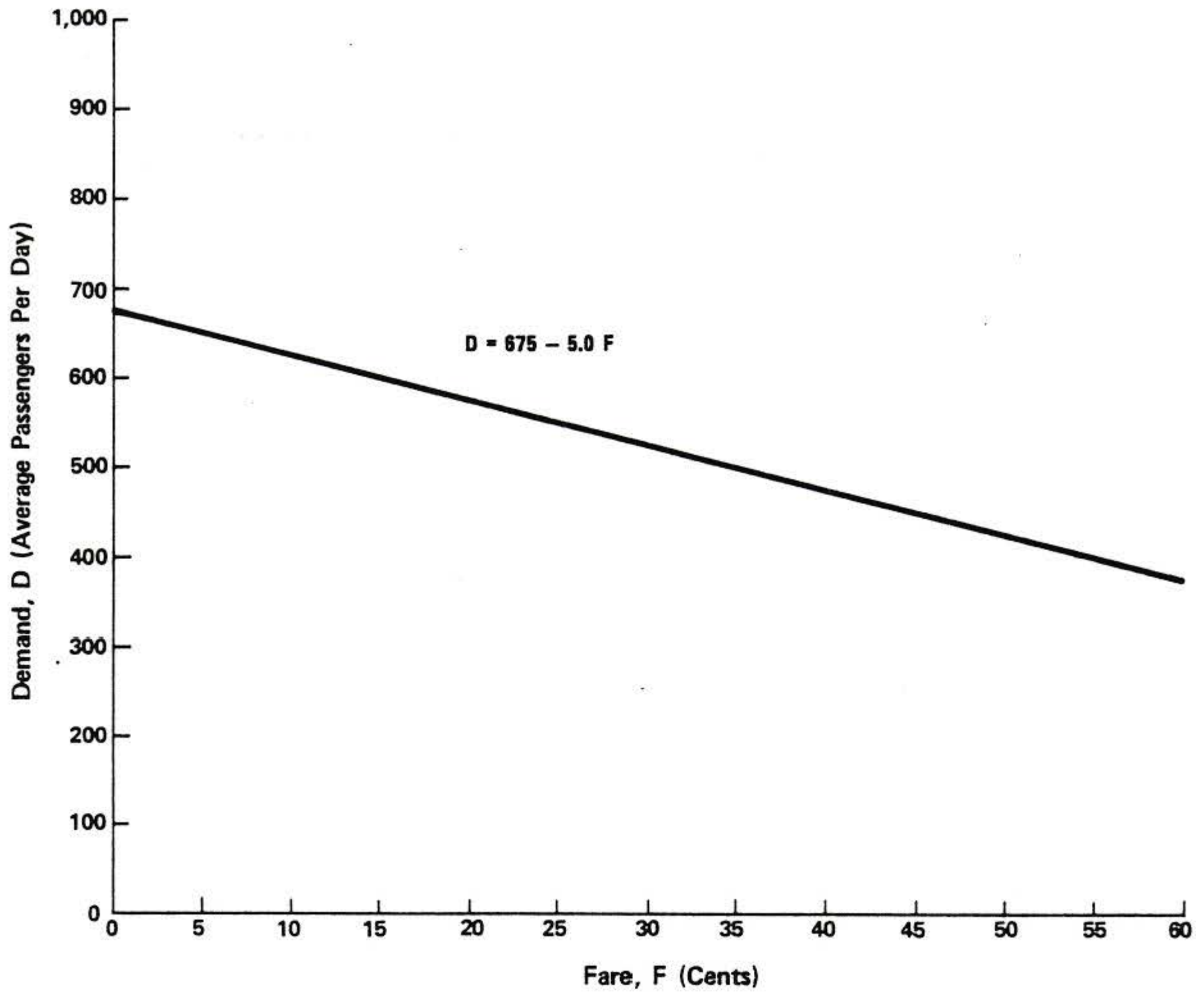

FIGURE III.1: HYPOTHETICAL RELATIONSHIP BETWEEN THE DEMAND FOR BUS SERVICE AND THE FARE shown in Figure III. 2, the characteristics of the point and arc elasticities are quite different from the case of a linear relation.

The point price elasticity in this case is always -0.3.[1] The constant value indicates that, for a nonlinear relation of this form, the market's sensitivity to changes in the fare remains the same regardless of the magnitude of the fare. In this particular example, the demand is also always inelastic to changes in the fare.

The arc price elasticity in this case depends on how much the initial fare is changed. For example, the arc price elasticity is -0.27 for an increase from 25 to 30 cents and -0.24 for an increase from 25 to 35 cents. In the linear case discussed earlier, the arc price elasticity is -0.23 for both of these changes.

For the above nonlinear relation, the arc price elasticity also depends on the direction of the change in the initial fare. For example, if the fare is raised 20 percent from 25 to 30 cents, the resulting arc elasticity is -0.27. If, however, the fare is dropped from 25 to 20 cents, a decrease of 20 percent, the resulting arc elasticity is -0.35. The fare reduction obviously has a greater effect on demand than the equivalent fare increase.

The market's full reaction to a change in a causal variable does not occur immediately and the measured value of the arc elasticity increases over time. For this reason estimated arc elasticities are often designated as either short-run or long-run, although these terms have never been given standard definitions. The important point is that an estimated value for an arc elasticity may be somewhat less than the ultimate or long-run value.

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[1] The point price elasticity, E_p, is calculated as follows:

$$E_p = \frac{\partial D}{\partial F} \cdot \left(\frac{F}{D}\right)$$

$$= (-0.3)\, 1000F^{1.3} \left(\frac{F}{1000F^{-0.3}}\right)$$

$$= -0.3$$

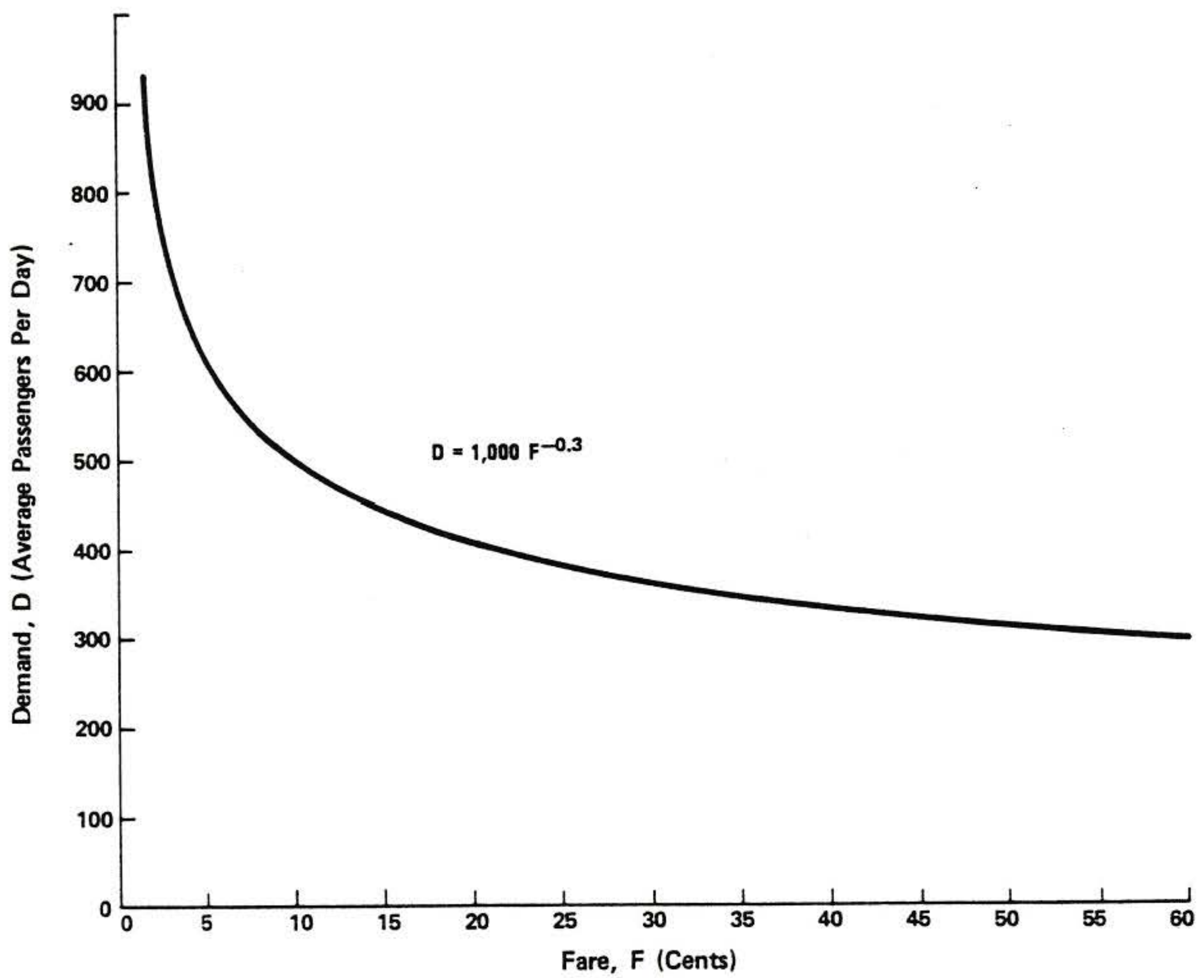

FIGURE III.2: HYPOTHETICAL NONLINEAR RELATIONSHIP BETWEEN THE DEMAND FOR BUS SERVICE AND THE FARE

Since many factors together determine the demand for public transit, the effect of a change in one causal variable depends on the values of other causal variables. Increasing the fare, for example, may cause a greater loss of ridership if the headway is one hour and the buses are often late than if the headway is only 15 minutes and the buses are usually punctual. Reducing the headway from 30 to 15 minutes may cause a larger increase in ridership if the fare is 20 cents rather than 50 cents. Because of the variability of demand elasticity, a single estimate of its numerical value for a particular causal variable does not fully summarize the characteristics of the demand. A better guideline for setting fare policy would be some notion of the range of values of the demand elasticity.

PRICE ELASTICITY AND REVENUE

Besides indicating the effect on ridership, the point price elasticity also indicates how a slight change in the fare will affect revenue. If the absolute value of the point price elasticity is less than 1.0, indicating inelastic demand, an increase in the fare will result in more revenue despite a loss in ridership, whereas a decrease in the fare will result in less revenue despite a gain in ridership. These effects occur because, for inelastic demand, the proportional change in the fare is greater than the resulting proportional change in ridership. Therefore, when the fare is raised, the revenue gained from the higher fare more than offsets the revenue lost from the decrease in ridership. Similarly, when the fare is lowered, the revenue lost from the smaller fare is greater than the revenue gained from the increase in ridership.

If the absolute value of the point price elasticity is greater than 1.0, indicating elastic demand, the opposite occurs. In this case, increasing the fare reduces both revenue and ridership, while decreasing the fare increase them. Table III.1 summarizes the effects of fare changes on revenue as implied by the point price elasticity.

Unlike point price elasticity, an arc price elasticity with an absolute value less than 1.0 does not necessarily mean that an increase in the fare will lead to more revenue. For example, suppose that the average daily ridership on a bus system declines from 1,000 to 600 passengers after the fare is raised from 25 to 40 cents. The arc price elasticity in this case is -0.67, indicating that the demand is inelastic. Instead of increasing, however, the average daily revenue drops from $250 to $240. The revenue would have increased only if the decrease in ridership had been less than 375 passengers per day.

TABLE III.1

EFFECTS OF FARE CHANGES ON REVENUE
AS INDICATED BY THE POINT PRICE ELASTICITY

Nature of the Demand	Absolute Value of Point Price Elasticity	Fare Change	Effect on Ridership	Effect on Revenue
Inelastic	<1.0	Increase	Decrease	Increase
Inelastic	<1.0	Decrease	Increase	Decrease
Unit Elastic	=1.0	Increase	Decrease	Constant
Unit Elastic	=1.0	Decrease	Increase	Constant
Elastic	>1.0	Increase	Decrease	Decrease
Elastic	>1.0	Decrease	Increase	Increase

Also unlike point price elasticity, an arc price elasticity with an absolute value over 1.0 does not mean that a reduction in the fare will always result in more revenue. To illustrate, suppose that lowering the fare from 40 cents to 25 cents causes the average daily ridership to increase from 1,000 to 1,500 passengers. The arc price elasticity equals -1.33, indicating that the proportional increase in ridership is greater than the proportional decrease in the fare. Nevertheless, the average daily revenue falls from $400 to $375.

The reason for these discrepancies lies in the definitions of the two forms of elasticity. Point price elasticities involve infinitesimal changes in the fare, while arc price elasticities can involve changes of any magnitude. Arc rather than point elasticities should be used, therefore, to determine the consequences of any actual fare change.

2. MEASURING TRANSIT DEMAND ELASTICITIES

There are two general approaches to determining demand elasticities for public transportation. The first involves measuring the demand before and after a change in some causal variable and computing the arc elasticity. The second involves calculating either arc or point elasticities from a mathematical model of transit demand. Both methods pose several problems.

DATA PROBLEMS

One of the major problems common to both approaches is the difficulty of obtaining complete and accurate data. Estimates of ridership are often based on revenue rather than actual counts of passengers. These estimates may be inaccurate if the fare is not the same for every rider. Typically, there is little, if any, current information on ridership by route, time of day, geographic zone, fare, trip purpose, trip length, and characteristics of the passengers. Also missing in many cases are accurate data on wait times, travel times, adherence to the schedule, and other characteristics of the transit service as well as the cost and the time involved in traveling by other modes.

MEASUREMENT PROBLEMS

A related problem is the difficulty of measuring certain causal variables. Two classic examples of variables which are hard to quantify are "comfort" and "convenience." The measurement of price changes can also be difficult if the fare schedule is complicated. Fare schedules may include surcharges for crossing zones, transferring, and riding during certain hours; reduced fares for the elderly, the handicapped, and school children; and discounts for books of tickets and monthly passes. When these complex fare schedules are modified, the percent change in the fare will not be the same for everyone. Although the different proportional changes that occur should be analyzed separately, often the necessary information on the distribution of fares before and after the change is unavailable. Researchers have settled the problem of determining the unit price and percent changes in price by using either the basic fare or the average fare to estimate price elasticity. Although the average fare is more appropriate for measuring the average change in price, it may vary over time even when the fare schedule remains unchanged as the composition of the ridership changes.

In estimating arc elasticities from observations of the demand before and after a change in the transit service, there is the additional problem of separating the effects of different causal variables. Frequently, transit managers change not only the fare but also the vehicles, the headways, and the routes. Personal income, the rate of unemployment, the cost of driving an automobile, and other variables over which the transit manager has no control may also change at the same time the transit service changes. Further compounding the problem are seasonal variations in the demand, secular trends, and the effects of unexpected or uncommon events. In many cases, the arc elasticity for a particular variable cannot be estimated with any assurance of accuracy.

When the arc elasticity can be estimated, its value will depend on the length of time over which the demand is measured after the fare or the service is changed. If the period is too short, the full effect of the change will not be captured, while if the period is too long, the effects of extraneous factors are more likely to intrude. Unfortunately, there is no easy solution to this problem.

FORMS OF MODELS

Problems involving the use of mathematical models to derive estimates of transit demand elasticities are mainly related to the type of data and the form of model used. These problems are more appropriately discussed in the later sections of this chapter where the results of several attempts to model the demand for transit are described. A point worth elaborating here is that the estimates of demand elasticity obtained from these models are no more valid than the models themselves.

One of the factors which determines the validity of a model is the strength of its theoretical foundation. The current transit demand models have been generally criticized for lacking a sound, comprehensive theory of travel behavior as their conceptual basis. Each type of model has its own methodological and theoretical shortcomings. Many models are developed around assumptions about elasticity which may not reflect actual travel behavior. Some econometric models, for example, assume that the demand elasticity for certain causal variables is constant. None of the current models include all of the variables that could possibly affect the demand for a transit service. In particular, few of them account for the effects which changes in the costs of other goods and services may have on the amount of time and money that individuals and households are willing to spend on transportation in general.

Econometric problems also affect the validity of mathematical models used to estimate transit demand elasticities but discussion of these problems is beyond the scope of the present discussion.

3. ESTIMATES OF TRANSIT PRICE ELASTICITIES

The findings of some previous research on transit price elasticity are reviewed in this section. The discussion is organized around types of markets for transit service, beginning with an analysis of the overall market or aggregate demand. The methods used to determine price elasticity are briefly described along with the results. The main purpose of this review is to assess the prospects of manipulating the transit fare to increase ridership and revenue.

OVERALL MARKET

One of the most widely used formulas for quickly estimating the effect of a fare increase on ridership is Curtin's Rule,[1] which simply states that the demand for transit service declines by one-third of 1 percent for every 1-percent rise in the fare . This rate of decline corresponds to an arc price elasticity of -0.33. This rule of thumb has been used by many transit managers and regulatory agencies.

Curtin's Rule is the result of an analysis of 77 cases of an increase in fares occurring over a period of 20 years. The percentage change in ridership for the 3 months following each fare increase was correlated with the percent change in the fare after secular trends were removed. The trend was determined by comparing the ridership preceding the fare increase with the ridership for the same period in the previous year and calculating the percentage change.

Through regression analysis, the following relation was derived:

Percent loss in ridership = 0.80 + 0.30 x Percent increase in fares.

According to this equation, the arc price elasticity decreases as the percent increase in the fare becomes larger. A 3-percent hike in the fare causes a 1.7-percent loss in ridership, yielding an arc price elasticity of -0.57, while a 50-percent increase in the fare causes a 15.8-percent loss in ridership, yielding an arc price elasticity of -0.32. The average arc price elasticity for the 77 cases was -0.36.

The American Public Transit Association (APTA) has also analyzed the effect of fare increases on ridership, using data reported by transit

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[1] John F. Curtin, "Effects of Fares on Transit Riding," in Highway Research Record Number 213, Passenger Transportation (Washington, D.C.: Highway Research Board, 1968), pp. 8-18.

managers between 1950 and 1967.[1,2] APTA has estimated arc price elasticities for 281 cases of an increase in fare in 114 American cities ranging in size of population from under 50,000 to over 1 million. To compensate for seasonal variations in the demand, APTA chose a period of 6 months after each fare increase in which to measure the effect of the higher fares on ridership. The agency assumed that the secular trend was represented by the percentage difference between the total ridership in the 3-month period preceding each fare increase and the total ridership in the same period in the previous year. This percentage was subtracted from the percentage change in total ridership over the previous year for the 6 months following each fare increase to yield a rough estimate of the percentage change in ridership due to the increased average fare. APTA then divided this net percentage by the percentage increase in the average fare to estimate the arc price elasticity.

The histogram in Figure III. 3 shows the wide variation in the arc price elasticities estimated by APTA. These elasticities ranged from -0.004 to -0.97. Although the average arc price elasticity was -0.33, the same as Curtin's Rule, in only 12.1 percent of the cases was the elasticity between -0.31 and -0.35. In slightly more than half of the cases, the arc price elasticity was below Curtin's Rule. Despite the roughness of these estimates, they reveal how the indiscriminate use of Curtin's Rule can lead to highly inaccurate estimates of the loss of ridership accompanying a fare increase.

The population of the central city accounted for a small variation in the arc price elasticities. Figure III. 4 shows that the absolute value of the average arc price elasticity increased as the population of the central city decreased, indicating that fare increases tended to have greater effect in the smaller cities. This finding may reflect the fact that transit service in smaller cities is normally less frequent and compares less favorably with the speed, comfort, and flexibility of a private automobile than in the larger cities. Residents of smaller urban areas, therefore, are likely to be more sensitive to increases in the fare. Figure III. 4, however, also shows that the arc price elasticities for the smaller cities were as highly variable as those for the larger ones.

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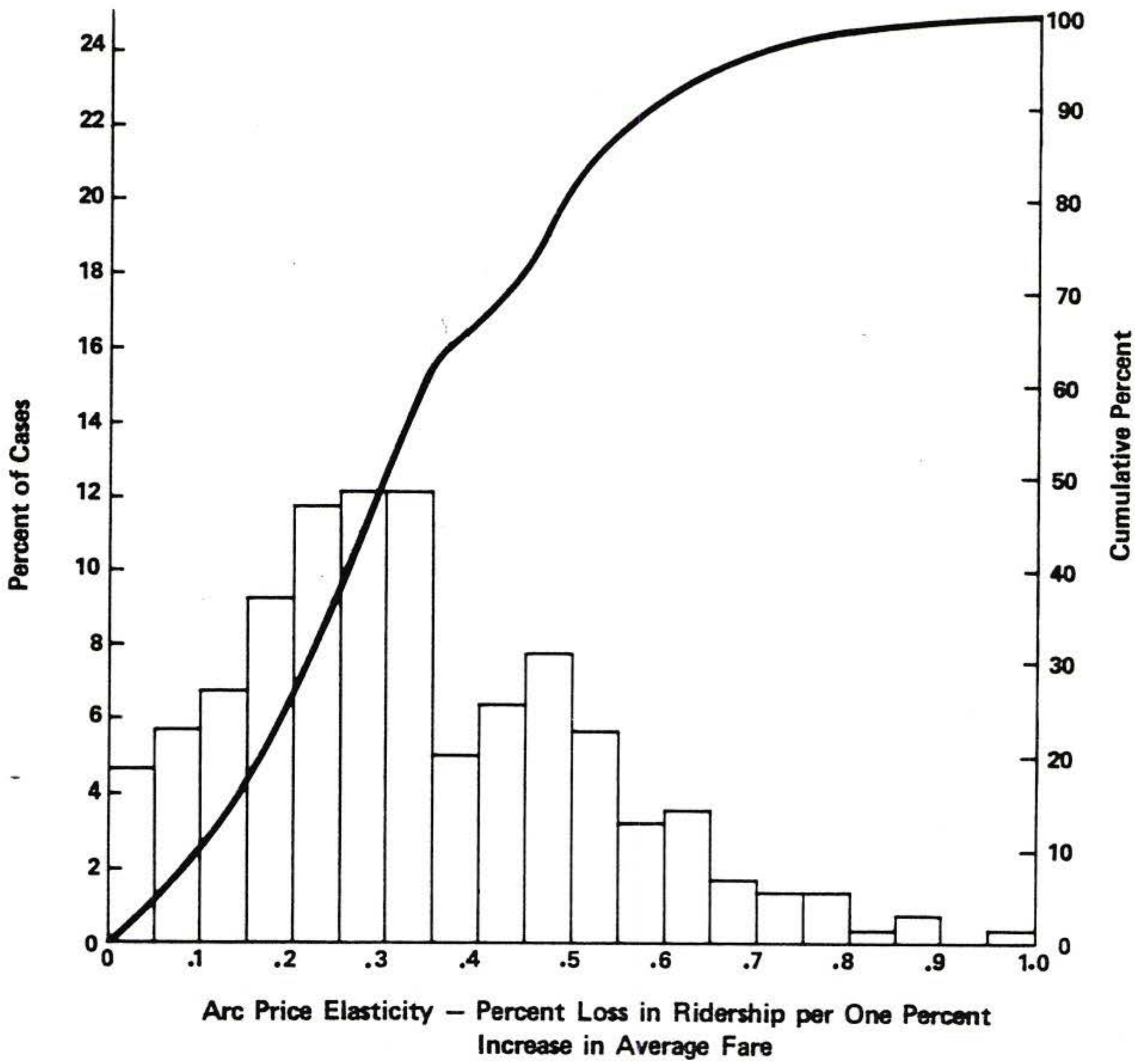
[1] American Public Transit Association, Estimated Loss in Passenger Traffic Incident to Increases in Urban Transit Fares (Washington, D.C.: American Public Transit Association, 1961).

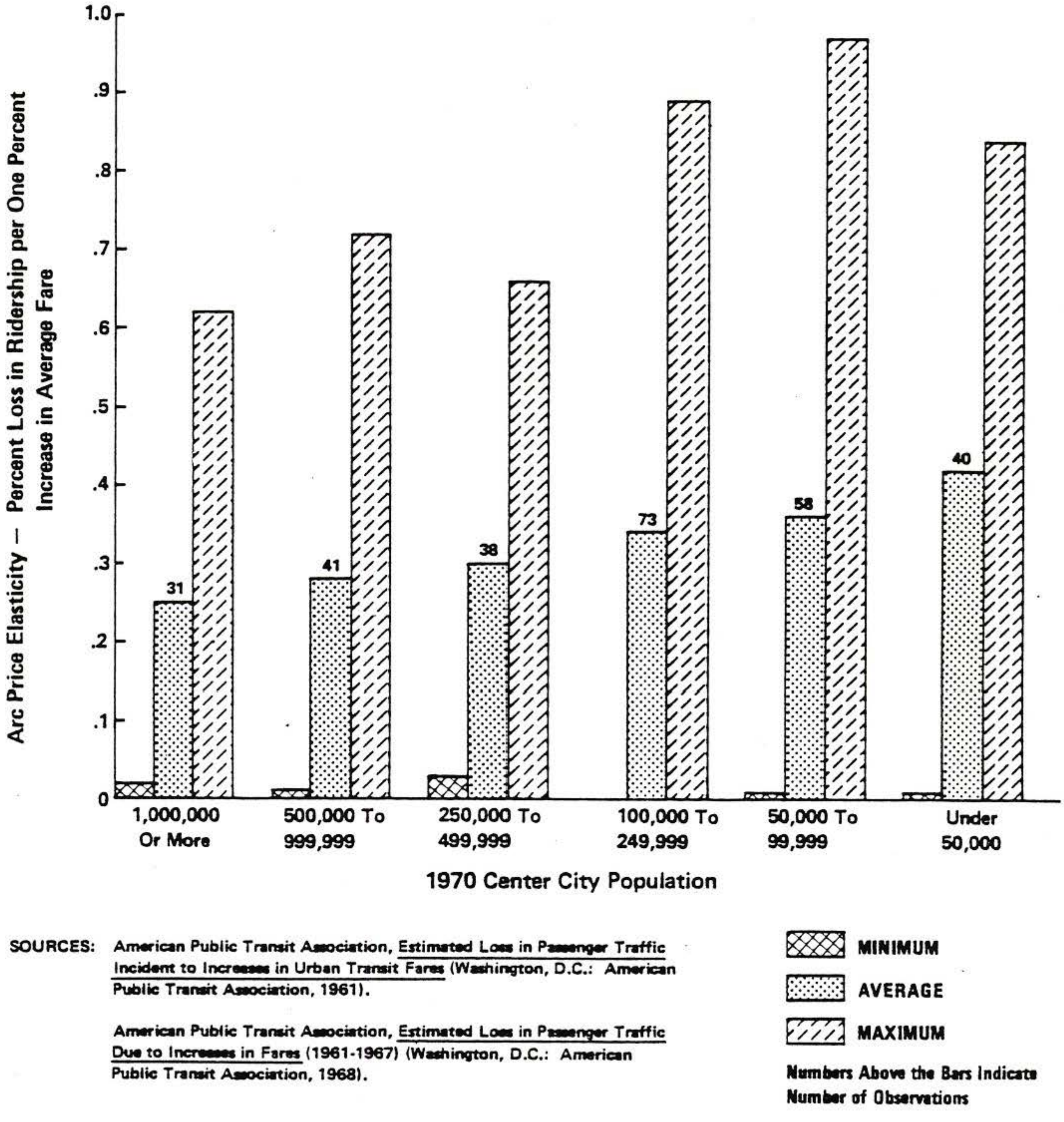
[2] Amercian Public Transit Association, Estimated Loss in Passenger Traffic Due to Increases in Fares (1961 - 1967) (Washington, D.C.: American Public Transit Association, 1968).



SOURCES: American Public Transit Association, Estimated Loss in Passenger Traffic Incident to Increases in Urban Transit Fares (Washington, D.C.: American Public Transit Association, 1961).

American Public Transit Association, Estimated Loss in Passenger Traffic Due to Increases in Fares (1961-1967) (Washington, D.C.: American Public Transit Association, 1968).

FIGURE III.3: DISTRIBUTION OF ARC PRICE ELASTICITIES FROM AN ANALYSIS OF 281 CASES INVOLVING A FARE INCREASE



SOURCES: American Public Transit Association, Estimated Loss in Passenger Traffic Incident to Increases in Urban Transit Fares (Washington, D.C.: American Public Transit Association, 1961).

American Public Transit Association, Estimated Loss in Passenger Traffic Due to Increases in Fares (1961-1967) (Washington, D.C.: American Public Transit Association, 1968).

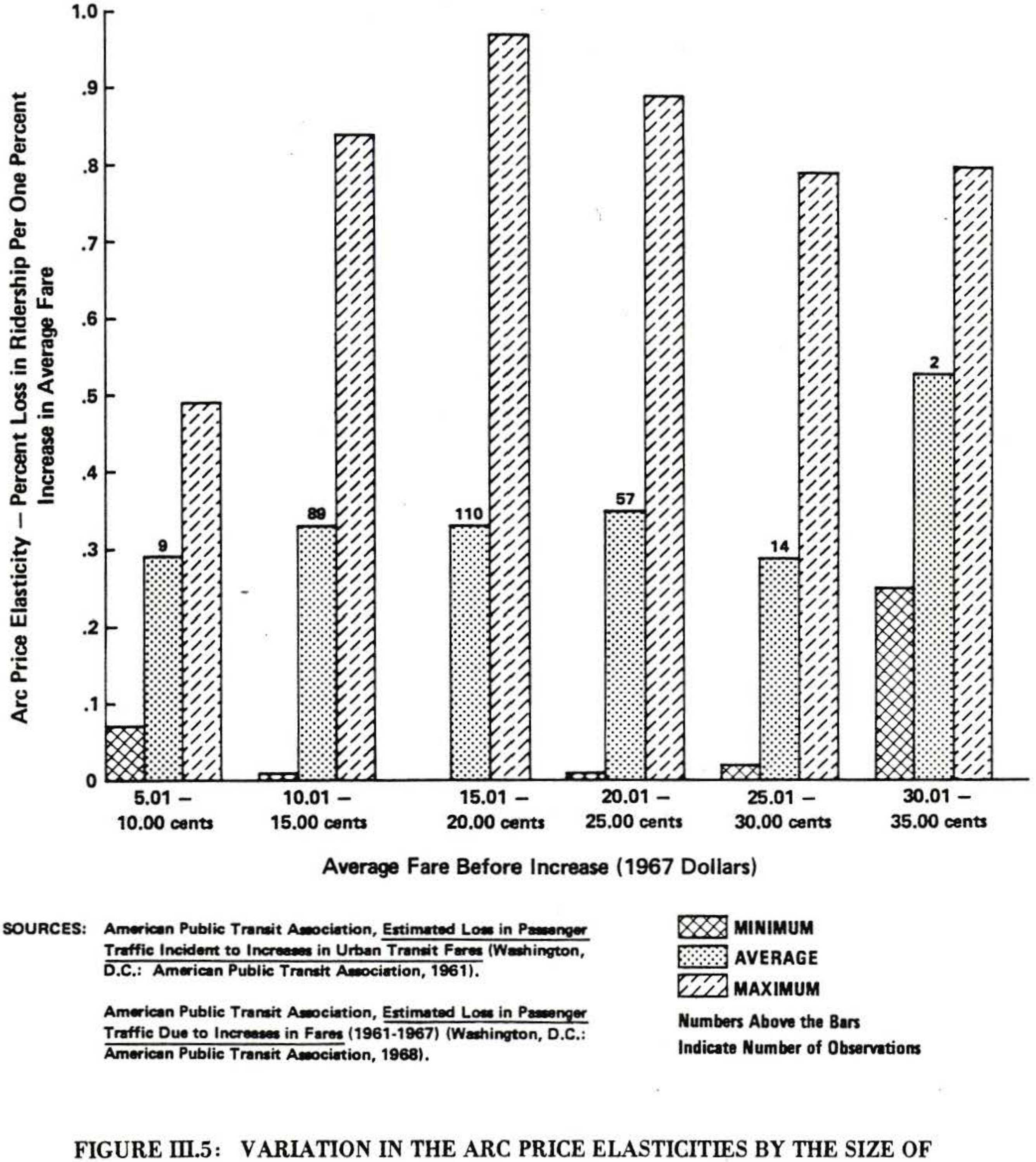
FIGURE III.4: VARIATION IN THE ARC PRICE ELASTICITIES BY POPULATION OF CENTRAL CITY FROM AN ANALYSIS OF 281 CASES INVOLVING A FARE INCREASE

The APTA data provide no further explanations for the large variation in the arc price elasticities. Figures III.5 and III.6 indicate that neither the magnitude of the average fare before the fare increase nor the percentage increase in the average fare had any discernible relation to the size of the arc price elasticity. The manner in which the average fare was raised also accounted for none of the variability. Several ways of increasing the average fare were comprised in the 281 cases. These included increasing the basic fare; either reducing or eliminating the discount on a token, ticket, or pass; imposing a surcharge for transferring; and replacing a flat fare with a fare schedule based on geographic zones. None of these approaches appeared to have a consistently greater effect on ridership than any of the others. There are numerous other factors which could have affected the arc price elasticity, including the characteristics of the riders and the amount and quality of the transit service at the time the fare was changed. The data, however, do not include any information on these other possible factors. Much of the variation in the estimats of arc price elasticity could be attributable to errors of measurement, errors in the assumptions, and the crudeness of the analysis.

APTA's estimates of arc price elasticity provide ample evidence that small and moderate increases in the fare lead to proportionally smaller losses of ridership and, in most cases, increased revenue. In all but two of the 281 cases, the percentage loss of ridership due to the higher average fare was small enough that the fare increase itself should have added more revenue. This conclusion, however, does not mean that the amount of revenue was always greater after the fare increase. In many of the cases, the total percentage loss in ridership during the period following the fare increase was considerably greater than the percentage loss attributable to the higher fare. Therefore, instead of contributing to the loss of revenue, the fare increase in many cases partially offset the loss of revenue resulting from the decline in patronage caused by other factors. The loss of revenue would have been greater if the fare increase had not been imposed.

The discussion to this point has only dealt with fare increases. The effect of a fare reduction on the aggregate demand for transit service could be quite different. Unfortunately, information on the consequences of fare reductions is not very plentiful and is often unsuitable for determining price elasticity.

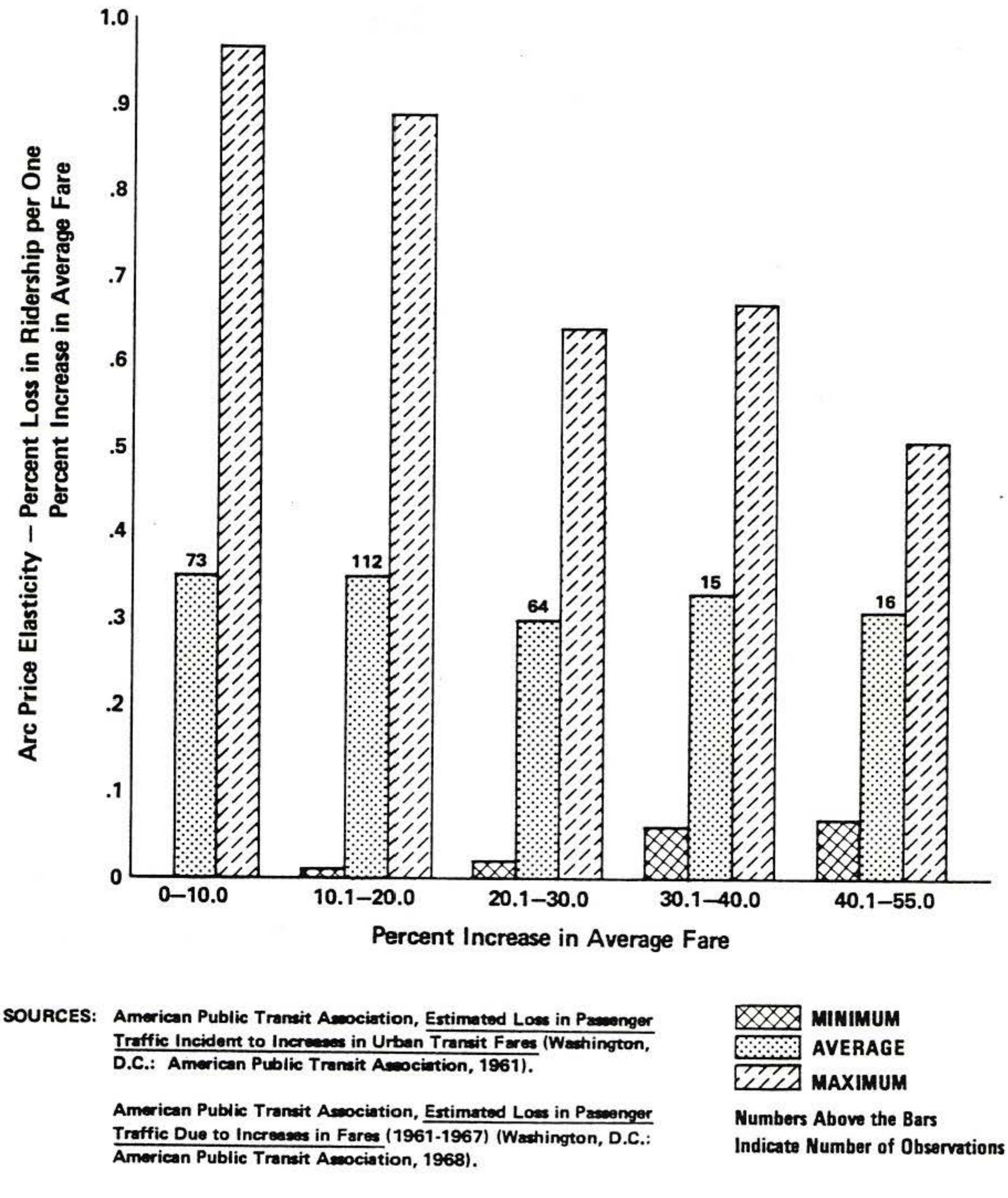
Kemp has analyzed the effect of both a fare increase and a fare reduction for the bus service in Atlanta, using monthly data on ridership and vehicle-miles of operation for the period between January 1970 and



SOURCES: American Public Transit Association, Estimated Loss in Passenger Traffic Incident to Increases in Urban Transit Fares (Washington, D.C.: American Public Transit Association, 1961).

American Public Transit Association, Estimated Loss in Passenger Traffic Due to Increases in Fares (1961-1967) (Washington, D.C.: American Public Transit Association, 1968).

FIGURE III.5: VARIATION IN THE ARC PRICE ELASTICITIES BY THE SIZE OF THE INITIAL AVERAGE FARE FROM AN ANALYSIS OF 281 CASES INVOLVING A FARE INCREASE



SOURCES: American Public Transit Association, Estimated Loss in Passenger Traffic Incident to Increases in Urban Transit Fares (Washington, D.C.: American Public Transit Association, 1961).

American Public Transit Association, Estimated Loss in Passenger Traffic Due to Increases in Fares (1961-1967) (Washington, D.C.: American Public Transit Association, 1968).

FIGURE III.6: VARIATION IN THE ARC PRICE ELASTICITIES BY PERCENT INCREASE IN THE AVERAGE FARE FROM AN ANALYSIS OF 281 CASES INVOLVING A FARE INCREASE

February 1973.[1] The fare increase, occurring in March 1971 while the bus system was privately owned, involved a rise in the basic fare from 35 cents to 40 cents. In March 1972, after the system was purchased by the Metropolitan Atlanta Rapid Transit Authority (MARTA), the fare schedule was altered considerably. The basic fare was reduced from 40 cents to 15 cents, and the surcharges for crossing zones and transferring were abolished. Only children traveling to and from school were unaffected, since their fare remained at 10 cents. The service itself was also overhauled. Between March 1972 and February 1973, 14 routes were added, 34 routes were either modified or extended, headways were reduced, and the hours of operation were expanded. These changes increased the number of annual vehicle-miles operated by 5.8 million.

Kemp used multiple regression to separate the effects of the fare changes from the effects of other factors. He hypothesized that the monthly volumes of bus passengers were determined by:

- the total vehicle-miles for the month, a measure of the amount of service provided;
- the basic fare;
- the number of working days in the month;
- the number of nonworking days in the month;
- a seasonal effect, represented by 12 dummy variables, one for each month of the year; and
- a secular trend, represented by a variable whose value begins at 1 for January 1970 and increases by 1 for each succeeding month.

Kemp derived 14 regression equations with different combinations of these factors. None of these models were calibrated with monthly data for March 1970 through February 1972, the months preceding the large fare reduction of March 1972, while the remaining five equations were calibrated with monthly data for the entire period, March 1970 through February 1973.

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[1] Michael A. Kemp, Transit Improvements in Atlanta: The Effects of Fare and Service Changes (Washington, D.C.: The Urban Institute, 1974).

Table III. 2 shows the range of estimated arc price elasticities for the fare increase of March 1971. To obtain these estimates, four of the nine regression equations in the first set were used to predict what the cumulative volumes of bus passengers would have been 3 months, 6 months, and 1 year after the fare increase if the basic fare had not been raised. These predicted volumes were then compared with the actual cumulative volumes, and each percentage difference was divided by the percentage change in the basic fare to yield an estimate of the arc price elasticity.

TABLE III. 2

ESTIMATED ARC PRICE ELASTICITIES
FOR THE MARCH 1971 FARE INCREASE IN ATLANTA

NUMBER OF MONTHS AFTER FARE INCREASE	ARC PRICE ELASTICITY*		
	Lowest Estimate	Highest Estimate	Average Estimate
3	0.40	0.59	0.51
6	0.44	0.60	0.53
12	0.42	0.58	0.52

Source: Michael A. Kemp, Transit Improvements in Atlanta: The Effects of Fare and Service Changes (Washington, D.C.: The Urban Institute, 1974), p. 34.

*Percent loss in ridership per 1-percent increase in the basic fare.

The estimated arc price elasticities were well within the range of the estimates obtained from the APTA data, although even the lowest of Kemp's estimates were above the arc elasticity implied by Curtin's Rule as well as the average arc elasticity in the APTA study. According to the results of Kemp's regression analysis, the fare increase in Atlanta should have increased revenue or at least have partially offset the loss of revenue caused by other factors.

The results also indicate that the full effect of the fare increase was felt within 3 months. The arc price elasticities 3 months, 6 months, and 12 months after the fare increase were virtually the same.

Table III. 3 summarizes the results of the analysis of the fare reduction in March 1972. All 14 regression equations were applied in this case.

TABLE III. 3

ARC PRICE ELASTICITIES
FOR THE MARCH 1972 FARE REDUCTION IN ATLANTA

NUMBER OF MONTHS AFTER FARE DECREASE	ARC PRICE ELASTICITY*		
	Lowest Estimate	Highest Estimate	Average Estimate
3	0.17	0.31	0.25
6	0.16	0.40	0.29
12	0.06	0.47	0.29

Source: Michael A. Kemp, Transit Improvements in Atlanta: The Effects of Fare and Service Changes (Washington, D.C.: The Urban Institute, 1974), p. 33.

*Percent gain in ridership per 1-percent decrease in the basic fare.

The results indicate that the fare reduction had less of an effect on ridership than the much smaller fare increase. The arc price elasticities for the fare reduction were of roughly half the value of those for the fare increase and slightly below the value implied by Curtin's Rule. These results may be indicative of the actual behavior of the aggregate market, or they may reflect some of the weaknesses of the analysis. The most salient weakness is the use of the basic fare as an indicator of price and changes in price. Clearly, the percentage change in the fare was not the same for everyone in either case, particularly for those who had to pay a zonal surcharge before such charges were eliminated when the basic fare was lowered. In his report, Kemp discusses the problems of using the basic fare, but notes that the use of an average fare also has its limitations, since the average fare may vary without any change being made in the fare schedule.

The fare reduction instituted in San Diego in September 1972 appeared to have a much greater effect on ridership, according to the results of a study by Kemp similar to the one for Atlanta.[1] The base fare in this case was reduced from 40 cents to 25 cents, a decrease of 37.5 percent. For some riders, however, the percentage decrease in the fare was as high as 72.2 percent, representing a drop from 90 cents to 25 cents, since all zonal surcharges were abolished. Kemp estimated that these changes caused the ridership to increase by 21.6 percent over a period of 12 months or by 0.58 percent for every 1-percent decrease in the basic fare. This estimate of arc price elasticity is twice as large as the average estimate for Atlanta.

A similar result was obtained for the fare reduction in Cincinnati.[2] In preparation for public takeover, the Southwest Ohio Region Transit Authority in April 1973 lowered the basic fare from 55 cents to 25 cents, a decrease of 54.5 percent, and revised the schedule of zonal surcharges, causing the highest fare to drop 40 percent from $1.00 to 60 cents. Using regression analysis, Kemp estimated that these revisions caused ridership to increase by 32 percent after 5 months, or 0.57 percent for every 1-percent decrease in the basic fare. Because the demand was inelastic, the bus system's revenue decreased by 40 percent between April 1973 and December 1973 when compared with the revenue for the previous year.

Fare reductions in two other cities produced opposite results.[3] In Kansas City, ridership continued to decline in 1972 at an annual rate of 6 percent after the basic fare was lowered from 50 cents to 40 cents in October 1971. In Auburn, New York, on the other hand, a free transit service offered during a 1-month experiment caused ridership to increase by 344 percent, equivalent to an arc price elasticity of -3.44.

The aggregate demand for public transit appears to be as inelastic to fare reductions as it is to fare increases, although the effect of either action in any given situation cannot be precisely determined from the limited available evidence. Fare increases seldom contribute to any loss in revenue, since the percentage loss in ridership that invariably

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[1] Michael A. Kemp, Reduced Fare and Fare-Free Urban Transit Services: Some Case Studies (Washington, D.C.: The Urban Institute, 1974).

[2] Ibid.

[3] John R. Carulo, and Roger P. Roess, The Effect of Fare Reductions on Public Transit Ridership (Brooklyn, N.Y.: Polytechnic Institute of Transportation Planning and Engineering, 1974).

follows them is usually much less than the percentage increase in the fare. Fare reductions do not stimulate enough of an increase in the overall demand to generate additional revenue. In the absence of any other inducements, fare revisions that are not oriented to any particular market are not likely to increase both ridership and revenue.

SPECIFIC MARKETS

Transit managers have been devoting more attention in recent years to selective changes in the fare schedule with particular markets in mind. Reduced fares for senior citizens during certain hours have become quite common, partially due to the National Mass Transportation Assistance Act of 1974. Also, an increasing number of cities have either lowered fares for the off-peak hours or raised them for the peak hours. Although these and other strategies have often been adopted for social and environmental purposes more than for economic reasons, certain combinations of these strategies could possibly increase revenue and ridership simultaneously.

A shortage of detailed information hinders efforts to assess the effects of these various fare-related strategies on different markets for transit service. There apparently have not been many well-designed before-and-after studies to determine how the demand for transit service changes by route, time of day, origin and destination, purpose of trip, and types of passengers after one of these strategies is implemented. The detailed results of previous studies and past experience have also been too diverse for use in predicting the precise consequences of a particular strategy in a specific situation. There is, however, sufficient evidence for a few specific markets to determine whether the price elasticity of the demand for transit service in these markets is elastic or inelastic. This evidence is summarized in the following discussion.

Senior Citizens

Current programs of reduced fares for senior citizens provide most of the available direct evidence on how these people respond to lowered transit fares. Carulo and Roess have described over 90 such programs in the United States, but only 52 of them have furnished any information on ridership and revenue. The results of these latter programs are summarized in Table III. 4.

TABLE III. 4: RESULTS OF SELECTED REDUCED FARE PROGRAMS FOR SENIOR CITIZENS

LOCATION	STARTING DATE	BASIC FARE (CENTS) SENIOR CITIZENS	OTHER ADULTS	APPLICABLE HOURS	EFFECT ON RIDERSHIP	EFFECT ON REVENUE	ARC PRICE ELASTICITY
Albuquerque, N. M.	Oct. 68	20	30	All hours	23% increase in elderly riders	Unspecified	-0. 69
Altoona, Pa.	Jul. 71	11 tickets for $2. 00	30	All hours	Increase; amount unspecified	Unspecified	*
Andover, Mass.	Mar. 69	20	30	10 a. m. - 3 p. m. weekdays	Increase during off-peak hours; amount unspecified	Unspecified	*
Asheville, N. C.	Mar. 70	20 5 tickets for $1. 00	30 7 tickets for $2. 00	10 a. m. - 3 p. m.	No change	$8, 034 annual loss	-0. 00
Baltimore, Md.	Apr. 72	15	30	9 a. m. - 4 p. m. and 6 p. m. - 7 a. m. weekdays; all hours on weekends	8% increase in elderly riders	First year: $561, 400 loss Second year: over $600, 000 loss	-0. 16
Bedford, O.	Jan. 70	15	40	9 a. m. - 3 p. m. on weekdays; all hours on weekends	Increase; amount unspecified	Unspecified	*
Binghamton, N. Y.	Mar. 71	20	35	9 a. m. - 3 p. m. on weekdays; all hours on weekends	Little Change	Unspecified	*
Chicago, Ill.	Apr. 69	20	40	9 a. m. - 3 p. m.	Unspecified	$7, 500, 000 annual loss	*
Cleveland, O.	Mar. 73	25	50	9 a. m. - 4 p. m. and 7 p. m. - midnight on weekdays; 5 a. m. - midnight on weekends	Unspecified	$569, 000 annual loss	*
Dallas, Tex.	Jul. 71	10	35	9 a. m. - 4 p. m. after 6 p. m. on weekdays; all hours on weekends	Unspecified	$135, 000 annual loss	*
Des Moines, Ia.	May 61	15	30	10 a. m. - 3 p. m. and after 6:30 p. m.	No noticeable change	Unspecified	-0. 00
Detroit, Mich.	May 56	15	40	9 a. m. - 3 p. m. and 6 p. m. - 6 a. m. on weekdays; all hours on weekends	Increase; amount unspecified	$1, 500, 000 annual loss	*
Euclid, O.	Sep. 67	15	25	All hours	7% increase in elderly riders	Unspecified	-0. 18
Fort Wayne, Ind.	Jun. 71	20	35	9 a. m. - 3 p. m. and after 6 p. m. on weekdays; all hours on weekends	Increase during midday; amount unspecified	$58, 300 annual loss	*
Fresno, Calif.	Aug. 71	10	30	All hours	Small increase, amount unspecified	$40, 000 annual loss	*
Gardena, Calif.	Mar. 67	20	25	All hours	No change	Unspecified	-0. 00
Grand Rapids, Mich.	Nov. 71	15	35	All hours	No change	$35, 000 annual loss	-0. 00
Honolulu, Hawaii	May 70	Free	25	All hours	8. 8% increase in elderly riders over 3 years	$1, 050, 000 annual loss	*
Ithaca, N. Y.	Unspecified	8 tickets for $1. 00	25	All hours	No noticeable change	Unspecified	-0. 00
Jamaica, N. Y.	Feb. 72	10	30	All hours	Small increase; amount unspecified	Unspecified	*
Long Beach, Calif.	Mar. 71	20	30	9 a. m. - 3 p. m. and after 6 p. m. on weekdays; all hours on weekends	Unspecified	$30, 000 annual loss	*
Los Angeles, Calif.	Jun. 61	15	22. 5 Average	10 a. m. - 3 p. m. and 7 p. m. - midnight on weekdays; 7 p. m. - midnight on Saturdays; all hours on Sundays	Increase of 1. 9 million elderly riders or 23. 9%	$130, 275 annual loss	-0. 72
Madison, Wis.	Aug. 73	15	25	All hours	20% increase in elderly riders	Unspecified	-0. 50
Miami, Fla.	Oct. 72	15	30	9 a. m. -4 p. m. and 6:30 p. m. -7 a. m. on weekdays; all hours on weekends	34. 5% increase in elderly riders during off-peak hours	Over $1. 09 million annual loss	*
Michigan City, Ind.	1970	10	25	All hours	Unspecified	$4,000 annual loss	*
Milwaukee, Wis.	May 73	25	50	9 a. m. - 3 p. m. on weekdays; all hours on weekends	8 - 10% increase in elderly riders	$750, 000 annual loss	-0. 16 to -0. 20

TABLE III. 4: (Continued)

LOCATION	STARTING DATE	BASIC FARE (CENTS) SENIOR CITIZENS	BASIC FARE (CENTS) OTHER ADULTS	APPLICABLE HOURS	EFFECT ON RIDERSHIP	EFFECT ON REVENUE	ARC PRICE ELASTICITY
Montebello, Calif.	Jun. 70	15	25	All hours	Less than 1% increase in elderly riders	$10,000 annual loss	≤ -0.025
New Bedford, Mass.	Jul. 71	15	30	Unspecified	Small increase; amount unspecified	Unspecified	*
New Haven, Conn.	Nov. 67	20	30	9 a.m. - 3:30 p.m. and after 7 p.m. on weekdays; all hours on weekends	Unspecified	$200,000 annual loss	*
Minneapolis, Minn.	Jan. 72	Free	30	9:30 a.m. - 3:30 p.m. and after 6:30 p.m. on weekdays; all hours on weekends	99% increase in elderly riders during first year	$1 million annual loss	-0.99
New York, N.Y.	Jul. 69	10	20	10 a.m. - 4 p.m. and 7 p.m. - midnight on weekdays; all hours on weekends	26.7% increase in elderly riders between 10 a.m. and 4 p.m.	$14 million annual loss	*
Oceanside, Calif.	Mar. 71	15	25	All hours	Small increase; amount unspecified	Unspecified	*
Oxnard, Calif.	Feb. 70	15	20	All hours	No change	$2,400 annual loss	-0.00
Philadelphia, Pa.	Jul. 73	Off-peak Free Peak: 10	Off-peak 35 Peak: 35	Free: 9 a.m. - 3:30 p.m. and 6:30 p.m. - 6 a.m. on weekdays; all hours on weekends	33% increase in elderly riders during first month; 44.7% increase at the end of 1973	$6.2 million annual loss	*
Pittsburgh, Pa.	Feb. 70	19 Average	34 Average	10 a.m. - 3 p.m. and after 7 p.m. on weekdays; all hours on weekends	21.3% increase in elderly riders	$628,900 annual loss	-0.48
Providence, R.I.	Jan. 70	20	35	All hours	2% increase in elderly riders	Unspecified	-0.05
Pueblo, Colo.	1970	15	25	All hours	No change	$12,000 annual loss	-0.00
Rochester, N.Y.	Feb. 72	25	40	9 a.m. - 3:30 p.m. and 6 p.m. - 2 a.m. on weekdays; all hours on weekends	Increase; amount unspecified	$326,000 annual loss	*
San Antonio, Tex.	Sep. 72	10	25	All hours	Over 30% increase in elderly riders after first month	Unspecified	> -0.50
San Buenaventura, Calif.	Oct. 69	10	20	All hours	Unspecified	$7,000 annual loss	*
San Diego, Calif.	Nov. 70	25	40	9 a.m. - 3 p.m. and after 6 p.m. on weekdays; all hours on weekends	Increase; amount unspecified	$197,230 annual loss	*
San Francisco, Calif.	Jun. 69	5	25	9:30 a.m. - 3:30 p.m. on weekdays; all hours on weekends	No noticeable change	$650,000 annual loss	-0.00
Santa Barbara, Calif.	Dec. 70	15	30	All hours	No noticeable change	Unspecified	*
Seattle, Wash.	Jan. 73	10	20	All hours	Unspecified	$70,000 annual loss	*
Sioux City, Iowa	Dec. 70	25	40	9 a.m. - 3 p.m. on weekdays	No change	$1,500 annual loss	-0.00
South Bend, Ind.	Jan. 65	15	30	9 a.m. - 3 p.m. on weekdays	20% increase in elderly riders	Unspecified	-0.40
Statesville, N.C.	1966	20	25	All hours	Decrease; amount unspecified	Unspecified	*
Tacoma, Wash.	Sep. 67	10	25	All hours	Increase; amount unspecified	$40,000 annual loss	*
Terre Haute, Ind.	Jun. 71	20	25	All hours	No change	Unspecified	-0.00
Torrance, Calif.	Nov. 70	10	35	All hours	30% increase in elderly riders	$6,000 annual loss	-0.42
Washington, D.C.	May 71	25	40	9:30 a.m. - 3 p.m. and 7 p.m. - 3 a.m. on weekdays; all hours on Sundays	26% increase in elderly riders	$250,000 annual loss	-0.69
Yakima, Wash.	Jul. 69	$2.00 monthly pass	25	All hours	Increase; amount unspecified	Unspecified	*

Source: John R. Carvlo and Roger P. Roess, The Effect of Fare Reductions on Public Transit Ridership (Brooklyn, N.Y.: Polytechnic Institute of Transportation Planning and Engineering, 1974).

A surprisingly large number of these programs have been markedly unsuccessful. In at least 16 cases, the reduced fare had little or no effect on the number of elderly passengers. Elderly ridership increased by less than 10 percent in at least 22 of the programs. Most of the more successful programs have also shown that the demand for transit service in this particular market is highly inelastic. The proportional increase in the number of elderly riders has typically been considerably less than the proportional difference between the basic fares for senior citizens and other adults, respectively. Because of the relatively small increases in ridership and the typically large proportional reduction in the fare, reduced fares for the elderly have consistently led to losses in revenue.

Where the reduced fares have been put into effect only during off-peak hours, one interesting result has often been a shifting of elderly riders from the peak to the off-peak period. In Los Angeles, for example, 862,250 elderly passengers over the year began riding during the off-peak instead of the peak hours.[1] In Milwaukee, 14 percent of the elderly bus passengers formerly rode during the rush hours.[2] The number of bus trips made by senior citizens in Pittsburgh increased by 46.5 percent during the off-peak hours and decreased by 31.8 percent during the peak hours.[3] Two desirable effects of reduced off-peak fares for the elderly have therefore been the dispersal of the demand for transit service over the day and the easing of the often crowded conditions or buses during peak hours. This redistribution of the demand, however, unfortunately contributes to the loss of revenue as the elderly take advantage of the lower off-peak fares.

Non-Captive Market

The overall demand for public transit by persons with a choice between transit and a private automobile appears to be highly inelastic to changes in the fare, according to an estimate of point price elasticity derived from McGillivray's discriminant model of modal choice. Estimates of point price elasticity derived from this model for different

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[1] Lewis M. Schneider, Marketing Urban Mass Transit: A Comparative Study of Management Strategies (Boston: Graduate School of Business Administration, Harvard University, 1965), p. 78.

[2] John R. Caruolo and Roger P. Roess, op. cit., p. 23.

[3] Ibid., p. 24.

trip purposes varied considerably, however, as shown in Table III. 5 Several of these estimates do not seem reasonable or logical. The point price elasticity for comparison shopping trips, for example, has the wrong sign. The estimated point price elasticity for work trips is unexpectedly larger than the estimates for non-work trips. Since the latter types of trips are usually more discretionary than work trips, the point price elasticities for non-work trips should logically be higher.

TABLE III. 5

POINT PRICE ELASTICITIES FOR PERSONS WITH A CHOICE BETWEEN PUBLIC TRANSIT AND PRIVATE AUTOMOBILE

TRIP PURPOSE	NUMBER OF OBSERVATIONS IN SAMPLE	POINT PRICE ELASTICITY*
All trips	986	-0.19
Work	599	-0.87
Personal business	126	-0.0
Visits	97	-0.77
Convenience shopping	56	-0.15
Comparison shopping	108	+0.34

Source: Michael A. Kemp, "Some Evidence of Transit Demand Elasticities", Transportation, 2, (April 1973), 45.

*Computed at the mean values of all of the causal variables.

The relatively high point price elasticity for work trips taken by persons with a choice between transit and private automobile has been corroborated by two other modal choice models. Warner derived an estimated expected value of -0.965 for the non-captive market in Chicago with a 95 percent probability that the true mean value is between -0.70 and -1.22.[1] For Warner's model, the point price elasticity in

[1]S. L. Warner, Stochastic Choice of Mode in Urban Travel: A Study in Binary Choice (Chicago: Northwestern University Press, 1962).

other cities depends on the proportion of work trips taken by automobile. Warner estimates that the point price elasticity for people with a choice of mode could be between -0.31 and -1.33 in cities where 75 percent to 90 percent of the work trips are made by car. Using the same data analyzed by Warner, Lave derived an estimated point price elasticity of -0.7 for persons with a choice of mode for the work trip at the mean values of the causal variables in the model.[1]

None of these models were calibrated with data reflecting actual changes in fare. McGillivray used data from an origin-destination survey in the San Francisco Bay Area, while Warner and Lave used data from a household survey in Cook County (Chicago), Illinois, in 1956. All three models attempt to predict the odds that an individual will choose transit over an automobile given the cost and time required to travel by each mode. The different costs of travel in the data, however, are due to different distances between the home and the place of work and not to actual revisions in the transit fare schedule.

Peak and Off-Peak Markets

Theoretically, the demand for public transit should be more responsive to changes in the fare during off-peak hours than during peak hours. Trips made during the off-peak periods are more likely to be taken for purposes not related to work and therefore are more discretionary than trips made during the peak periods. If the transit fare is raised, for example, a person who uses the transit service for non-work trips may decide to walk to a closer destination, combine several transit trips into one, or forego certain trips altogether. In short, travel habits can be changed more easily for non-work trips than for work trips in response to changes in the fare.

This hypothesis is supported by Lassow's study of the effect of a fare increase, imposed in July 1966, on New York City subway ridership.[2] The basic fare in this case was raised from 15 cents to 20

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[1] C. A. Lave, Modal Choice in Urban Transportation: A Behavior Approach. Stanford University Ph.D. Thesis (Ann Arbor, Michigan: University Microfilms, 1968).

[2] William Lassow, "Effect of the Fare Increase of July 1966 on the Number of Passengers Carried on the New York City Transit System," Highway Research Record Number 213, Passenger Transportation (Washington, D.C.: Highway Research Board, 1968).

cents. Lassow compared hourly totals of passengers entering the subway's turnstiles on October 20, 1965, with those for October 5, 1966. The results, shown in Table III. 6, indicate that the largest proportional decreases in ridership occurred in the midday and evening hours. The estimates of arc price elasticity included in the table are very crude since no attempt was made to separate the effects of other factors. These estimates, furthermore, may not be indicative of the effects of the fare increase on bus ridership in New York City.

Reduced fares in off-peak periods have had varying degrees of success in increasing ridership.[1] In most cases, the percentage gain in ridership has been less than the percentage decrease in the basic fare.

- The New Castle, Pennsylvania, Transit Authority in 1968 conducted an experiment lasting 23 days in which the basic fare during off-peak hours was reduced from 25 cents to 10 cents. The experiment did not produce any detectable increase in ridership but did cause some shifting of demand from peak to off-peak hours.

- In May 1971, bus fares in Denver were lowered in both peak and off-peak period but by different amounts. The basic adult fare was dropped from 40 cents to 35 cents for the peak hours and to 25 cents in the off-peak hours. Between May and September of 1971, ridership increased by 1.6 percent. Since the 15 percent decline in ridership expected to occur under the former fare was averted, the proportional increase in ridership was reported as 16.6 percent. The increase in ridership during each of the two periods of the day was not reported. The lower fares resulted in a 14.8 percent decrease in revenue.

- In Louisville, Kentucky, the basic adult fare was reduced in July 1973 from 50 cents to 25 cents during off-peak hours on weekdays and during all hours on weekends. As a result, adult ridership increased by 7 percent over the same period in 1972. The total proportional increase in adult ridership was reported as 25 percent, since the reduced fare averted

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[1] Caruolo and Roess, op. cit., pp. 29-39.

TABLE III. 6

CHANGES IN NEW YORK CITY SUBWAY RIDERSHIP FOLLOWING THE JULY 1966 FARE INCREASE

PERIOD OF THE DAY	PERCENT DECREASE IN RIDERSHIP*	ARC PRICE ELASTICITY@
7 a.m. - 10 a.m.	2.4	0.07
10 a.m. - 4 p.m.	8.0	0.24
4 p.m. - 7 p.m.	5.0	0.15
7 p.m. - 11 p.m.	14.6	0.44
11 p.m. - 7 a.m.	3.7	0.11

Source: William Lassow, "Effect of the Fare Increase of July 1966 on the Number of Passengers Carried on the New York City Transit System," Highway Research Record Number 213: Passenger Transportation (Washington, D.C.: Highway Research Board, 1968), p. 5.

* Based on a comparison of passenger counts on October 20, 1965, and October 5, 1966

@ Percent decrease in ridership per one percent increase in the basic fare.

an expected 18 percent decline in demand. The proportion of bus trips taken during the off-peak period increased from 55 percent to 67 percent. The effect of the reduced fare on revenue was not indicated.

- Free bus service was provided during off-peak hours in Madison, Wisconsin, for one week in September 1973. Overall ridership increased by 93.5 percent, compared to the average weekly ridership before the demonstration.

- One of the largest increases in ridership accompanying a decrease in the fare during off-peak hours occurred in Lowell, Massachusetts. The demand increased by 79 percent after the basic fare during the off-peak period was reduced by 60 percent from 25 cents to 10 cents. This is equivalent to an arc price elasticity of -1.32. Because of the relatively large proportional decrease in the fare, however, revenue fell by 36 percent.

Wabe and Coles have provided some indirect evidence of the relatively higher elasticity of the demand for transit in the off-peak period.[1] They developed regression models to predict the proportion of work trips made by bus and the annual number of non-work trips made by bus, given the average fare per passenger-mile, the annual number of vehicle-miles operated by the transit system, the population of the city, and the number of registered cars per employed person. The models were calibrated with cross-sectional data from 30 British towns; consequently, they were not based on any actual changes in fare. At the average values of the causal variables, Wabe and Coles derived point price elasticities of -0.19 for work trips and -0.49 for non-work trips.

The evidence presented to this point strongly suggests that, in most circumstances, simply changing the fare will have only a minimal to moderate effect on the demand for public transit. Fare hikes normally generate more revenue at the expense of losing ridership, while fare reductions increase ridership usually at the expense of losing revenue. Tailoring only the fare to the different markets for public transit also appears to be ineffectual as a means of increasing both ridership and revenue. Although there is insufficient quantitative information about the demand for transit in certain particular markets, the available evidence does suggest that none of these markets is highly responsive to changes in the fare alone.

[1] Cited in Paul Mullen, "Estimating the Demand for Urban Bus Travel," Transportation, (September 1975), p. 231.

4. COMPARISON OF PRICE AND SERVICE ELASTICITIES

The speed, frequency, convenience, and certain other qualities of a transit service seem to have more of an effect on the demand than the fare. Many attitudinal studies have found that both transit users and nonusers often regard the fare as being less important than waiting time, vehicular travel time, adherence to the schedule, and other factors related to the quality and quantity of the transit service.[1] Estimates of demand elasticities for variables measuring the quality or the quantity of the transit service have generally been higher in absolute value then corresponding estimates of price elasticity. Although the available evidence on service elasticities is sketchy and often does not provide much guidance, it does suggest that selective improvements in the transit service can induce

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[1] F. T. Paine, A. N. Nash, S. J. Hille, and G. A. Brunner, Consumer Conceived Attributes of Transportation: An Attitude Study (College Park, Maryland: University of Maryland, 1967).

F. C. Bock, Factors Influencing Modal Trip Assignment, National Cooperative Highway Research Program Report 57 (Washington, D.C.: Highway Research Board, 1968).

R. K. McMillan and H. Assael, National Survey of Transportation Attitudes and Behavior: Summary Report, National Cooperative Highway Research Program Report 49 (Washington, D.C.: Highway Research Board, 1968).

R. K. McMillan and H. Assael, National Survey of Transportation Attitudes and Behavior: Analysis Report, National Cooperative Highway Research Program Report 82 (Washington, D.C.: Highway Research Board, 1968).

T. F. Golob, E. T. Cantry, and R. L. Gustafson, An Analysis of Consumer Preferences for a Public Transportation System (Warren, Michigan: General Motors Research Laboratories, 1970).

Peat, Marwick, Mitchell & Co., Immediate Travel Impacts of Transbay BART (Washington, D.C.: Peat, Marwick, Mitchell & Co., 1975).

Peat, Marwick, Mitchell & Co., Market Survey Working Paper Number 18, Baltimore Region Phase II Transit Study (Washington, D.C.: Peat, Marwick, Mitchell & Co., 1975).

more ridership than a moderate or even large decrease in the fare. This evidence is summarized below, first for the overall market and then for specific submarkets.

OVERALL MARKET

In the past, the managers of privately owned transit companies attempted to maintain or increase their revenue in the face of rising costs and declining patronage by raising their fares and curtailing their transit services. Between 1945 and 1974, the total annual vehicle-miles operated by the transit industry fell by 41.4 percent and the average fare rose by 365 percent, while the annual number of revenue passengers declined by 70.5 percent.[1] This huge decrease in ridership cannot be attributed entirely to the curbing of service and the increases in the fares, nor can a clear causal relation between these two managerial strategies and the decline in ridership be established, since the latter often preceded and induced the former. Nevertheless, these twin actions usually exacerbated rather than eased the transit company's fiscal problems.

In more recent years, the managers of several publicly owned transit systems have reduced the fares and improved the service in an effort to increase ridership. The success of these efforts has varied considerably, depending on the nature and extent of the improvements, the efforts to promote the improved service, and numerous endemic characteristics of the locality. In only a few cases has an attempt been made to determine the relative effects of the reduced fares and the improvements in the service.

In Atlanta the number of revenue passengers transported between March 1972 and February 1973 rose 15.8 percent over the ridership in the previous twelve-month period partially in response to a reduction in the fare and numerous modifications of the service. On March 1, 1972, the Metropolitan Atlanta Rapid Transit Authority (MARTA) reduced the basic fare from 40 cents to 15 cents, a decrease of 62.5 percent, and abolished all surcharges for crossing geographic zones and transferring. Between March 1972 and February 1973, MARTA added 14 new routes, revised or extended 34 existing routes, and made 91 other improvements involving either reduced headways or more hours of services. These improvements

[1] American Public Transit Association, Transit Fact Book. '75 - '76 Edition (Washington, D.C.: American Public Transit Association, 1976).

increased the total vehicle--miles of service from 19,107,860 for the period between March 1, 1971, and February 29, 1972, the last twelve months of private ownership, to 21,105,170 for succeeding period, the first twelve months of public ownership.

As reported earlier in this chapter, Kemp endeavored to determine the relative effects of the changes in the fare and the amount of service by performing a regression analysis with data on monthly ridership and vehicle-miles of service. In only three of the 14 regression equations developed was the regression coefficient for the variable measuring the level of service statistically significant, and only two of these equations were calibrated with the full set of data. These two equations predicted that, with the reduced fares and the improvements in the service, the expected total ridership for the period between March 1, 1972, and February 28, 1973, should have been either 51,087,440 or 50,996,890 revenue passengers, depending on which equation was used.[1] With the reduction in the fare but without the improvements in the service, the expected total ridership for the twelve-month period should have been 49,476,250 revenue passengers according to the first regression model and 49,480,920 revenue passengers according to the second. The differences between the two sets of estimates represent the effect of the improved service. The 10.5 percent increase in total vehicle-miles of service added 1,611,190 passengers, a 3.3 percent increase, according to the first model, and 1,515,970 passengers, a 3.1 percent increase, according to the second model. The estimated arc service elasticities are +0.31 and +0.30, respectively.

These service arc elasticities are slightly higher in absolute value than the arc price elasticities for the fare reduction. With the improvements in the service but without the reduction in the fares, the expected total ridership should have been 44,412,000 passengers according to one regression model and 44,089,000 passengers according to the other. The 62.5 percent decrease in the basic fare therefore increased the total ridership by 15.0 to 15.7 percent. The estimated arc price elasticities are -0.24 and -0.25.

The estimated arc service elasticities are probably too low. Since the adjustments in Atlanta's transit service were made incrementally throughout the twelve-month period, the effects of changes made toward the end of the period were probably not fully reflected in the data for the latter months.

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[1] The actual total ridership was 50,947,800 revenue passengers.

Reduced fares and improvements in the service had a much greater effect in San Diego than in Atlanta. The fare schedule was completely revised: the basic fare was reduced from 40 cents to 25 cents; all zonal surcharges were eliminated; the elderly were given a further discount; and the price of a monthly pass, previously \$16 to \$36, was lowered to \$10 for all residents. Changes in the service resulted in a 28 percent increase in total annual vehicle-miles. The result of all these changes was a 72 percent increase in ridership for the period between September 1972 and June 1973 when compared with the ridership during the same period in the previous year.

Applying the same methodology used for Atlanta, Kemp estimated that, with the improvements in the service, the reduced fares caused a 21.6 percent increase in ridership, while the effect of the increase in vehicle-miles of service, given the fare reduction, was a 19 percent increase in ridership. These increases translate into an arc price elasticity of -0.58 and an arc service elasticity of +0.68.

Boyd and Nelson derived several estimates of point price elasticity and point service elasticity from yearly statistics on ridership, revenue and vehicle-miles of service between 1960 and 1970 for 17 transit systems.[1] Two studies were conducted with this data.

In the first study, Boyd and Nelson used regression analysis to relate changes in annual ridership to changes in the average fare and the annual vehicle-miles of service. Two general versions of the mathematical relationship were hypothesized. The short-run version took the following form:

$$\frac{Q_t}{Q_{t-1}} \equiv a \left(\frac{F_t}{F_{t-1}}\right)^{b_1} \left(\frac{B_t}{B_{t-1}}\right)^{b_2}$$

where: Q_t and Q_{t-1} = the total ridership in years t and t-1, respectively;

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[1] J. Hayden Boyd and Gary R. Nelson, Demand for Urban Bus Transit: Two Studies of Fare and Service Elasticities (Washington, D.C.: Institute for Defense Analyses, 1973).

F_t and F_{t-1} = the average fare, deflated by the Consumer Price Index, in years t and t-1, respectively;

B_t and B_{t-1} = the total bus-miles of service per capita in years t and t-1, respectively; and

a, b_1, b_2 = the parameters of the model.

The long-run version included terms to account for the lagged effects of pervious changes in the average fare and the bus-miles of service. This model had the following form:

$$\frac{Q_t}{Q_{t-1}} = a \left(\frac{F_t}{F_{t-1}}\right)^{b_1} \left(\frac{B_t}{B_{t-1}}\right)^{b_2} \left(\frac{F_{t-1}}{F_{t-2}}\right)^{b_3} \left(\frac{B_{t-1}}{B_{t-2}}\right)^{b_4}$$

where: F_{t-2} = the average fare, deflated by the Consumer Price Index, in year t - 2; and,

B_{t-2} = the total bus-miles of service in year t - 2.

In the above models, b_1 and b_2 are the short-run point price and service elasticities, respectively, while $b_1 + b_3$ and $b_2 + b_4$ are the long-run point price and service elasticities. Each model assumes that the point price elasticity does not depend on the total bus-miles of service and that, likewise, the point service elasticity does not depend on the average fare.

Boyd and Nelson calibrated these models first under the assumption of constant price and service elasticity. The following estimates were obtained:

- Short-run point price elasticity: -0.475
- Long-run point price elasticity: -0.533
- Short-run point service elasticity: +0.764
- Long-run point service elasticity: +0.765

The difference between the short-run and long-run elasticities for each causal variable was not statistically significant, indicating that the full effects of changes in the average fare and the vehicle-miles of service are felt in the short-run.

The models were also calibrated under the assumption that both price and service elasticity are variable, but that the point price elasticity depends only on the value of the average fare, while the point service elasticity depends only on the number of bus-miles per capita. A statistical test of this assumption, however, indicated that the point price elasticity did not vary significantly with the size of the average fare. The estimated constant values of point price elasticity were -0.469 for the short-run and -0.636 for the long-run. As in the previous calibration, the difference between these two estimates was not statistically significant.

The following estimates of point service elasticity were derived from the second calibration:

- Short-run point service elasticity = 1.027 - 0.034 B_t
- Long-run point service elasticity = 1.195 - 0.045 B_t

Both equations imply that the demand for public transit is more sensitive to changes in the amount of service when the number of bus-miles is low. As the number of bus-miles of service increases, the demand becomes less responsive to further changes. Table III.7 displays the expected values of point service elasticity for the 17 transit systems in 1970. With the exception of Savannah, Georgia, the short-run and long-run service elasticities were larger in absolute value than the respective short-run and long-run price elasticities. Savannah, Georgia, and New Orleans had the highest ratios of bus-miles per capita and, therefore, the lowest point service elasticities, while Flint and Grand Rapids, Michigan, had the lowest amount of service per capita and, therefore, the highest point service elasticities.

In their second study, Boyd and Nelson used the same source of data but only selected observations of annual ridership for yearly increases in average fare greater than ten percent along with 75 random observations to calibrate the short-run form of the model. Observations of annual ridership for fare increases exceeding ten percent were specifically chosen because such increases usually indicate actual changes in the fare schedule, while the 75 random observations of annual ridership were included to capture the underlying trends in ridership not caused by changes in the average fare and the number of bus-miles. In this study, the average fare was not

TABLE III. 7

POINT SERVICE ELASTICITY FOR 17 TRANSIT SYSTEMS IN 1970

City	1970 Urbanized Area Population (Thousands)	Bus-Miles Per Capita	Point Service Elasticity	
			Short-Run	Long-Run
Savannah, GA	164	15.5	.500	.498
New Orleans, LA	962	14.4	.535	.547
Syracuse, NY	376	11.7	.627	.668
Fitchburg - Leominster, MA	78	11.4	.637	.682
Charleston, WV	158	11.3	.641	.686
Charlotte, NC	280	11.3	.641	.686
San Antonio, TX	773	10.6	.665	.718
Springfield, MO	121	10.6	.665	.718
Jacksonville, FL	530	10.0	.685	.745
Greenville, SC	157	8.1	.750	.830
Harrisburg, PA	241	7.9	.757	.839
Louisville, KY	739	7.6	.767	.853
Indianapolis, IN	820	7.5	.771	.857
Raleigh, NC	152	7.2	.781	.871
Green Bay, WI.	129	5.3	.846	.956
Grand Rapids, MI	353	4.7	.866	.983
Flint, MI	330	4.3	.880	1.001

Source: J. Hayden Boyd and Gary R. Nelson, Demand for Urban Bus Transit: Two Studies of Fare and Service Elasticities (Washington, D.C.: Institute for Defense Analyses, 1973), p. 9.

deflated by the Consumer Price Index, and the total number of bus-miles of service was used instead of the number of bus-miles per capita.

As in the first study, the model was calibrated first under the assumption of constant elasticity. The resulting estimates--0.673 for point price elasticity and +0.838 for point service elasticity--were slightly higher in magnitude than the short-run estimates obtained in the other study.

In another calibration of the short-run form of the model, both price and service elasticity were assumed to vary only as a function of time. The following relations were derived:

- Short-run point price elasticity = -0.896 + 0.032T
- Short-run point service elasticity = 1.073 -0.047T

where T is the number of years from 1960. These equations simply show that, for the 17 transit systems included in the analysis, the price and service elasticities were declining during the 1960's. The average point price elasticity for the 17 systems dropped from -0.896 in 1960 to -0.576 in 1970, while the average point service elasticity fell from +1.073 to +0.603.

Carstens and Csanyi derived estimates of price and service, and revenue between 1955 and 1965 for 13 urban bus systems in Iowa.[1] Although they used the same type of data as Boyd and Nelson, their assumptions about the variability of price and service elasticity were quite different.

Carstens and Csanyi developed the following mathematical model of the demand for public transit:

$$R_c = -33.97 + 1.46 N (\log P) + 0.033 (\log P)^3 / F + 3.00 S$$

where:

R_c = annual revenue passengers per capita.

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[1] R. L. Carstens and L. H. Csanyi, "A Model for Estimating Transit Usage in Cities in Iowa," Highway Research Record Number 213, Passenger Transportation (Washington, D. C.: Highway Research Board, 1968), pp. 42-9.

N = ratio of number of nonworkers to workers in the central city;

P = population of central city;

F = average fare in dollars, obtained by dividing the annual passenger revenue by the number of annual revenue passengers; and

S = the number of annual revenue miles of service divided by the total population of the incorporated areas served by the bus system.

Through partial differentiation of this equation, the point price and service elasticities are defined as follows:

- Point price elasticity = $-0.033 \frac{(\log P)^3}{F} \frac{1}{R_c}$

- Point service elasticity = $\frac{3.00\ S}{R_c}$

As indicated by these formulae, Carstens and Csanyi assumed that the values of price and service elasticity depend not only on the associated causal variables but on all of the other causal variables in the model as well.

Table III. 8 provides an example of how widely the point price elasticity derived from Carsten's and Csanyi's model varies within the ranges of the average fare and the annual revenue miles per capita covered by the data. The table shows, for three different levels of revenue miles of service per capita, how the point price elasticity changes as the average fare increases. The calculations were based on a central city population of 100,000, a bus service area population of 120,000 and a ratio of nonworkers to workers equal to 1.38, the national average for the urban population.

The table reveals some very interesting patterns. At the lowest level of service observed in the data, the demand for bus service is highly elastic to changes in the average fare. The point price elasticity more than doubles as the average fare increases from the lowest to the highest level observed in the data. When the level of service is average, the demand for bus service is inelastic to changes in the average fare but is still highly sensitive to such changes. The price elasticity, however, changes only slightly as the average fare increases. Changes in the average fare have the least effect on ridership at the highest observed level of service. In this case, the effect of a fare change is greatest when the average fare is very low.

TABLE III. 8

POINT PRICE ELASTICITIES FOR TRANSIT USAGE IN IOWA*

ANNUAL REVENUE MILES PER CAPITA	AVERAGE FARE ($)	POINT PRICE ELASTICITY
4.20 (Lowest observation)	0.126 (Lowest)	-1.53
	0.193 (Average)	-2.12
	0.253 (Highest)	-3.25
8.62 (Average of all observations)	0.126 (Lowest)	-0.94
	0.193 (Average)	-0.92
	0.253 (Highest)	-0.89
15.98 (Highest observation)	0.126 (Lowest)	-0.58
	0.193 (Average)	-0.47
	0.253 (Highest)	-0.40

*Assumptions:

- Population of central city = 100,000
- Population of area served by bus system = 120,000
- Ratio of nonworkers to workers = 1.38 (National average for urban population)

Source: Carstens and Csanyi, op. cit.

These patterns clearly show how the significance of the fare depends on the amount of transit service provided.

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TABLE III. 9

ICITIES FOR TRANSIT USAGE IN IOWA*

	ANNUAL REVENUE MILES PER CAPITA	POINT SERVICE ELASTICITY
	4.20 (Lowest)	+0.59
	8.62 (Average	+0.74
	15.98 (Highest)	+0.84
	4.20 (Lowest)	+1.25
	8.62 (Average)	+1.11
	15.98 (Highest)	+1.06
0.253 (Highest observation	4.20 (Lowest)	+2.52
	8.62 (Average)	+1.42
	15.98 (Highest)	+1.19

*Assumptions:
. Population of central city = 100,000
. Population of area served by bus system = 120,000
. Ratio of nonworkers to workers = 1.38 (National average for urban population)

Source: Carstens and Csanyi, op. cit.

SCRTD
municipal operators
California Utilities Commission
Public Utilities Commission ?
Los Angeles City

Estimates of price and service elasticity derived from the Carstens and Csanyi model tend to be much higher than those from other demand models. There is, however, some evidence which supports the relatively high values of point price elasticity implied by the model. Carstens and Csanyi calculated arc price elasticities for 30 occurrences of a fare change in 12 of the 13 Iowa cities. Although the values ranged widely, half of them were greater than 0.67 in absolute value. If the estimates of point price and service elasticity derived from the Carstens and Csanyi model are accurate, they are more likely indicative of the demand for bus service in Iowa than of the demand for bus service in general.

Mullen has provided further estimates of point price and service elasticity with the average fare and the vehicles-miles of service as the causal variables.[1] In developing a mathematical model of the demand for bus service in 12 British towns with a population over 100,000, Mullen assumed that both fare and service elasticity were constant. Using yearly statistics on ridership, revenue, and vehicle-miles of service, he calibrated a simple regression model for each town relating the percent change in ridership to the percent changes in the average fare and vehicle-miles of service.

The resulting estimates of point price and service elasticity are shown in Table III.10. The values of the point service elasticities compare favorably with the short-run values estimated by Boyd and Nelson and shown in Table III.7, while the point fare elasticities are somewhat lower than Boyd's and Nelson's short-run estimates. With the exception of Glasgow, the point service elasticities were greater than the corresponding point fare elasticities.

The studies of fare and service elasticity described so far offer very little guidance to transit managers seeking the most effective ways to improve their transit service. These studies have simply shown that a proportional change in the number of vehicle-miles of service operated can have a much greater effect on ridership than a similar proportional change in the fare. The number of vehicle-miles operated, however, is a poor measure of the quality of the transit service primarily because of its generality. Variability in vehicle-miles has no consistent relation with important characteristics of transit systems, such as walking distance to the transit stop, waiting time, vehicular travel time, adherence to the schedule, comfort, personal safety, the friendliness and courtesy shown by the drivers, and many other qualities of the service.

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[1] Paul Mullen, "Estimating the Demand for Urban Bus Travel," Transportation, 4 (September 1975) pp. 231-52.

TABLE III. 10

POINT PRICE AND SERVICE ELASTICITIES FOR
12 BRITISH URBAN BUS SYSTEMS

TOWN	POINT ELASTICITIES	
	VEHICLE-MILES	FARE
Coventry	+0.82	-0.33
Derby	+0.52	-0.41
Leeds	+1.01	-0.32
Portsmouth	+0.63	-0.18
Cardiff	+0.98	-0.45
Northampton	+0.70	-0.37
Plymouth	+1.19	-0.35
Glasgow	+0.22	-0.25
Bradford	+0.42	-0.40
Sheffield	+0.35	-0.17
Southampton	+0.27	-0.25
Leicester	+0.30	-0.24
Average	+0.62	-0.31
Regression analysis on data for all towns together	+0.63	-0.31

Source: Paul Mullen, "Estimating the Demand for Urban Bus Travel," Transportation, Volume 4, November 3 (September 1975), p. 241.

Gaudry has estimated point service elasticities for waiting time and vehicular travel time.[1] These estimates were derived from a linear mathematical model calibrated with monthly statistics on transit operations in Montreal between 1956 and 1971. The model related the aggregate demand for public transit, both bus and subway, to numerous factors including the fare adjusted by the consumer price index; the number of automobiles in the area served by transit; real average income; waiting time and vehicular travel time for transit trips; travel time by automobile; the amount of rainfall and snowfall; temperature; retail sales; number of workdays, Saturdays, Sundays, and holidays in the month; and the occurrence of special events such as Expo and transit strikes. From this model Gaudry obtained the following point price and service elasticities, calculated at the means of the causal variables:

- Fare: -0.15
- Waiting time: -0.54
- Vehicular travel time by public transit: -0.27.

These values indicate that waiting time is much more critical than the time spent traveling in the transit vehicle. Any improvements made to reduce the amount of waiting would have a much greater effect on demand than would efforts to speed up the service or to reduce the fare.

SPECIFIC MARKETS

Several studies of price and service elasticity have focused on the market composed of persons who have a choice between public transit and private automobile.

McLynn and Goodman experimented with three different modal choice models to predict how the demand for express bus service along the Shirley Highway near Washington, D.C., would respond to changes in the cost of commuting by bus and in the overall amount of time required to commute by bus.[2] These models were calibrated

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[1] Marc Gaudry, "An Aggregate Time-Series Model of Urban Transit Demand: The Montreal Case," Transportation Research, 9 (August 1975) 249-58.

[2] J. M. McLynn and K. M. Goodman, Mode Choice and the Shirley Highway Experiment (Washington, D.C.: Urban Mass Transportation Administration, U.S. Department of Transportation, 1973).

with data collected in a survey of bus and automobile commuters in the Shirley Highway corridor. Their purpose was to predict the probability that a commuter will choose the bus over a private automobile, given the cost and overall travel time of commuting by each mode. The cost of traveling by bus included not only the fare, but also the cost of reaching the bus stop or the park-and-ride lot, waiting for the vehicle, traveling in the vehicle, and reaching the final destination after leaving the vehicle.

Estimates of arc elasticities derived from these models are shown in Table III. 11 for two different reductions in the cost and overall travel time involved in commuting by bus. These results imply that commuters who have a choice of modes for the work trip consider the overall travel time to be much more important than the overall cost. The results also show that, as the precentage decrease in overall travel time by bus doubled, the percentage increase in bus ridership also doubled. There is, however, a large variation in the absolute values of the overall travel time elasticities from the three models, reflecting the differences in theoretical bases and underlying assumptions of the models. The overall travel time elasticities are also much larger in magnitude than the waiting time and vehicular travel time elasticities estimated by Gaudry for the aggregate market. These differences may indicate that commuters with a choice of mode place more emphasis on time than the average transit user, or they may reflect the relatively high quality of the Shirley Highway express bus service, which in many cases provides a faster way of travel than a private car, since the buses travel on exclusive right-of-way over the line-haul portion of the trip.

Point elasticities for overall travel time derived from the previously described modal choice models developed by McGillivray and Love agreed closely with the arc elasticities estimated by McLynn and Goodman. McGillivray's discriminant model yielded a value of -1. 16 for persons with a choice between public transit and private automobile for the work trip, while Lave's probit model yielded a value of -0. 90 for the same market. Both of these estimates were computed at the means of all of the causal variables included in the respective models. They tend to reinforce the conclusion made earlier that commuters with a choice of mode consider time to be an extremely important factor in determining how to travel.

In two other studies, price and service elasticities were compared for different trip purposes. Domencich and Kraft estimated point price and service elasticities for work trips and shopping trips made

TABLE III. 11

ARC PRICE AND TRAVEL TIME ELASTICITIES FOR THE SHIRLEY HIGHWAY EXPRESS BUS SERVICE

Type of Change	Predicted Percent Increase in Number of Bus Users			Arc Elasticity		
	Competitive Model	Logit Model	Utility Model	Competitive Model	Logit Model	Utility Model
Ten cent reduction in cost of travel by bus*	6.7	8.1	6.3	-0.24	-0.29	-0.22
Twenty-five cent reduction in cost of travel by bus*	16.5	20.1	17.7	-0.23	-0.28	-0.25
Five percent reduction in overall travel time by bus	5.2	6.3	8.0	-1.04	-1.26	-1.60
Ten percent reduction in overall travel time by bus	10.5	12.8	16.3	-1.05	-1.28	-1.63

Source: J. M. McLynn and K. M. Goodman, Mode Choice and the Shirley Highway Experiment (Washington, D.C.: Urban Mass Transportation Administration, U.S. Department of Transportation, 1973) p. 9.18.

*The arc price elasticities are based on a reduction from the median cost of $.35 per trip.

by public transit.[1] The elasticities were derived from regression equations for predicting the number of work trips or shopping trips made by public transit between two geographic zones. The causal variables incorporated into these equations included:

- Access time - the time spent in reaching the principal mode of transit (either bus, subway, or commuter rail) used during the trip and the time spent in waiting for a vehicle;

- Line-haul - the time spent while traveling by the principal mode of transit;

- Line-haul cost - the fare paid on the principal mode of transit; and

- Access cost - all costs except the fare paid on the principal mode of transit.

The data used to calibrate the regression models were collected during 1963 and 1964 in an origin-destination survey covering the Boston regional planning area. Consequently, the models were not necessarily based on any actual revisions in transit fares or modifications in the available transit systems. For transit work trips, the following results were obtained:

- Point access time elasticity = 0.462 - 0.025 x access time in minutes;

- Point line-haul time elasticity = 0.191 - 0.006 x line-haul time in minutes;

- Point access cost elasticity = -0.005 x access cost in cents; and

- Point line-haul cost elasticity = 0.036 - 0.002 x the roundtrip line-haul cost in cents.

These formulae should not be used to calculate elasticities for values of the causal variables that lie outside the range of values found in the data. Extrapolating these formulae leads to anomalous results for point access time and point line-haul cost elasticities. The sign of the point access time elasticity changes when the access time

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[1] T. A. Domencich and G. Kraft, Free Transit: A Charles River Associates Research Study (Lexington, Massachusetts: Heath Lexington Books, 1970).

reaches approximately 18.5 minutes, while the point line-haul cost elasticity changes its sign when the round-trip line-haul fare reaches 18 cents. Table III.12 shows the range and average values of each elasticity for the range of values of the causal variables found in the data. Since access and line-haul costs and times vary over the region at any given time, the elasticity of the demand for public transit for traveling to work also varies over the region at any one time.

TABLE III.12

ESTIMATES OF POINT PRICE AND SERVICE ELASTICITIES FOR WORK TRIPS

CAUSAL VARIABLE	POINT ELASTICITY	
	RANGE	AVERAGE
Access time	*	-0.71
Access cost	*	-0.10
Line-haul time	*	-0.39
Line-haul cost	-0.01 to -0.53	-0.09

Source: T. A. Domencich and G. Kraft, op. cit., pp. 18-19.

*the range of the point elasticity cannot be determined, since the range of the causal variable was not specified.

Transit demand elasticities for shopping trips were assumed to be constant. The following estimates were obtained:

. Point elasticity for total cost: -0.32; and

. Point elasticity for overall travel time: -0.59.

Wabe's and Coles' cross-sectional model of demand for bus service in 30 British towns, described earlier in this chapter, yielded the following estimates of point elasticity:

- For work trips:
  - Point price elasticity based on average fare: -0.19; and
  - Point service elasticity based on vehicle-miles of service per capita: +0.58.
- For nonwork trips:
  - Point price elasticity based on average fare: -0.49; and
  - Point service elasticity based on vehicle-miles of service per capita: +0.76.

The results show that the demand was more responsive to changes in the number of vehicle-miles of service than to changes in the average fare regardless of the category of the trip purpose. Changes in either the average fare or the level of service had a greater effect on transit usage for non-work trips than for work trips.

ESTIMATES OF CROSS AND INCOME ELASTICITIES

The demand for public transit is influenced by many other factors besides those which are under the control of the transit manager. These extraneous factors include the cost and speed of traveling by automobile and the income of the traveler. How these factors affect transit ridership is not precisely known. The results of a few of the studies that have been made to quantify the effects of these factors are summarized below.

Cost and Speed of Auto Travel

In their study of express bus and automobile commuters in the Shirley Highway Corridor, McLynn and Goodman predicted that a $1.00 tax levied on auto commuters would increase bus ridership between 58.4 and 75.7 percent. These percentages correspond to arc cross elasticities between +0.32 and +0.41 when the tax is added to the median round-trip cost of commuting by auto. By constrast, the estimated arc price elasticities for a 25-cent reduction in the daily cost of commuting by express bus were between -0.23 and -0.28.

McLynn and Goodman also predicted the percent change in bus ridership that would occur if auto travel time were reduced. The results, shown in Table III. 14, indicate that reductions in auto travel time cause less of a change in bus ridership than do corresponding reductions in bus travel time.

Gaudry, in his previously described study of transit usage in Montreal, estimated a point cross elasticity of +0.42 for auto travel time. This cross elasticity is much larger in magnitude than the estimated point elasticity of -0.27 for transit travel time but is slightly less than the point elasticity of -0.54 for transit waiting time.

Income

The income elasticity of the demand for public transit naturally depends on the level of income. Persons with a low income are likely to use public transit more often as their income increases. Above a certain level of income, however, they are more likely to abandon public transit in favor of a private automobile. These presumptions are supported by the estimates of income elasticity shown in Table III. 13.

TABLE III. 13

INCOME ELASTICITY FOR DIFFERENT INCOME LEVELS

LEVEL OF INCOME	INCOME ELASTICITY
$0-$3,999	+0.28
$4,000 - $6,999	-0.51
$7,000 - $9,999	-0.11
$10,000 and above	-0.03

Source: Sidney Davis, Household Consumption of Housing Service Flows in Atlanta, Ph. D. Dissertation (Atlanta, Georgia: Georgia State University, 1973).

TABLE III. 14

COMPARISON OF EFFECTS OF REDUCTIONS IN AUTO AND BUS TRAVEL TIMES ON BUS RIDERSHIP IN THE SHIRLEY HIGHWAY CORRIDOR

	PREDICTED INCREASE IN NUMBER OF BUS USERS			ARC ELASTICITY		
	COMPETITIVE MODEL	LOGIT MODEL	UTILITY MODEL	COMPETITIVE MODEL	LOGIT MODEL	UTILITY MODEL
Five percent reduction in travel time						
By bus	+5.2	+6.3	+8.0	-1.04	-1.26	-1.60
By auto	-3.9	-4.7	-4.8	+0.78	+0.94	+0.96
Ten percent reduction in travel time						
By bus	+10.5	+12.8	+16.3	-1.05	-1.28	-1.63
By auto	-7.7	-9.3	-9.5	+0.77	+0.93	+0.95

Source: J. M. McLynn and K. M. Goodman, op. cit., pp. 9-18.

ELASTICITIES FOR UNCONVENTIONAL FORMS OF TRANSIT

In the past ten years, transportation planners and researchers have been devoting greater attention to several types of transit service that are quite unlike the more common urban bus, subway, and commuter rail systems. Collectively, these unconventional forms of transit are known as paratransit. They include regular and shared-ride taxi services, dial-a-ride, jitneys, shared-ride auto transit, carpools, vanpools, and buspools. Experience with most of these services is somewhat limited; consequently, estimates of demand elasticity are few in number. Several case studies, however, suggest that the success of a transit service depends more on the qualities of the service than on the fare.

Dial-a-ride services providing shared-ride, door-to-door transportation at the request of the user have been known to attract more passengers than the fixed-route, fixed-schedule bus services which they replaced. In one section of Regina, Saskatchewan, a new dial-a-ride service carried approximately 400 passengers per weekday, while its predecessor had carried only 50 riders a day. The fare on the dial-a-ride system was 10 cents higher.[1] In Columbia, Maryland, a fixed-route, fixed-schedule bus service which had been transporting 50 passengers a day was replaced by a subscription bus service during the peak period and by a dial-a-ride service during the off-peak period. The two new services together hauled 285 to 335 passengers a day.[2] In Batavia, New York, ridership on the new dial-a-ride system rose from 944 during the first week of operation to over 2000 during the sixteenth week. By comparison, the previous bus service had carried an average of only 1,440 riders a week during its last year.[3]

Because most dial-a-ride systems are relatively new, there have been few instances of a change in fare. The few fare changes that have been made, however, have produced interesting results. In Bay Ridges,

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[1] Ronald F. Kirby, Kiran U. Bhatt, Michael A. Kemp, Robert G. McGillivray, and Martin Wohl, Para-Transit: Neglected Options for Urban Mobility (Washington, D.C.: The Urban Institute, 1974).

[2] Ibid.

[3] Robert P. Alex, "B-Line Dial-a-Bus System in Batavia," Special Report 136: Demand-Responsive Transportation Systems (Washington, D.C.: Highway Research Board, 1973), pp. 23-6.

Ontario, the fare was increased from $.25 to $.30 in May 1972, with no discernible effect on ridership.[1] In Ann Arbor, Michigan, the cash fare was lowered from $.60 to $.25 in July 1973, and senior citizens were allowed to ride for half the regular fare by purchasing 10 tokens for $1.25. A comparison of ridership for 16 days in September 1972, with that for 16 days in September 1973, indicated that the demand had risen by 48 percent. The imputed arc price elasticity is -0.83, based on the percent change in the regular cash fare. The large reduction in the fare caused a 20 percent loss of revenue.[2] In Haddonfield, New Jersey, the basic fare of $.60 was abolished on March 16, 1973, for one day only. The system transported 1,421 passengers on Free Fare Day, 93.6 percent more than the average number of riders on weekdays.[3]

One of the most successful forms of paratransit has been the bus pool or commuter bus club. A bus pool is an express bus service organized and managed by the users themselves. One of the most celebrated of these bus pools is the Reston Commuter Bus Club, which carries commuters between the new town of Reston, Virginia, and Washington, D.C. Between 1968 and 1973, the number of users has risen from 48 per day to 1,700, while the number of buses increased from 1 to 22. This growth in ridership has occurred despite the fact that, during this same period, the fare for a round trip rose from $1.60 to $2.40.[4] Particularly noteworthy is the fact that, by adding a straggler bus at 7:00 p.m. to pick up commuters unable to catch any of the earlier buses, the bus pool was able to attract 80 new riders.[5]

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[1] Kirby, et al., op. cit.

[2] Michael J. Berla, "Growing Demand-Responsive Systems in the United States and Canada," Panel discussion, Special Report 147: Demand-Responsive Transportation (Washington, D.C.: Transportation Research Board, 1974).

[3] George E. Mouchahoir, Fare Policy of the Haddonfield Dial-a-Ride Demonstration (McLean, Virginia: The MITRE Corporation, 1974).

[4] Kirby, et al., op. cit.

[5] Alan M. Voorhees and Associates, Transportation Pooling (Washington, D.C.: Federal Highway Administration, U.S. Department of Transportation, 1974).

The commuter bus club operating between Columbia, Maryland, and Washington, D.C., has also expanded considerably since its inception. Despite two fare increases, weekly ridership has grown from 500 in November 1970 to over 3,000 in July 1973, while the number of buses increased from two to eight.[1] The success of the Reston and Columbia bus pools indicates that persons who would otherwise commute to work by automobile are willing to pay relatively higher fares for a transit service that is tailored to meet their special needs.

SUBSCRIPTION SERVICES

One approach to attracting new riders to urban mass transit has been to offer specialized and improved service to meet the needs of specific market segments. Subscription commuter service and service for special events are two examples of such efforts. Succeses of these special services suggest the potential for service improvements to increase transit ridership and revenue. Because these special services provide an entire package of service improvements, it is difficult to identify and quantify reaction to specific service attributes. Nonetheless, two examples of subscription services are described below to suggest the potential for success from such efforts.

Subscription service was selected for this analysis as an example of a special service which could provide some insight into passenger responses to service improvements. Subscription service is a type of special service which is provided on a regular, prearranged basis and is designed to meet the needs of specific groups of travelers between specific origin and destination pairs. Generally, the service is express between a limited number of origins and destinations and covers longer line-haul distance than does nonsubscription transit. Another reason subscription service was selected for this analysis is because some regular service is likely to exist for the same areas and thus, comparison of subscription and comparable regular service could provide a basis for evaluating the success of the subscription service and some of its characteristics.

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[1] James T. Truby, Door-to-Door Buspools: Recommendations for Public Policy (Washington, D.C.: Consortium of Universities, 1973).

To determine which subscription services would be analyzed for this study, the literature on subscription service[1] was reviewed and selective telephone interviews were conducted to determine:

- which subscription services offered transportation between origin and destination pairs or in areas which were also serviced by regular service; and

- which subscription services had any evidence of passenger responsiveness to changes in the characteristics of the service.

Based on this prescreening, four transit subscription services were contacted to obtain further information concerning the subscription service and any comparable regular service offered in the area. The services selected for further analysis were:[2]

- STATAR (Steps Toward Automated Transportation Around Rochester);

- Golden Gate Bridge, Highway, and Transportation District;

- COM-BUS, serving routes in the Los Angeles metropolitan area; and

- Port Authority of Allegheny County.

To obtain specific information about the subscription service offered by the four transit operators and the regular service comparable to the subscription service, a set of questions was developed to which each of the transit operators agreed to respond. The purpose of the questions was to collect data and information on comparisons between subscription service and comparable regular service on the characteristic

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[1] R. F. Kirby and K. U. Bhatt, Guidelines on the Operation of Subscription Bus Services (Washington: The Urban Institute, 1975); and A. M. Voorhees and Associates, Inc., Buspools (Washington: U.S. Department of Transportation, 1974).

[2] No response was received from the latter two services. Queens Transit Corporation was also initially included on the list as an operator of express commuter service. Telephone discussions revealed, however, that management was reluctant to respond to the questions.

of service and ridership response. The set of questions is illustrated in Exhibit III. 1. Where further information was required beyond that supplied in response to the questions, the responses were accompanied by follow-up telephone discussions, either with the transit operator or with the organization which provided the comparable regular transit service. The following are the main results of the subscription service analysis.

Steps Toward Automated Transportation Around Rochester

Steps Toward Automated Transportation Around Rochester (STATAR) is a non-profit organization which runs a single route of subscription service in the Rochester area between Pennfield (a suburb of Rochester) and downtown Rochester and then on to Kodak Park, for a total one way distance of 20.6 miles. An informal STATAR group determines the service schedule and route. The service has three principal pickup points and makes use of park-and-ride lots which the organizaton has arranged. The service, provided on 45- to 53-passenger busses rented from the public transit authority, is express and guarantees a seat to each passenger. An average trip is 9.6 miles and takes 35 minutes. The average per-trip fare for the services ranges from 54 to 70 cents depending on the period for which payment is made. Table III. 15 shows details of the fare structure for STATAR service. The STATAR fares are intended to be just high enough to cover the cost of chartering the service. The average number of riders has ranged frm 25 to 60; the current reported passenger level is 45. In 1974-75, the STATAR service operated at a deficit of approximately $850 or $3.40 per day.

Although no completely comparable service exists in the area, the Regional Transit Service in Rochester does provide the opportunity to park and ride from Pennfield to Kodak Park using the regular non-express service at a different time and with one transfer. The fare for regular service is 55 cents during the peak hour and travel time (excluding time waiting to transfer) is estimated at 44 minutes.

The regular service is not a perfect substitute for the STATAR service; the subscription service does indicate the potential for attracting new riders to transit by developing special service (express, guaranteed seat in this case) between an origin and destination currently not directly served by regular transit and offering the service at a fare structure which can provide a break-even operation.

Golden Gate Bridge, Highway, and Transportation District

In February 1971, the Golden Gate Bridge, Highway, and Transportation District (GGBH&TD) began a commute club providing peak-hour service between Marin and Sonoma Counties and San Francisco.

TABLE III. 15

AVERAGE FARE PER RIDE CALCULATIONS: STATAR SERVICE
AS OF MARCH 11, 1975

Kind of Fee	Number of Days	Number of Rides	Average Fare Per Ride
Annual: $260.00			
	250 (maximum)	500	.52
	240 (minus two weeks)	480	.54
	235 (minus three weeks)	470	.55
	230 (minus four weeks)	460	.565
Period: $25.00			
	20 (maximum)	40	.625
	19	38	.66
	18	36	.69
Weekly: $7.00			
	5	10	.70

A commute club is a group of commuters who organize and operate subscription commuter busses for their members. Each commute club obtains its vehicles and drivers from the GGBH&TD. The members of the commute clubs, in cooperation with GGBH&TD, establish routes and schedules, solicit members, and collect dues. Each commuter bus has free passage over the Golden Gate Bridge and use of the exclusive bus lane. The busses are air-conditioned, deluxe vehicles usually with reclining seats. The service generally picks up a member within one or two blocks of his home and discharges him within one or two blocks of his destination. GGBH&TD subsidizes both the subscription service and the regular service it provides in the same area.

Beginning as one club with one bus and thirty members, the commute club service now consists of six clubs, 17 routes, and 572 members. Two of the six clubs complement regular service offered by the GGBH&TD. For the other four clubs, either no regular service exists between the same origin and destination pairs or significant inconvenience is involved in taking regular service between the two points (i.e., two transfers are necessary).

Generally, the commute clubs have charged a monthly fare whose per-trip equivalent is less than that on comparable regular service. As of June 1, 1975, however, the commute clubs were required to charge the equivalent GGBH&TD zone fare times the average number of days in a month. This increase has been caused by increases in vehicle contract costs which require either a fare or a subsidy increase. The commute clubs have observed no substantial decrease in ridership as a result of equalizing their fares with regular service fares.

Club Baker, one of the six commute clubs, consists of one bus originating in Lucas Valley, moving through Terra Linda, and operating express to the San Francisco Central Business District. The Club Baker route is also served by Golden Gate Transit regular service. Among the reasons expressed by management for passengers selecting the commute club are the somewhat higher speed, the certainty of getting a seat on the commute club service, and the preference for the club atmosphere. Club Fox, another commute club consisting of three busses serving East Petaluma, serves an origin and destination which is also served by regular transit. People ride the commute club service because of the more ready access to the service (including a pick-up loop closer to their origin), a better seat availability, and a preference of the club atmosphere. The commute club service, in general, indicates the potential for attracting long-haul commuters to transit by providing convenient, reliable, responsive service.

EXHIBIT III. 1

QUESTIONNAIRE SENT TO OPERATORS OF SUBSCRIPTION SERVICE

A great deal of the information requested below may be available as raw data in your files. To avoid unnecessary transcription, it would be sufficient if you were to provide us with copies of these raw data.

I. FOR EACH ROUTE OF THE SPECIALIZED SERVICE, PLEASE PROVIDE THE FOLLOWING INFORMATION FROM THE DATE WHEN SPECIALIZED SERVICE WAS FIRST INITIATED TO THE PRESENT (MONTHLY DATA IF POSSIBLE--OTHERWISE, ANNUAL):

- revenue passengers
- vehicles miles of service
- number of inbound vehicie trips per route
- average fare per one-way trip (per trip and per subscription period)
- average trip length
- average in-vehicle travel time
- average cost per vehicle mile
- average revenue per vehicle mile

II. FOR EACH ROUTE OF THE SPECIALIZED SERVICE, PLEASE INDICATE WHICH OF THE FOLLOWING WERE CHARACTERISTICS OF THE SERVICE WHEN IT WAS STARTED (MORE THAN ONE CHARACTERISTIC MAY APPLY):

- guaranteed seat
- closed door express, priority lane
- closed door express, mixed traffic
- air conditioning
- reclining seats
- new equipment
- professional driver
- park and ride access
- collection-distribution and line haul
- line haul only
- OTHER (specify)

III. FOR EACH ROUTE OF THE SPECIALIZED SERVICE, INDICATE WHICH (IF ANY) OF THE ABOVE CHARACTERISTICS HAVE BEEN CHANGED SINCE SERVICE WAS STARTED (DESCRIBE EACH CHANGE AND INDICATE THE DATE OF EACH CHANGE IN SERVICE).

IV. FOR EACH ROUTE OF THE SPECIALIZED SERVICE, INDICATE WHETHER 'REGULAR' SERVICE EXISTS FOR THE SAME TRIP (ORIGIN AND DESTINATION PAIR).

V. FOR EACH ROUTE OF 'REGULAR' SERVICE WHICH SERVES THE SAME ORIGIN AND DESTINATION AS A ROUTE OF SPECIALIZED SERVICE, PLEASE PROVIDE THE FOLLOWING INFORMATION FROM TWO YEARS PRIOR TO THE INITIATION OF SPECIALIZED SERVICE TO THE PRESENT. SUCH INFORMATION SHOULD RELATE TO THE TIME PERIODS COMPARABLE TO THE PERIODS WHEN THE SPECIALIZED SERVICE IS PROVIDED. (MONTHLY DATA IF POSSIBLE--OTHERWISE, ANNUAL).

- revenue passengers
- vehicle miles of service offered
- average fare per one-way trip
- average trip length
- average in-vehicle travel time per one-way trip
- average trip time per one-way trip
- number of transfers required
- average cost per vehicle mile
- average revenue per vehicle mile

VI. FOR EACH ROUTE OF 'REGULAR' SERVICE WHICH SERVES THE SAME ORIGIN AND DESTINATION AS A ROUTE OF SPECIALIZED SERVICE, PLEASE INDICATE WHICH OF THE FOLLOWING CHARACTERISTICS DESCRIBED THE 'REGULAR' SERVICE TWO YEARS PRIOR TO THE INITIATION OF SPECIALIZED SERVICE (MORE THAN ONE CHARACTERISTIC MAY APPLY)--SUCH INFORMATION SHOULD RELATE TO THE TIME PERIODS COMPARABLE TO THE PERIODS WHEN THE SPECIALIZED SERVICE IS PROVIDED:

- guaranteed seat
- closed door express, priority lane
- closed door express, mixed traffic
- air conditioning
- reclining seats
- new equipment
- professional drivers
- park and ride access
- collection-distribution and line haul
- line haul only
- OTHER (specify)

EXHIBIT III. 1 (Continued)

VII. FOR EACH ROUTE OF 'REGULAR' SERVICE WHICH SERVES THE SAME ORIGIN AND DESTINATION SPECIALIZED SERVICE, PLEASE INDICATE WHICH (IF ANY) OF THE ABOVE CHARACTERISTICS HAVE BEEN CHANGED OVER THE PERIOD DESCRIBED ABOVE (DESCRIBE EACH CHANGE AND INDICATE THE DATE OF EACH CHANGE IN SERVICE).

NOTE: IF 'REGULAR' SERVICE EXISTS ALONG ROUTES ON WHICH SPECIALIZED SERVICE IS PROVIDED, AND THIS 'REGULAR' SERVICE IS PROVIDED BY ANOTHER ORGANIZATION, PLEASE INDICATE THE NAME OF THE ORGANIZATION FROM WHICH INFORMATION REGARDING THIS SERVICE COULD BE OBTAINED:

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VIII. FOR EACH ROUTE OF THE SPECIALIZED SERVICE, PLEASE PROVIDE ANY AVAILABLE INFORMATION ON THE INCOME RANGE, AGE, AND OCCUPATION WHICH MOST CLOSELY CHARACTERIZE THE RIDERSHIP ON BOTH THE SPECIALIZED AND THE REGULAR SERVICE:

Age	Income	Occupation
Under 20	Under $10,000	• Professional and semi-professional
20 - 29	$10,000 - $20,000	• Other proprietors, managers, and officials
30 - 39	$20,000 - $30,000	• Store and office clerks and salesmen
40 - 49	Over $30,000	• Craftsmen, foremen, skilled laborers
50 - 59		• Operators, semiskilled and unskilled workers, and labors
60 - 65		• Other (specify)
Over 65		

5. ADDITIONAL EVIDENCE ON ATTITUDES TOWARD FARES AND SERVICE CHARACTERISTICS

Among the weaknesses of elasticity studies as they relate to the development of fare policy are the incomplete measurement of transit quality of service attributes, and the inadequate treatment of different transit preferences of different market groups. In recognition of these weaknesses in elasticity studies, the results of studies which provide supplementary information useful in the development of fare policy will be presented.

CASE STUDIES

PMM&Co. has surveyed actual and potential mass transit riders in several urban areas to determine reactions to different transit price and service characteristics. These surveys attempted to determine trade-offs between improved service and reduced price passengers are willing to make, and the reaction of passengers to different combinations of fare and service. The studies have also attempted to look at the differences in preferences among different passenger groups. The surveys included two large urban areas (San Francisco and Baltimore) and one smaller urban area (Columbia, South Carolina).

San Francisco

As part of the process of evaluating the Bay Area Rapid Transit (BART) service in the San Francisco Bay Area, a survey of transbay travelers was undertaken in October 1974 (i.e., approximately six weeks after the initiation of transbay BART service). The intent of the survey was to measure the impacts of the BART service on travel behavior in the Bay Area immediately after the start of transbay service. A mail-back questionnaire for transbay BART, bus, and automobile travelers yielded 2,000 usable sets of results. They provided information about the characteristics and attitudes of the travelers and the characteristics of the trips taken.[1]

Based on the survey analysis and other passenger counts, the number of midweek one-way daily transbay traveler trips was

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[1] Peat, Marwick, Mitchell & Co., Immediate Travel Impacts of Transbay BART (Washington: U.S. Department of Transportation, 1975).

estimated at 135,600, with 19 percent of the trips made on BART, 13 percent on buses, and 68 percent by automobile. It was further estimated that, of the BART travelers, 54 percent had previously traveled by bus, 35 percent by car, and 11 percent of the trips had not previously been made.

The data indicate a willingness on the part of the traveler to pay a higher price for a higher quality of transit service, but the data do not account for the effect of other travel characteristics which travelers consider in making their modal choice. Traveler preference for these characteristics was measured by one portion of the transbay survey which asked the travelers to select from a list of 14 travel characteristics those four which were most important to them, in order of importance, in choosing their mode. The list was:

- total time;
- comfort;
- dependability;
- cost;
- flexibility;
- waiting time;
- seat availability;
- walking time;
- security;
- safety;
- privacy;
- parking space;
- multipurpose; and
- activity en route.

The result was a listing of the 14 attributes, in order of importance, with rankings based on the total number of times each factor was mentioned by survey respondents as being either the first, second, third, or fourth most important reason for modal choice. Although cost and time are among the attributes classed by travelers as important, other attributes, including comfort, dependability, and flexibility appear to be important as well. The data suggest that BART offers different values to BART travelers diverted from bus than to those diverted from cars. Former automobile passengers placed a higher value on trip cost, safety, and the ability to do what they wanted while traveling, while former bus passengers placed a higher value on travel time, dependability, and flexibility. Table III. 16 shows the percentage of respondents, by mode, choosing each attribute as the most important reason for selecting their current mode. Besides indicating the primary importance of total travel time for travelers on all modes, and the high (but not highest) importance placed on trip cost, the table shows that BART travelers more often than bus travelers ranked trip comfort as important. Bus travelers, more often than BART travelers, placed a high value on dependability and seat availability. Automobile travelers tend to place a high value on flexibility and the ability to combine different trip purposes.

When these first-choice results were cross tabulated by trip and traveler characteristics, the responses indicated some differences for different market subgroups. The results of stratifying responses by income, time of day traveled, and trip purpose are discussed below for travelers selecting BART, bus, and automobile modes. Bus travelers going to work are more likely to rate dependability more highly than are bus travelers overall, and they are less likely to highly rate getting a seat. School travelers using BART are more likely to highly rate doing what they want and less likely to highly rate getting a seat. Shopping travelers using BART are more likely to place more importance on parking problems; bus shoppers are more likely to rate dependability highly and less likely to highly rate the chance of getting a seat. Shoppers traveling by car are more likely to place importance on security and waiting time and less likely to highly rate dependability. Some of the differences in preferences indicated by travelers at different times of day include:

- BART morning peak travelers are more likely to value safety, while bus morning peak travelers are more likely to value dependability and less likely to value the probability of getting a seat;

- BART late morning travelers are more likely to value doing what they want and less likely to value comfort; bus late morning travelers are more likely to value dependability and less likely to value travel time and the chance of getting a seat; and

TABLE III. 16

MOST IMPORTANT REASON FOR SELECTING CURRENT MODE: TRANSBAY SURVEY RESULTS

Characteristic	Mode (% of respondents)		
	BART	Bus	Automobile
Total travel time	31.6	42.2	33.4
Walking time	2.7	5.5	.8
Waiting time	2.8	3.8	2.4
Dependability	8.4	15.5	10.7
Seat availability	3.1	14.0	1.8
Comfort and smoothness	10.6	.4	.4
Safety from accident or injury	4.7	3.2	1.4
Security from crime	1.6	.9	2.7
Privacy	.3	.3	.9
Do what you want	5.2	.9	2.9
Flexibility to travel	8.6	2.6	21.3
Combine different purposes	.6	.3	15.4
Total trip cost	16.4	10.0	4.5
Find a place to park	3.5	.4	1.6

Source: BART Impact Program, October 1974 Surveys of Transbay Travel.

- BART late evening travelers are more likely to value travel time; bus late evening travelers are less likely to value the chance of getting a seat.

The choice of most important modal characteristic also shows some differences by income group, and some trends in preferences which can generally be correlated with income. For example, bus travelers with incomes under $5,000 are more likely to value dependability and cost and less likely to value travel time, whereas auto travelers with income under $5,000 are less likely to value flexibility. General trends suggested by the data in the table include the following:

- importance of modal flexibility increases with income for BART and auto travel;

- importance of getting a seat increases with income for bus travelers; and

- importance of trip cost decreases with income for bus and automobile travelers, while for BART travelers, the importance of cost increases and then decreases as income increases.

The following general conclusions can be drawn from the BART survey data:

- Transbay travelers have indicated through their actions and their preferences a willingness to pay higher fares for improved service. Among the service improvements most highly valued by travelers in the Bay Area relative to cost are travel time, comfort, dependability, and seat availability.

- Introduction of a new mode of transportation has induced passengers to switch modes in those cases in which the passengers recognize that the fare and service package better matches their preferences.

- Some differences have been identified in the relative preferences for modal attributes expressed by different market groups when responses were differentiated by income, trip purpose, and time of day traveled. Some of these differences may reflect differences in the service experienced by these segments of the market. For example, bus respondents traveling in the late morning might place less importance on the chance of getting a seat if there were more seats available on non-crowded midmorning buses.

Baltimore

As part of the process of evaluating transit development alternatives in the Baltimore metropolitan area, a random telephone survey was conducted to determine, among other things, how different levels of transit price and service were valued by Baltimore residents, both as a whole and differentiated by market segment. The results of the survey indicate that respondents value dependability, frequency of service, and low per-trip cost most highly, and at-the-door service least highly. The relative preferences of the respondents for these attributes are discussed more specifically below.

In one portion of the survey, each respondent was asked how much more than the current MTA 30-cent bus fare he would be willing to pay to increase frequency of service (i.e., from once every half hour to once every ten minutes). Responses stratified by income group (see Table III.17) indicated the not surprising result that those in higher income groups are willing to pay more than those in lower income groups for the more frequent service.

Another question on the survey asked respondents about their relative preferences for low cost versus frequent service. The data in Table III.18 show that those in higher income groups were proportionately more interested in frequent service than in low cost (Table III.19). Respondents showed a greater preference for dependability over low cost. Breakdowns according to different socioeconomic characteristics (Table III.19) showed:

- the greatest preference for dependability over low cost was indicated by those employed full-time;
- the greatest preference for dependability over low cost by age group was indicated by those aged 25-34, followed closely by the 14-18 and 35-54 age groups; and
- a higher preference for dependability over low cost was indicated by those in higher income groups.

Preferences were strong for low cost over at-the-door service (Table III.20) with younger age groups and college students indicating the highest proportionate preference for low cost. Preferences were slightly higher for low cost over a short waiting time (Table III.21).

TABLE III. 17

WILLINGNESS TO PAY HIGHER FARES FOR MORE FREQUENT SERVICE: BALTIMORE SURVEY RESULTS

Income Level	Amount of Additional Fare (% of respondents)								
	0¢ More	10¢ More	20¢ More	30¢ More	40¢ More	50¢ More	60¢ More	70¢ More	Number of Respondents
Less Than $3,000	52.0	36.0	8.0	1.0	1.0	2.0	0.0	0.0	100
$3,001 - $4,000	33.3	51.0	7.8	5.9	0.0	0.0	2.0	0.0	51
$4,001 - $8,000	21.7	57.5	11.3	6.6	0.9	0.9	0.0	0.9	106
$8,001 - $9,500	31.6	52.6	12.3	1.8	0.0	0.0	0.0	0.9	57
$9,501 - $11,000	18.6	58.6	15.7	2.9	1.4	2.9	0.0	0.0	70
$11,001 - $16,000	23.0	41.3	24.6	4.0	0.8	3.2	1.6	1.6	126
$16,001 and above	19.0	36.6	30.8	5.9	2.9	2.6	1.1	1.1	273

Source: PMM&Co., Market Survey Working Paper #18, prepared for the Baltimore Region Phase II Transit Study, March 1975.

TABLE III. 18

PREFERENCES FOR LOW COST VERSUS FREQUENT SERVICE: BALTIMORE SURVEY RESULTS STRATIFIED BY INCOME LEVEL OF RESPONDENT

INCOME LEVEL	LOW COST VS. FREQUENT SERVICE (Percentage of Respondents)	
	LOW COST	FREQUENT SERVICE
Less than $3,000	66.7	33.3
$3,001 - $4,000	61.7	38.3
$4,001 - $8,000	50.0	50.0
$8,001 - $9,500	47.3	52.7
$9,501-$11,000	50.0	50.0
$11,001 - $16,000	48.1	51.9
$16,001 and above	39.8	60.2
Number of Respondents = 761		

Source: PMM&Co., Market Survey Working Paper #18, published in March, 1975 for the Baltimore Region Phase II Transit Study.

TABLE III. 19

PREFERENCES FOR LOW COST VERSUS DEPENDABILITY: BALTIMORE SURVEY RESULTS STRATIFIED BY STATUS, AGE, AND INCOME LEVEL OF RESPONDENT

BY STATUS	LOW COST VS. (Percentage of Respondents)	DEPENDABILITY
Employed Full-Time	18.0	82.0
Employed Part-Time	29.5	70.5
Homemaker	25.0	75.0
Pre-college Student	22.2	77.8
College Student	23.1	76.9
Retired	42.6	57.4
BY AGE		
14 - 18	20.3	79.7
19 - 24	26.2	73.7
25 - 34	18.9	81.1
35 - 54	20.5	79.5
55 and over	32.7	67.3
BY INCOME LEVEL		
Less than $3,000	44.1	55.9
$3,001 - $4,000	39.6	60.4
$4,001 - $8,000	29.7	70.3
$8,001 - $9,500	19.3	80.7
$9,501 - $11,000	26.1	73.9
$11,001 - $16,000	19.5	80.5
$16,001 and above	12.3	87.7

Number of Respondents by Status = 885; by Age = 897; by Income level = 765

Source: PMM&Co., Market Survey Working Paper #18, published in March, 1975 for the Baltimore Region Phase II Transit Study.

TABLE III. 20

PREFERENCES OF LOW COST VERSUS AT-THE-DOOR SERVICE: BALTIMORE SURVEY RESULTS STRATIFIED BY STATUS AND AGE OF RESPONDENT

	AT THE DOOR SERVICE VS. (Percentage of Respondents)	LOW COST
BY STATUS		
Employed Full-Time	19.6	80.4
Employed Part-Time	19.2	80.8
Homemaker	17.4	82.6
Pre-college Student	18.2	81.8
College Student	11.5	88.5
Retired	35.5	68.5
BY AGE		
14 - 18	15.7	84.3
19 - 24	10.0	90.0
25 - 34	18.0	82.0
35 - 54	18.6	81.4
55 and over	29.4	70.6
Number of Respondents: By Status = 900; By Age = 912		

Source: PMM&Co., Market Survey Working Paper #18, published in March, 1975 for the Baltimore Region Phase II Transit Study.

TABLE III. 21

PREFERENCES OF LOW COST VERSUS SHORT WAIT:
BALTIMORE SURVEY RESULTS DIFFERENTIATED
BY SEX OF RESPONDENT

SEX	LOW COST VS. SHORT WAIT (Percentage of Respondents)	
	LOW COST	SHORT WAIT
Male	54.1	45.9
Female	50.3	49.7
Number of Respondents = 876		

Source: PMM&Co., Market Survey Working Paper #18, published in March, 1975 for the Baltimore Region Phase II Transit Study.

The following general conclusions can be drawn from the Baltimore data:

- The respondents are willing to make certain reduced fare/ improved service trade-offs. They indicate a higher preference for certain quality of service characteristics (i.e., dependability, frequency) over low cost and a willingness to pay more for these service improvements.

- Relative preferences for transit fare and service characteristics vary according to certain socioeconomic characteristics of the respondents. Respondents in higher income groups, for example, indicate a greater willingness to pay more for improved frequency of service and a higher preference for frequent and dependable service over low cost. The elderly and retired segment of the market is more concerned with dependability than with low cost and prefers low cost to at-the-door service; however, this subgroup is more concerned with at-the-door service than is any other subgroup.

Columbia

As part of the planning process for Columbia, South Carolina, a survey questionnaire was mailed to 300 homes to determine respondent attitudes toward bus transportation. The purpose of this survey was to determine under what circumstances residents of Columbia would consider using bus service.

One section of the questionnaire sought to measure traveler preference for the characteristics of different modes. Each respondent was asked, given a hypothetical free fare, how much more (in 2-cent increments up to 16 cents) he or she would be willing to pay for each of nine modal characteristics listed on Table III.22.

The results of the survey were stratified by three respondent characteristics: occupation, income, and age. The major differences in rankings that exist among occupational groups include the following (Table III.23):

- Respondents employed full time are more willing to pay more for reduced waiting time than are respondents overall. This group is less likely to pay more for the certainty of getting a seat, comfort, air conditioning, and prevention of crime.

TABLE III. 22

AVERAGE AMOUNT RESPONDENTS WOULD BE WILLING TO PAY FOR EACH TRIP FOR EACH IMPROVEMENT: COLUMBIA SURVEY RESULTS

Improvement	Average Amount Respondents Would Pay (cents)
Crime prevention	10.5
Pickup at the door instead of 7 minutes away	9.4
On-time service	9.0
Air conditioning	8.5
Waiting time reduced from 20 minutes to 10 minutes	8.4
Heated, cooled, dry bus shelter	8.1
Clean, comfortable seat	7.9
Riding time reduced from 20 minutes to 10 minutes	7.7
Certainty of getting a seat	7.4

TABLE III. 23

HOW MUCH RESPONDENTS WOULD PAY FOR SERVICE IMPROVEMENTS: COLUMBIA SURVEY RESULTS STRATIFIED BY OCCUPATION GROUP OF RESPONDENTS

SERVICE IMPROVEMENT \ OCCUPATION	AVERAGE AMOUNT RESPONDENTS WOULD PAY FOR IMPROVEMENT				
	EMPLOYED FULL-TIME	EMPLOYED PART-TIME	HOUSEWIFE	RETIRED	TOTAL
Cut waiting time from 20 minutes to 10 minutes	9.0	6.8	8.3	8.5	8.4
Pickup at-the-door, instead of 7 minutes away	9.7	6.9	11.0	9.5	9.4
On-time service	8.8	7.9	10.1	9.0	9.0
Certainty of getting a seat	6.7	7.0	10.2	7.9	7.4
Clean, comfortable seat	7.1	7.4	9.4	8.9	7.9
Air conditioning	7.9	7.4	10.0	9.0	8.5
Cut riding time from 20 minutes to 10 minutes	7.5	7.3	8.0	8.8	7.7
Prevent crime	9.7	10.1	12.1	11.4	10.5
Heated, cooled, dry bus shelter	7.7	7.5	9.2	8.8	8.1

- Respondents employed part time are less willing than respondents overall to pay more for reduced wait time, at-the-door service, and on-time service.

- Housewife respondents are more willing than the average respondent to pay more for at-the-door service, on-time service, certainty of getting a seat, comfort, air conditioning, crime prevention, and bus shelters.

- Retired respondents are more willing than the respondents overall to pay more for comfort and reduced travel time.

Stratification of preferences by income indicates the following (Table III. 24):

- Respondents with less than $4,000 income are less willing than the average to spend more to prevent crime.

- Respondents with incomes between $4,000 and $8,000 are less willing to spend more for reduced waiting time, on-time service, and the certainty of getting a seat.

- Respondents with incomes between $8,000 and $11,000 are more willing to pay more for on-time service and less willing to pay more for air conditioning.

- Respondents with incomes between $11,000 and $16,000 are more willing to pay more for on-time service.

- Respondents with incomes between $16,000 and $20,000 are less willing to pay more for reduced riding time.

- Respondents with incomes above $20,000 are less willing to pay more for the certainty of getting a seat and for bus shelters.

Stratification of preferences by age group indicates the following (Table III. 25):

- Respondents between ages 14 and 21 are more willing than the average to pay more for bus shelters.

- Respondents between ages 22 and 26 are willing to pay more for on-time service.

TABLE III. 24

HOW MUCH RESPONDENTS WOULD PAY FOR SERVICE IMPROVEMENTS: COLUMBIA SURVEY RESULTS STRATIFIED BY INCOME GROUP OF RESPONDENTS

INCOME GROUP / SERVICE IMPROVEMENTS	AVERAGE AMOUNT RESPONDENTS WOULD PAY FOR IMPROVEMENT						
	LESS THAN $4,000	$4,001 to $8,000	$8,001 to $11,000	11,001 to $16,000	$16,001 to $20,000	$20,001 and above	TOTAL
Cut waiting time from 20 minutes to 10 minutes	8.1	7.0	7.9	8.0	7.5	9.2	8.4
Pickup at-the-door, instead of 7 minutes away	8.8	9.2	9.1	9.8	8.9	9.8	9.4
On-time service	9.9	7.5	10.7	10.1	8.8	9.2	9.0
Certainty of getting a seat	7.9	6.3	8.0	7.3	6.7	3.3	7.4
Clean, comfortable seat	7.8	7.4	8.5	7.6	7.2	7.3	7.9
Air Conditioning	7.9	9.3	7.5	8.1	7.9	8.6	8.5
Cut riding time from 20 minutes to 10 minutes	8.5	7.8	7.9	7.8	5.8	8.2	7.7
Prevent crime	9.0	9.5	10.8	10.7	10.4	10.2	10.5
Heated, cooled, dry bus shelter	8.8	8.6	8.9	7.3	8.3	7.0	8.1

TABLE III. 25

HOW MUCH RESPONDENTS WOULD PAY FOR SERVICE IMPROVEMENTS: COLUMBIA SURVEY RESULTS STRATIFIED BY AGE GROUP OF RESPONDENTS

SERVICE IMPROVEMENT \ AGE	AVERAGE AMOUNT RESPONDENTS WOULD PAY FOR IMPROVEMENT							
	14-21	22-26	27-31	32-41	42-51	52-61	62-88	TOTAL
Cut waiting time from 20 minutes to 10 minutes	7.8	7.5	6.7	8.8	8.6	9.3	8.9	8.4
Pickup at-the-door, instead of 7 minutes away	9.4	9.1	7.5	10.7	9.3	10.1	9.5	9.4
On-time service	9.6	10.0	7.8	8.9	8.4	9.7	8.7	9.0
Certainty of getting a seat	8.3	7.2	5.1	8.0	7.1	7.5	8.1	7.4
Clean, comfortable seat	8.3	7.6	6.1	7.6	7.9	8.2	8.7	7.9
Air Conditioning	9.0	8.0	6.9	8.8	8.5	8.5	8.9	8.5
Cut riding time from 20 minutes to 10 minutes	8.1	8.0	6.2	7.7	7.7	7.6	8.5	7.7
Prevent crime	10.8	10.6	9.2	10.8	10.5	10.1	11.3	10.5
Heated, cooled, dry bus shelter	9.4	8.7	6.7	7.7	7.8	9.1	8.8	8.1

- Respondents between the ages 27 and 31 are less willing to pay more for all nine service characteristics.

- Respondents between the ages 32 and 41 are more willing to pay more for at-the-door service.

- Respondents between the ages 52 and 61 are more willing to pay more for bus shelters.

Other portions of the questionnaire attempted to measure responsiveness to bus travel given different levels of costs involved in automobile travel. Specifically, the questionnaire probed the responsiveness of bus ridership given different levels of parking cost and the price of gasoline. Approximately 72 percent of the respondents indicated that they would ride the bus if daily parking rates were 50 cents or more; and 58 percent would use the bus instead of their car if gasoline cost $.90 or more per gallon.

The conclusions of these survey results include the following:

- Respondents indicated a willingness to pay for improved service.

- Respondents indicated a high value placed on crime prevention, followed by high preferences for convenience and reliability.

- Differences in preferences among respondents were identified when responses were stratified by demographic and other characteristics of the respondents.

Conclusions

Although the results of these surveys cannot necessarily be generalized to all urban areas, they suggest some general conclusions which have implications for the development of fare policy. The conclusions are discussed below.

- Reduced fares are not necessarily the most important modal attribute to the travelers surveyed in these studies. The respondents consistently expressed a willingness to pay more for better service and, when rating preferences for modal attributes, rated low cost high but never as the most important concern in choosing a mode.

- Although elasticity values cannot be estimated for all the service attributes, traveler preferences for the range of service attributes can be measured on a relative scale.

- Preferences for service attributes are not consistent across all the urban areas analyzed. San Francisco, Baltimore, and Columbia respondents all expressed a high preference for dependability, but there were differences in the preferences for other attributes held by travelers in the three urban areas including notably:

  - Columbia respondents expressed a high preference for crime prevention and at-the-door service; San Francisco transbay travelers placed little importance on crime security and Baltimore residents placed a low value on at-the-door service.

  - San Francisco travelers put a high value on travel time and (for BART travelers) on comfort, while Columbia residents expressed relatively lower preferences for travel time and comfort. Some of these differences in preferences indicate the existence of certain urban-area-specific factors which influence traveler preferences; for example, travel time would be expected to be more important to travelers in a larger urban area where travel distances are longer.

  - Differences in preferences were expressed by different subgroups of the urban mass transportation market when subgroups were isolated according to traveler and trip characteristics. Some differences among market groups appeared consistently over more than one urban area surveyed; for example, San Franscisco bus and Baltimore work travelers showed a higher preference for dependability, and San Francisco bus and Columbia work travelers indicated a lower preference for the probability of getting a seat. For other characteristics and market segments, differences in preferences among urban areas have been observed; for example, lower income bus travelers in San Francisco were more likely to value dependability than were most San Francisco bus travelers, while Columbia travelers in the $4,000 to $8,000 income range were less likely to place an importance on dependability.

6. SYNTHESIS OF INFORMATION

The characteristics approach to economic demand makes a clear distinction between the objective characteristics of a good or service and the subjective preferences of individuals for different combinations of those characteristics. Following that approach, this section will use the information on market segments, and on fare and service elasticities, to construct a synthesis of transit characteristics and consumer preferences. The section will end with some recommendations for further research, which will be clearly implied by the shortcomings of the synthesis.

TRANSIT MARKETS

An extensive, although certainly not exhaustive, listing of transit market characteristics is given in Table III. 26. Each combination of market characteristics yields a separate market segment with preferences different from any other market segment. Even the rather limited list of characteristics in the table yields 288 different market segments, each differing from the other by at least one market characteristic. Seven typical market segments are represented by specific lists of characteristics. For example, market segment (1) would be peak period work trips by middle aged, middle income persons with typical ability to use transit and with an automobile available for the trip. Market segment (2) has the same characteristics, except an automobile is not available. Market segment (3) includes the high income, peak period, work travelers with typical ability to use transit and with an automobile available: it is the suburban rail commuter. Similarly, market segment (7) is an off-peak trip by low income, elderly persons, somewhat handicapped in ability to use transit, without an automobile available, with the purpose of the trip being for some miscellaneous activity.

Although these market segments do not describe preferences for transit service characteristics, they do imply an underlying set of preferences which can be determined by market research. It is expected that preferences for transit service characteristics will be more consistent within market segments than they are between segments. Once the major market segments have been identified for a transit service area, and the preferences for transit characteristics have been determined, appropriate transit services can be designed.

TABLE III. 26

SOME TYPICAL TRANSIT MARKET SEGMENTS

MARKET CHARACTERISTICS	TYPICAL MARKET SEGMENTS						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
TRIP PURPOSE							
Work	X	X	X				
School					X		
Shopping				X		X	
Other							X
TIME-OF-DAY							
Peak	X	X	X		X		
Off-Peak				X		X	X
AGE OF TRAVELER							
Youth					X	X	
Middle	X	X	X	X			
Elderly							X
INCOME LEVEL							
High			X				
Middle	X	X		X			
Low					X	X	X
TRANSIT USAGE ABILITY							
Typical	X	X	X	X	X	X	
Handicapped							X
AUTO AVAILABILITY							
Available	X		X	X			
Not Available		X			X	X	X

TRANSIT SERVICE CHARACTERISTICS

The characteristics of transit service are much more limited in number than are the characteristics of the different market segments. The main transit characteristics include:

- Fare;
- Travel time;
- Access time and cost;
- Wait time (based on service frequency);
- Arrival time variance;
- Equipment reliability; and
- Seat availability.

Again, this list is not exhaustive, but it seems to include the most important transit service characteristics. All of these characteristics are objectively measurable and do not depend on the perceptions or subjective evaluation of transit users.

SYNTHESIS

The task now is to put these sets of market and transit service characteristics together using the information on elasticities developed in the previous sections of this chapter. Such a synthesis is given in Table III.27. Estimates of demand elasticity with respect to changes in transit service characteristics are limited. Often vehicle miles is used as a measure of transit service, although this measure constitutes only an approximate substitute for most of the major service characteristics listed in Table III.26. The table that some of the transit service characteristics which seem a priori to be important are missing from the synthesis. Data on the elasticity of demand with respect to these characteristics is not available from present data sources. Finally, there is some inconsistency in the estimated values of the fare elasticities. This lack of consistency occurs, in part, because the estimates are for both point and arc elasticities, and are developed from different models. But the inconsistencies also occur because different transit operations

TABLE III. 27

TRANSIT DEMAND ELASTICITIES FOR A SYNTHESIS OF MARKET SEGMENTS AND TRANSIT CHARACTERISTICS

MARKET SEGMENT AND LOCATION	TRANSIT SERVICE CHARACTERISTICS					
	FARE	TRAVEL TIME	VEHICLE MILES	ACCESS TIME	WAITING TIME	ACCESS COST
TOTAL MARKET						
APTA	-0. 33	-	-	-	-	-
Atlanta (Kemp) (increase)	-0. 51 to -0. 53	-	-	-	-	-
Atlanta (Kemp) (decrease)	-0. 25 to -0. 29	-	+0. 30	-	-	-
San Diego	-0. 58	-	+0. 68	-	-	-
17 cities (Boyd and Nelson)	-0. 475 to -0. 533	-	+0. 765	-	-	-
Montreal (Gaudry)	-0. 15	-0. 27	-	-	-0. 54	-
12 British cities (Mullen)	-0. 31	-	+0. 63	-	-	-
WORK TRIPS						
Boston (Kraft and Domencich)	-0. 09	-0. 39		-0. 71		-0. 10
NON-CAPTIVE (Kemp)						
All trips	-0. 19	-	-	-	-	-
Work	-0. 87	-	-	-	-	-
Personal business	0. 00	-	-	-	-	-
Visits	-0. 77	-	-	-	-	-
Convenience shopping	-0. 15	-	-	-	-	-
Comparison shopping	+0. 34	-	-	-	-	-
Shirley Express (McLynn and Goodman)	-0. 22 to -0. 29	-1.04 to -1. 63	-	-	-	-
PEAK/OFF-PEAK						
New York (Lassow) peak	-0. 07 to -0. 15	-	-	-	-	-
off-peak	-0. 24 to -0. 44	-	-	-	-	-
Work trips (Wabe and Coles)	-0. 19	-	-	-	-	-
Non-work trip (Wabe and Coles)	-0. 49	-	-	-	-	-
ELDERLY						
Various cities (Carulo and Roess)	0. 00 to -0. 99	-	-	-	-	-

evidence very different elasticities. In short, elasticity information attainable from the studies conducted to date provide a limited basis for establishing transit fare and service policies in any particular community. In selected instances more detailed information on elasticities may be necessary for specific area analysis.

REQUIREMENTS FOR FURTHER RESEARCH

The requirements for further research should be clear from the analysis of transit demand elasticities presented in this chapter, and from the synthesis in Table III. 27.

There is little need for additional fare elasticity studies of the "shrinkage ratio" type conducted for an entire, undifferentiated conventional transit market. Neither fare nor service elasticities for entire markets are of particular relevance to the design of transit fare policy or marketing strategy.

There is great need for studies of the demand for transit in specific markets, with estimates of user response to particular fare and service characteristics in these markets. In some instances, the studies might consist of carefully designed surveys intended to elicit information from existing and latent transit markets concerning their responses to specific kinds of fare and service changes. Surveys of this sort have many problems inherent in them, but they can be used to design demonstration services and other small experiments to validate the results of the surveys. Also, continued detailed analyses should be made of customer response to specific kinds of transit services, particularly the commuter and subscription services. These services frequently offer service characteristics such as convenient accessibility, high frequency during peak periods, high reliability, low arrival time variance, and high probability of seat availability which should attract substantial additional patronage, even at compensatory fares. The research that is required on the demand for transit is good market research, with the objective of designing transit service packages and offering them at fare structures that will attract customers.

CHAPTER IV
TRANSIT COST FUNCTIONS, FARES, AND SUBSIDIES

1. INTRODUCTION

Much of the previous transportation literature on fares and revenues concentrates on market demand. The major implications of demand for fare policy have been analyzed in the previous chapter. This chapter turns to the supply, or cost, side of the market. The purpose of the chapter is to review what is known about costs of urban transportation--including auto, bus, and rail--and to draw some inferences for transit fare policy.

SOME DEFINITIONS

Much of this chapter will use economic terminology which relates to cost functions, or to production functions which underlie cost functions. Since it is unlikely that anyone not already familiar with the meanings of each of these terms will remember all of the definitions, it seems useful to draw them together here at the beginning of the chapter for future reference.

Cost

The notion of cost would seem self-evident; but, in fact, that is not the case. The most general economic meaning of cost is any action by a person or persons which reduces the well-being of another person or group of persons. This definition generalizes the notion of cost to include costs which reflect the use of resources, such as the consumption of fuel or concrete, or of a person's time, for a particular purpose; and costs which do not consume resources, such as the disposal of waste or noise in the environment, but which reduce the well-being of another person or group of persons. Urban transportation incurs all of these costs. Resource costs are paid for either by the users or from subsidies, whereas pollution costs which do not absorb resources may be paid for either by users or by others, depending on whom they are imposed. In all references to cost, economists mean the least cost of producing a given level of output.

Private Cost

Private costs are costs which accrue to a decision-maker, who may be a firm or an individual. If, for example, an individual decides to make an auto trip, the private costs accruing to him include operating costs of the automobile, the cost of his own time, the probability of causing an accident, and perhaps congestion costs on the road and parking costs.

Social Cost

Social costs resulting from some particular action, such as a decision to make an auto trip, are those costs which accrue to society but not fully (or not at all) to the person making the decision. Examples would include pollution and congestion costs.

Long-run Cost

Long-run costs are the costs of producing a particular level of output when the quantity of all inputs used is variable. With all inputs variable, they can be used in the combination which requires the least input to achieve a given level of output. Long-run costs are those which prevail when sufficient time is allowed to adjust the amount of all inputs used to the level of output. Clearly, if demand fluctuates rapidly, output will seldom be produced at the lowest long-run cost.

Short-run Cost

Short-run costs are the costs which prevail when there is not sufficient time to adjust all inputs, especially the size of the plant, to a new level of demand. Short-run costs indicate the cost of producing a given level of output with a particular plant size.

Fixed Cost

Fixed costs are the costs of input that cannot be changed in order to produce a new level of output with the smallest amount of input. Fixed costs usually represent the costs of plant and equipment which have been acquired for a specific level of output and have a relatively long life. In situations in which a firm is operating with a relatively long-term union contract which prevents the rapid discharge of a portion of the labor force, labor costs may be relatively more fixed than capital, which can frequently be leased or sold.

Variable Cost

Variable costs are the costs of inputs that can be varied readily in amounts to meet changes in the level of demand and output. In most instances, at least portions of the labor supply are variable, as are inputs such as materials, supplies, fuel, or energy, and so forth. In general, variable costs are those costs which could be immediately avoided if production were to cease.

Average Cost

Average cost is simply the cost per unit of output. There are, however, six average costs, three each for long-run and for short-run cost conditions. The six average costs are the following:

	Long-run	Short-run
Fixed cost	LRAFC	SRAFC
Variable cost	LRAVC	SRAVC
Total Cost	LRATC	SRATC

These are read long-run average fixed cost (LRAFC), and so forth.

Marginal Cost

Marginal, or incremental, cost is the change in total cost that results from a small change in the level of output. Reiterating a definition that was given in the Introduction, marginal cost is a theoretical economic term which typically means the change in total cost resulting from a unit change in output; or, more precisely, from an infinitesimal change in output. Incremental cost is a more operational term used by accountants and business analysts, which means the change in total cost resulting from a specific change in output.

Economies of Scale

The term economies of scale refers to production situations in which the average cost per unit produced decreases as the level, or scale, of production increases. Economies of scale can occur for any one, or a combination, of three reasons:[1] (1) large initial fixed outlays are required in order to start productions, as is the case with rail transit; (2) economies occur from large volume purchases of inputs, such as one large transit company being able to negotiate a better unit price for the purchase of fuel or buses than could several small companies; and (3) there are technically "increasing returns to scale" such that a proportional increase in inputs will yield a more than proportional increase in output.

As a caution, it should be noted that the term "returns to scale" is often used when "economies of scale" is really meant. Returns to scale refers only to the production function, and not to cost functions, and means the change in output that results from a proportional change in all inputs.[2] The term scale refers to the scale, or size, of the plant and, therefore, implies long-run adjustments in the input relations that underlie the long-run cost functions. If output increases in the same proportion as inputs, the plant is operating under constant returns to scale. If output increases more than proportionally to the input increases, the plant is operating under increasing returns to scale; and if output increases less than proportionally to increases in all inputs, the plant is operating under decreasing returns to scale. Under the assumption that input prices remain constant, increasing returns to scale imply decreasing long-run average costs; whereas decreasing returns imply increasing long-run average costs.

ISSUES IN THIS CHAPTER

Most of the urban transportation cost analysis done to date has been for the purpose of comparative cost analysis, principally among auto, bus, and rail modes. Although the discussion in Section 3 of the chapter draws heavily on these analyses, cost comparison is not the purpose of the chapter.

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[1] Kelvin Lancaster, Introduction to Modern Microeconomics (Chicago: Rand McNally, 1969), pp. 88-91.

[2] James M. Henderson and Richard E. Quandt, Microeconomic Theory (New York: McGraw-Hill, 1958), p. 62.

The overall purpose of the chapter is to review what is known about the shapes and levels of urban transportation cost curves, and to draw some inferences for the pricing of urban transportation, especially transit prices. The implications of pricing at marginal cost are explored in the chapter, particularly as this issue relates to short-run congestion costs and the potential existence of economies of scale. The implications of marginal cost pricing for subsidy are also examined.

2. RELATIONS BETWEEN COST AND FARE

It was noted in Chapter II that there are a number of economic rationales for transit fares, one of which is cost. This section outlines the arguments for pricing any economic good or service, specifically transit services, at cost. The cost measure of particular interest is marginal cost; and particular emphasis is placed on the implications of long-run and short-run cost functions for pricing.

ARGUMENTS FOR PRICING AT MARGINAL COST

The definitions in Section 1 identified two sets of unit costs which are used frequently in economic analysis. These are average cost and marginal cost. Since the average cost is total cost divided by the number of units of output, it includes both variable cost and an allocation of a portion of the fixed costs. As a result, the calculation of average cost is based on a determination of an allocation of fixed cost (depreciation) per unit of time or per unit of production, which is largely arbitrary. Also, when fixed capital is used in producing more than one type of good, the allocation of that cost among different goods is also quite arbitrary.

The second measure of unit cost is marginal cost, or the more pragmatic accounting notion of incremental cost. Since marginal cost includes only those costs which change as the level of production changes, it excludes fixed costs. There is no problem of arbitrary allocation since only those costs which are directly incurred in producing the next increment of output are included.

Both marginal and average cost may be defined as including all social costs; these are costs that accrue to society but not to the producer. In the subsequent discussion, it will be assumed that the term cost includes social costs unless otherwise noted.

The argument for pricing economic goods and services at marginal cost derives from the proposition that, under a limited set of assumptions, an optimum allocation of resources will occur and the welfare of the community will be maximized. The assumptions include the following:

- The welfare of a community depends solely on the welfare of the individuals which it comprises.

- The individual is the best judge of his own welfare.

- The income distribution is equitable.

- All goods whose demand is closely related to the demand for the good in question are also priced at marginal cost.

Under these assumptions, the price of each input purchased to produce a good or service reflects the value of that input in its next most valuable use. In particular, if transit services are not priced at cost, inputs which would be more valuable in some other use will be employed in the production of transit services.[1]

Once the notion of pricing at cost is accepted, the reason for pricing at marginal cost follows as a logical definition of marginal cost. Since marginal cost represents the value of the additional inputs required to produce an additional increment in output, that output should be produced only if someone is willing to pay the value of the resources consumed by the production.[2] The point can be illuminated with a transit example.

If peak period demand for bus service increases, the transit operator may be expected to respond by increasing service. This increase in service may require additional equipment, and will certainly require additional fuel, operator time, maintenance, tire wear, scheduling, dispatching effort, and so forth. The marginal or incremental cost of the additional service will be the cost of all of these additional inputs which are required to supply it. Each of these inputs has some alternative use from which it has been diverted in order to be used for producing transit services. The highest value of the inputs in their alternative uses is represented by their cost. If the inputs are not at least as valuable in the production of transit services as they are in alternative uses, as evidenced by the willingness of transit users to pay the cost of using the resources for transit, society will be better off if the resources are put to some alternative use. To the extent that resources are allocated to the production of transit services when they have some higher value use, society's economic well-being is reduced. For this reason there is a general proposition that economic goods or services should be priced at their marginal cost. This statement

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[1] Cf. Marcel Boiteux, "Marginal Cost Pricing," in James R. Nelson (ed.) Marginal Cost Pricing in Practice (Englewood Cliffs, N.J.: Prentice-Hall, 1964), p. 52.

[2] Ibid., pp. 53-4.

contains some problems, however, that need to be resolved in the explicit context of transit pricing. There are both long-run and short-run marginal costs, and it has not been made clear which is relevant to transit fare policy. The rest of this section will be devoted to that question.

RELATION BETWEEN AVERAGE AND MARGINAL COST

The following discussion requires an understanding of one further commonplace relation from economic analysis. If average cost declines as output increases, marginal cost must be less than average cost. Under these conditions, fares set at marginal cost will yield an average revenue that is less than average cost and some form of subsidy will be required. If, alternatively, average cost increases as output increases, marginal cost will exceed average cost and fares set at marginal cost will yield average revenue in excess of average cost.

The validity and usefulness of the notion of pricing at marginal cost have often been questioned because of confusion as to whether it is short-run or long-run marginal cost that is meant. The following discussion should clarify the point as it applies to transit pricing.

LONG-RUN COST FUNCTIONS

The first point to understand is that long-run cost functions are a fiction: they are a theoretical construct and do not exist in reality. Accordingly, as Boiteux has explained in detail, the long-run marginal cost function "has--a priori at least--nothing to do with pricing." [1]

Mathematically, the long-run average total cost curve is tangent to (or is the envelope to) a set of short-run average total cost curves. On the assumption that all inputs are completely divisible, the long-run average cost curve indicates the lowest cost for producing any particular constant rate of output.

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[1] Marcel Boiteux, "Peak-Load Pricing," in James R. Nelson (ed.), Marginal Cost Pricing in Practice, op. cit., p. 68.

If all inputs are variable and completely divisible, long-run average total cost would be constant since any production process could be perfectly replicated as many times as necessary to achieve the required rate of output. If long-run average total cost is constant, marginal cost is also constant and equal to it.

In the production of public mass transportation services, however, all inputs are seldom completely divisible. The most obvious instance is that of rail transit. If rail transit service is to be provided, minimum right-of-way, trackage, control systems, maintenance facilities, rolling stock, and other capital equipment must be provided. Once the basic facilities are installed, increased demand can be accommodated, in the short run, by using the capital plant more intensively, and probably by hiring additional operating and maintenance labor. Longer-term adjustments might call for the acquisition of more rolling stock and, perhaps, upgrading the train control system to achieve higher trackage capacity. Finally, if the increase in demand is considered to be permanent (and assuming that the plant size was optimum for the previous demand) the right-of-way and trackage could be increased intensively (multiple trackage in high demand corridors) or extensively (line extensions) to provide a capacity that is optimal for the new demand. Thus, rail transit supply may be expected to exhibit economies of scale (long-run decreasing average total cost) over a fairly wide range of outputs. The scale economies occur, however, not because of increasing returns to scale, but because there are some indivisibilities in the provision of fixed capital so that some costs are fixed even for long-term adjustments.

Most transit analysts assert the existence of increasing returns to scale, but corroborative data are relatively scarce. Meyer, Kain, and Wohl show some comparative cost data for a number of different route lengths for one-way passenger loads up to 50,000 passengers per hour.[1] The rail cost curves constantly decrease as passenger volume increases. Similarly, using American Public Transit Association (APTA) data, Wells et al., analyze the cost of eleven rail rapid transit firms and find that, except for Boston, cost per car mile decreases as the number of vehicle miles increases.[2]

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[1] J. R. Meyer, J. F. Kain, and M. Wohl, The Urban Transportation Problem (Cambridge: Harvard University Press, 1965), pp. 235-49.

[2] John D. Wells, et al., Economic Characteristics of the Urban Public Transportation Industry (Washington, D.C.: U.S. Department of Transportation, 1972), pp. 673-77.

From the viewpoint of the bus operator, bus services are provided under approximately constant long-run average total costs, which generally reflect constant returns to scale. If the supply of bus vehicle miles doubles, the cost of providing that service also approximately doubles. Bus operations do not have the initial large outlay of fixed capital that characterizes rail transit.

In addition to operator supplied inputs, transportation requires inputs of user time. It is argued that when user time is included as an input in the production of transit services, long-run average cost decreases as the output rate increases. As a result, the long-run decreasing average total cost characteristic of rail transit is strengthened, and bus services are supplied under decreasing rather than constant long-run average total cost.

The argument for the effect of passenger time was first suggested by Vickrey[1] and has been elaborated by Mohring.[2] The argument holds that bus services are produced with scale economies because of two customer-supplied inputs: time in transit and waiting time. The argument assumes that transit riders arrive at random either because they do not know or do not care about the scheduled arrival time of a transit vehicle. Under these conditions, the expected waiting time is one-half the average headway. If demand doubles on a route and, as commonly happens, the transit firm responds by doubling service, the bus cost per passenger would remain unchanged as would the amount of time the typical passenger spent on the vehicle. Headways would be halved, however, as would expected waiting times. With the number of passengers doubled, each would wait half as long as before; thus total waiting time would remain the same. In general, total waiting time is independent of the number of passengers. Under these conditions, the gap between the average and marginal costs of a bus trip equals the value that the average passenger places on the time that he waits.

An analogous argument can be made for changes in the density of bus schedules over space. If there is a doubling of the number of points in an area in which service is demanded, a transit firm may be expected

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[1] William C. Vickrey, "Some Implications for Marginal Cost Pricing for Public Utilities," American Economic Review, Proceedings 45 (1955): 615.

[2] Herbert Mohring, "Optimization and Scale Economies in Bus Transportation," American Economic Review 62 (1972): 591-604.

to respond with changes in the density of points served. As a result, walking times and distances will decrease. Also, bus operating cost per passenger will decrease since the system will be serving a higher density market. Thus, even though bus cost per mile tends to be constant as bus miles increase, the total cost per passenger will decline with increases in density of patronage and service.

It is evident, therefore, that long-run average total cost of both rail and bus operations will decrease as output increases. The reason is changing input proportions. In the case of bus service, less passenger time is required, per passenger, as the rate of output increases; and in the case of rail, less passenger time and fixed capital are required, per passenger, as the rate of output increases.

The key point is that if the long-run average total cost function decreases as the rate of output increases, long-run marginal cost for any rate of output will be less than long-run average total cost. Fares set so that they cover long-run marginal cost will fall short of average total cost and will imply the need for a subsidy.

SHORT-RUN COST FUNCTIONS

It is the short-run cost functions which reflect the cost of producing different rates of output with a particular plant or set of production facilities. Accordingly, the short-run marginal cost measures the value of resources being used to produce transit services and should be used as a basis for pricing transit services. In the short run with a fixed plant, transit services should be produced for which the users are willing to pay at least the additional, or marginal, cost of the output.

Constant Demand

If demand for transit services were constant, or uniformly distributed over the day and the week, it would be possible to adjust system size so that short-run and long-run average total cost would be equal. That is, for the constant rate of output, there would be a system (or plant) size for which the short-run average cost was just equal to the long-run average cost, and this would be the lowest cost system for producing that (constant) rate of output. At this rate of output, the long-run and short-run marginal costs would also be equal. Since, however, the transit services are being produced under conditions of decreasing long-run (and also short-run) average total cost, marginal cost would be less than average total cost, and pricing at short-run marginal cost would require a subsidy to make up the difference between fare revenue and cost.

Fluctuating Demand

When demand fluctuates, decisions on pricing and on the correct size of the transit system are more complex than that just described. During the peak periods, marginal cost will be higher than during off-peak periods. More buses (or transit cars and trains) and operators will be placed in service. The buses and cars will be crowded during the peak period, will be subject to more wear and tear, and so forth. Trips will be slower, at least for buses on streets shared with automobiles, so time in transit will be longer, although the higher frequencies will make waiting times shorter. The crowding of passengers on vehicles also causes discomfort and cost, but this is quite difficult to measure.

It is clear, however, that short-run marginal cost in the peak is higher than in the off-peak, and fares set at short-run marginal cost will reflect this. If fare is to be set equal to short-run marginal cost for one or more periods of the day, the question remains as to what system size is the correct one. The correct scale will be the one for which the total (daily) cost of accommodating the demand at a given set of prices is the lowest possible cost. As a general approximation, this condition will be achieved when the sum of the marginal costs in each of the peak and off-peak periods equals the long-run marginal cost. Stated alternatively, the plant size should be set so that the fare in each period is set at short-run marginal cost and the arithmetic mean of these fares is just equal to the long-run marginal cost.[1]

Fares set in this way will still fail to cover the full cost of the transit service by the difference between long-run (equal to short-run) marginal cost and long-run average total cost. In the case of bus systems, however, this cost difference reflects the time costs of passengers and not the resource costs of the transit firms. As a result, the fare policy should provide financial equilibrium (total revenue = total cost) for the bus operator.[2] In the case of rail transit service, however, part of the differential reflects passenger time costs and part reflects fixed costs of the transit operator. An investment policy of the kind suggested, combined with

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[1]Boiteux, "Peak Load Pricing," op. cit., pp. 73-6.

[2]Mohring, op. cit., p. 597.

pricing at short-run marginal cost, will leave a deficit in this case, but it will not be as large as the gap between short-run marginal cost and long-run average total cost. A subsidy would still be required in the case of rail transit as long as fares were set as marginal. Other fare structures might be developed, however, which would reduce or eliminate the subsidy while retaining most of the objectives of marginal cost pricing.

The foregoing analysis argues that if transit fares are to be based on cost, the appropriate cost measure is short-run marginal cost since it is this cost that reflects the value of resources used to produce the incremental output. From the viewpoint of the bus operator, the incremental costs of expanding service are approximately constant and equal to the average cost of service, so that fares set at marginal cost would cover total cost.

It has been argued further, however, that when passenger-supplied costs are included in total cost of transit service, average total cost decreases as the scale of output increases, and long-run marginal cost will be less than long-run average total cost. Moreover, for any scale of plant which has been optimally adjusted to the level of demand, fare set at short-run marginal cost (for constant demand) or at the arithmetical average of short-run marginal costs (for fluctuating demands) will equal long-run marginal cost. In this case, the average fare collected will be less than the long-run average cost, but will fall short by the cost of passenger-supplied time. Fare will still be adequate to cover the transit operator's costs.

The result in the case of rail transit is more complex since both passenger-supplied time costs and some fixed capital will yield long-run average total costs that decrease as the scale of output is expanded. As before, fares set at short-run marginal cost will, at least on the average, equal long-run marginal cost and will fall short of long-run average total cost. If subsidies are to be avoided, some alternatives to strict marginal cost pricing would have to be explored for rail transit.

3. REVIEW OF URBAN TRANSPORTATION COST FUNCTIONS

BACKGROUND

A significant amount of empirical work on urban transportation cost functions has been carried out over the past decade. The beginning of this work is marked by the original contribution of Meyer, Kain, and Wohl,[1] and the most recent contribution is the three-volume study by Keeler, Merewitz, Fisher, and their associates at the University of California, Berkeley.[2] The major studies occurring between include those by Mohring;[3] Boyd, Asher, and Wetzler;[4] and Bhatt.[5] In addition, works by Reed[6] and Smith[7] are significant.

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[1] J.R. Meyer, J.F. Kain, and M. Wohl, op. cit., Part II and Appendices.

[2] T.E. Keeler, L.A. Merewitz, P. Fisher, and others, The Full Cost of Urban Transportation; Part I, "Economic Efficiency in Bus Operations, Preliminary Intermodal Comparisons and Policy Implications," 1974; Part II, "Marginal Costs of Fixed Rail Transit Services in the San Francisco Bay Area," 1975; and Part III, "Automobile Costs and Final Intermodal Cost Comparisons," 1975 (Berkeley: Institute for Urban and Regional Development, University of California).

[3] Herbert Mohring, "Optimization and Scale Economies in Bus Transportation," American Economic Review, 62 (1972), 591-604; and "Relation Between Optimum Congestion Tolls and Present Highway User Charges," Highway Research Record, No. 47 (1967).

[4] Hayden J. Boyd, Norman Asher, and Eliot Wetzler, Evaluation of Rail Rapid Transit and Express Bus Service in the Urban Commuter Market (Arlington, Va.: Institute for Defense Analysis, 1973).

[5] Kiran U. Bhatt, Comparative Analysis of Urban Transportation Costs: A Summary (Washington: The Urban Institute, 1975).

[6] Marshall F. Reed, Jr., Comparison of Urban Travel Economic Costs, Technical Study Memorandum No. 6 (Washington; Highway Users' Federation, 1973).

[7] Edward Smith, "An Economic Comparison of Urban Railways and Express Bus Services," Journal of Transport Economics and Policy, 7 (1973), 20-31.

All of the cost studies have had the main purpose of comparing costs among modes. Intermodal cost comparisons are not issues in the following discussion, however. Rather, the purpose of the discussion is to present the empirical information on cost functions that is relevant to urban transportation pricing. From this point of view, there are two main issues: the level and shape of marginal and average cost functions over the range of typical levels of output; and the relation between marginal and average cost over this range. The analysis concerns only the three major modes, or combinations of modes: auto, bus, and rail.

A few prefatory comments will be helpful in interpreting the results discussed subsequently. The discussion is largely restricted to the four major studies: Meyer, Kain, and Wohl; Boyd, Asher, and Wetzler; Bhatt; and Keeler, Merewitz, Fisher, and associates. All of the studies include residential collection/distribution, line-haul, and downtown distribution trip segments; and three of the four studies (except Boyd, Asher, and Wetzler) include the automobile in their modal analyses. The Boyd, Asher, Wetzler analysis does, however, include jitneys, which are "taxi-like automobiles operating along either fixed or semi-fixed routes"[1] and are similar to an auto mode.

Each of the studies reports costs for several line-haul route lengths. The results reported here have been restricted to a ten-mile route length (twelve-mile in Keeler, Merewitz, and Fisher) but this should not produce any bias in the conclusions.

Since the focus of the following discussion is on the characteristics of the cost functions of the individual modes, rather than on a comparison among modes, the results of each of the studies are presented by mode. For the same reason, no attempt has been made to reduce the reported cost data to a single year. Meyer, Kain, and Wohl do not indicate the year, or years of their data, but presumably they are from the early 1960's; the years for the other three studies are 1972 and 1973, and require no adjustment for comparability.

AUTO COSTS

Meyer, Kain, and Wohl

In all of the Meyer, Kain, and Wohl analyses, automobile costs are

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[1] Boyd, Asher, and Wetzler, op. cit., p. 5n.

virtually constant for all peak-hour corridor volumes, largely because the analysis does not include the cost of passenger-supplied time inputs. For a ten-mile line-haul trip with passenger origins of ten per block at the home end of the trip and a two-mile downtown collection/distribution system, auto trip costs are estimated at about $0.80 for a medium density city (such as Pittsburgh) and about $1.23 for a high density city (such as Chicago). With a four mile downtown collection/distribution route length, the cost increases to about $0.90 for a medium density city and $1.30 for a high density city.[1]

<u>Bhatt</u>

Bhatt estimates automobile costs and car pool costs separately. The automobile estimates assume only a single passenger occupancy, and the car pool estimates assume a four passenger occupancy.[2] The automobile occupancy assumption is probably too low since average automobile occupancy is 1.6 persons.[3] Since Meyer, Kain, and Wohl use the 1.6 occupancy factor, the Bhatt estimates are not directly comparable.

Automobile costs are virtually constant at all peak-hour flows from 7,500 to 60,000 passengers. For a ten-mile corridor and a one square mile central business district, automobile door-to-door costs, including parking, are estimated at about $2.15 for a peak-hour volume of 7,500 passengers. Cost reaches a minimum of about $2.00 at a peak-hour volume of some 40,000 passengers, and remains virtually constant thereafter. If a load factor of 1.6 were used, the automobile costs would be about $1.34 and $1.25, respectively, for 7,500 and 40,000 peak-hour passenger flows. Car pool costs are estimated at about $0.70 at a peak-hour volume of 7,500 passengers, and decline to a minimum of about $0.60 at a peak-hour volume of about 40,000 passengers.

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[1] Meyer, Kain, and Wohl, op. cit., pp. 299-306; costs include right-of-way, roadway, parking, and operating costs.

[2] Bhatt, op. cit., p. 23.

[3] Mayo S. Stuntz, Jr. and Eric Hirst, <u>Energy Conservation Potential of Urban Mass Transit</u>, Conservation Paper Number 34 (Washington: Federal Energy Administration, Office of Transportation Programs, [1975]), p. 13.

Keeler, Merewitz, and Fisher

Keeler, Merewitz, and Fisher undertake a more detailed analysis of urban automobile trip costs than is done in any of the other studies reported here. In addition to automobile supplier costs, their analysis includes the cost of user-supplied time and of congestion. Some of the main results of their analysis of San Francisco Bay Area automobile costs on freeways are summarized in Table IV.1. The computations assume a user time cost of $2.25 per hour. This cost is the lower of the two used in the study, and is similar to that used in other studies reported here. Under existing pricing, average peak-hour speed on the 8-mile section of freeway analyzed was 31.3 miles per hour, and the total user cost was 8.3 cents per mile. Under an optimal pricing scheme, average speeds would increase significantly, time costs would decrease correspondingly, while user charges, including peak-hour tolls, would increase substantially. Total cost would range between 9.8 and 15.3 cents per mile, depending on the interest rate.

For a twelve-mile trip plus collection and distribution, a 12 percent interest rate, a value of time of $3.00 per hour for in-vehicle time and $9.00 per hour for walking and waiting time, Keeler, Merewitz, and Fisher estimate the total automobile work trip cost for subcompact automobiles at $5.63 per passenger trip for all peak-hour corridor volumes.[1]

Conclusion

Although there are a number of differences in the assumptions underlying the three automobile cost estimates discussed, they are roughly comparable, with one exception. The Meyer, Kain, and Wohl and the Bhatt studies do not include the value of user supplied time. With that caveat, the passenger cost of an automobile trip, as estimated in the three studies, is the following:

Study	Cost
Meyer, Kain, and Wohl	$0.80
Bhatt	1.25
Keeler, Merewitz, and Fisher	5.63

All of the studies are consistent, however, in finding that automobile costs are virtually constant over all peak-hour corridor volumes.

[1] Keeler, Merewitz, and Fisher, op. cit., Part III, pp. 103 and 129.

TABLE IV.1

ACTUAL AND OPTIMAL PEAK-HOUR TRIP COSTS ON A TYPICAL BAY AREA FREEWAY

	Speed MPH	Time Cost* (cents/mile)	User Charge (cents/mile)	Time Cost & User Charge (cents/mile)
Existing pricing	31.3	7.19	1.15	8.3
Optimal pricing				
6% interest	50.6	4. 4	5. 4	9.8
12% interest	48.3	4. 7	10. 6	15.3

*With a time cost of $2.25 per hour

Source: Keeler, Merewitz, and Fisher, op. cit., Part III, p. 63.

BUS COSTS

Meyer, Kain, and Wohl

The following description of bus system costs includes two alternatives: a fully integrated bus rapid transit system using downtown subway, and a fully integrated bus rapid system using downtown streets. Cost curves for a ten-mile line-haul route, passenger trip origins of ten per block at the home end, and a two-mile downtown collection/distribution system route length are shown on Figure IV.1 for medium density and high density cities.

In all cases, the cost of the bus system using city streets is less than the cost using subway due to the cost of the subway and the omission of passenger time costs. In medium density cities, the overall cost per passenger falls sharply for hourly volumes up to 20,000 passengers. Thereafter, costs per passenger are either constant or tend to rise slightly. In the case of the high density city, about the same cost pattern is observed, except that costs fall for peak-hour volumes of up to 40,000 passengers, and are either constant or rise nominally thereafter.[1]

Boyd, Asher, and Wetzler

There are some major differences between the analytical approach of Boyd, Asher, and Wetzler and the previous work of Meyer, Kain, and Wohl. The Boyd, Asher, and Wetzler analysis includes estimates of the value of time so that it includes both user and supplier costs. Estimates are also made of pollution emissions, but these are not included in total costs.

Bus transit costs per passenger are shown in Figure IV.2 for bus transit operating on arterials and on busways. As would be expected, buses on busways are more costly at low hourly corridor passenger volumes, but less costly at higher corridor volumes. The curves on the graph in Figure IV.2 represent costs for a ten-mile line-haul with a three mile feeder route and a passenger value time of $1.20 per hour for in-vehicle time and $3.00 per hour for walking and waiting time. Except for inclusion of value of passenger time, the curves on Figure IV.2 are defined approximately equivalent to those in Figure IV.1 from Meyer, Kain, and Wohl.

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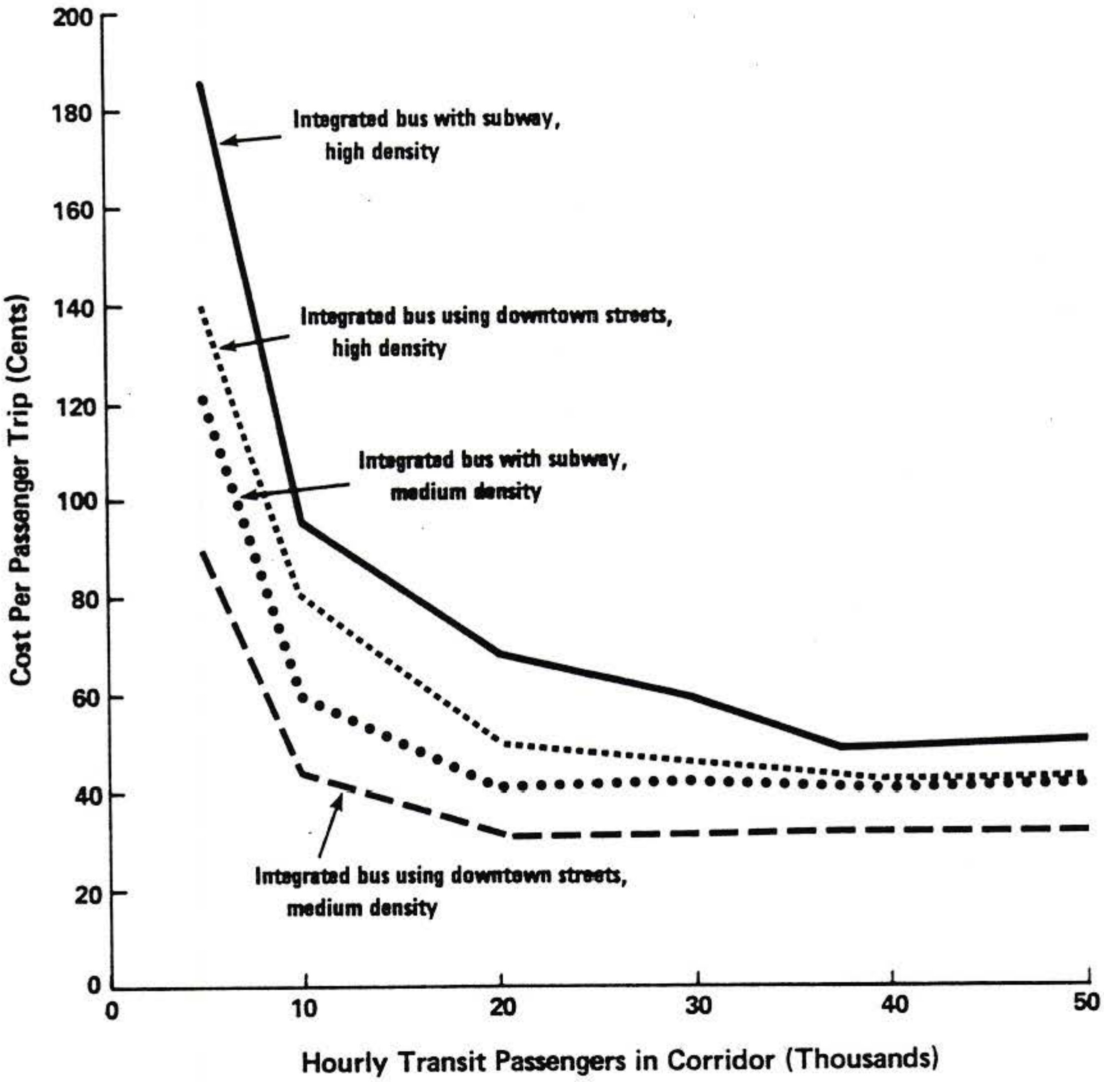
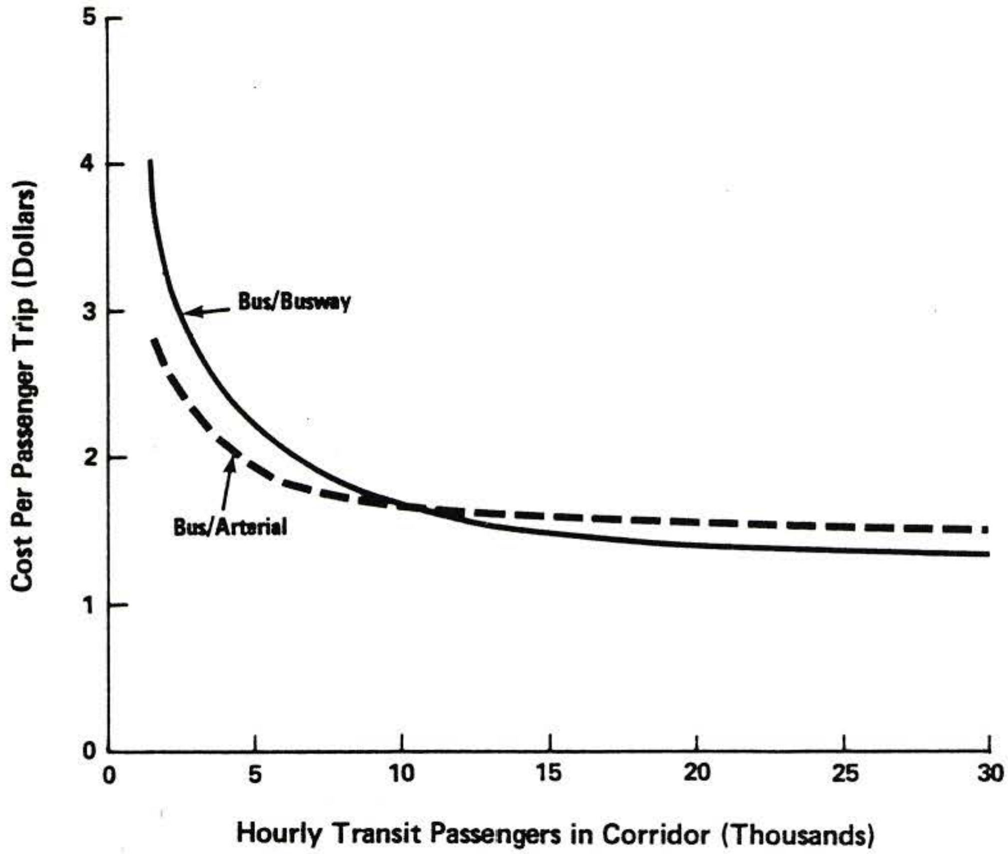
[1]Meyer, Kain, and Wohl, op. cit., pp. 299-306.



SOURCE: Meyer, Kain, and Wohl, op. cit., pp. 300-02.

FIGURE IV.1: BUS TRANSIT COSTS



SOURCE: Boyd, Asher, and Wetzler, op. cit., p. 117.

FIGURE IV.2: BUS TRANSIT COSTS

Bhatt

Bhatt estimates eight different transit combinations based on buses. Three have been chosen for comparison here. These include:

	Residential	Line Haul	CBD
(1)	Feeder Bus	Busway	Integrated Busway
(2)	Integrated Bus	Busway	Integrated Surface Bus
(3)	Feeder Bus	Busway	Integrated Surface Bus

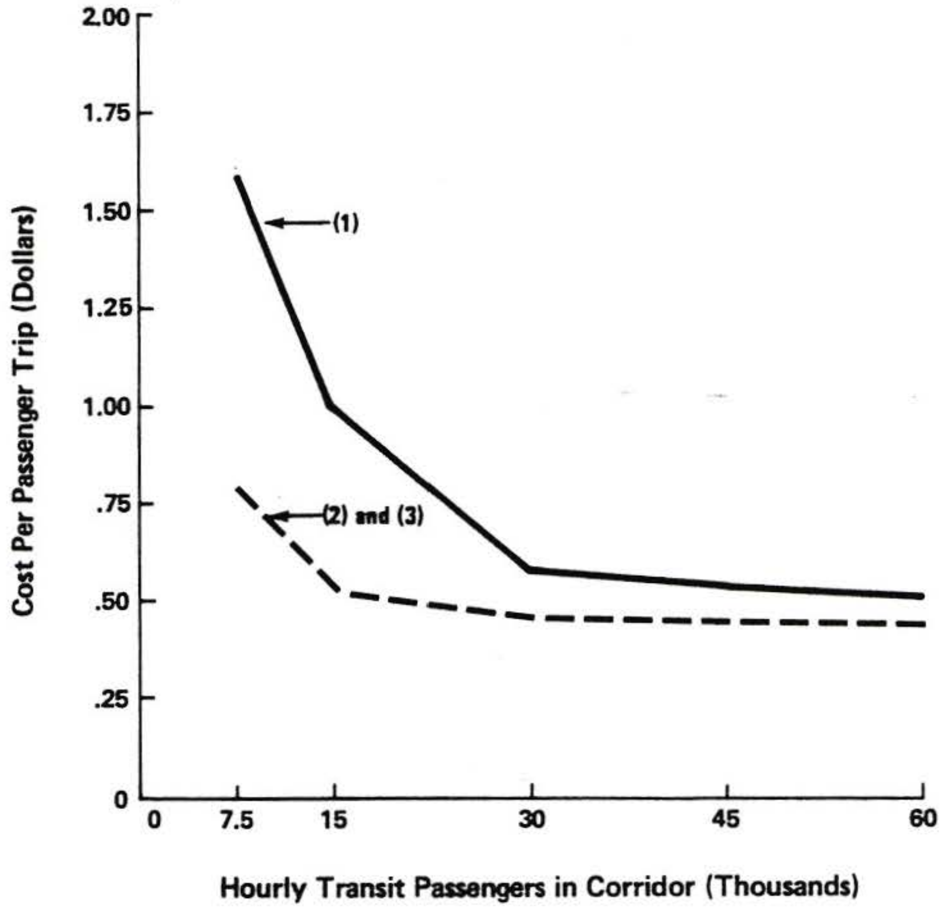
The costs of these three modal combinations are shown in Figure IV.3. The cost of modal combination (1) decreases sharply as hourly corridor volumes increase to 30,000 passengers; and at higher volumes the costs are quite constant. The lower line in the graph in Figure IV.3 shows the costs for modal combinations (2) and (3) since there is no significant difference between the two. The costs for these combinations also decrease as hourly corridor volumes increase to 30,000 passengers, and then become constant.

Keeler, Merewitz, and Fisher

Keeler, Merewitz, and Fisher estimate cost curves for an integrated bus transit system. The cost curve for a twelve-mile line-haul system with collection and distribution systems, an interest rate of 12 percent and a value of time of $3.00 per hour for in-vehicle time and $9.00 per hour for walking and waiting time is shown in Figure IV.4. Costs fall rapidly up to a peak-hour corridor volume of 10,000 passengers and a cost of about $4.75 per passenger; thereafter, costs fall more slowly to a cost of about $3.75 per passenger at a peak-hour corridor volume of 30,000 passengers.

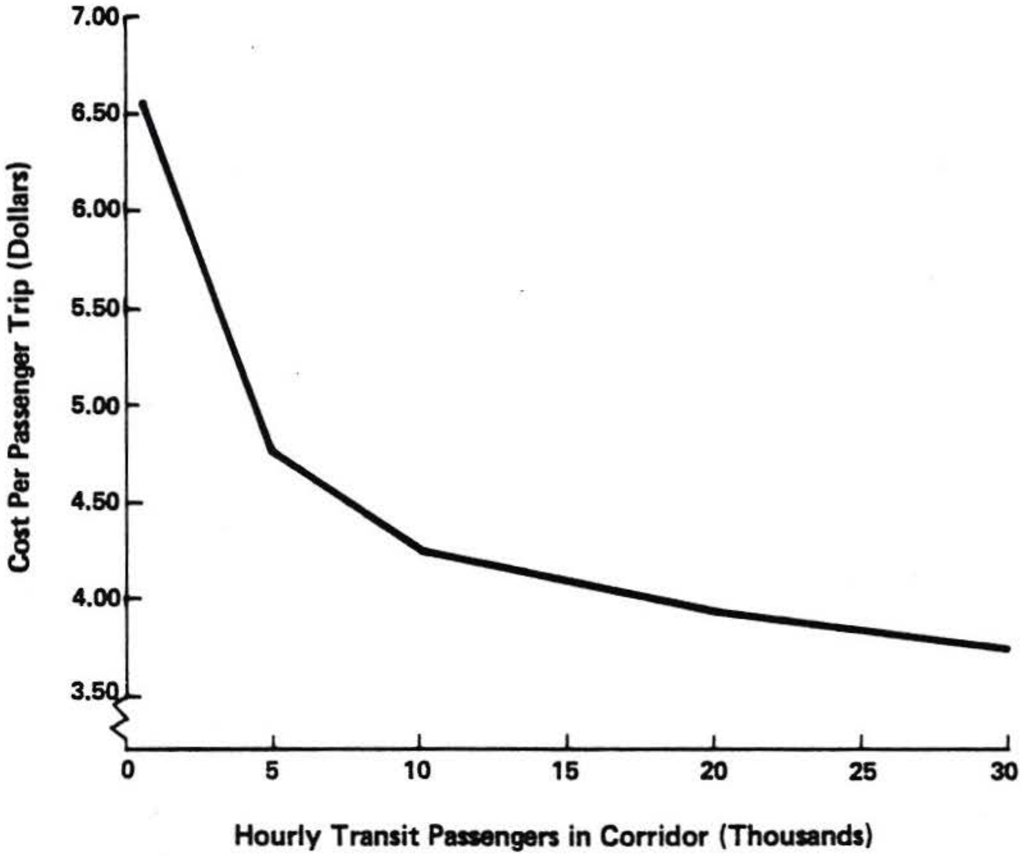
Comparison

A comparison of representative bus transit costs from the four studies discussed is shown in Table IV.2. Some of the differences in the cost estimates are explained by the fact that the Meyer, Kain, and Wohl data are about ten years older than the data in the other three studies. Neither the Meyer, Kain, and Wohl nor the Bhatt studies include the cost of user-supplied time. Finally, Keeler, Merewitz, and Fisher include social overhead costs other than the value of user-supplied time.



SOURCE: Bhatt, op. cit., p. 36.

FIGURE IV.3: BUS TRANSIT COSTS



SOURCE: Keeler, Merewitz, and Fisher, op. cit., Part III, p. 125.

FIGURE IV.4: BUS TRANSIT COSTS

TABLE IV. 2

COMPARISON OF BUS TRANSIT COST PER PASSENGER MILE

Study	Peak-Hour Corridor Volumes		
	10,000	20,000	30,000
Meyer, Kain, and Wohl[a]	$0.44	$0.32	$0.32
Boyd, Asher, and Wetzler[b]	1.67	1.38	1.33
Bhatt[c]	.70	.52	.45
Keeler, Merewitz, and Fisher[d]	4.20	3.82	3.65

[a] Integrated bus using downtown streets, medium density city.

[b] Integrated bus on busway.

[c] Feeder bus in residential area, busway line haul, and integrated surface bus in CBD.

[d] Integrated bus.

RAIL COSTS

Meyer, Kain, and Wohl

Two alternative rail services are considered in the following discussion: a rail rapid transit with park-ride residential services and downtown subway; and a rail rapid transit with feeder bus residential service and a downtown subway. Cost curves for a ten-mile line-haul route with passenger trip origins of ten per block at the home end and a two-mile downtown distribution system route length are shown in Figure IV.5.

The systems using feeder bus for residential service are generally lower cost than those using park-ride service. Residential density does not make much difference in cost, except for very low hourly corridor volumes on the systems using feeder bus for residential service. The cost of all systems decreases rapidly as the hourly corridor volumes increase to 20,000 passengers, and continues to decrease for volumes between 20,000 and 50,000 hourly passengers, but the decrease is at a much slower rate.

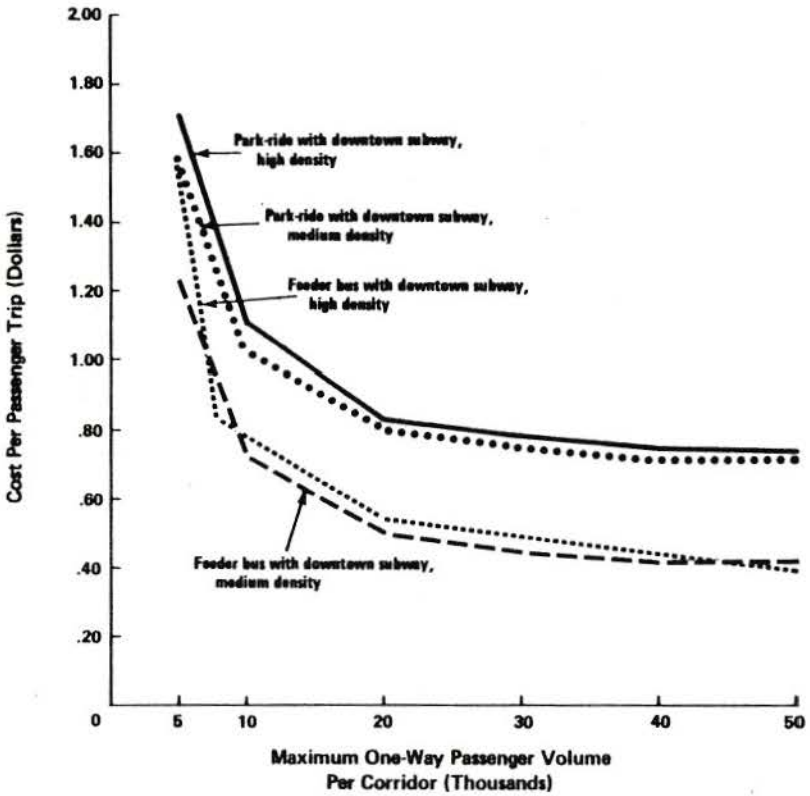
Boyd, Asher, and Wetzler

A typical cost curve from the Boyd, Asher, and Wetzler study is shown in Figure IV.6. The cost is based on a ten-mile rail line-haul, a three-mile feeder route served by an eight-passenger bus-wagon, and passenger values of time of $1.20 per hour for in-vehicle time and $3.00 per hour for walking and waiting time. Total cost per passenger declines continuously as hourly corridor volumes increase, but reach only about $2.50 at a volume of 30,000 hourly corridor passengers.

Bhatt

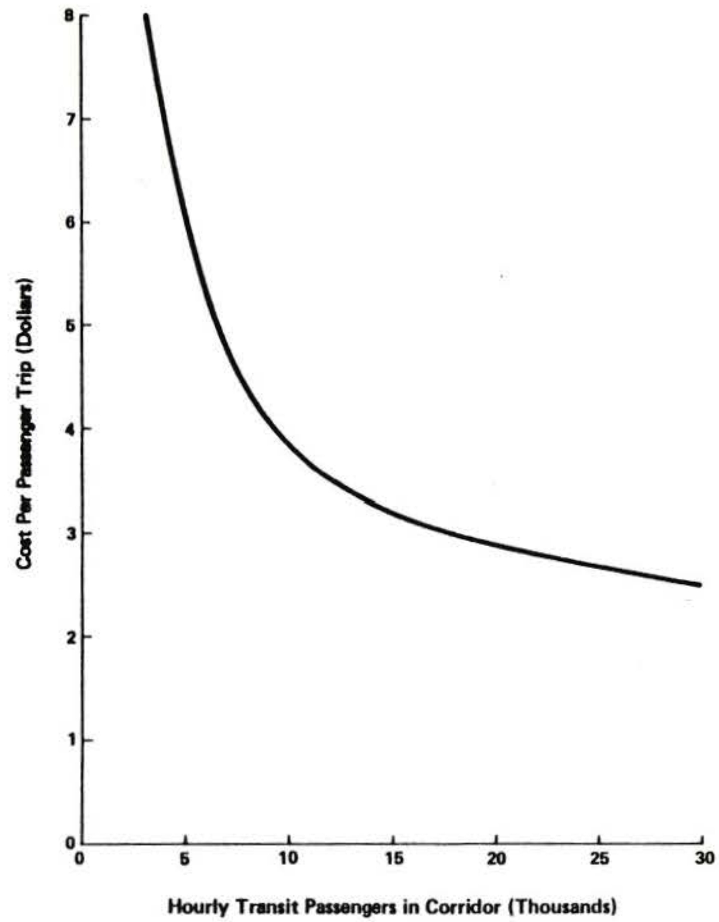
Bhatt estimates five different modal combinations based on rail rapid transit. Three have been chosen for comparison here. These include:

	Residential	Line Haul	CBD
(1)	Feeder Bus	Rail Rapid Transit	Integrated Rail Rapid Transit
(2)	Feeder Bus	Rail Rapid Transit	Surface Bus
(3)	Park-Ride	Rail Rapid Transit	Integrated Rail Rapid Transit



SOURCE: Meyer, Kain, and Wohl, op. cit., pp. 300-302.

FIGURE IV.5: RAIL TRANSIT COSTS



SOURCE: Boyd, Asher, and Wetzler, op. cit., p. 117.

FIGURE IV.6: RAIL TRANSIT COSTS

The costs for these three modal combinations are shown in Figure IV.7. The costs are based on a ten-mile line-haul corridor and a one square mile CBD.

Systems (1) and (3) are the most costly, due largely to rapid transit distribution systems in subway in the CBD. System (3), with park-ride access in residential areas, is significantly more costly than the other two systems. System (2) with feeder bus in residential areas and surface bus in the CBD is the least costly.

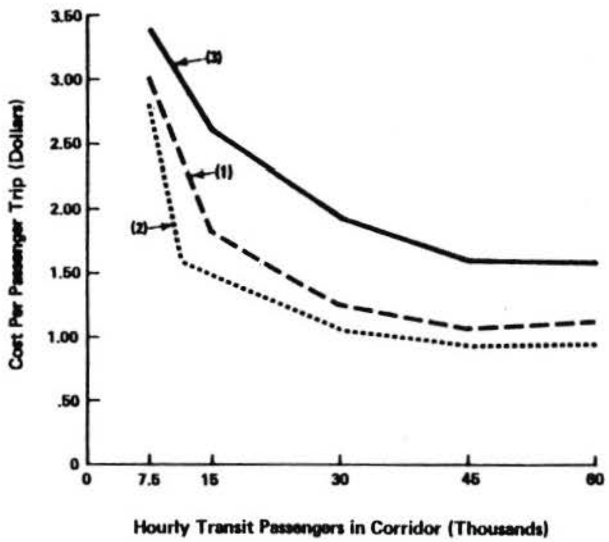
Keeler, Merewitz, and Fisher

The rail transit cost function shown in Figure IV.8 is for the San Francisco Bay Area (BART) system with feeder bus. The cost is for a twelve-mile line-haul with a collection and distribution system, an interest rate of 12 percent, and a value of time of $3.00 per hour for in-vehicle time and $9.00 for walking and waiting time.

Shown only by notation on the graph in Figure IV.8, the cost per passenger at an hourly corridor volume of 1,000 passengers is $46.91, and for an hourly corridor volume of 5,000 passengers is $13.43. The lowest cost achieved by BART is $5.68 per passenger for a corridor volume of 30,000 passengers.

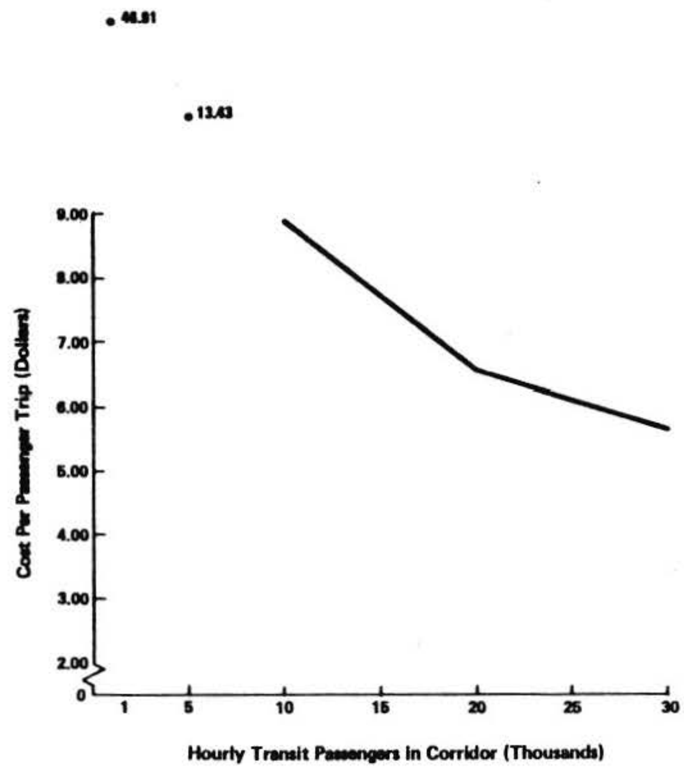
Comparison

A comparison of representative rail transit costs from the four studies is shown in Table IV.3. As with the bus costs, part of the difference among cost estimates is explained by the neglect of the costs of user time by Meyer, Kain, and Wohl and by Bhatt. Moreover, the Keeler, Merewitz, and Fisher costs are for the BART system, which has a number of very costly features (although the trans-bay tube is not included in the costs) and may not be representative. Nonetheless, this latter study is the most recent and the most complete analytically, and may be the most accurate estimate of rail transit costs.



SOURCE: Bhatt, op. cit., p. 38

FIGURE IV.7: RAIL TRANSIT COSTS



SOURCE: Keeler, Merewitz, and Fisher, op. cit., Part III, p. 125.

FIGURE IV.8: RAIL TRANSIT COSTS

TABLE IV. 3

COMPARISON OF RAIL RAPID TRANSIT COSTS PER PASSENGER

Study	Peak-Hour Corridor Volumes		
	10,000	20,000	30,000
Meyer, Kain, and Wohl[a]	$0.70	$0.50	$0.45
Boyd, Asher, and Wetzler[b]	3.75	2.88	2.50
Bhatt[c]	2.65	1.65	1.25
Keeler, Merewitz, and Fisher[c]	8.88	6.51	5.68

[a] Feeder bus with downtown subway.

[b] Feeder bus-wagon with integrated downtown subway.

[c] Feeder bus with integrated downtown subway.

4. COST, FARES, AND SUBSIDIES

It was argued in Section 2 that economies of scale occur in bus and rail transit operations because of passenger-supplied time inputs, and, additionally, in rail transit because of initial fixed costs. In addition to scale economies, a number of other arguments have been put forth in justification of transit subsidies. The purpose of the discussion in this section is to put forth the major arguments and to evaluate their validity. The major arguments fall in the categories of:

- "second best" adjustments;
- external economies;
- income redistribution; and
- energy conservation.

SECOND BEST ADJUSTMENTS

The second-best problem in economic theory arises from the fact that, if not all of the marginal conditions for an optimum are fulfilled, it is not necessarily better to fulfill some of them. Systematic deviations from marginal conditions will often be required to achieve a desirable allocation of resources. The specific argument for second best adjustments for public mass transportation has three parts. Urban highways are underpriced, at least when account is taken of the congestion cost caused by fluctuating demands. As a result, urban highways tend to be both overbuilt and overutilized during peak periods. It is currently impossible to establish a correct set of prices for urban highways. It is concluded, therefore, that underpricing of transit can redress the imbalance in demand and achieve approximately the same relative use of highways and transit as would occur if they were both priced at their marginal cost.

Underpriced Urban Highways

The notion of highway congestion cost has been thoroughly developed in both transportation economics and transportation engineering literature over the past several years.[1] Moreover, some of the more recent empirical results have been presented in Section 3 of this chapter. There is no need to reiterate the theory in any detail but a brief sketch of some of the basic notions will be useful.

A great deal is known about highway capacity and about the relation between vehicle flow and speed for all types and configurations of roads. The empirical speed-flow relation is the basis for congestion pricing. This relation shows that, as the flow (vehicles per hour) increases, average vehicular speed declines. In general, speed begins to decrease at rather low traffic flows, and the decrease continues at a relatively low rate until the flow is quite close to the capacity of the road. As flow approaches capacity, speed declines very rapidly.

This empirical relation between flow and speed is the basis of congestion pricing. As speed decreases, the amount of time required to accomplish any particular trip increases. Since the time of highway users is an economic resource, the production of a trip consumes that resource, as well as the resources used to provide the highway and vehicle inputs. As the number of users increases, the amount of user time required to accomplish a given trip increases. Since the average time cost is increasing, the marginal time cost function lies above the average and increases more rapidly than does the average curve. In highly congested situations, where the flow on a highway is close to its capacity, an additional user will cause a marked decrease in average speed, an increase in average time cost, and a very high marginal time cost. Since it is this marginal cost which reflects the true cost of the marginal user entering the flow, it is this price which the user should pay for the privilege of using the highway at a congested time.

Failure to price highways at their marginal cost results in the overuse of highways during peak periods because the price of use is too low, and underuse of highways during nonpeak periods because the

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[1] See particularly A.A. Walters, "The Theory and Measurement of Private and Social Cost of Highway Congestion," Econometrica 29 (1961): 676-99; William S. Vickrey, "Pricing in Urban and Suburban Transport," American Economic Review 53 (1963): 452-65; Herbert D. Mohring, "Relation Between Optimum Congestion Tolls and Present Highway User Charges," Highway Research Record No. 47 (1967), pp. 1-14; and Martin Wohl and Brian Martin, Traffic System Analysis for Engineers and Planners (New York: McGraw-Hill, 1967), Chapter 10.

price is too high. This mispricing has caused both short-run and long-run misallocations of economic resources. In the short run, individual highway users will not, under current pricing schemes, perceive the cost that their use imposes on contemporaneous users of the highways. Highway users will make their decisions to use the highway network at a particular time only on the basis of the cost they perceive, which is only the average congestion cost. Accordingly, highway users will make trips when the value of the trip equals the average social cost which, during congested peak-periods, will be below the marginal social cost.

Correct Highway Prices

There is fairly broad agreement among economists about the desirability of a set of urban highway prices based on marginal congestion costs.[1] The most important dissent from this position occurs in Wohl's somewhat artificial case of a permanent (no possibility of expansion) short-run situation. Despite some minor disagreements in principle, the main issues in the implementation of congestion pricing concern practicality and politics.

Numerous ideas have been suggested for imposing charges, differentiated by time of day, on motorists using congested urban highways. Suggestions include special stickers, meters, parking charges, roadside detectors, and others. The technology appears to have been available for at least a decade for establishing congestion-based charges for urban highway use. Although some would have relatively high initial or continuing costs, some are not expensive. A system of parking surcharges, for example, might be used to approximate a set of more direct peak-period charges, with relatively small collection, enforcement, and administrative costs. The cost of other pricing systems, however, may exceed the benefits gained from them.

In addition, there are political barriers to implementing congestion-based charges. The suburban commuters who will be required to pay the largest share of the congestion charges are frequently the group with the greatest political influence in the community. Even though they may not be able to directly affect the voting of center city legislators, they frequently control businesses which have a good deal of influence in those center cities.

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[1] For a recent argument for setting both urban auto and transit prices equal to marginal cost, see Stephen Glaister, "Transport Pricing Policies and Efficient Urban Growth," Journal of Public Economics, 5 (1976), 103-17.

In general, it has not proven possible to establish urban highway prices based on peak-period congestion costs. Presumably, if such prices were implemented, there would be some shift of highway traffic from one time period to another during the day. Some of the peak traffic would shift to periods of less congestion and lower cost. Additionally, it is expected that, as the cost of urban highway trips increases in relation to the cost of transit trips, more travelers, perhaps substantially more, would shift from the auto to the transit mode. With a set of prices for highways based on marginal cost, it would then be appropriate to establish a set of transit prices also based on marginal cost. Without the correct set of highway prices, however, the second-best set of transit prices will, in general, not equal marginal cost.

Underpricing Mass Transit

If urban auto trips are underpriced during congested times, and it is not possible to increase those prices to more nearly reflect costs, second-best arguments suggest that transit trips should also be underpriced to achieve the distribution of demand that would occur under a correct set of auto and transit prices.

Objections can be made to this argument at two levels. First, the argument considers only a small portion of the economy and may not make sense when the entire economy is considered; and second, a subsidy of transit fares may not achieve the desired objective at any nonzero fare.

Briefly, the first argument is the following. There is some transit subsidy that would achieve the same allocation of demand between transit and auto trips that would occur if they were both priced at their marginal costs. But the price of urban transportation is too low, so there is already a misallocation of resources into urban transportation and away from more valuable uses. Lowering the price of public mass transportation through subsidies would only serve to worsen that misallocation. Urban sprawl with its attendant excessive energy consumption is already a symptom, at least in part, of artifically low urban transportation costs.[1]

Even if the general effects on the economy are disregarded, there are two major difficulties with the subsidy argument. First, it is not known what the distribution of trips between auto and transit modes would be if both were priced at their marginal costs. There is, therefore, no way of determining how much change in mode choice should be achieved by the price reduction, or how large a reduction in price is appropriate.

[1] Cf. Glaister, op. cit., passim.

Second, the notion of significantly increasing transit usage by fare reductions runs counter to all empirical evidence on the relation between transit fares and mode choice. The classic paper on the issue is the Moses and Williamson study.[1] In that study, based on Chicago data, Moses and Williamson estimated the fare reductions required to induce commuters to shift from auto to their next most preferred mode. The analysis showed that negative fares would be required in all modes to achieve a 50 percent shift in modal choice. Since the price estimates are the minimum prices required to induce shifts, and, for several reasons, are probably underestimated, the study offers little hope that fare reductions can be a very useful technique for achieving a more economically efficient choice of mode.

If transit subsidies are to be used for the purpose of increasing transit patronage and reducing urban highway congestion, the available evidence indicates that they will be more effective if the funds are used to improve service characteristics and direct transit service toward particular markets rather than to cut fares. The evidence on the reaction of demand to changes in fares or service characteristics detailed in Chapters III and IV clearly shows patronage to be much more responsive to improvements in service characteristics than to decreases in fares. Of course, increasing the quality of transit service while holding fares constant amounts to a reduction in the implicit prices of those characteristics. In this sense, subsidies used to provide service can also be viewed as allowing a price decrease, even though fares are held constant or even increased.

EXTERNAL ECONOMIES

Another frequently raised argument for subsidies to urban mass transportation rests on the notion that urban automobile travel imposes major external costs on the community as a whole. The two major costs are air pollution and noise. It is argued that subsidies to urban mass transportation will lead to reductions in transit fares below what they would otherwise have to be. These lower fares would cause a higher

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[1] Leon N. Moses and Harold F. Williamson, "Value of Time, Choice of Mode, and the Subsidy Issue in Urban Transportation," Journal of Political Economy 71 (1963): 247-64, reprinted in Richard E. Quandt, ed., The Demand for Travel: Theory and Measurement (Lexington, Massachusetts: Heath Lexington Books, 1970).

proportion of modal choice for transit and reduce the vehicle miles of travel by automobile. Air pollution and noise will be reduced accordingly, the community will be cleaner and quieter, and subsidies will be economically justified. The argument rests on three main points:

- The amount of urban automobile travel (in vehicle miles) will be responsive to transit subsidies that reduce fares or improve service.

- Relative emissions of air pollutants and noise by auto and transit are such that a shift in passenger miles from auto to transit will reduce overall pollution.

- Subsidy to transit is the most effective means of expending resources to reduce pollution from automobiles.

Each of the arguments will be considered in turn.

Responsiveness of Auto Travel to Transit Subsidy

Moses and Williams have shown that reductions in transit fares cannot be expected to have a major impact on increasing transit ridership or reducing auto vehicle miles of travel. As was noted earlier, the Chicago data used by Moses and Williamson indicated that negative transit fares would be required in order to achieve a significant amount of modal shift. These findings are also generally confirmed by the relatively low direct and cross elasticities of transit and auto travel, respectively, with regard to changes in transit fares.

The subsidies could, of course, be used to improve the quality of service, as just discussed. The result will depend on the improved service characteristics, and the elasticity of demand with respect to those characteristics. It was clear from the discussion in Chapter 4 that not enough is known about those elasticities at present to form the basis for an effective subsidy policy to reduce air pollution.

Although the evidence is limited and not very systematic, one fairly clear result emerges: transit ridership cannot be significantly affected by reducing transit fares as long as the current service characteristics are maintained. It is probable, however, that subsidies used to make significant changes in service characteristics would cause a reduction in automobile miles traveled, an increase in transit miles traveled, and a consequent reduction in the air and noise pollution caused by automobiles. If increases in service quality are combined with a greater rationalization of the pricing of auto trips on congested highways, the impact on pollution should be even greater.

Relative Pollution from Auto and Transit

Rail and bus transit, as well as automobiles, create both noise and air pollution. If pollution costs are expected to be reduced by subsidies that induce modal shift from automobiles to transit, it must be demonstrated that public transit generates less pollution per passenger mile of travel than do automobiles.

Some comparative data on air pollution emissions are given in Table IV.4. The data give estimates of pollution emissions per seat-mile for various vehicles. Since jitneys are approximately equivalent to a large proportion of private automobiles used in urban travel, they can represent automobiles in examining the estimates. It is evident that savings in pollution emission as a result of shifts from automobiles to transit depend on the type of emission and the type of transit. Shifting from auto (jitney) to any form of mass transit will produce a marked reduction in carbon monoxide and hydrocarbon, but will produce additional oxides of nitrogen. Emissions per seat-mile will be slightly less for buses operating on busways than for those operating on arterial streets. Rail transit, regardless of the energy source used, produces less carbon monoxide and hydrocarbon pollution than automobiles and generally less than bus. Rail transit using natural gas produces the least air pollution of any form of urban transportation, but rail transit using coal or heating oil as a source of power produces more oxides of nitrogen than do buses or automobiles. The pollution may not be produced in the urban area air shed, however.

Assuming that load factors are held approximately constant among modes, pollution per passenger-mile will be proportional to pollution per seat-mile, and pollution emissions of carbon monoxide and hydrocarbons will be reduced by shifts in passenger miles from auto to transit while emissions of oxides of nitrogen will be increased. Whether this is a gain or a loss will depend on the relative weights one places on the various pollutants.

The situation for noise pollution is essentially similar to that of air pollution. Although transit vehicles generate more noise per vehicle than do automobiles, they are generally quieter per passenger. Shifts

TABLE IV.4

ESTIMATE OF POLLUTION EMISSION PER SEAT-MILE
FOR VARIOUS TRANSIT VEHICLES, 1973

Type of Vehicle (Qualification)	Pollution Emission in Thousandths of a Pound		
	Carbon Monoxide	Oxides of Nitrogen	Hydrocarbon
Jitney (arterial)	3.600	.192	.400
Bus (arterial)	.176	.462	.019
Bus (busway)	.122	.322	.013
Rail (coal)	.013	.519	.005
Rail (natural gas)	negligible	.266	negligible
Rail (heating oil)	negligible	.494	.015

Source: J. Hayden Boyd, Norman J. Asher, and Elliot S. Wetzler, Evaluation of Rail Rapid Transit and Express Bus Service in the Urban Commuter Market, report by the Institute for Defense Analyses for the U.S. Department of Transportation (Washington, D.C.: GPO, 1973), p. 56.

of passenger miles from auto to transit would tend to reduce noise emissions of transit vehicles. Subsidies to transit could be an effective way of achieving the objective of noise reduction if they were used for two purposes:

- to provide special service that would attract relatively large numbers of persons from their automobiles to transit; or

- to pay at least a part of any cost differentials between buses with standard noise emission characteristics and buses with significantly lower noise levels.

Unless subsidies to transit were used for these purposes, it is unlikely that they would have any substantial effect on reducing transportation noise in urban areas.

Effectiveness of Subsidies

The relative insensitivity of auto travel to transit subsidies and the pollutant emissions of transit relative to the automobile prevent making a clear case for the use of transit subsidies to reduce air and noise pollution costs of automobile travel in urban areas. The current federal strategy for meeting air quality standards is to establish fairly stringent emission controls for vehicles as well as stationary pollution sources. These are expected to be effective in most urban areas at most times in meeting the air quality standards. Exceptions will be the largest urban areas, particularly during adverse weather conditions. In these exceptional areas and times, reductions in vehicle miles of travel will be necessary to meet the standards. Subsidies, even when combined with other measures for traffic control, are not likely to be very effective in achieving those reductions.[1]

It appears, therefore, that resources put into subsidizing mass transit are not likely to have much effect on pollution costs. In order to achieve reductions in air and noise pollution, emission controls appear to be the best strategy, probably when combined with selective

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[1] Cf. John F. DiRenzo, Raymond H. Ellis, and Robert L. Bolick, "An Assessment of Immediate Action Travel Reduction Strategies for Achieving Air Quality and Energy Conservation Objectives," paper presented at 1975 Intersociety Conference on Transportation, Atlanta, Georgia, July 1975.

traffic controls and high peak-period prices for auto trips. Some selective transit subsidies, particularly those used for high quality service rather than reduced fares, may be a valuable part of an overall transportation control strategy. By themselves, however, they do not appear to be an effective means of reducing the external costs of auto travel in urban areas.

INCOME REDISTRIBUTION

The argument that transit subsidies can be justified on the grounds that they serve as a mechanism for redistributing income is based on the following assumptions:

- Deficit subsidies permit transit operators to maintain lower fares.
- Lower fares, in effect, increase the real income of transit users.
- Transit users are predominantly lower income individuals.
- Consequently, deficit subsidies serve as a mechanism to redistribute income from the wealthy to the poor.

It is not always the case, however, that transit users are predominantly lower income persons. In particular, the users of rail transit systems tend to be middle and upper income individuals.

Moreover, the foregoing characterization of the income redistributing effects of subsidies is partial and oversimplified. To assess the effect of a subsidy program on income distribution, two factors must be examined. It must be known how the benefits of the subsidy are distributed among income groups and what groups bear the burden of the revenue mechanisms that finance the subsidy program.

This more complete characterization of subsidy effects fails to support the proposition that transit subsidies provide a more egalitarian distribution of income. Present techniques for providing subsidies tend to be, at best, inefficient mechanisms for achieving this end.

Distribution of Subsidy Benefits

Transit subsidies permit transit operators to maintain lower fares for transit patrons. But the distribution of benefits resulting from lower fares depends, among other things, on the type of transit service provided in each urban area. Major differences can be seen, for example, when rail transit is compared with bus transit. Table IV.5 demonstrates the disparity in distribution of benefits by comparing income and transit mode.

Rail transit typically serves commuter markets in major urban areas. In 1970, 66.2 percent of the trips by elevated or subway train, and 80.9 percent of trips by other trains in Standard Metropolitan Statistical Areas (SMSAs) were for the purpose of commuting to or from work.[1] The users of rail service are typically middle and upper income individuals.

The use of bus transit service, however, tends to be more evenly distributed between work and nonwork trips. In 1970, 52.6 percent of the trips made by bus in SMSAs were for the purpose of commuting to and from work while the remainder were for other trip purposes.[2] Bus transit service is more frequently used by lower and middle income individuals.

Only 8.4 percent of bus commuters had incomes of $15,000 or greater in 1970, whereas 23.5 percent of rail commuters were in this income bracket. At the other end of the income scale, 34.8 percent of the bus commuters had incomes of less than $5,000, while only 8.5 percent of the rail commuters were in this low income bracket. The data in Table IV.5 clearly show rail transit to be dominated by middle or upper income users, with bus transit typically serving the lower to middle income brackets.

By themselves, these data suggest that the ability of subsidies to redistribute income is greater in the case of bus transit than in rail transit. The income distributional effects of the financing mechanisms

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[1]U.S. Department of Transportation, 1974 National Transportation Report: Current Performance and Future Prospects Summary (Washington, D.C., U.S. Department of Transportation, 1974), p. IV-3.

[2]Ibid.

TABLE IV. 5

USE OF PUBLIC TRANSPORTATION IN 1970 BY INCOME GROUP

ANNUAL HOUSEHOLD INCOME	BUS TRANSIT		RAIL TRANSIT
	Percentage of All Person-Trips[a]	Percentage of Commuter Trips[b]	Percentage of Commuter Trips[b]
INCOME CATEGORIES			
Less than $3,000	14.9	13.5	1.3
$3,000-$3,999	8.0	11.6	2.7
$4,000-$4,999	8.6	9.7	4.5
$5,000-$5,999	12.7	9.5	17.6
$6,000-$7,499	12.9	13.3	12.3
$7,500-$9,999	11.9	16.5	16.7
$10,000-$14,999	15.6	17.6	21.5
$15,000 and above	14.9	8.4	23.5
COMBINED CATEGORIES			
Less than $5,000	31.7	34.8	8.5
$5,000-$9,999	37.5	39.3	46.6
$10,000-$14,999	15.6	17.6	21.5
$15,000 and above	14.9	8.4	23.5

[a]Calculated from data in Jose Antonio Gomez-Ibañez, Federal Assistance for Urban Mass Transportation, unpublished doctoral dissertation (Cambridge: Harvard University, 1975), p. 210.

[b]Calculated from data in U.S. Department of Transportation, Federal Highway Administration, National Personal Transportation Study: Report No. 8, Home to Work Trips and Travel (Washington, D.C.: Federal Highway Administration, 1973).

used to support these subsidy programs must be considered, however, before firm conclusions are justified.

Burden of Revenue Mechanisms

The distribution of the burden of the financing mechanisms that develop funds to provide transit subsidies is not easily determined. Taxes on corporate income or property, for example, may fall initially on individuals with high incomes. But the burden of these taxes can be shifted in many cases to others with relatively lower incomes. The incidence of a tax, furthermore, is largely determined by the definition of the tax base, which may vary from place to place. The sales tax is normally considered a very regressive mechanism for generating public revenues. The regressive effect of this tax may be significantly reduced, however, by removing such items as food and prescription drugs from the tax base.

The incidence of state and local revenue mechanisms may be particularly difficult to determine, because in many cases no single tax instrument that generates revenues to support subsidies can be identified. Instead, a multiplicity of taxes form the basis of the general revenue fund from which financial support of mass transit is then obtained.

Based on information compiled in the 1974 National Transportation Study, however, the overall incidence of the combined revenue raising system appears somewhat regressive. The incidence of specific local financing mechanisms would have to be investigated individually but, on balance, current techniques for financing transit subsidies do not redistribute income from the wealthy to the poor.

Net Benefit Incidence

When this assessment is combined with information presented on the incidence of benefits from transit, several implications for fare policy can be drawn. The foremost implication is that indiscriminate systemwide fare reductions are not an effective mechanism for redistributing income from the wealthy to the poor for the following reasons:

- Subsidies for radial rail transit service or express bus service are likely to result in a less rather than more egalitarian distribution of income because of the preponderance of the middle and higher income passengers.

. Although subsidies for local bus service or off-peak mass transit service may accrue to lower income persons, the mechanisms used to finance subsidies are mildly regressive. Consequently, the net distributional effects of the subsidy program are inconclusive and are not sufficient to justify public operating assistance.

Even if the distributional effects were conclusive and tended to encourage the achievement of policy objectives, transit subsidization is an inefficient mechanism for redistributing income because the program would generate benefits only for those who use transit, and this may be only a very small portion of the urban poor population. The poor who do not use transit, because they do not go to work, will be an even more needy group. All evidence suggests that transit subsidies are a very poor method for redistributing income to the urban poor.

ENERGY CONSERVATION

Since the energy crisis became apparent in the winter of 1973-74, it has often been suggested that a massive modal shift from urban auto trips to transit trips would conserve energy. It is argued, therefore, that transit should be subsidized to promote energy conservation. The issue is similar in many respects to the air pollution issue and needs only a brief discussion beyond what has been said on that topic.

As with the pollution issue, the argument for subsidies to conserve energy raises two questions: (1) What is the difference in energy consumption per passenger mile between automobiles and the various forms of transit? and (2) How responsive would the relative amounts of transit and auto passenger miles be to transit subsidies?

The energy intensiveness of the major urban transportation modes is shown in Table IV. 6. It is evident from the data that conventional public transit is only one-third to one-half as energy intensive as the private automobile, and a vanpool is less than one-quarter as energy intensive as the automobile. In general, these transit modes are much more energy efficient than is the automobile because they operate with relatively high load factors. Dial-a-ride, however, is less energy efficient than the automobile largely because they operate with relatively low load factors. It appears, therefore, that if persons can be induced to use transit, some fairly significant energy savings might be achieved. The problem, however, remains that of inducing large numbers of urban travelers to use transit rather than private automobiles.

TABLE IV. 6

ENERGY INTENSIVENESS OF URBAN TRANSPORTATION MODES, 1973

Travel Mode	Energy Intensiveness: BTU/PM	Energy Intensiveness: As Percentage of National Average Automobile
Automobile:		
National average (1.6 PM/VM, 11.3 MPG)	6,900	100
Gas hog (1 PM/VM, 9 MPG)	13,900	200
Gas miser (3 PM/VM, 20 MPG)	2,100	30
Public Transit:		
Bus (11.5 PM/VM, 3.8 MPG)	3,100	45
Rail (24.5 PM/VM, 2.4 MPG)	2,300	33
Dial-A-Ride	7,400+	110+
Vanpool (8 PM/VM, 10 MPG)	1,600	23

Source: Mayo S. Stuntz, Jr. and Eric Hirst, Energy Conservation Potential of Urban Mass Transit, Conservation Paper Number 34 (Washington: Federal Energy Administration, Office of Transportation Programs, [1975]), p. 12.

It was noted in the previous discussion of air pollution that mode choice in favor of transit is very insensitive to subsidies which simply reduce fares. It was suggested there, however, that data on service elasticities suggest that if subsidies were used to make significant improvements in service some mode shift toward transit might be achieved. This argument must be more suggestive than definitive, however, because too little is known about the elasticities of transit service characteristics. At this point, one must conclude that the heavy use of transit could do much to promote energy conservation, but it is not at all clear that subsidies can help very much to induce the required use of transit.

5. CONCLUSIONS

The concluding observations to this chapter comprise the key economic issues, social issues, institutional implications, and the resulting requirements for further research.

ECONOMIC ISSUES

There were three major sets of economic issues raised in this chapter. It will be useful to summarize the status of those issues before proceeding to recommendations for fare policy in the next chapter. These issues are:

- the implications of the second-best theory for transit prices;
- the implications of scale economies for fares and subsidies; and
- the extent to which the several social issues, such as pollution or energy conservation, make transit subsidies economically desirable.

Second-Best Issue

The general theory of second-best holds, it will be recalled, that in order to achieve a desirable allocation of economic resources, the price of a good or service should diverge from its marginal cost if the prices of the goods or services with which it is competitive also diverge from their marginal costs. In the case of urban transportation, this point argues for pricing public transportation below its marginal cost because urban automobile transportation is priced below its marginal cost. The purpose of the underpricing for public transportation would be to achieve the same distribution of modal choice between public and private transportation as would occur if they were both priced at their marginal costs.

One difficulty with the argument is that one does not know what the distribution of modal use would be under a correct set of prices. A second problem is that available evidence indicates that transit usage is quite inelastic to fare reductions, and that negative fares might be required to achieve the desired modal choice.

Rather than attempting to deal indirectly as a second-best problem with the effect on transit fares of underpriced urban auto trips, it would be better to approach the problem directly through making appropriate changes in urban auto trip prices through tolls, parking surcharges, and the like. This approach would be more effective than would transit subsidies, and it would be consistent with Secretary Coleman's general policy statement.

Scale Economies

It was argued in Section 2, and shown empirically in Section 3, that throughout a fairly wide range of hourly corridor demand, public transportation shows economies of scale, or decreasing long-run average total cost. Urban automobile trips generally exhibit constant long-run average costs and no scale economies; and public transportation, particularly bus systems, shows tendencies toward constant costs at fairly high hourly corridor volumes. It will be recalled that, when average costs are decreasing, marginal cost must be less than average cost, so fare set at marginal cost will fail to cover full cost. The implications of this argument for subsidies will depend on the source of the decreasing costs; particularly whether it is average supplier or user costs which are decreasing.

In the case of bus transit, supplier costs will increase fairly proportionately with increases in scale so that the supplier's average total cost will remain fairly constant and equal to its marginal cost. Decreassing average total cost occurs because less user-supplied time is required per user because an increase in the scale of operations increases the frequency and geographic density of service, and reduces the requirements for user time inputs per person trip. Fares set at supplier's marginal cost should be adequate to cover the supplier's full cost of operations.

For rail transit, however, economies of scale occur because the extensive fixed capital is used more efficiently, as well as because less user supplied time input is required per passenger trip. In this case, supplier marginal cost will tend to be less than average cost, and some subsidy will be required if fares are set at marginal cost.

SOCIAL ISSUES

Several social issues, which are frequently cited as reasons for transit subsidy, were discussed in Section 4. These issues include air pollution, income redistribution, and energy consumption, among others.

It was evident from the analysis that significant and desirable income redistributions are not achievable through transit subsidies. There seems to be no reason to commingle the complex problems of urban income distribution and poverty with the already complicated problems of the efficient development and utilization of urban transportation systems.

Conclusions with respect to energy consumption, congestion, and air pollution are not so clear, however. The argument is often made that transit should be subsidized to reduce urban auto travel (particularly work trips) and, thus, to reduce congestion, air pollution, and energy consumption.

It is clear from the evidence that subsidies used to reduce transit fares will have little or no effect on achieving the desired modal shift to transit. It is by no means clear, however, that subsidies used to improve transit characteristics in ways which are relevant to specific markets might not achieve a significant mode shift toward transit. Moreover, if pricing and marketing strategies were implemented in conjunction with auto pricing strategies which more closely align perceived auto trip prices with costs, a significant modal shift to transit might not be achieved. The point is that the problem of achieving a modal shift to transit must be approached through supplying transit trip characteristics which are seen as desirable by specific markets. If subsidies are required to provide these characteristics, an economic case might be made for them. No economic case can be made for simply subsidizing fares to achieve these social objectives.

INSTITUTIONAL ISSUES

There is one main institutional issue which has been mentioned several times, but which can stand reemphasis here. That issue is the one of automobile pricing. Urban auto trips are significantly underpriced, particularly during peak periods. Raising the perceived price of urban auto trips is more of a political and institutional problem than it is an economic issue; and it still has some technical problems. It is evident, nonetheless, that a rational and effective transit fare policy depends, ultimately, on rationalization of automobile pricing.

REQUIREMENTS FOR FURTHER RESEARCH

The discussion in this chapter suggests the need for further research in two areas: cost analysis, and policy analysis for pricing urban auto trips.

Although there has been a substantial amount of cost analysis undertaken in the past decade, and particularly in the past five years, the results are not definitive. Many of the assumptions underlying the different analyses vary considerably. More work would be desirable, following the analytical foundations established by the Keeler, Merewitz, and Fisher work, but with empirical analysis across a broader range of systems. It would be desirable, too, to undertake more cost analysis with the objective of identifying feasible pricing and investment strategies for particular systems in specific urban areas.

A companion piece of research would involve the analysis of policy strategies for changing the perceived price of auto trips. It appears that this research should be directed more toward the kinds of implementation strategies that might work, rather than toward specific pricing alternatives. A wide range of alternatives has been suggested over the past several years. These range from various kinds of tolling and metering techniques to parking surcharges and the establishment of auto free routes or zones. Tolling and metering techniques still have many technical and financial problems and are unlikely to be very acceptable in the near future. A traffic free zone has been instituted in Singapore with a good deal of success, and appears to have potential for other applications. Parking surcharges appear to be one of the most easily administered approaches, but the notion has not had much public acceptance. In view of the importance of auto trip pricing for transit fares, it would appear desirable to undertake more research on acceptable approaches.

CHAPTER V

TRANSIT FARE POLICY APPROACHES

1. INTRODUCTION

No single transit fare policy will be appropriate to all transit operators. The approach will be much the same for all operators, however, because there are certain key questions with which all transit operators must deal in determining a fare policy. These issues are identified with the institutional, demand, and supply aspects of the transit market. The issues have been discussed in detail in this study, and the task of this chapter is to draw together the key points from those discussions, and to suggest their implications to transit management for determining a fare policy. Before discussing each of these three sets of market issues, it will be useful to review the role of fare policy in transit management strategy.

2. RELATION OF FARE POLICY TO MANAGEMENT STRATEGY

Transit fare policy is a course of action, selected from the set of possible alternatives, with the objective of establishing the best fare structure to achieve the objectives of the transit firm. To be effective, fare structure must be an integral and complementary part of an overall strategy of transit management. Accordingly, it is evident that an effective transit fare policy must be developed in relation to other major policies of the transit firm. The fare policy must be complementary with policy decisions in three other aspects of management strategy, notably marketing, operations, and finance.

MARKET ORIENTATION

A business can be operated from any one of several perspectives. These normally include financial, product research and development, production or operations, marketing, public relations, governmental relations, and others. The operating perspective of the business will depend largely on the background of management, the economic environment in which the firm operates, and the problems which management sees as important.

Traditionally, transit firms have been concerned with operational problems, and have disregarded marketing and financial issues. At the present stage in transit development, however, it is becoming increasingly evident that marketing is the key issue in the provision of public transit services over the long run. The key aspects of marketing strategy are to segment the overall market into submarkets with similar demands for transit services; to plan the transit services in each market in order to provide the set of characteristics demanded by users in that market; and to price the services to meet the economic and financial objectives established for that market segment. Finally, the market strategy will include promotion and advertising to inform the public about the available services, but the key elements of the marketing strategy are market research to determine the appropriate market segments and the transit service characteristics demanded by those segments, service planning to provide the demanded characteristics, and pricing to achieve the desired customer response.

OPERATING STRATEGY

The second aspect of transit management which must be coordinated with fare policy is operating policy. The discussion of fare and service elasticities in Chapter III suggests the important relations which exist among fare, service characteristics, ridership, and revenue. A fare charged for a transit trip can be interpreted as a set of prices paid for each of the various service characteristics provided by the trip. These service characteristics will include frequency of the trip, accessibility of the service, required trip time, seat availability, and others.

Two critical aspects of operating policy which affect fare policy are the planning of services with specific characteristics for particular market segments, and the reliable provision of that service once it has been planned. It has been continually emphasized in this study that fare policy necessarily comprises policy on the characteristics of the service provided, as well as on the price or prices charged for a transit trip. This means that if the objectives of increased ridership and improved financial conditions are to be met, operating policy must be coordinated with fare policy in a coordinated marketing strategy.

FINANCIAL POLICY

The third major aspect of transit management strategy which relates closely to fare policy is the financial policy of the firm. Specifically, the issue concerns the transit firm's policy on the proportion of costs that must be covered from revenue, and the portion to be covered from subsidies.

Financial policy involves two specific issues relating to transit fare policy. One is the degree to which the firm will attempt to achieve financial equilibrium, in the sense of generating revenues which at least equal total cost; and the second issue is the deliberate and directed use of subsidies.

Although it is most unlikely, under current conditions, that many transit firms can achieve financial equilibrium for their entire operation, most firms should expect some of their services to break even or generate a surplus if they are to be continued. Some services should be discontinued if they do not earn at least as much revenue as they cost.

A second, related financial policy issue concerns the use of subsidies. With the exceptions of subsidies for school children, most transit subsidies have not been related to any particular aspect of transit service. Rather, they have been used for the acquisition of capital equipment or, more recently, to pay a portion of general operating costs, without respect to the service provided. The general result of the subsidies has been to allow transit operators to expand service vastly without corresponding increases in fares. Until the energy shortage, transit ridership and revenue had been in chronic decline since the 1940's despite substantial reductions in fares in real terms. There is no evidence that decreasing or stabilizing fares will, in general, have any significant impact on transit usage. Some of the service elasticity estimates, however, indicate that ridership and revenue may be quite responsive to changes in specific service characteristics. It appears that subsidies directed into specific kinds of services may prove beneficial for mitigating traffic congestion and air pollution. This conclusion must be somewhat speculative, however, since there is nothing but general elasticity estimates with which to validate the point.

CONCLUSIONS

It is evident that transit fare policy must be integrated and coordinated with a number of the main aspects of transit management strategy. The most important of these is the management strategy. Fare policy must provide guidelines for the definition of different market segments and for the implementation of appropriate fare structures and sets of service characteristics for each of those markets.

Operating policy is also necessarily closely related to fare policy. Operating policy is critical because it directly affects the provision of service characteristics. Since there is an inseparable connection between fares and transit service characteristics, a fare policy cannot be implemented without also implying an operating policy which affects the planning and delivery of different sets of transit service characteristics in different markets.

Financial policy directly affects decisions on the revenues to be generated by any particular transit service. It will also be required to determine which services will be subsidized, which will be required to break even, and which should generate some net income. Taking the overall point of view of transit management strategy, the following section considers specific fare policy issues which have arisen from discussions of three different aspects of the market for transit services: institutional structure, demand issues, and cost issues.

3. MAJOR FARE POLICY ISSUES

INSTITUTIONAL STRUCTURE

Within the institutional structure of the transit market, there are three major sets of issues which most directly affect transit fare policy. The most important of these is the pricing of urban automobile trips and the effects those prices have on the pricing of transit trips. It has been argued in this study and elsewhere that transit fares cannot be set at economically appropriate levels until such time as automobile trips are economically priced.

In a sense, then, the pricing of urban automobile trips is the cornerstone of transit fare policy, and transit management is forced to deal with the issue. Admittedly, transit management cannot establish automobile tolls or control systems which will raise the perceived price of urban auto trips to the level of costs incurred, but they can take an active part in urging that appropriate control measures be established where they are justified by congestion costs and air pollution.

A second issue in the institutional structure of transit markets is the continuing stressed concern with operations at the expense of marketing. As long as the market for transit services was secure, as it was in the early days of the industry, and the technology was developing, a primary concern for operations was appropriate. That condition has not existed for several decades, however, and a change in emphasis has lagged behind the need. Both the planning and the implementation of operations are important for the provision of transit services which will appeal to the various markets. The important point is, however, that operations planning must be in a marketing context, and must be closely related to the fare policy of the transit operator.

A third institutional problem which has grown in the last few years has been the emphasis on social benefits of transit as a justification for extensive transit subsidies. The implications of those arguments will be reviewed in the subsequent discussion of cost issues and subsidies. The point here is that a tradition of major transit subsidies has been built up, particularly in the last dozen years. It will be very difficult for transit management to orient financial planning away from such a heavy dependence on subsidy and toward more innovative use of marketing strategy, particularly fare and service policies, to generate revenues. If the revolt of taxpayers against paying ever increasing transit deficits continues, however, transit management will be forced to strengthen its marketing efforts. Transit users rather than government legislatures will be increasingly relied on to provide the financial resources required by transit firms.

DEMAND ISSUES

In looking at the demand side of the market for approaches to transit fare policies, one finds some promising directions, but little data to validate that they will work. The emphasis of the fare policy of any transit firm must be consistent with its marketing strategy. This means that opportunities should be sought to identify individual transit markets that have potential for development with the right combination of service characteristics, fare structure, and promotion.

Current examples of these market segments include the special commuter and subscription services. As reviewed in Chapter III, these special services have proved quite successful, although some have not established fares which would allow them to break even. The prepaid sale of multiple-trip tickets for these services has generally been the custom.

Extrapolating from the success of the subscription and commuter services, there appear to be opportunities for regular services to offer many of the same characteristics, charge fares accordingly, and at least break even. Specially identified buses could be operated along routes in common with other buses. These special buses would offer high frequency express services from more distant suburban communities, would offer a high probability of getting a seat, could offer amenities such as reading material, and would be available at premium fares which would be high enough to keep the average load factor below the capacity of the bus. Since the special services would be operated in common with regular services, persons along the route would have the choice of the lower priced, lower quality service or the higher quality, higher priced special service. There would seem to be extensive possibilities for services of this type in most urban areas. They have the potential advantage of providing different qualities of service for those persons willing to pay for it, without complicating the fare collection process. There could be a single fare for the service, or a distance-based fare. Since there would be relatively few boarding points inbound, or deboarding points outbound, it would be relatively easy for the driver to control a different fare for each point.

Peak and off-peak fares should also constitute a key part of any transit firm's fare policy. A fare structure differentiated by time of day tends to reflect differentials both in the value of service (fare elasticity) and in the cost of service between peak and off-peak periods. A fare policy which combined a peak period fare differential with an urban traffic control scheme could reduce traffic congestion, improve average trip time, reduce air pollution, and reduce the transit deficit simultaneously.

Finally, it appears that most transit fare and service policies should include low cost, high frequency downtown circulation systems using conventional buses, taxis, jitneys, light rail, or some combination of these. In addition to internal circulation in the central business district, this inner-city system would provide low cost, high frequency, high speed transportation to a large proportion of the low income inner-city residents. If downtown traffic restraint strategies are implemented, a high quality public circulation system is essential and should be very effective because the streets would largely be clear of private automobiles.

COST AND SUBSIDY ISSUES

The desirable relation between cost and fare must be determined by a transit operator for each specific market segment. As a general proposition, it has been argued that fares charged for a particular service should equal the short-run marginal cost of providing that service. In cases where the transit service is provided under economies of scale, fares set at short-run marginal cost will be less than average cost and subsidies will be implied. It was pointed out in Chapter IV that economies may justify some subsidy for both bus and rail transit operations.

To date, the extensive subsidy program for public transportation has caused massive expansion of many systems, but has not resulted in corresponding increases in either ridership or revenue. The subsidy programs are an integral part of transit fare policies and attempts have been made to justify them on grounds of social benefits, including reduced congestion, reduced air pollution, income redistribution, energy conservation, and others. Data presented in Chapter IV suggest that a significant modal shift from auto to transit would probably be effective in reducing energy consumption and air pollution. It should also be effective in reducing traffic congestion, particularly if accompanied by some form of traffic restraint scheme. But the subsidy programs have not been effective in achieving a modal shift to transit.

The data on service elasticities suggest that if subsidies were used in a directed manner to improve specific service characteristics they might be more effective in achieving the desired modal shift in favor of transit. In this case, it is likely that significant reductions in the costs of pollution, energy consumption, and congestion would justify the subsidies.

CONCLUSION

It is recommended that, from the cost viewpoint, transit fare policy should move toward pricing individual services and market segments at their marginal cost. Subsidies would then be used selectively and deliberately in situations in which marginal costs were below average costs or in which it was evident that subsidies could achieve some real social benefits in reducing congestion, mitigating air pollution, or aiding in energy conservation. Subsidies to low income families for the use of transit may be a desirable objective, too, but should be a part of the general welfare program of a community and not a part of transit fare policy.

CHAPTER VI
INTERRELATION OF TRANSIT FARE POLICY WITH OTHER PUBLIC POLICIES AND PROGRAMS

1. INTRODUCTION

OVERVIEW OF THE CHAPTER

The transit fare policies discussed in this study have the objectives of increasing the quality of transit service provided to urban populations, increasing transit ridership, and decreasing the deficits from transit operations. Transit fare policy does not operate in isolation from other public policies and programs, particularly those that affect the provision of pricing of other transportation services.

If a transit fare policy is to be successful, in the sense of accomplishing some or all of the enumerated objectives, it must be implemented with cognizance of related policies and programs. Conversely, changes in those policies or programs may be instrumental in making particular fare policies more effective.

The chapter is introduced with a brief background account of highway and public mass transportation policies as they have evolved from the Enabling Act of 1802 through the Federal-Aid Highway Act of 1973 and the National Mass Transportation Assistance Act of 1974. The purpose of the narrative is to trace the main legislative contributions to the planning,[1] development, and financing of urban transportation systems, and to note the shift in emphasis away from highways and toward public mass transportation in cities. Against this background, the chapter analyzes the policies and programs which potentially interact with transit fare policy.

BACKGROUND

Urban transportation policies have developed largely along modal lines, with public involvement in the supply of urban public transportation being a relatively recent occurrence. Because the alternative to urban public transportation is transportation by private auto, it is useful to trace briefly the development and interrelation of federal policy for both modes.

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[1] For a detailed analysis of urban transportation planning, see Edward Weiner, Evolution of Urban Transportation Planning ([Washington: U.S. Department of Transportation], Urban Analysis Program, Office of Transportation Systems Analysis and Information, Assistant Secretary for Policy, Plans and International Affairs, 1976).

Federal Highway Policy

Federal responsibility for road development is specifically provided for in the U.S. Constitution, which delegates the Federal government the power to establish post office and post roads. Federal aid for highways began with the Enabling Act of 1802, which authorized construction of the National Turnpike. More than a century later, in 1912, Congress first seriously considered a nationwide program of federal aid for highways.[1]

Transportation planning, including planning for cities as well as rural areas, had its beginnings in the Federal-Aid Road Act of 1916. This act was the foundation of subsequent federal-aid highway legislation, and was concerned primarily with stimulating intercity highway construction. The main forces for federal action were agrarian interests in access to city markets; the automobile industry, which saw that intercity highways would promote automobile usage; and the railroads which were looking for links between agricultural production areas and railroad terminals. The rural emphasis was so strong that the U.S. Bureau of Public Roads was initially placed in the Department of Agriculture.[2]

As a condition for federal aid, each state was required to establish and maintain a highway agency staffed and equipped to carry out a highway program. Thus, the 1916 Road Act established the basis for a federal-state partnership in which most highway planning and construction was determined by state highway agencies.[3]

The initial result of the federal-aid highway program was a scattering of projects without continuity. This result was corrected by the Federal-Aid Highway Act of 1921 which required the states to select up to seven percent of their total mileage as a system of primary and interstate highways.[4]

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[1]Laurence I. Hewes and Clarkson H. Oglesby, Highway Engineering (New York: John Wiley, 1954), pp. 8-9.

[2]Melvin R. Levin and Norman A. Abend, Bureaucrats in Collision: Case Studies in Area Transportation Planning (Cambridge: Massachusetts Institute of Technology, 1971) p. 31.

[3]Ibid., p. 32.

[4]Hewes and Oglesby, op. cit., pp. 8-9.

The Federal-Aid Highway Act of 1944 was a major piece of transportation legislation. Among other things, the act:[1]

- called for continued federal-state cooperation in designating a national system of interstate highways to connect the principal metropolitan areas, although the System of Interstate and Defense Highways was not funded for another dozen years, in 1956;

- specified that a percentage of funds be allocated to cities of over 5,000 population; and

- provided funding for the Federal-Aid Secondary Highway System to supplement the primary system.

Although urbanized areas began to be recognized in the 1944 Act, emphasis continued to be on the intercity highway systems. Indeed, the 1944 Act set the pattern for federal highway appropriations until 1961.

The National System of Interstate and Defense Highways, although actually authorized in the Federal-Aid Highway Act of 1944, is generally recognized as having begun with the Federal-Aid Highway Act of 1956. It was this latter act, that provided 90 percent funding, which gave the interstate system the required impetus.

Urban Transportation Policy

Section 701 of the Housing Act of 1954 provided matching grants to states for urban highway and mass transportation planning which were to be administered by the Urban Renewal Administration of the Housing and Home Finance Agency (HHFA). In the latter half of the 1950's it became increasingly apparent that there was a need to coordinate highway and urban mass transportation planning in urban areas, and to provide some financial assistance for the latter. In November, 1960, the U.S. Bureau of Public Roads (BPR) and the HHFA agreed to work jointly to provide funds for metropolitan area transportation planning.[2] The agreement between BPR and HHFA constituted the initial step in federal leadership for urban transportation planning which encompassed more than highway planning.

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[1]Levin and Abend, op. cit., p. 34.

[2]Ibid., p. 39.

In March 1960, a bill was introduced in the Senate which called for a federal policy that was intended to encourage state and local governments to plan, coordinate, and financially assist their public transportation systems. The bill also would have authorized $100 million in long-term low-interest loans to public bodies for mass transportation improvements. The bill called for the amendment of section 701 of the 1954 Housing Act to authorize federal aid for urban transportation planning. The bill passed the Senate, but failed to pass the House.[1]

In 1961, the Federal government released two reports, both of which outlined deficiencies in federal policy toward urban transportation.[2] A report of the Advisory Commission on Intergovernmental Relations (ACIR) noted that urban transportation facilities generally failed to meet community standards and that the public was generally frustrated with the inability of cities to remedy their transportation problems. The ACIR suggested that both of these problems stemmed from the failure of the federal government to provide funds for mass transportation on a scale similar to those provided for highways. The National Transportation Policy report indicated that deficiencies in federal policy toward urban transportation had led to (or at least had not corrected) fragmentation in facilities, planning, administration, and finance.[3]

With the increasingly evident need for a coordinated federal urban transportation policy, the unsuccessful urban transportation bill of 1960 was reintroduced in the Senate in January 1961. The bill called for:

- a revolving loan fund for purchase of new equipment, rights-of-way, and terminals;
- matching grants for demonstration projects; and
- matching grants for area or regional planning for mass transportation.

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[1]Ibid., p. 41.

[2]U.S. Advisory Commission on Intergovernmental Relations, Intergovernmental Responsibilities for Mass Transportation Facilities and Services in Metropolitan Areas (Washington: GPO, 1961); and U.S. Congress, Senate, Special Study Group on Transportation Policies in the United States, National Transportation Policy, preliminary draft of a report prepared for the Committee on Interstate and Foreign Commerce, 87th Congress, 1st session, January 1961.

[3]Levin and Abend, op. cit., pp. 37-8.

It was agreed that HHFA, rather than BPR, would be the appropriate agency to administer the new mass transportation program. HHFA was experienced in working directly with cities, whereas BPR had worked only with state highway agencies. The provisions for assisting urban mass transportation were ultimately incorporated in the omnibus Housing Act of 1961. The final level of appropriations was so low, however, that the legislation represented only a nominal start in federal assistance for urban mass transportation.[1]

The Federal-Aid Highway Act of 1962 inaugurated the so-called "3-C process," which specified that future highways must conform to a comprehensive and continuing planning process carried out in cooperation with the state and local levels of government. This provision was to take effect July 1, 1965. Thus, the 1962 act guaranteed that urban areas would at least give consideration to transportation alternatives other than highways.

As the legislation emerged requiring comprehensive urban transportation planning, some legislation was needed to provide the funds required to implement those plans. Loans were available from the 1961 Housing Act, but even low cost loans were of little value to communities which had no possibility for repaying any loans. If public mass transportation were to survive in its known form, or to revive, substantial federal grants would be required.

The foundation legislation for the federal urban mass transportation is the Urban Mass Transportation Act of 1964. This act not only provided grants-in-aid for the improvement and development of mass transportation systems, but encouraged the development of area-wide balanced transportation systems by providing at least some of the funds needed for the improvement or development of non-highway transportation systems.

The 1964 Act contained three major provisions:

- the demonstration grants provided under 1961 Housing Act were continued, except that the HHFA (now Urban Mass Transportation Administration) was given authority to initiate the grants;

- the low interest rate loans begun in the 1961 Housing Act were continued; and, most important,

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[1]Ibid., pp. 42-4.

- the act provided two grant-in-aid programs:
  - a short-run emergency program to keep jeopardized transit systems operating under emergency conditions, and
  - a long-run program which would pay up to two-thirds of the net project costs of a capital project that was needed to carry out a unified urban transportation program that had been developed through the 3-C process.[1]

The Urban Mass Transportation Act of 1966 made several important changes in the program that had been created in 1964. These changes included:

- increasing funding authorization;
- making funds available for the planning, engineering, and design of urban mass transportation projects;
- authorizing funds for management training;
- establishing a program for grants to nonprofit educational institutions to conduct comprehensive research in urban transportation problems and to train persons for research or managerial activities with transit companies; and
- authorizing a program to study, develop, and demonstrate new urban transportation systems, thus establishing the New Systems Research Program.[2]

The main policy issues emerging in the 1966 amendments were the increased federal funding for urban mass transportation, and the increased research and training in both the design and operations of urban mass transportation systems.

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[1]George M. Smerk, Urban Mass Transportation; A Dozen Years of Federal Policy (Bloomington, Ind.: Indiana University Press, 1974), pp. 56-7.

[2]Ibid., p. 66.

The most significant feature of the Urban Mass Transportation Assistance Act of 1970 was the creation of long-term obligational authority. Attempts had been made to create a transit trust fund, similar to the Highway Trust Fund, to provide sustained support for transit programs. The excise tax on automobiles was suggested as a source of trust fund money as this money did not go into the Highway Trust Fund, but the Office of Management and Budget took a dim view of the trust fund approach, and the idea was killed.

Transit interest groups made it clear, however, that they had an important stake in a well financed transit program. With the Highway Trust Fund coming up for review by Congress in 1972, it was made clear that highway interests had good reason to support some long-range form of transit financing.

Resolution to the problem took the form of a proposal that appropriated a total of $3.1 billion which would remain authorized until obligated. Although increasing portions of the $3.1 billion became available in successive years, so that the entire amount was not immediately available for obligation, the proposal permitted, for the first time, the creation of long-range transit financing plans.

The Federal-Aid Highway Act of 1970 permitted, for the first time, a small transit incursion into the Highway Trust Fund. The act provided that monies earmarked for the Interstate, Urban, and Urban Extension Systems could be used for construction of transit support facilities, which would include:

- exclusive or preferential bus lanes;
- traffic control devices or systems;
- bus passenger loading areas and facilities;
- shelters;
- fringe area parking; and
- transportation corridor parking facilities to serve bus and other public transportation passengers.

But the act restricted expenditures for mass transportation purposes to amounts which would not exceed those which would have been spent in conventionally provided highway capacity.

With the passage of the Federal-Aid Highway Act of 1973, federal priorities took a decided shift toward public mass transportation, and away from the highway orientation that had marked federal urban transportation policy in the post World War II period.

The 1973 Act relaxes the constraint in the Federal-Aid Highway Act of 1970 on the use of trust fund monies for mass public transportation. Whereas the 1970 Act limited mass transit funds to amounts that would have been used to conventionally provide highway capacity, the 1973 Act provides that all apportioned highway funds in the various systems can be used for the transit-related purposes enumerated in the 1970 Act. The 1970 Act provided additional contract authority and increased the rate of federal participation up to a mandatory 80 percent for all projects after July 1, 1973. Moreover, transit planning can receive up to 100 percent federal funding.

Whereas the 1970 Act allowed the use of Highway Trust Fund monies only for highway-related public mass transportation facilities, the 1973 Act provided that in fiscal year 1974, cities could use their share of the Urban Systems apportionment for buses, for rail transit facilities, or for rail transit vehicles, although the money was to come from the general fund in fiscal year 1974. In fiscal year 1975, up to one-quarter of the funds apportioned for Urban Systems could be used for mass transit, although the funds can be used only for bus-related projects. Finally, in fiscal year 1976, the cities can use the entire urban systems apportionment in the Highway Trust Fund for bus or rail transit capital projects. Cities, in coordination with their state governments and upon approval of the Secretary of Transportation, are allowed to exchange money from the Interstate Highway System apportionment in the Highway Trust Fund for an equal amount of general fund money for mass transportation.[1]

The effect of the 1973 Act was to provide local officials with the authority to use Urban System trust fund monies in the ways they thought best within broad limits. It did not require that the funds be allocated to public mass transportation. From a policy viewpoint, the main issue is that the 1973 Act left local officials with both the fiscal power and the responsibility to choose the components of a coordinated urban mass transportation system.

The last piece of urban transportation legislation is the National Mass Transportation Assistance Act of 1974. In addition to substantially

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[1] Ibid., pp. 82-84.

increasing contract authority for capital projects above those provided in the Mass Transportation Assistance Act of 1970, the 1974 Act contained two significant provisions. Probably the least important of the two is the provision of a limited amount of grant funds for rural public mass transportation. The most important provision of the Act is section 5 which allocates funds among urbanized areas on a population and population density formula and provides that these funds may be used either for capital projects or for operating subsidies with up to 50 percent federal participation. With the 1974 Act, transit interests achieved not only a marked increase in contract authority, but they also secured the operating subsidies which they had sought and had been denied for a decade.

2. RELEVANT POLICIES AND PROGRAMS

There are vast arrays of public policies and programs at the federal, state, and local levels which potentially have implications for transit fare policy. The purpose of this section is to identify what appear to be the most important of these, to briefly describe each of the policies or programs, and to show the implications of those policies or programs for transit fare policy. The analysis also suggests changes which would facilitate realization of the objectives to transit fare policies.

The policies and programs include:

- general national transportation policy;
- transit financing programs, including
  - capital assistance, and
  - operating assistance;
- highway policies, including
  - federal-aid highway programs,
  - allocation of portions of the Highway Trust Fund to public transportation; and
  - pricing policies;
- transportation system's management programs;
- environmental protection policies, especially air pollution control; and
- energy conservation policies.

GENERAL URBAN TRANSPORTATION POLICY

Description of the Policy

To a large degree, federal urban transportation policy can be gleaned from the brief legislative history narrated in the introductory section of this chapter. In general, the trend in legislation indicates movement towards the planning, financing and developing of comprehensive urban transportation systems, with reduced emphasis on highways and the private automobile, and with increased emphasis on public mass transportation.

Secretary of Transportation Coleman's recent general policy for urban transportation contained the following major elements:[1]

(1) Analysis of the cost-effectiveness of transportation alternatives should be required as a condition of eligibility for federal assistance for any major mass transporation investment;

(2) The development and implementation of transportation system management plans to improve efficiency in the use of existing facilities and services and to conserve energy should be required as a condition for federal funding of urban transportation investments;

(3) Increase emphasis on near-term improvements in service as against investment in facilities to meet anticipated long-term demand;

(4) Regard the present types of rail transit systems as appropriate only in a few heavily and densely populated metropolitan areas;

(5) Support efforts to develop a type of rail system which is less costly to build, operate, and maintain than are present systems;

(6) Give preferences in federal funding to localities that demonstrate consistency with broader community development goals; effective processes for resolving jurisdictional conflicts; effective cost controls; and a substantial state, regional, and local financial commitment; and

(7) Encourage the coordinated, metropolitan area-wide planning and operation of public transit.

Other national transportation policies which interact directly with transit fare policies are policies for coordinated funding of urban transportation and for transit subsidies. The Secretary's national transportation policy calls for coordination of urban transportation financing

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[1] William T. Coleman, Jr., Secretary of Transportation, A Statement of National Transportation Policy (Washington: GPO, 1975), pp. 8-9.

through "complete merger of the highway and mass transit funding authority for metropolitan areas."[1] This policy is essentially a statement in general terms of the federal transportation funding realignment attempted by the proposed "Unified Transportation Assistance Act of 1974", which was utlimately preempted by the National Mass Transportation Assistance Act of 1974. The latter act forms the current basis of federal mass transportation financing, but does not contain the funding coordination of the previously proposed Unified Mass Transportation Assistance Act.

The Secretary's proposed approach to developing a transportation subsidy program includes the following elements:[2]

(1) Federal subsidies are necessary in certain instances to serve important national purposes;

(2) Federal subsidies should periodically be reexamined;

(3) Wherever possible, the costs of federal support should be recovered by user charges;[3]

(4) The effect of subsidies on competing modes should be considered and, where there is an adverse effect, the preference should be to reduce or eliminate the subsidy or adjust the user charges so that all users pay their full share;

(5) There should be a preference for capital rather than operating subsidies, however,

(a) capital subsidies should not induce excessive investment, and

(b) where state and local governments are involved in investment or operating decisions, they should bear a share of the total cost sufficient to ensure commitment to efficient management; and

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[1]Ibid., p. 27.

[2]Ibid., pp. 19-20.

[3]The meaning of this point is not clear when it is taken out of the context of the rest of the policy statement since "federal support" would not be a subsidy (although it could be a cross-subsidy) if it were recovered by user charges. The policy seems to be saying that subsidies should be restricted to paying the cost of output which yields general public benefit for which the users should not pay. The other costs of federal support should be recovered from user charges.

(6) Where the political process determines that a subsidy is essential to the national interest, there should be compatible adjustments in federal support of competing modes to avoid inconsistent subsidies.

Although some aspects of these policy objectives are not operational, in the sense that it is difficult to define criteria which measure achievement of the objective, other objectives are operational and can be directly related to transit fare policy. Those relations will be identified in the next section.

Implications for Transit Fare Policy

The general policy statement concerning urban transportation is broadly consistent with the alternative fare policies discussed in this study and summarized in the previous chapter. A fare policy in which the fares charged more closely reflect costs would improve the meaningfullness of the cost-effectiveness analyses which are mentioned as the first element in the general policy statement. Also, there is (or should be) a close relation between some elements of the Transportation System Management (TSM) program (element 2) and differential transit fares. Some of the main relations between fare policy and the TSM programs will be discussed.

The other principal point of relation between Secretary Coleman's public transportation policy and the fare policies discussed herein concerns points (3) and (4) in his transportation subsidy program. With respect to point (3), the fare policies recommended in the proceding chapter are generally consistent with the objective of recovering federal support from user charges when ever possible. This policy means, in effect, that only those services should be subsidized for which full recovery of costs would defeat the purpose of the federal support. For public transportation, this implies that high quality service to upper income areas should pay at least their full cost, with subsidies being provided mainly for services to low income areas. A fare policy which met this objective would substantially reduce operating deficits below current levels.

Point (4) in the Secretary's subsidy policy concerns subsidies to competing modes; in the present case, principally to the automobile. Road pricing policies which do not reflect the full cost of an urban automobile trip to the user subsidizes the automobile user and causes an economically inefficient choice of mode in favor of the automobile. According to the Secretary's policy, the preferred course of action would be to eliminate the conflicting subsidy when it occurs; and most economists would agree with that approach. It has been pointed out repeatedly in this study that subsidies to urban automobile trips, particularly peak period work trips, appear to be a major impediment to the establishment of transit fares which would substantially reduce deficits. These deficits could be significantly reduced, or eliminated, through automobile trip pricing policies such as auto-free zones or parking surcharges, which would make the cost of the trip as perceived by the auto tripmaker more nearly approximate the true cost.

In addition it would have been desirable if the policy statement included a policy element that encouraged local communities to establish transit fare structures that bore a reasonable relation to the costs of the service provided in specific markets, and the ability of the market to pay for those services. A statement of this sort would have reiterated the Federal Government's policy of assisting local communities in the provision of better transit services with reduced deficits.

TRANSIT FINANCING PROGRAMS

Description of the Policy

Evolution of the transit financing programs has been sketched in the preceding section of this chapter. In a very capsulized version, that policy has three main elements:

- increased capital funding, to put urban mass transportation on approximately a financial part with urban highway systems;
- extensive operating subsidies which will permit stabilization of fares, since most communities cannot come close to avoiding massive operating deficits under a fare stabilization policy; and
- coordinated urban transportation planning.

Implications for Transit Fare Policy

The first two policy elements have, with increasing frequency, implied unconstrained access to the Highway Trust Fund or, what amounts to the same thing, the establishment of a ground transportation trust fund from which all federal appropriations for ground transportation would be made. Since the principal source of funds for either trust fund would be the federal fuel tax and other current sources of funds for the Highway Trust Fund, the two trust funds do not constitute real alternatives.

In pressing for operating assistance, transit firms have largely taken the position that fares should be stabilized to attract ridership and provide public service; the resulting deficit should be made up from federal or other payments. Under the 1974 Act, federal operating subsidies must be matched from local sources other than fares.

The fare policies suggested in this study emphasize the possibility of increasing ridership and reducing deficits through the appropriate manipulation of fare structures and transit service characteristics. Although there is no direct conflict between the fare policy alternatives discussed in this study and a policy of extensive federal operating assistance to transit firms, neither are the two complementary. A successful fare policy should largely or entirely eliminate the need for operating subsidies. Conversely, as long as a transit firm can look to the federal government for partial coverage of its transit deficits, it has less motivation for introducing innovative fare policies.

The provision that fare revenue could not be used as the local share to match federal subsidies was intended to assure that local communities maintained at least the same level of non-fare expenditure effort as before the federal operating subsidies. Nonetheless, the provision has the effect of providing the local communities with little or no incentive to attempt to increase fare revenue in order to match available federal subsidies. In order that the federal subsidies provide some motivation to local communities to increase fare revenue, the "maintenance of effort" requirements should be provided in some other way.

HIGHWAY POLICIES

Description of Policies

There are three major aspects of highway policy which potentially interrelate with transit fare policy. These include:

- the federal-aid highway program;
- allocations of portions of the Highway Trust Fund to public mass transportation; and
- highway pricing policies.

The general outline of the federal-aid highway program has been discussed in the previous section of this chapter. It was evident from the discussion that, since World War II, few changes in federal-aid highway legislation have been intended specifically to aid the development of highway systems. Those changes that were specific include:

- creation of the Secondary System and the establishment of the Interstate System in the Federal-Aid Highway Act of 1944;
- provision of 90 percent federal funding for the Interstate System in the Federal-Aid Highway Act of 1956;
- establishment of the Urban Systems; and
- change in federal participation to 80 percent for federal aid Primary, Secondary, Urban Extensions, and Urban Systems in the Federal-Aid Highway Act of 1973.

Many of the other significant changes in highway legislation have been concerned broadly with urban transportation systems or explicitly with providing funds for urban mass transportation.

The second major aspect of federal highway policy which relates directly to transit fare policy is the allocation of portions of the Highway Trust Fund to urban mass transportation. As was discussed in the first section of the chapter, the major changes came with the Federal-Aid Highway Act of 1970 and 1973. The former act opened up the notion of using Highway Trust Fund monies for urban mass transportation, but placed severe constraints on that use. The latter act substantially relaxed the constraints so that Highway Trust Fund could be used for virtually any urban mass transportation capital project.

Highway pricing policy is based on the notion of the fuel tax as a user charge, with the exception of the few toll facilities. For this reason, the price of an auto trip only accidentally and very seldom reflects the cost of the trip.

Implications for Transit Fare Policy

The federal-aid highway programs have, at least in part, exacerbated the urban transportation problem. The increased urban highway construction permitted by the Interstate and the Urban Systems did not bring the urban mobility that was expected of them. Instead, the growth of automobile traffic and the resulting highway congestion have made it evident that the requirements for urban mobility could not be met by highways and the private automobile alone. Contemporaneously, however, the changing patterns of urban land use permitted by highway construction lead to the rapid demise of public transportation: transit could not compete with the automobile by providing the services that it traditionally provided and charging the fares that it would have to charge to maintain financial equilibrium. Rather than identifying and marketing a new set of services at profitable prices, transit chose to reduce fares (at least in constant dollars), provide traditional services that had decreasing appeal to the travel market in competition with the automobile, and seek public ownership and financial support when the strategy failed. In a very real sense, the federal highway program made a major contribution to the creation of an economic and social environment in which transit firms no longer had a market for their traditional services at prices which would allow them to sustain themselves, let alone grow. The situation was not unique to transit; but has been faced by many industries at various times, not all of them successfully. What was needed, and was not forthcoming, was a set of new product, pricing, and marketing strategies that would allow public transportation to meet the competition created by the highway system and the automobile.

It is particularly the price and product strategies to which this study is addressed. They must be designed, in conjunction with marketing strategies, to function in an urban transportation environment that has been strongly influenced by the federal-aid highway program. It does not appear that the federal-aid highway program will have much further effect on transit fare policy. Most of the additions to the system will be marginal and inconsequential insofar as transit service or fare policies are concerned, except for the provision of special services, such as preferential busways. In a sense, the damage to public transportation by the urban highway system has been done, and many new highway projects will tend to benefit transit.

Policies on the allocation of monies to public mass transportation from the Highway Trust Fund need to be closely integrated with transit fare and service policies and marketing strategies. To date, not much of the Highway Trust Fund has been allocated to transit, but the monies are available to provide service improvements if local officials decide to use them for that purpose. It seems likely, however, that before massive reallocations are made from highway to transit programs, a good deal of shifting political priorities will have to occur. If it is to occur, at least two things will be required to stimulate it:

- transit interests will have to have more evidence than currently exists on the beneficial effects of massive public transportation expenditure; and

- a quid pro quo will be required for rural areas which do not stand to benefit from urban mass transportation programs.

Additional problems which may make it even more difficult to divert Highway Trust Fund monies from highways to transit are the rapidly growing concerns of highway maintenance and inflation. It is becoming increasingly apparent that the states have committed themselves to massive annual highway maintenance bills with the interstate system. The maintenance costs, combined with inflation, have sharply reduced the availability of state matching money for new highway capital projects. It does not seem unlikely that the states will generate pressure for allocation of some of the Highway Trust Fund to maintenance, just as there has been an apportionment of public mass transportation monies to operating subsidies.

Highway price policy probably has a greater effect on transit fare policies than does any other aspect of the highway program. The concept of user charges has been a long established basis for highway financing. In 1919, the Oregon legislature decided to tax gasoline for highway construction. The tax proved so successful that, by 1926, all of the states had enacted motor vehicle fuel taxes.[1] The motor vehicle fuel tax is a useful device for raising revenue (or for allocating resources) for highway construction, maintenance, and operation, but it is not so useful for allocating existing highway capacity to users.

The price per unit of highway services consumed depends only on the tax rate and the gasoline consumption efficiency of the automobile being used. The price is largely independent of the costs of delay that one motorist imposes on other motorists on the highway during a congested time. Because the highway price system fails to account for some important highway costs, such as congestion, air pollution, and noise, it is a relatively inefficient guide to the best short-run use of highway capacity.

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[1]Hewes and Oglesby, op. cit., p. 86.

Recognizing that highway user charges do a relatively poor job of allocating existing highway capacity, transportation analysts have urged some form of marginal cost (congestion) pricing for urban highways. The main theme of those arguments was discussed in Chapter V, and need not be recounted here.

Highway user charges based largely on the motor vehicle fuel tax constituted a relatively adequate price system as long as the main economic issue was the development of a highway system. The price system may have allowed some portions of the system to be overbuild, but that is of no relevance now. The main problem now is the efficient use of the existing highway system as an integral part of an urban transportation system which includes public mass transportation. Efficient use of the existing highway system requires a price system which is responsive to short-run costs, principally congestion and pollution costs. It seems likely that if auto trips are even approximately priced to reflect these costs, transit fare policy can more closely reflect the costs of that mode. Moreover, a realistic price structure for urban transportation--including both auto and transit trips--will allow the evident gaps between revenue and cost to indicate the desirable areas for subsidy, investment, and disinvestment.

TRANSPORTATION SYSTEM MANAGEMENT PROGRAM

Description of the Program

Although there is little evidence of much change in urban highway pricing policy, there is substantial concern with making the best possible use of the existing urban transportation system. This concern is reflected in the Transporation System Management (TSM) program.

The objective of the TSM program is to coordinate the individual elements--automobiles, public transit, taxis, pedestrians, and bicycles--through operation, regulation, and service policies so as to achieve maximum efficiency and productivity of the system as a whole.[1] The components of the TSM program are listed in Table VI.1.

As part of the process of implementing the 1973 Highway Act and the 1974 Public Transportation Act, criteria have been developed for

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[1] Federal Register, Vol. 40 (September 17, 1975), 42979.

the urban planning processes which are prerequisites for approval of grants for funding. These criteria call for increased emphasis on multi-modal planning, for the solving of transportation problems through increased operating efficiency, and for use of a shorter term perspective in the planning process. The short-term planning places emphasis on detailed 3 to 5 year staging and management planning, although the requirements for longer term planning are preserved. The planning requirements integrate the individual planning requirements of the FHWA and the UMTA.

The TSM element of the planning process involves the integration of highway and public transportation improvements in to an overall short-range approach to urban transportation which makes efficient use of existing facilities and resources. The TSM program involves development of low cost improvements involving traffic engineering, expanded use of public transportation, regulation, pricing, management improvements, operational improvements for both transit and highways, all as enumerated in Table VI.1. The TSM improvements are such that they can be implemented immediately and will not require the development of new transportation facilities or major changes in existing facilities.

Implications for Transit Fare Policy

Several specific items in the TSM program bear a direct relation to transit fare policy. In general, any of the actions which increase overall traffic speed or which give preference to transit will improve transit service characteristics and will make transit more attractive to riders. Policies which provide preferential use of lanes on streets and freeways will increase transit speed during peak periods and will tend to make transit more competitive with the automobile in trip times.

Regulation of parking and parking supply, and the imposition of parking taxes will tend to increase parking costs and the total cost of auto trips. The increased cost and difficulty of parking, it accompanied by improvements in public transportation services, would be expected to lead to modal shifts away from auto and toward transit.

Actions which reduce automobile use in congested areas by the exclusion of automobiles from specific areas or streets through special auto licensing or other techniques would also be expected to cause some shift to transit. All of these measures will have the effect of raising the perceived cost of auto trips so that the perceived cost more closely approximates the actual cost. Also, if the limitations on, and increased cost for, use of the automobile are accompanied

TABLE VI. 1

COMPONENTS OF THE TRANSPORTATION SYSTEM MANAGEMENT PROGRAM

ACTIONS TO ENSURE EFFICIENT USE OF EXISTING ROAD SPACE

- Traffic operations improvements to manage and control vehicle flow through:
  - traffic channelization
  - one-way streets
  - signalization
  - progressive timing of traffic lights
  - computerized traffic control
  - metered freeway access
  - reversible traffic lanes
  - freeway incident detection
- Preferential treatment of transit and high occupancy vehicles through:
  - preferential lanes on streets
  - preferential lanes on freeways
  - exclusive bus use of streets
  - bypass lanes
  - bus preemptions of traffic signals
  - bus turning lanes
  - exclusive lanes at toll plazas
  - exclusive access ramps to freeways
- Provisions for pedestrians and bicycles, such as:
  - bicycle paths and lanes
  - pedestrian-vehicle separation
  - bicycle storage areas
- Management and control of parking through:
  - eliminating on-street peak-period parking
  - regulation of parking supply
  - parking taxes
  - encouraging short-term parking
  - suburban parking/transfer facilities

TABLE VI. 1 (Continued)

- Reductions in peak-period travel and encouragement of off-peak use of transportation facilities and transit through:
  - staggered work hours
  - flexible work hours
  - reduced transit fares for off-peak use
  - peak-period commuter tolls

ACTIONS TO REDUCE VEHICLE USE IN CONGESTED AREAS

- Encouragement of car pooling or other forms of ride sharing.
- Diversion, exclusion, and metering of automobile access to specific areas.
- Establishment of auto licensing, parking surcharges, and other means of congestion pricing.
- Establishment of car-free zones and closure of specific streets to local or through traffic.
- Restriction of truck delivery during peak hours.

ACTIONS TO IMPROVE TRANSIT SERVICE

- Provision of better collection, distribution, and internal circulation services in low-density areas.
- Provision of express bus service.
- Planning greater flexibility and responsiveness in scheduling, routing, and dispatching of transit vehicles.
- Provision of extensive park-ride services.
- Provision of shuttle service from CBD fringe parking areas.
- Encouragement of paratransit and other flexible paratransit services.

TABLE VI. 1 (Continued)

. Provision of simplified fare collection systems.

. Provision of shelters and other passenger amenities.

. Provision of better passenger information systems.

ACTIONS TO INCREASE INTERNAL TRANSIT MANAGEMENT EFFICIENCY

. Improve marketing techniques;

. Develop cost accounting and other management tools;

. Establish maintenance policies that provide greater equipment reliability.

. Increase use of surveillance and communications technology.

Source: Federal Register, Vol. 40 (September 17, 1975), 42979 by significant improvements in the quality of transit service, some rather marked model shifts might be expected to occur.

Actions to improve transit services are clearly complementary to, or an integral part, of the transit fare policies discussed previously. Any action which markedly improves the quality or quantity of transit service should permit fare increases without significant reductions in ridership. Indeed, improved service and increased fares to cover the costs of those improvements may increase ridership. Finally, actions to increase management efficiency are also clearly complementary with the recommended transit fare policies. In particular, changes in maintenance policies which provide greater equipment reliability should be strongly complementary with higher fares.

For the most part, all of the specific elements in the TSM program are complementary to the recommended transit fare policies for two reasons: they tend to increase the quality of transit service; and they tend to raise the perceived cost of automobile trips so that they more closely approximate actual economic costs. Some aspects of the TSM program will also increase the efficiency of the automobile and reduce the costs of auto trips. Although these changes may defer shifts in urban travel from auto to transit, they are still consistent with the broad objectives of the recommended transit fare policies because they increase the overall efficiency of urban transportation.

ENERGY CONSERVATION POLICIES

Description of the Policies

The general policy of the federal government has been to initiate sets of short-run measures to achieve immediate reductions in energy consumption and long-run measures to achieve energy independence.

Transit can be considerably more energy efficient than the automobile, as was shown in Chapter V. It was noted there that, in urban travel, the average public transit bus passenger mile has an energy intensiveness of only 45 percent that of the national average automobile passenger mile; and the average rail passenger mile is only 33 percent as energy intensive as the automobile. Vanpool passenger miles, presumably because of their high load factors, are only 23 percent as energy intensive as the national average automobile passenger mile. Dial-a-ride, however, using approximately the same vehicles as vanpools, has an energy intensiveness of 110+ percent of the automobile because of the low load factors. According to a 1974 study, urban passenger transportation consumes about 43 percent of the transportation fuel used. Of this, mass transit uses only about 0.5 percent.[1] These data have two implications. First, there is opportunity for major reductions in transportation fuel consumed if a major modal shift from auto to mass transit could be achieved. Second, a shift in mode choice of a magnitude which would be sufficient to make any noticeable change in transportation fuel consumption would imply an extensive restructuring of the urban transportation market.

The energy efficiency of mass transportation depends heavily on vehicle load factors. This is nowhere more evident than in the comparison of dial-a-ride and vanpool services, which use comparable vehicles. In the case of vanpools, the nature of the service virtually guarantees high load factors and high energy efficiency; whereas, in the case of dial-a-ride, low load factors and energy intensiveness are much more likely to occur. Vehicles serving specific origins and destinations, and of a size that can be operated with high load factors, will be the most energy efficient. In contrast, vehicles which serve low traffic density routes and random points will tend to be quite energy intensive.

Relation to Transit Fare Policy

Transit faces something of a dilemma with respect to energy conservation. Conventional transit service is quite energy efficient relative to the automobile, but does not appeal to a very large fraction of the urban transportation market. Yet, many of the special services, including a whole range of paratransit services, which appear to have some market appeal, also have energy intensiveness approximating that of the automobile. Clearly what is required for energy conservation is a combination of transit fare and service policies, and other control measures, which will make transit with relatively high load factors attractive to the auto tripmaker.

One set of transit fare and service measures which meet this criterion are special commuter services that will at least partially replace automobile trips. Examples would include some of the commuter services provided by Golden Gate Transit between San Francisco and Marin County, and the Shirley Highway express service in Washington, D.C., metropolitan area. Although these services

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[1] Jack Faucett Associates, Project Independence and Energy Conservation: Transportation Sectors, Project Independence Blueprint Final Task Force Report (Washington: Federal Energy Administration, 1974), cited in Mayo S. Stuntz, Jr. and Eric Hirst, Energy Conservation Potential of Urban Mass Transit, Conservation Paper Number 34 (Washington; Federal Energy Administration, 1975) p. 5.

are somewhat different in detail, they both provide relatively high quality service to compete with the automobile in congested corridors.

In general, commuter clubs, park-ride services, or other services which provide express service with high load factors will contribute to energy conservation. If transit is to be an effective conservator of energy, however, these highly energy efficient services will have to be provided with additional service characteristics that will cause a significant shift in mode choice toward transit. These other service characteristics would include service reliability; comfort, including reliable air conditioning and a high probability of seat availability; short walking distances; high frequency; homogeneity of ridership; and so forth. Any fare policy which increases modal choice toward transit and enhances load factors on vehicles will be consistent with the broad objectives of the national energy conservation policy.

The case is not quite so clear for paratransit, however. As was pointed out previously, average data for dial-a-ride shows it to have a slightly higher energy intensiveness than does the average private automobile. Operating a high level of random public transportation with low load factors may meet certain mobilitty objectives of a community, but it will typically run high deficits and may be very energy intensive. Jitney services may prove to be a partial solution, however, the jitney has basically the same operating costs and energy consumption characteristics as a private automobile or taxi, but can operate with significantly higher load factors and lower energy intensiveness per passenger mile than the private automobile.

The general transit fare policy recommended in this study emphasizes an increasing transit ridership through appropriate combinations of fare and service characteristics designed to meet the demands of specific markets. That policy is generally consistent with the national long-run energy conservation goals. In the short-run, there appears to be relatively little that public mass transportation can do to reduce energy consumption, unless there are severe constraints on the availability of motor vehicle fuel. Without that constraint, as existed in the winter of 1973-74, public mass transportation cannot be made sufficiently attractive in the short run to attract any significant portion of urban trips.

In the long run, however, transit fare and service policy may succeed in making transit sufficiently attractive to induce a modal shift toward public mass transportation which will be sufficient to significantly reduce the consumption of energy in urban transportation.

The transit fare policies recommended in this study work in that direction, but would have to be highly successful to achieve any significant reduction in energy consumption in urban transportation.

ENVIRONMENTAL PROTECTION POLICIES

Description of the Policies[1]

The Clear Air Amendments of 1970 (hereinafter, "Act") required the Administration of the Environmental Protection Agency (EPA) to establish national primary and secondary ambient air quality standards. The Act specified three main approaches to achieving the emission standards. These include establishment of emission standards for new cars, trucks, and motorcycles; establishment of emission standards for stationary sources; and a requirement that each state establish a state implementation plan (SIP) which includes any omission control regulations or other measures needed, together with the emission standards, to achieve the ambient air quality standards. The Act specifically envisions the probable need in some SIP's for transportation control measures to reduce automobile emissions below the levels that would be achieved under the emission control standards.

There are two basic types of transportation controls contemplated. The first are measures that reduce emissions of individual vehicles, and the second are measures that reduce the vehicle miles of travel by automobile. The second set of measures includes transit improvements, carpool programs, and disincentives for the use of low-occupancy automobiles. It is specifically the policies for transit improvement and for disincentives for the use of low-occupancy automobiles that relate most directly with transit fare policy.

Relation to Transit Fare Policy

To attract urban trips from automobiles, transit must be able to provide a service that is equivalent or superior to that of the automobile, and to provide it at a cost which is comparable to auto cost.[2] Because

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[1]The following discussion is based on Joel Horowitz and Steven Kuhrtz, Transportation Controls to Reduce Automobile Use and Improve Air Quality in Cities; The Need, The Options, and Effects on Urban Activity (Washington: U.S. Environmental Protection Agency, Office of Air and Waste Management, 1974), pp. 1-3.

[2]Ibid., p. 13.

of the diversity in urban trip origins and destinations, it is not likely that public mass transportation can offer a widespread service that is as fast as the automobile. Since trip time is a key variable in the choice of mode, it is unlikely that transit will generally be able to compete with the auto. Nonetheless, high quality transit service has been able to compete quite successfully in specific high density corridors. For example, the Shirley Highway Express bus service in the Washington, D.C., areas has achieved a peak period ridership of about 40 percent, compared with an average peak period ridership of 19 percent for the system as a whole.[1]

Transit fare policies that have the objective of providing substantally improved service, including reduced trip time, in high density corridor markets at higher fares would be expected to attract trips from auto to transit and would be complementary with policies intended to achieve the prescribed ambient air quality standards. Similarly, paratransit services, such as vanpools or jitneys, that operate with relatively high load factors may also be improvements over the automobile, but will be less effective than conventional transit trips. In general, any aspect of transit fare policy which reduces vehicle miles of travel will make a positive contribution to improving ambient air quality and will be complementary with other environmental protection policies.

The second aspect of transportation control strategy which is directly related to transit fare policy is the set of measures intended to encourage the use of transit and carpooling and, by implication, to discourage the use of low-occupancy automobiles. Some of the measures suggested, which relate most directly to transit fare policy include:

- priority treatment of high occupancy vehicles, including transit vehicles;
- increased automobile user charges and reduced fare transit; and
- parking restrictions.

These and other aspects of transportation control strategies or, more broadly, transportation system management, are crucial adjuncts to a rational transit fare policy. In general, the individual measures will increase the quality of transit service, principally by reducing transit

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[1]Ibid.

trip times relative to the automobile, or by increasing perceived automobile trip cost relative to transit, which will have the effect of bringing perceived cost closer to actual cost. In general, there is a close complementarity between transit fare policy and the transportation control strategies needed to help meet the established ambient air quality standards.