TRANSPORTATION RESEARCH RECORD 1039

Transit Marketing and Fare Structure

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C. 1985

Transportation Research Record 1039
Price $7.40
Editor: Edythe Traylor Crump
Compositor: Lucinda Reeder
Layout: Marion L. Ross

mode
2 public transit

subject areas
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Printed in the United States of America

Library of Congress Cataloging-in-Publication Data
National Research Council. Transportation Research Board.

Transit marketing and fare structure.

(Transportation research record ; 1039)
1. Local transit—Fares—Congresses. 2. Bus lines—Fares—Congresses. 3. Local transit—Marketing—Congresses. 4. Bus lines—Marketing—Congresses.
I. National Research Council (U.S.). Transportation Research Board. II. Series.
TE7.H5 no. 1039 380 s 86-5312
[HE4341] [388.4'042]
ISBN 0-309-03955-X ISSN 0361-1981

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The Impact of Technology and Labor Management Strategies on the Efficiency of Telephone Information Services

MARC R. CUTLER

ABSTRACT

The impact of two trends on the operational efficiency of telephone information services provided by public transportation authorities is evaluated: (a) rapid technological advancement, and (b) new strategies in labor management. This paper is based on data acquired from 15 on-site case studies conducted at diverse transit authorities across the country, as well as a background literature search. Three technologies are examined: (a) automated and microfiche data retrieval systems, (b) automatic call-distributor (ACD) equipment with management information system (MIS) capability, and (c) computerized rider information systems (CRIS). Four experiments in labor management strategies are examined: (a) use of part-time agents, (b) use of entry-level clerks instead of former bus drivers as agents, (c) contracting out the service to a private firm, and (d) replacement of most agent positions with prerecorded taped messages. The central finding is that strategies that enhance labor productivity by increasing management's control over work practices and labor standards are effective for improving the efficiency of telephone information. This includes ACD equipment, use of part-time employees, and contracting out the service. Although CRIS also has this potential, its capital cost is high, particularly given the uncertainty of its marketing effectiveness in the United States. Replacement of agents with prerecorded announcements reduces costs and hence improves efficiency, but at an unacceptable cost to service effectiveness. Although automated data retrieval may improve the quality (and hence the effectiveness) of the service, it does not, by itself, improve the efficiency.

The purpose of this paper is to examine the impact of two dynamic trends on the operational efficiency of telephone information services provided by public transportation authorities. These two trends are (a) rapid technological advancement and (b) new strategies in labor management.

For the purpose of this paper, telephone information includes only the provision of information on the services offered by transit authorities, and not complaint-handling and other related functions handled by telephone. Included in this definition are two distinct types of calls: the schedule call--the caller knows the route he wants, but needs some specific information such as schedule or fare, and the itinerary call--the caller needs to know how to get from point A to point B.

Telephone information is considered one marketing strategy for getting information about transit services to the public. Other strategies include media advertising, timetable and map distribution, bus stop signs, on-street video displays, and community relations. Telephone information is distinguished from these other strategies by its simultaneous dependence on technology and labor intensiveness, which are interrelated.

By far the largest component of the cost of telephone information is the salaries of the telephone information agents. These costs can be contained and productivity can be improved either by changing the way in which these agents are managed, or by changing the technology on which they are dependent.

Until the 1970s, telephone information (and marketing in general) was often viewed as an unimportant backwater of public transit management. Telephone agents were frequently former bus drivers who were dumped into this role when they could no longer perform the job for which they were trained. Technology consisted of old-fashioned switchboards. Public complaints about busy signals, long waits on hold, and rude agents were common.

The budget crises of the late 1970s and 1980s have forced transit authorities to attempt to improve productivity in all segments of their operation. In addition, a more business-like approach to transit management has revitalized interest in private-sector marketing strategies. These trends have combined with a technological explosion to make telephone information one of the more dynamic areas in transit management. New technologies include automatic call distributor (ACD) equipment, automated and microfiche data retrieval, and computerized rider information systems (CRIS). These technologies (discussed in detail in a later section), have been made even more available as a result of the coincidental deregulation of the telephone industry. New labor strategies (discussed later) include the use of entry-level clerks, part-time employees, private contractors, and replacement of most agents with prerecorded announcements.

The focus of this paper is on the efficient production of telephone information service. Efficiency relates to the quantity of service produced for a given cost. In considering techniques to make telephone information more efficient, the ultimate effectiveness of telephone information as a marketing strategy has not been ignored. Effectiveness refers to the end product of an activity. Does it serve any useful purpose? In the case of telephone information, this might be increasing ridership or revenue for the system, providing essential information to citizens, or enhancing the image of the transit system.

Effectiveness can be enhanced by improving the efficiency of production or the quality of the final product (in this case, information). Quality may be improved through efficiency measures, or in opposition to efficiency. For example, the quality of a product can be improved by increasing the per unit cost of production (less efficiency) or by refining production techniques (more efficiency). Similarly, efficiency measures may have positive, negative, or neutral impacts on effectiveness. These impacts may be intended or unintended. Throughout this paper, an attempt is made to relate efficiency and effectiveness. This part of the discussion is, of necessity, mainly theoretical. Although there have been studies relating telephone information in general to effectiveness measures such as transit ridership, the relationship between a specific change in telephone information and an increase in ridership is mainly hypothetical at this time. Only the manufacturers of CRIS technology have claimed such a direct connection.

In the next section the methodology of this study and previous research conducted in the field is discussed. Given the large number of case study sites, transit authorities are referred to throughout this paper by city (or county) name, rather than by transit authority name or acronym. This is done to enhance the readability of the paper, and is not intended to imply that these transit authorities are city (or county) agencies.

METHODOLOGY

This paper is based on 15 case studies conducted at transit authorities across the country and a literature review of existing research in the field.

Case Studies

The data on which the findings of this paper are based were developed by using 15 on-site case studies. Although this represents too small a sample on which to base claims of statistical validity, it does represent a broad range of transit authority characteristics, geographic locations, and approaches to telephone information. Table 1 gives the characteristics of the transit authorities and their telephone information systems. Where hard data are lacking, the perceptions of transit authority officials working in this area have been relied on.

Case study sites ranged in size from Chicago, which has 5,071 revenue vehicles, to South Bend, Indiana, which has 57. The sites ranged from cities with intense transit use and long transit histories, such as Chicago and Milwaukee, to sunbelt cities with neither, such as Orange County, and San Diego, California, and San Antonio, Texas. The sophistication of the telephone information systems ranged from the most advanced automated equipment in Washington, D.C., to a switchboard operated by one agent in South Bend, Indiana, and Allentown, Pennsylvania.

Not all of the case study sites generated data relevant to this particular paper (although they may have generated data relevant to the study as a whole because the complete study concerned a wide range of issues relating to telephone information). Only those sites that did produce data specifically related to the topic of this paper are included in this discussion.

Evaluation Methodology

A literature search was conducted to establish a methodology for evaluating the data to be obtained from the case study sites. This research led to the definition of seven measurements of efficiency for telephone information.

- Percentage of calls that are placed on hold and wait in a queue before being handled by an agent.
- Length of time the average caller spends on hold.
- Percentage of calls that are lost from hold; that is, the caller gets tired of waiting and hangs up.
- Percentage of calls that receive a busy signal and thus cannot get into the system.
- Number of calls serviced (the caller actually gets to talk to someone) per agent per hour.
- Average transaction time (on-line with an agent) of each call.
- Cost per call.

Being placed on hold is a tremendously frustrating experience for the consumer. Many will give up and never call again (and perhaps never ride transit again, either). The literature indicated that in the transit industry, it is not unusual for 80 to 90 percent of calls to be placed on hold, with lost call rates of 11 to 22 percent (1). At the 15 case

TABLE 1 Case Study Characteristics

City	Transit Authority	No. of Reserve Vehicles	Special Characteristics
Chicago	Regional Transit Authority (RTA), Chicago Transit Authority (CTA)	5,071	Private contractor; microfiche
Los Angeles	Southern California Rapid Transit District (SCRTD)	2,905	Automated data, ACD
Washington, D.C.	Washington Metropolitan Area Transit Authority (WMATA)	2,061	Automated data
Seattle	Seattle Metro	1,299	Marketing Philosophy[a]
St. Paul	Metropolitan Transit Commission (MTC)	1,078	Automated data
Portland	Tri-County Metropolitan Transportation District of Oregon (Tri-Met)	660	Reduction of agent staff; microfiche
Miami	Metro Transit Agency	608	ACD (planned)
Milwaukee	Milwaukee County Transit System (MCT)	595	ACD
San Antonio	Via Metropolitan Transit	546	Marketing philosophy, part-time agents
Orange County	Orange County Transit District (OCTD) (Calif.)	497	Microfiche, part-time agents
Louisville	Transit Authority of River City (TARC)	311	Marketing philosophy
San Diego	San Diego Transit Corporation	280	CRIS
Albany (N.Y.)	Capital District Transportation Authority (CDTA)	240	Marketing philosophy
Allentown	Lehigh and Northampton Transportation Authority (LANTA)-(Pa.)	59	Marketing philosophy
South Bend	South Bend Public Trans (TRANSPO) (Ind.)	57	Marketing philosophy

[a] Marketing philosophy refers to a strongly held position of the authority either in favor of, or against, telephone information as an effective marketing tool.

study sites, an average of 58 percent of calls were placed on hold for an average time of almost 2 min. It was also found that 11 percent of these callers hung up (lost calls) before their calls were serviced.

A caller who receives a busy signal cannot access the system. Industries that place a premium on caller access for marketing success, such as the airlines, consider call busy rates in excess of 1 to 3 percent to be unacceptable (2). On the basis of limited data, an average busy rate of 15.7 percent was found.

The efficiency of agents in handling calls is an important determinant of overall system productivity. The literature suggested call handling rates that ranged from 20 to 40 calls per agent per hour (3). An average of 31 was found among the case study sites. Related to the number of calls handled is the amount of time spent on each call (transaction time). Although a few authorities stressed quality time over the quantity of calls handled, most emphasized providing essential information in the minimum amount of time in order to handle the maximum number of calls. An average transaction time of almost 2 min was found among the case study sites.

The average cost per call was $0.50, ranging from almost $1.00 to under $0.20. The main determinant in cost per call was the prevailing wage rate in the area. The remainder of this paper contains an analysis of the impact of new technologies and labor management strategies on improving these measurements of efficiency.

IMPACT OF NEW TECHNOLOGIES

Three technologies were evaluated in the course of this study:

- Automated and microfiche data retrieval,
- Automatic call distributor equipment with management information system (MIS) capability, and
- Computerized rider information systems.

Traditionally, telephone information agents would find information by flipping through well dog-eared timetable and routing books. From this they construct a routing (itinerary) for callers wanting to know how to get from point A to point B. Depending on the size of the transit authority and the skill of the agent, some agents would memorize many answers over time and thus speed up the process.

The first application of a new technology to this function came in the mid-1970s with the use of microfiche readers. These machines work in one of two ways. The most familiar type enables the user to scroll through a microfiche file to locate, by trial and error, a specific item. A more advanced version permits the user to enter a code on a keyboard that will automatically locate a specific item, in this case a route timetable. Five transit authorities (Chicago, Miami, Orange County, Portland, and Washington, D.C.) either currently use microfiche or have used it in the past.

Automated data retrieval systems take the functions of data storage and retrieval from paper and microfiche and place them on a computer. Thus, each agent works at a video display terminal calling up answers from a computer memory. In addition, many of these systems also perform the function of calculating the best available routing by means of a software algorithm. In theory, this added function eliminates the interpretive role of the agent in working out answers to complex itinerary (routing) questions. Two authorities, Washington, D.C., and Los Angeles, have systems that perform all three of these functions (data storage, retrieval, and calculation). In St. Paul the system performs only the data storage and retrieval functions.

Automatic call distributor equipment has its origins in the call sequencers developed for the airlines during the boom years of the 1960s. The basic function of this equipment is to sequence calls on a first-come, first-served basis so that no callers experience random long-holds. It was hypothesized that this feature would reduce the number of calls lost from hold. The newest generation of this equipment includes a complete management information system component. For example, data will be compiled on both live video screens and hard copy printouts on the type of efficiency measurements discussed. This enables the system managers to evaluate the productivity of their operation as a whole and the performance of individual agents. Whereas supervisors previously had to check up on agents by peering around the room or listening in on calls, they can now simply view, in real time, a numeric description of an agent's performance on a video display. The following transit systems have installed this type of ACD equipment: Chicago, Los Angeles, St. Paul, and Milwaukee.

The final technological advance investigated was the computerized rider information system (CRIS). The basic function of a CRIS is to replace agents with a computer-generated voice response. The service area of the authority is divided into a series of route or even service-stop-specific components. Each component receives a unique telephone number that riders may call to receive a computer-generated voice response describing service in their specific service area. These calls can be made from home, or in some cases, from telephones installed at major service stops. The real potential of a CRIS system lies in its ability to be updated on a real-time basis. For example, if weather or traffic has disrupted a vehicle's schedule, this information could be substituted for the standard timetable. Thus riders (particularly those in inclement climates) would not have to run out and wait for a vehicle that was delayed. Theoretically, this would make these riders more likely to use transit. One test of CRIS technology conducted in San Diego was investigated. UMTA is currently sponsoring CRIS tests in Columbus, Ohio, Erie, Pennsylvania, Pittsburgh, and Salt Lake City.

Automated and Microfiche Data Retrieval

Microfiche data retrieval is a technology whose time appears to have passed. There is no evidence that microfiche enhances any of the efficiency measurements. In fact, three problems associated with microfiche appear to be almost universal:

- The machinery tends to break down under heavy use.
- It is expensive and time-consuming to update the data base.
- The system is ineffective for answering itinerary-type questions, particularly those requiring a transfer.

For these reasons, both Washington, D.C., and Miami abandoned microfiche in the late 1970s. Washington automated, and Miami returned to a manual system. Although the three authorities that still use microfiche expressed general satisfaction with its performance, no authority not currently using it expressed any interest in adopting it.

The situation is more complex among automated data retrieval systems. These projects were instituted as highly publicized UMTA capital and research grants. This is particularly true of the Washington, D.C., project known as Automated Information Directory System (AIDS) and the Los Angeles Computerized Customer Information System project (CCIS). Both have been studied in depth and have developed a strong constituency for the concept in the public sector and in the private software development field.

As mentioned previously, the Washington, D.C., and Los Angeles systems perform the three functions of data storage, retrieval, and calculation. The St. Paul system does not perform calculation. Nevertheless, there are significant differences between the Washington, D.C., and Los Angeles systems:

- AIDS was implemented throughout the entire Washington, D.C., service area whereas CCIS was implemented as an experiment in only a small part of the Los Angeles service area. Los Angeles is now preparing to implement CCIS areawide.
- Washington uses a dedicated minicomputer, whereas Los Angeles' telephone information center shares time with other departments of the transit authority on a mainframe computer.
- Washington's agents were trained in-house and were actively involved in designing the system, whereas this was not the case initially in Los Angeles.

A variety of problems have affected all three systems. Rewiring and upgrading of air conditioning (for the computer) has been expensive and time-consuming. The time-sharing arrangement in Los Angeles resulted in processing slowdowns when other departments did large batch-processing jobs. This problem has been resolved by improved scheduling. On the other hand, Washington, D.C., has encountered processing slowdowns by exceeding the capacity of its minicomputer far more quickly than anticipated. This capacity is now being upgraded. Los Angeles, by initially turning over project design and training to an outside contractor, encountered severe staff resistance.

Despite these divergent experiences, the impact of the equipment has been quite consistent. Contrary to initial expectations at all three authorities, automated data retrieval has not resulted in improved operational efficiency.

This conclusion is demonstrated by the data in Table 2. The three systems that have automated retrieval are near or below average in almost all efficiency measurements. This interpretation is also supported by the telephone information managers who were interviewed. Among the three systems, Washington, D.C., had perhaps the most realistic expectations regarding automated retrieval as an efficiency tool, and the least disappointment.

What automated data retrieval has done, according to system managers, is improve the quality (i.e., effectiveness) of information by providing more accurate, up-to-date, and consistent answers to questions. This is accomplished (in the Washington, D.C., and Los Angeles systems) by providing agents with a single, correct answer to difficult itinerary questions, instead of having each agent figure out his own answers. In addition, updating a computerized data base is significantly easier than either hard copy or microfiche update. Thus, the data base can be more easily kept current and accurate. System managers, particularly in Washington, believe that this improved service quality translates into enhanced marketing effectiveness.

TABLE 2 Impact of Automated Data Retrieval on Efficiency

Measurement	Washington, D.C.	Los Angeles[a]	St. Paul	15-City Average
Calls on hold, %	75	75	50	57.5
Time on hold	4:45	4:30	2:30	1:50
Lost from hold, %	8	39	10	11.1
Calls per agent per hour	22.5	27	25	30.9
Transaction time	2:45	2:12	1:38	1:50
Busy signals, %	18	13	NA	15.7
Cost per call, $	0.47	0.83	0.94	0.50

[a] The Los Angeles data represent the period between the installation of CCIS in a test area and the installation of new ACD equipment.

Reasons for the failure of automated retrieval to improve agent efficiency vary. In Washington, D.C., this function always played a secondary role in management's philosophy to improve the quality of information. Thus, agents are instructed to use AIDS only when needed and to answer questions fully rather than quickly. Reflecting this philosophy, Washington, D.C., had the lowest level of calls per agent per hour (20 to 25) of all the authorities studied.

On the other hand, Los Angeles officials have always stressed the efficiency potential of CCIS. Their explanation (supported by St. Paul officials) as to why this potential has not been reached is that this technology by itself cannot solve problems rooted in labor performance. Controlled tests conducted at Los Angeles during the implementation of CCIS found agents capable of handling 28 to 32 calls per hour, whereas they only handled the then standard Los Angeles rate of 20 while actually on-line with CCIS (4). The explanation of Los Angeles officials for this phenomenon is that agents use CCIS to pursue their own, rather than the authority's agenda. Thus, instead of handling more calls per hour, the agents use the enhanced data retrieval capability of CCIS to handle the same number of calls per hour as before, while providing themselves with additional informal downtime. This downtime can take the form of checking answers unnecessarily with the computer, or simply resting between calls. The telephone equipment in use required the agent to request the next call feed.

All three authorities planned to combat this problem by turning to automatic-call-distributor equipment. The impact of this equipment is examined next.

Automatic-Call-Distributor Equipment

Automatic-call-distributor equipment with management information system capability is the one technological development that has statistically demonstrated the capability of improving the efficiency of telephone information.

This capacity is demonstrated by the data in Tables 3 and 4 using two different efficiency measurements. The data in Table 3 display the change in the calls lost from hold rates for the four authorities that installed new ACD equipment. As shown, three of the four authorities (Chicago, Los Angeles, and Milwaukee) documented improvements ranging from 43 to 86 percent in this productivity measure. This means that far fewer callers were hanging up after

TABLE 3 Improvement in Calls Lost from Hold, ACD

Authority	Previous Calls Lost from Hold (%)	Current Calls Lost from Hold (%)	Improvement (%)
Chicago	35	5	86
Los Angeles	39	11	72
Milwaukee	11.3	6.4	43
St. Paul	10	10	0[a]

[a] Reduction in agent staff is 17 percent.

TABLE 4 Improvement in Agent Efficiency, ACD

Authority	Previous Calls per Agent per Hour	Current Calls per Agent per Hour	Improvement (%)
Milwaukee	22.6	41	81
Chicago	31.5	35	11
Los Angeles	27	30	11
St. Paul	25	25	0

being placed on hold. This could only be due to a reduction in the average amount of time spent on hold. While Chicago instituted a major change in its labor arrangements simultaneously with the installation of AIDs equipment, the situations in Los Angeles and Milwaukee were relatively stable and controlled. Although St. Paul was unable to document a similar improvement, transit officials were able to maintain the same level of performance with a 17 percent reduction in the number of agents employed.

The data in Table 4 indicate a similarly dramatic impact on agent efficiency, ranging from an 11 percent improvement at Chicago and Los Angeles to 81 percent at Milwaukee. Although St. Paul could not document improvement, if fewer agents were handling the same number of calls as before the change, each agent had to be handling more calls per hour. It is reasonable to assume that improvements in lost call rates would coincide with increases in agent call-handling levels.

ACD equipment can, in theory, accomplish the following:

- Improve call sequencing to eliminate the random "long" hold.
- Provide managers with better data to enhance their ability to schedule staff between peak and off-peak periods.
- Provide supervisors with better data to monitor individual agent performance.
- Feed calls automatically to the next available agent, removing the power from the agent to call for a call when ready.

The managers at all four authorities attributed the efficiency improvements primarily to the last two points, the improved ability of supervisors to monitor individual agent performance, and the automatic call feed. For example, Milwaukee's marketing director stated that "the key to agent productivity is availability to answer calls." He went on to point out that an agent should be available (according to their work rules) to answer calls 440 min during the day. With ACD equipment, they now have the means to enforce that standard. In Los Angeles, the installation of new ACD equipment will enable managers to enforce a new, higher standard for calls serviced (actually answered by an agent), and to institute very specific work rules regarding time away from the work station. They believe that this will enable them to take full advantage of the efficiency potential of the automated data retrieval system.

Computerized Rider Information Systems (CRIS)

The impact of a CRIS system was reviewed at San Diego, which had conducted a test financed jointly by the transit authority and a leading CRIS contractor. Two caveats must be expressed regarding the results of this test. First, San Diego is a sunbelt city with the most benevolent climate in North America. The value of the CRIS concept was first demonstrated in Canadian cities where climate made up-to-date bus status reports a highly valued piece of information (5). Second, disagreements between the San Diego transit authority and the contractor resulted in delays and mid-experiment design changes that could also have affected the results.

San Diego officials viewed CRIS as a tool for improving both the effectiveness and efficiency of telephone information. CRIS technology is being aggressively marketed specifically as a device for increasing transit ridership, particularly in off-peak periods (6). The theory is that casual, sporadic off-peak riders will be more likely to use transit if they can obtain real-time status reports on the operation of their route. San Diego, as a classic sunbelt transit authority, had low market penetration, low visibility, and little tradition of transit riding. They were therefore particularly interested in CRIS' potential as a marketing tool.

However, the San Diego Transit Authority also recognized that they had a severe capacity problem on their telephone information system, a situation confirmed by this author's evaluation. Basically, the lack of knowledge about transit among riders induced a high level of calling for information. This phenomenon was observed not only in San Diego, but also in the other sunbelt cities as well. Thus, the hope was that if a significant percentage of calls could be diverted from live agents to CRIS, the efficiency of the "live" system would be improved without the long-term operating costs of hiring more agents.

Five typical routes were chosen as CRIS test routes, and three similar routes were chosen as control routes. The control routes were subjected to traditional direct mail and on-board marketing campaigns. CRIS was heavily marketed on the test routes. The test was to be considered a success if the CRIS routes increased ridership by at least 3 percent more than the control routes. The test lasted for 6 months.

Routes	Ridership Change (%)
CRIS	-2.8
Control	+1.3
Rest of authority	-7.0

As indicated below, while both the control and test routes outperformed all other routes in the authority, the control routes outperformed the CRIS routes by 4.1 percent. The CRIS routes actually experienced a net ridership decrease (although not as severe as the rest of the authority). At least in a sunbelt city such as San Diego, CRIS did not prove to be an appropriate tool for increasing the effectiveness of telephone information as a marketing tool.

Nevertheless, San Diego officials still believe that CRIS has the potential to improve the efficiency of telephone information. For example, they estimate that they lose approximately 5,000 calls per day. If 20 percent of these calls are the schedule-type call (as opposed to an itinerary call) that can be handled by CRIS, this could divert 1,000 calls per day from the live telephone system. (CRIS is not effective for itinerary calls because the caller must first know what route telephone number to call.) To handle these calls would require four additional agents. In the long run, the initial capital investment for CRIS ($500,000 for only five routes) might prove more cost-effective than hiring additional agents and increasing operating costs long into the future.

Thus, the experience of CRIS in San Diego was really the opposite of the automated data retrieval experience in Washington, D.C., and Los Angeles.

AIDS and CCIS, initially perceived as means of increasing efficiency, have proven to be mainly devices for enhancing effectiveness. CRIS, perceived as a device for enhancing effectiveness, was found to have greater potential for improving efficiency. However, its initial capital cost compared with either ACD equipment or automated data retrieval is high. The complete AIDS installation in Washington, D.C., cost about $1,000,000 for all routes. Milwaukee estimated that its ACD equipment cost $500 per month more than its old telephone equipment. Based on efficiency improvements, Milwaukee transit officials estimated a 5-year breakeven point. New ACD equipment in Los Angeles cost $300,000. In San Diego, agents' starting salary was $12,418 per year. Assuming 100 percent overhead, the avoidance of the need for four new agent positions will save almost $100,000 per year. This will result in a 5-year payback for the capital cost ($500,000), without discounting for inflation or considering the operating costs of CRIS. However, this only covers 5 of San Diego's more than 25 routes. Thus, CRIS may be an expensive method of improving efficiency and hard to justify without more certain payback in increased ridership and revenue.

LABOR MANAGEMENT ISSUES

In this section the impact of four trends or experiments in labor relations involving telephone information agents is examined:

- Use of entry-level personnel instead of former bus drivers,
- Use of part-time employees,
- Contracting out of work to a private firm, and
- Elimination of most agents positions in favor of prerecorded announcements.

Use of Entry-Level Personnel

Of the 15 transit authorities included as case studies, only 3 continue to employ significant numbers of former bus drivers as telephone information agents: Milwaukee, St. Paul, and Portland. Both Milwaukee and St. Paul officials hope to phase out this practice. Chicago and Los Angeles eliminated the practice of using former bus drivers in recent years.

Agent productivity in Milwaukee was the best among all the case studies (41 calls per agent per hour) following installation of new ACD equipment. Productivity in St. Paul was relatively poor (25 calls per agent per hour), and officials there conceded that serious problems existed in labor-management relations. Productivity in Portland was just slightly below average (29 calls per agent per hour). Although Portland officials expressed general satisfaction with agent performance, they eliminated most agents in a dramatic cost-cutting move. (See section on Eliminating Agent Positions.)

There are generally two complaints about the use of former bus drivers as telephone information agents. First, although bus drivers may be knowledgeable about the route network, they are poorly suited by temperament and training for the task. Second, they are expensive. They have seniority, and typically maintain their membership in the bus driver's union. Portland had the highest starting salary of the 15 authorities ($11.82/hr), primarily because they had eliminated most of their junior-level employees. Milwaukee had the second highest level ($9.01/hr), whereas St. Paul's starting salary was closer to average. The impact of the use of former bus drivers can be seen in the fact that wage rates in Portland and Milwaukee exceeded those of much larger and more expensive cities such as Chicago, Los Angeles, and Washington, D.C.

Entry-level personnel, in addition to costing less, can be trained from the start of their employment with the transit authority to perform this specific, difficult function. Bad habits do not need to be changed.

Most managers believed that entry-level personnel provided better quality (hence more effective) service once they learned the route network. They also believed that being more responsive to management direction, they provided more efficient service as well, although insufficient data existed to prove this point.

Use of Part-Time Employees

Transit telephone information suffers from the same peak-to-base ratio problems as transit service itself. The morning and late afternoon ridership peaks roughly correspond to similar calling peaks. The cost-effective management solution for telephone information service, as for operations, is the use of part-time employees.

Traditionally, with the use of former bus drivers as agents, union rules prohibited the employment of part-time agents. However, this pattern is changing. Eight of the 15 case study sites currently employ part-time agents, and one other is negotiating with its union for the right to do so. Three systems (Allentown, San Antonio, and Orange County) employ primarily part-time agents. This list includes both unionized and nonunionized authorities. Of those not employing part-time agents, officials in Washington, D.C., and San Diego opposed the practice; St. Paul and Portland had strong unions and used former bus drivers, and Albany and South Bend were too small for it to be an issue.

The major arguments against the use of part-time agents is that (a) they do not work enough hours to become proficient, and (b) they have high turnover rates requiring frequent and expensive training of new hires. None of the authorities currently employing part-time agents reported any problems of this nature. Although the sample is small, and many factors are involved, there is no statistical evidence that part-time agents are less proficient, nor is there statistical evidence that authorities with large numbers of part-time agents employ fewer agents than authorities of comparable size.

Contracting Out the Service

One of the most dramatic experiments encountered in researching this paper was the decision of the Chicago area Regional Transit Authority (RTA) and the Chicago Transit Authority (CTA) to contract out their telephone information service to a private firm. This author is unaware of other authorities that have taken this step. It is a particularly startling development given that it took place in one of the old-line, strongly unionized, northern urban transit authorities.

The Chicago Transit Authority operates the bus and rapid rail systems in the city of Chicago and nearby communities. The Regional Transit Authority operates or contracts for the operation of commuter rail and suburban bus services, as well as performs regional multimodal planning and financing functions. Until March 1983 CTA provided all telephone information service for Chicago area public transit in-house under contract to the RTA. At that time, the RTA contracted out all transit telephone information to the firm of Very Important Personnel, Inc. (VIP). VIP is essentially a temporary employment agency that provides fill-in support staff to private corporations.

The decision to contract out was made for both cost and quality reasons. Chicago officials estimate that by contracting out they will reduce the cost of telephone information by $500,000 annually. This cost savings is due almost entirely to the change from unionized CTA agents (primarily former drivers and ticket agents) earning $9.00/hr to nonunionized, entry-level clerks earning $6.00/hr. RTA officials also believe that the quality of the service has been improved. They characterized CTA agents as often "unfriendly" and "difficult to discipline or fire" because of union regulations.

As discussed in the section on Automatic-Call-Distributor Equipment, Chicago has experienced significant efficiency improvements; however, it is impossible to definitively attribute these improvements to any one of the following factors:

- New ACD equipment,
- Replacement of former bus drivers with entry-level clerks, or
- Replacement of unionized government employees with nonunionized private sector employees.

Chicago officials tended to downplay (for understandable reasons) the significance of the last point. This author tends to believe that, along with the ACD equipment, it was highly significant. In combination, these two changes enabled Chicago to regain management control and impose and enforce work standards on their employees.

The transition to the new system was not without its problems. Initial cost savings were not as high as anticipated. New agents were rushed into service with low knowledge levels. Although caller complaints about agent rudeness essentially stopped, complaints about inaccurate information and calls taking too long soared.

Chicago officials recognize that mistakes were made because the process was rushed (undoubtedly to secure a fait accompli for political reasons). CTA personnel were initially used as trainers and, not surprisingly, resented losing the service. Microfiche data and microfiche data retrieval machines were vandalized during the last weeks of operation at CTA. By the time the machines arrived at VIP, most were in need of repair.

In retrospect, it is somewhat surprising that Chicago did not experience even more serious labor problems in implementing this decision, as it involved the transfer of CTA jobs. It does appear that Chicago ameliorated the potential for labor problems by placing agents in other open positions within the organization. A few even accepted transfer to VIP at the lower salary. Nevertheless, it is a commentary on the strength of management's hand in labor relations today that this change could be effected with as little trouble as occurred.

Eliminating Agent Positions

An equally dramatic experiment was undertaken at the Portland transit authority (Tri-Met). Due to budgetary constraints, Portland needed to reduce the cost of its telephone information service. Public opinion surveys revealed that 10 percent of callers made 65 percent of all calls. (The "frequent caller" syndrome is a commonly perceived problem in the industry but little data exist regarding its extent.) Portland's goal was to create a special product that would remove frequent callers from the regular telephone system and to target live telephone information to new riders with little knowledge of routes and schedules.

This goal was pursued through the replacement of 11 out of 17 live telephone agents with prerecorded taped messages for each of the 65 Portland routes. This system is known as Call-A-Bus (CAB). Because Portland's agents are mainly highly paid former bus drivers, this action resulted in savings of $242,000 in annual operating costs.

The CAB is not advanced technology, it is rather a different application of older technology implemented specifically to reduce labor costs. Thus, it has been included in the labor management section rather than the section on new technologies. This is not a CRIS system; the messages are prerecorded by humans rather than computer-generated, and there is little real-time updating capability. Also unlike CRIS, each message must supply information on an entire route, not just a small relevant section. This results in extremely long and complex messages.

Four agents now staff a traditional live telephone information service during business hours only. Most calls (70 percent) go to the CAB system, which operates 24 hr/day. A small office has been set aside to house the tape recorders, and a separate machine is required for each tape. One telephone agent spends approximately one-half of her time maintaining the tapes. This work involved performing semiannual updates, reroutings, and record-keeping such as call rates per machine. The tape system affords callers instant access in that there are almost no holds or busy signals. Portland officials estimate that given the anticipated expansion of the transit authority, including the addition of light rail service, the CAB will save $1,015,597 in personnel costs by 1986. This calculation is based on 8 percent inflation, the present reduction in staff, and the augmentation in staff that would have been necessary to maintain current service levels.

To compensate for the reduced availability of live information, other forms of marketing were substantially increased. New informational bus stop signs were located throughout the region. These signs include information on fare zones, routes, frequencies, and directions. In addition, Portland had previously invested heavily in interactive video communication. The downtown transit mall consists of eight trip planning kiosks that provide systemwide maps and menu-driven, user-activated video screens that identify routes, destinations, and relevant schedule data. This concept will be greatly expanded with the advent of the light rail system.

The CAB system is clearly oriented to the user who has a certain degree of familiarity with the route network. As callers with absolutely no knowledge of the transit network, we must confess to being left behind by a typical taped message within 5 sec. It clearly would be impractical to create a separate message for smaller route segments and to maintain a separate tape recorder for each.

Portland officials report that during the first few months of operation, there were considerable complaints about the change. However, after almost a year of operation, there were few complaints. Nevertheless, there were some disturbing changes in Portland's efficiency measurements. Most particularly, the lost call rate increased from approximately 14 percent to 26.4 percent--the highest level observed among the 15 case studies. Lost calls are a prime indication of unmet demand. The increase in this indicator clearly suggests that Portland has reduced the supply of live agent service beyond the reduction in demand for this service and its diversion to CAB.

On the other hand, cost savings were indeed substantial. The cost per call for CAB is $0.06, compared with $0.74 for agent-handled calls. Among the case study sites, Portland now devotes the lowest share of its operating budget (0.2 percent) to telephone information.

Lacking public opinion survey data, it cannot be stated definitively whether the CAB system provides as effective a service as live agents. Certainly the lost call rate is indicative of unmet demand. The relative lack of complaints could mean that Portland is meeting people's informational needs in other ways (as Portland officials contended), or that a portion of the constituency has simply ceased to attempt to obtain information. Although Portland may have found a cost-effective way to meet the needs of frequent riders, there must be concern about the impact of this system on future ridership growth. Given the complexity of the CAB message, and the high lost call rates, individuals with the greatest need for information (non-riders or infrequent riders) receive the poorest informational service from Portland. If the needs of this market segment are not met, from where will ridership growth come?

At the time of the case study, Portland officials vigorously defended this system as one begun for budgetary reasons, but one that had become desirable in its own right. Since that time, several management changes have taken place and some telephone information agent positions have been restored.

CONCLUSIONS

The conclusions from this study are that the crucial element in improving the efficiency of telephone information is labor productivity. Actions, whether technological or management-oriented, that attack the problem of labor productivity, have the potential to produce more efficient service. These actions include installation of ACD equipment with management information system capability, use of part-time agents, and contracting out services. All of these actions have one feature in common: they provide management greater supervision over employee work habits and greater control over the establishment of work assignments.

On the other hand, automated data retrieval, despite the expectations for it, has not had this impact. In theory (although no hard data exist), it is capable of improving the quality of the information provided. But this is different from improving the efficiency with which the information is provided. Automated data retrieval has had a positive impact on efficiency only when combined with a management-control tool--ACD equipment.

Both CRIS and Portland's CAB system appear to have the potential to improve some efficiency measurements, but their impact on effectiveness is questionable. Although CAB improved the cost per call, it harmed other efficiency measurements such as lost call rates. This, in turn, may well have a negative impact on effectiveness by failing to meet the demand for information. Contrary to expectations, CRIS had a relatively neutral impact on effectiveness in San Diego. CRIS is marketed by private contractors primarily as a means to directly affect ridership (hence revenue) levels by improving the quality of telephone information. This, in turn, justifies its capital cost. Viewed as a means to improve the efficiency of producing telephone information, with a much more tenuous connection to ridership and revenue (i.e., effectiveness), the cost is hard to justify in comparison with other available tools.

Thus, in considering a change in the telephone information system, it is important for a transit system to understand its goal. If the system is primarily concerned with improving marketing effectiveness, automated data retrieval may well be the answer. CRIS may also be effective in certain circumstances (such as cold weather climates). If the interest is in improving efficiency, ACD equipment (by itself or in combination with automated retrieval) or labor management strategies are more appropriate. In selecting a goal, the agency must realize the potential interrelationship of efficiency and effectiveness. Strategies that improve certain efficiency measurements (such as Portland's CAB system) may have negative consequences for marketing effectiveness, and thus cost the authority money in the long run by depressing ridership growth. However, both automated data retrieval and efficiency actions such as ACD equipment may enhance the ultimate effectiveness of telephone information. Automated data retrieval provides better information, even though it does not improve the efficiency by which the information is produced. ACD equipment, for a modest capital investment, can improve the amount of information disseminated, which also may have an impact on effectiveness. It definitely does have an impact on staffing levels, unit costs, and other efficiency measurements such as lost calls and holds.

A topic for future research might be the establishment of a relationship between these various actions and transit ridership levels. UMTA is conducting such a study in regard to CRIS, but this author is not aware of studies involving automated data retrieval or ACD equipment. It would be particularly worthwhile to know whether information quality (consistent, up-to-date answers as produced by automated data retrieval) or quantity (short and infrequent holds produced by ACD equipment) is the more significant factor, or if either has any impact.

ACKNOWLEDGMENT

The research on which this paper is based was conducted under a contract with the Transportation Systems Center (TSC), U.S. Department of Transportation. The project was sponsored by the Urban Mass Transportation Administration, Technical Assistance Program. The author would like to acknowledge the assistance and support of John Durham, project sponsor, and Mary Jane Miner, project monitor, as well as that of the marketing and telephone information managers at the 15 case study sites. These individuals willingly contributed their time and expertise to this project.

The results of this research have been published by the U.S. Department of Transportation under the title "The Effectiveness of Telephone Information Service in Transit" (February 1984).

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The opinions expressed in this paper represent only those of the author.

Publication of this paper sponsored by Committee on Public Transportation Marketing and Fare Policy.

Transit Marketing: The State of the Art

CAROL WALB and ROSEMARY BOOTH

ABSTRACT

The role of marketing in the transit industry has undergone numerous changes in the past decade, expanding as the task of attracting new riders or retaining existing riders has become more complex. A review of current marketing practice at representative transit agencies in North America is summarized in this paper. The review demonstrates the complexity of the marketing function, which encompasses market research, service development, pricing, promotion, consumer aids, and evaluation. Although most agencies surveyed reported activities in each of these areas, few had comprehensive programs that linked all elements. Considerable sophistication was demonstrated in specific promotional techniques such as radio and television advertising; use of car cards and billboards and in consumer information aids such as schedules and timetables, telephone information systems, and system maps. Quantifiable evidence of the effectiveness of such techniques is generally lacking, however, and a need for further research is evident. The review revealed a number of promising new practices. Included among these are market segmentation and target marketing, direct contact marketing, electronic user information aids, and consumer orientation training for transit agency employees.

In recent years significant advancements in marketing practice have generated considerable interest in the transit industry in transferring some of the successful techniques to the public sector. At the same time, there is a recognition that the marketing of a public sector service good such as transit is different in many respects from the marketing of consumer goods in the private sector.

Although the level of interest in transit marketing has been increasing since the 1970s, little attention has been given to evaluating marketing programs or specific marketing techniques. As a result, transit marketing often occurs without a clear cost justification and cannot command the full support of top management. Some evidence of what works in the context of transit marketing is provided by current and past practice. In this paper an assessment is presented of current practice in transit marketing. The research for this paper was sponsored by the Urban Mass Transportation Administration under the Service and Methods Demonstration Program.

This paper is the product of three research steps, including a review of prior research, an inventory of current marketing techniques, and a survey of marketing directors from 25 transit agencies in North America. The remainder of the paper is organized into three sections. The first provides a discussion of the role of marketing in transit and its relationship with other planning and operational functions within an agency. The second section includes a description of the range of marketing techniques currently used by transit operators. The final section contains a summary of the organization and function of marketing in the transit industry today and an assessment of the relative effectiveness of the most commonly used techniques in each functional area.

ROLE OF MARKETING IN TRANSIT

Although transit managers almost universally agree that some level of marketing is necessary, there is far from consensus on what marketing is, and how much is needed. Transit managers who have a more traditional product-oriented approach tend to define marketing as advertising and promotion, whereas managers who have a more consumer-oriented approach tend to view marketing as an active element of service planning, operations, and strategic planning. If marketing is to make a significant contribution toward the cost-effective delivery of transportation services, its scope must be broadened beyond the limits of advertising and promotion.

One possible framework for a comprehensive approach to marketing in the transit industry is shown in Figure 1. It is based on recommendations of prior research efforts in transit marketing (1-3) and on discussions with transit marketing professionals. The proposed shift from production to consumer orientation and the role for marketing in directing all agency activities are consistent with current marketing theory (4).

From the perspective of the marketing department, marketing is seen as a set of interrelated activities, including market research and program evaluation in addition to the more traditional activities of promotion, advertising, public relations, and customer information. From an organizational perspective, the marketing function can be seen as being part of other functional areas of the transportation agency--product planning, pricing, and operations. This is not to suggest that marketing staff should be responsible for the activities of these areas, but rather that marketing activities should provide direction for them. Marketing works best when a consumer orientation pervades the organization, top to bottom.

The individual elements of a comprehensive marketing program might function as follows:

- Market research, the link between the consumer and the transit agency, should play a central role in any comprehensive marketing program, from the development of objectives and marketing strategies through promotion of transportation services, provision of customer services, and evaluation and monitoring of specific marketing programs.
- Service development and pricing play the role of adjusting service or packaging it in such a way as to be more appealing to the consumer. Current riders are provided rewards or additional reasons for using transit and prospective riders are provided more good reasons for considering transit use.
- Consumer information services provide current and prospective users the information needed to use the transit system.
- Public relations activities are fundamental to developing and maintaining community support and awareness of agency activities.
- Advertising and promotion activities are fundamental to attracting and maintaining transit system ridership. In contrast to public relations, these strategies concentrate on conveying a specific message to targeted segments of the transit market rather than a broader message to the general public.
- Evaluation activities are designed to measure the effectiveness of individual marketing activities, other marketing elements, and the overall marketing program.

A review of current transit marketing practice in North America shows that the integration of marketing

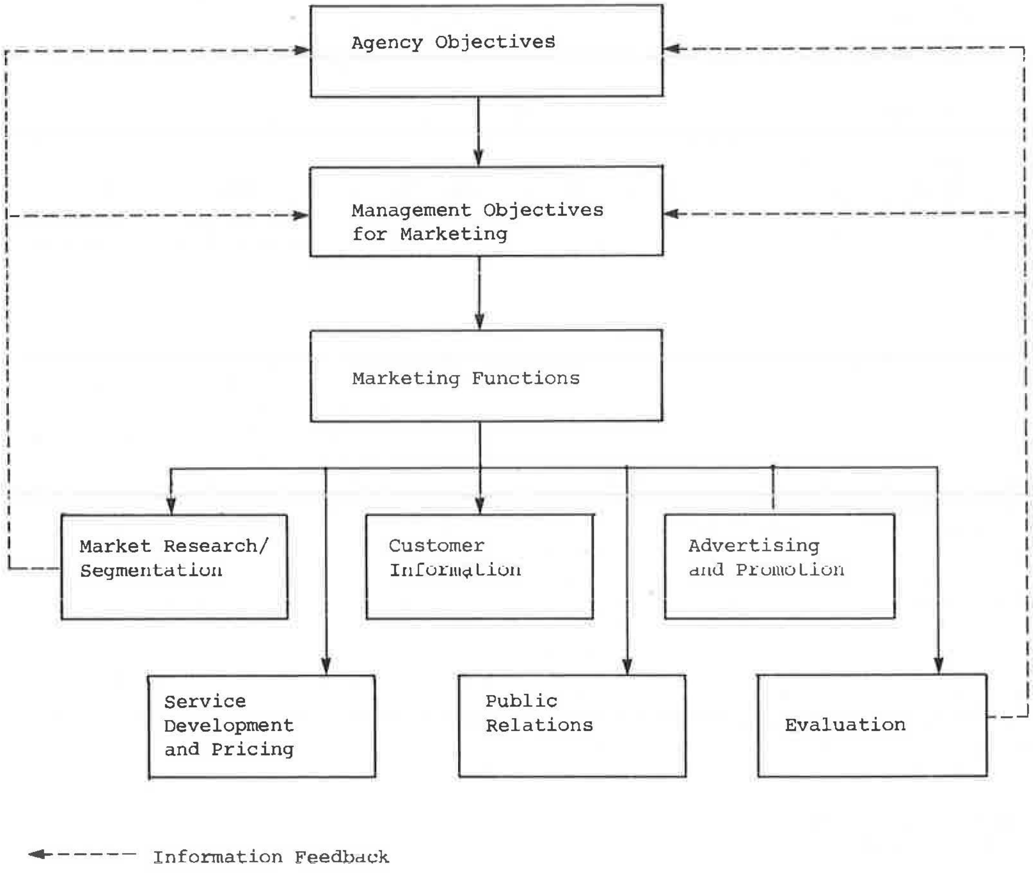

FIGURE 1 Integrated structure for marketing.

with other transit agency activities is not common. Many properties use sophisticated approaches to marketing, with well-developed and effective marketing techniques, but few have an organizational structure and planning process that fully exploits the contributions of a comprehensive marketing program. The most common organizational structure found among transit agencies--even those with sizable marketing budgets--separates service development, pricing, and promotion. Considerable information can be lost when responsibility for these functions is dispersed.

REVIEW OF MARKETING PRACTICE

Individual transit agencies use a wide variety of techniques to meet a range of marketing and system objectives. Highlighted in this section are some techniques currently used by transit operators to market transit services in terms of their objectives, how they work, and how their effectiveness is measured. [A list of techniques and examples of their use are given in Table 1 and detailed information can be found in reference (5).] The techniques are divided into the same functional areas as in the previous section. The marketing function at any given transit agency may not be structured exactly this way and may not include activities in all areas, but the categorization is intended to cover the current range of all transit marketing activities.

Market Research

Historically, marketing activities in both the public and private sectors have largely been concerned with product or service packaging and promotion. Changes in demographics and lifestyles over the past several decades have resulted in a proliferation of markets and a recognition that the logical first step in product development is identifying what the consumer wants and needs. In the private sector this has meant moving from an emphasis on making products and then selling them to an orientation that emphasizes producing what the consumer wants. Market research is the key element in this process.

The transit industry has begun to move in this direction for a variety of reasons. Publicly operated transit systems are called on to provide a wider variety of transit services than those provided by their privately operated predecessors, usually in a highly visible and political arena. In addition to meeting the needs of commuters, publicly owned systems must address the mobility needs of such diverse groups as shoppers, the elderly and handicapped, students, and others. Increasingly, marketing is being viewed as a comprehensive process that identifies the needs of specific consumer groups, develops services to meet those needs, suggests promotional strategies, and feeds back evidence of success or failure in the transportation marketplace. This view of marketing puts market research in a central position.

Current transit market research practice emphasizes a market segmentation approach, which identifies subgroups and non-user markets, each of which seeks different attributes from the transportation system. In target marketing, individual activities are developed and aimed at a particular market segment, based on characteristics such as demographics, travel patterns, and residential location. Nearly all transit agencies do some target marketing, and it is not unusual for an agency to target all of its marketing activities.

Although market research is widely viewed as an important and effective component of transit marketing, its full potential has yet to be realized. Transit agencies use a variety of market research techniques, but generally lack the resources to apply them fully and consistently. On-board surveys and telephone surveys are among the market research techniques most widely used to determine user attitudes and assist in the design of improved service delivery. Employer surveys have been used to find out more about employee travel behavior. Newer market research techniques include the use of request cards and coupons, focus groups, and electronic questionnaires to determine consumer attitudes toward transit services. In cities with limited resources available for market research surveys, attitude and awareness studies have been conducted by local universities.

Service Development and Pricing

Typically, marketing and service development are treated as distinct areas of responsibility within transit agencies. Although the amount of interaction between marketing and service planning varies from agency to agency, basic issues of service and pricing are the responsibility of service planning, and marketing is responsible for promotion and customer service. This gap between service planning and marketing often results in service development and pricing decisions that lack the consumer perspective provided by marketing.

The process of selling a product or service usually includes making adjustments to its design or packaging it in a way that is more attractive to the consumer, and marketing professionals can play an important role in this aspect of service development. In the context of transit marketing, service development includes techniques that make transit service more convenient and attractive to use.

The range of techniques being employed is considerable, from minor changes in the process by which a transit rider pays for service to major service modifications. Many systems, for example, routinely provide transportation services for special events to increase off-peak ridership. Other transit agencies emphasize making their services more convenient to use, particularly through the introduction of transit passes, often with various purchase options such as special sales outlets, credit card payments, or employer programs. Because the way a service is delivered is often equated with the product in the mind of the consumer, more attention is being focused on programs to increase employee professionalism and enhance morale. Many marketing departments also take advantage of the acquisition of new or upgraded equipment to promote improved service. Service development marketing techniques result in a more attractive package--they reinforce the user's reasons for choosing transit while creating a more attractive package for the individual who is considering its use. In addition, these activities often provide opportunities for collaboration with the private sector; business contributions to promotional or operating costs, or both, can maximize marketing resources.

Consumer Information

Consumer information activities are designed to provide the public the information needed to use the transit system. At a minimum this requires disseminating route and schedule information to current and potential users. As transit marketing becomes more sophisticated, however, consumer information services are further refined to address ease and efficiency of system use. Consumer research has shown

TABLE 1 Selected Marketing Techniques

Specific Technique	Objective	Representative Examples of Use
Market Research		
On-board surveys	Determine user attitudes; improve delivery of transit services.	Universal
Telephone surveys	Determine user and nonuser attitudes and awareness of system and services; improve delivery of transit services.	Widespread
Focus groups	Determine consumer attitudes; improve delivery of transit services.	Miami, Los Angeles, Twin Cities, Spokane
Employer surveys	Determine employee travel behavior; improve delivery of transit services.	Houston, Boston
Request cards, coupons	Determine travel behavior and consumer attitudes.	Bridgeport, Orange County
Service Development and Pricing		
Special events transportation	Increase off-peak ridership.	San Diego, Monterey, Oakland, Los Angeles, Pittsburgh, Buffalo, Cincinnati, Columbus, Peoria, Albany, Chicago, Knoxville
Subscription commuter service	Increase commuter ridership; make transit more convenient to use.	Tucson, San Jose
Transfer reciprocity	Make transit more convenient to use.	San Francisco (BART/Muni); Monterey, California; Bridgeport
Transit passes	Increase peak-period ridership; make transit more convenient to use; improve property's cash flow; increase operating efficiency.	Seattle, Houston, Denver, Spokane, Toronto, Peoria, Madison, Portland, Boston, Bridgeport
Purchase options (sales outlets, credit card payment, employer pass programs)	Make transit more convenient to use; increase pass sales; improve property's cash flow.	Boston, Tucson, Bridgeport, San Francisco (BART), Los Angeles, Baltimore, Denver, Houston
Employee development program	Increase employee professionalism; enhance employee morale; improve service to public.	Seattle, Albany, Syracuse, Oakland, Milwaukee, San Francisco (Muni), San Mateo, Twin Cities
Consumer Information		
Timetables, maps, signs, schedules	Provide information; make transit easier to use; increase operating efficiency.	Universal
Telephone inquiry: (a) live, (b) automated or computer-assisted	Provide necessary information; make transit easier to use; increase operating efficiency.	Universal; Columbus; Washington, D.C.; Toronto; Twin Cities; Los Angeles; Portland
Information center	Provide necessary information; make transit easier to use; increase operating efficiency.	Toronto; Houston; Cleveland; Boston; Huntington, West Virginia; San Antonio
Trip planner	Make transit easier to use for infrequent or first-time rider; increase off-peak ridership.	Tucson; Orange County; Lancaster, Pennsylvania
Tourist information aids	Increase off-peak ridership; make transit easier to use.	Toronto, New York, San Francisco (BART), San Diego, San Antonio
Cable television	Disseminate information to general public; increase awareness of property's role and function within community; enhance property's image; promote use of transit services.	Denver; Seattle; Columbus; Paducah, Kentucky; Iowa City
Displays	Disseminate information to general public; increase awareness.	Los Angeles, Boston, Milwaukee, San Diego, Cincinnati, Spokane
Public Relations		
Community education programs	Make transit easier to use; increase off-peak ridership.	Albany; Columbus; Madison; Dayton; Houston; Cincinnati; Pittsburgh; Philadelphia; Fort Worth; San Jose; Tri Cities, Washington
Community outreach programs	Disseminate information to general public; increase awareness; enhance property's image.	San Francisco (Muni), Los Angeles, Baltimore, Atlanta, Philadelphia, Boston, San Diego,
Newsletters	Keep riders up-to-date on transit system's activities.	Houston, New York, Toronto, Tucson, Milwaukee, Portland
Press releases	Increase awareness; enhance image.	Universal
Media events	Increase awareness; disseminate information to general public.	Milwaukee, Dayton, Tulsa, St. Louis, New York, Fort Wayne, Topeka, Spokane, Buffalo, Miami
Community service	Demonstrate commitment to community; enhance property's image.	Syracuse; Albany; Fort Wayne; Denver; Seattle; Los Angeles; Pittsburgh; Milwaukee; Reno; Chicago; Allentown, Pennsylvania
Advertising and Promotion		
Newspapers	Increase awareness; promote transit services; enhance property's image.	Universal
Radio	Increase ridership by target marketing automobile commuters; increase awareness.	Denver, Twin Cities, Houston
Outdoor (billboards, transit vehicles)	Increase ridership by target marketing automobile commuters; increase awareness.	Universal
Direct contact marketing	Increase ridership on specific routes or services; promote transit use.	Seattle; Twin Cities; State College, Pennsylvania; Los Angeles; Denver; Bridgeport; Toronto; Spokane; San Diego
Commercial television	Promote transit use; increase awareness; enhance property's image.	San Antonio, Spokane, Cincinnati
Advertising tradeouts	Reduce advertising costs by leveraging advertising resources	Denver, New York, Seattle
Merchant discounts	Increase pass sales; enhance values of pass; increase peak period ridership; increase off-peak ridership; gain participation of local businesses.	Boston; Seattle; Tucson; Peoria; Madison; Portland; Washington, D.C.; New York; San Diego; Spokane; Bridgport
Free or reduced fares	Increase ridership (primarily in off-peak); gain participation of local businesses.	Bridgeport; Salt Lake City; Orange County; Rochester; Syracuse; Canton; Huntington, West Virginia; Allentown, Pennsylvania; Dayton; Nashville; Pittsburgh; Denver
Anniversary celebrations	Promote transit system use; increase awareness; enhance property's image.	Chattanooga; Seattle; Monterey; Lynwood, Washington, D.C.; Cincinnati; Birmingham; Duluth
Sponsor contests	Promote transit system use; improve system aesthetics; enhance property's image.	Williamsport, Pennsylvania; Orange County; Dayton; Madison; Phoenix; Dayton; Baltimore; Pittsburgh; Boston
Promotional items	Increase awareness; raise revenues to defray production or operating costs.	Pittsburgh; Reading, Pennsylvania; Wilkes-Barre; Miami; Los Angeles

that many people shy away from transit because they find it hard to understand. User aids and community education activities can play an important role in de-mystifying the transit system and making it easier to use. In addition, informed users make a system run more efficiently; for example, a rider who knows that exact fare is required and has it ready is less likely to cause a delay than one who is unaware of the policy. Depending on their design, consumer aids and consumer education activities can also promote system use to the general community.

A wide variety of marketing techniques are currently used to support the consumer information function. Two broad categories are user aids and community information programs. User aids run the gamut from traditional information sources such as timetables, maps, signs, and schedules, to sophisticated information systems. Automated or computer-assisted telephone inquiry systems, for example, are being used in a number of cities to make transit easier to use and to increase operating efficiency. Some transit agencies have used trip planners to assist infrequent or first-time riders in using transit; tourist information aids in many large cities serve the same purpose. More general information about transit services is offered to a wider audience via community information programs that include the use of displays, newsletters, and community outreach or education programs. Cable television is a relatively new technique that is being applied to enhance a property's image and promote the use of transit services. Although the relative effectiveness of cable television has yet to be documented, it is likely to be less effective for advertising and promotion than more traditional media such as radio, commercial television, and newspapers because of its significantly smaller audience.

In general, the cost-effectiveness of different consumer information techniques is not well documented. Appropriate evaluation tools appear to be lacking, or at any rate not often applied. Transportation marketing staff perceive these activities to be effective, however, based on the number of requests generated and the customer feedback received.

Public Relations

Public relations encompasses activities designed to develop and maintain community support and awareness. Public transportation agencies do more than just provide transportation services; they also play an important role in helping to solve a region's current and projected transportation problems and in influencing economic development and revitalization. The ability of a transit agency to meet its stated objectives depends on the level of support it receives from the general public, local officials, and the business community. Public relations activities are designed to meet this need.

Needless to say, there is considerable overlap between public relations and other marketing activities, particularly in the area of community information programs and advertising. Here, public relations refers to press releases, media events, and community service activities. These techniques are designed to increase public awareness of an agency and, if possible, enhance its image. Community service activities are also designed to demonstrate a commitment to the community on the part of a transit agency. Most public relations techniques are universally used. Their effectiveness, however, is difficult to measure directly, and as a result, agencies tend to measure their effectiveness by considering factors such as the amount and tone of media coverage and public responses and results of attitude and awareness surveys.

Advertising and Promotion

Across the board, transit agencies devote most of their nonpersonnel marketing budgets to advertising and promotional activities. Until relatively recently the transit market was viewed as homogeneous. Advertising and promotion reflected this view and tended to use the "shot gun" approach of communicating a singular message to the general public. The growing recognition that transit systems are used by many different groups for a number of purposes has resulted in a new approach by transit marketing professionals--one that recognizes the need to develop a range of advertising and promotional techniques to reach individual market segments. Although broad advertising and promotional activities are still conducted, they no longer predominate and, when used, they generally serve as an "umbrella" under which targeted activities are carried out.

In general, advertising is viewed as a mechanism for enhancing a system's image and for promoting transit system use. Promotional activities, as defined for this review, have the objective of attracting ridership to specific services or at specific times of the day. In the following sections techniques are described that are currently used to advertise and promote transit services. Although advertising and promotional activities are presented separately, they are more likely than not to be combined in practice.

Advertising

Transit marketers rely on a mix of advertising media. The overall mix varies significantly from agency to agency because of differences in resources and urban area characteristics. Among the most popular media for transit advertising are newspapers, radios, billboards, and the interior and exterior of transit cars. Advertising resources can be maximized through tradeout arrangements with newspapers or radio stations. Tradeouts do not normally provide choice treatment, but if the agency is willing to purchase additional advertising, the tradeout can often be used toward the purchase of more desirable space or time. Direct contract marketing is one of the newer techniques being used to increase ridership on specific routes and promote transit use to selected groups of consumers.

It is particularly difficult to assess the effectiveness of activities designed to enhance awareness or image because the payoff tends to develop over time. Although all media were judged to be effective in some circumstances, little formal documentation of relative effectiveness exists. Most agencies rely on attitude and awareness surveys to measure effectiveness. A recent Michigan Department of Transportation evaluation of media advertising revealed that newspaper advertisements claimed the highest recall, followed by radio. The Kingston Transit System (Ontario, Canada) evaluated a program that included radio, newspaper, and on-bus advertising and concluded that advertising alone will not increase transit ridership enough to justify the cost of the program.

Promotion

Promotional activities provide consumers with non-service-related motivation to use the transit system;

for example, reduced fares, merchant discounts, or contests. Many of the activities can be categorized as incentive promotions, or short-term programs designed to increase ridership over the long run. An incentive (e.g., free or reduced fare) is offered to induce consumers to try the service on the assumption that they will recognize its value and continue as regular paying customers. Incentive promotions are the first step in the process of changing consumer behavior.

Transit agencies are using a wide variety of promotional techniques to increase ridership and also to promote awareness of the system. For example, some agencies negotiate an agreement with local merchants to offer discounts on merchandise to transit riders. Other agencies offer free or reduced fares to attract off-peak riders. In many cities, contests and celebrations are held to promote transit system use. Although an incentive promotion may result in a short-term revenue loss, it is expected to increase ridership in the long run. Incentive promotions can provide good opportunities for collaboration with the private sector. In many cases, local businesses are willing to cover all or a portion of promotion costs. Although incentive promotions are popular with consumers and marketing staff, their cost-effectiveness has yet to be proven.

Evaluation

Although the recent Transportation Research Board review of transit marketing evaluation practice (6) was limited to promotional marketing endeavors (advertising, incentive promotions, and consumer information aids), its conclusions are relevant to marketing activities across the board:

- A large proportion of promotional activities are evaluated but the majority are evaluated by weak experimental designs lacking control groups and before and after measurements.
- The consumer's actual behavior is most often used to measure effectiveness.
- Direct observation of consumer behavior is the most popular data collection technique used.
- Transit marketing evaluation places heavy emphasis on gross indicators of consumer response such as overall system ridership and revenue.

These views are also supported by other research efforts (7,8).

It is often difficult to evaluate the effectiveness of a particular marketing activity. Formal evaluation requires the development of a good consumer data base. Because market research tends to be underfunded, evaluation efforts are often hampered by a lack of appropriate data. In addition, marketing activities typically coincide with other system changes, and evaluation is then complicated by the presence of other factors. Some of the measures used by transit marketing professionals to evaluate the effectiveness of their marketing activities are as follows:

- Consumer information and education. Attitude and awareness measures and behavioral measures, such as the number and nature of phone calls received, are generally used to determine the effectiveness of these activities. The effectiveness of user aids is measured by both preference and ability to use, which require different measures, and by the degree to which costs can be covered by sponsoring or sales.
- Advertising and promotion. Advertising effectiveness is measured by awareness indicators, number of phone calls received, and media analysis. The degree to which promotional costs are covered by other businesses and organizations is used as well. The success of incentive promotions is usually measured by a combination of behavioral indicators including ridership, revenues, rate of response of coupon return, and increase in retail sales; direct contact is also used in some cases.
- Public relations. The amount and tone of media coverage are the primary measures used to evaluate public relations activities. Attitude and awareness surveys also provide additional information.
- Service development. Both behavioral indicators such as ridership, revenues, number of passes, and so forth, and attitudinal indicators are used to measure effectiveness. User and attitude and awareness surveys are also used.

Agencies generally attribute their limited evaluation activity to a lack of staff and financial resources. An appropriate evaluation effort has the potential to pay for itself, however, by identifying the relative cost-effectiveness of individual marketing activities. Without evaluation, management has little way of knowing whether marketing objectives have been met. Conversely, evaluation data can provide strong evidence to persuade management of the usefulness of specific marketing programs and marketing in general. A strategy for assessing relative benefits and costs should be built into the planning phase of individual marketing activities and should be used to evaluate the effectiveness of each completed activity.

ASSESSMENT OF CURRENT PRACTICE

Organization and Function

Currently, there is an increased emphasis on cost-effectiveness in the delivery of transportation services. By providing a vital link between the consumer and the producer of services, marketing can make a significant contribution toward increased productivity in the transit industry. If the potential of marketing is to be realized, the role of marketing must be expanded from advertising and promotion to include market research and evaluation, and the marketing function must be integrated with activities of other agency operating departments.

Within most transit agencies, however, marketing is viewed primarily as a mechanism for advertising and promotion. This traditional view is also reflected in the organizational structure of most transit agencies. More than 90 percent of the agencies surveyed combine marketing with activities such as communications, public information, or community relations to form a department. Information services are included with marketing by almost all agencies and account for a significant portion of the marketing budget. The agencies included in this review reported that, on average, 66 percent of marketing personnel are devoted to telephone services alone, and Seattle reported that information services account for 66 percent of its total marketing budget.

The amount of coordination between marketing and other operating departments varies significantly from agency to agency. At best, marketing staff work closely with staff from other departments to develop promotional strategies and to share insights about consumer attitudes and behavior. At worst, the role of marketing is limited to packaging and promoting a product developed by another department.

Marketing Techniques

Significantly more progress has been made toward developing innovative marketing techniques than toward developing an organizational structure that takes full advantage of the marketing function. The state of the practice in transit marketing includes the use of a wide variety of techniques that are used by individual agencies to meet a range of marketing and system objectives. Transit agencies rarely perform structured evaluations of marketing activities and are more inclined to rely instead on perceived effectiveness. As a result, documentation of the effectiveness of marketing activities is rather limited. Research sponsored by the Urban Mass Transportation Administration and the Transportation Research Board has provided valuable insight into the effectiveness of marketing techniques such as fare prepayment, fare-free systems, short-term economic incentives, and promotional activities, and an assessment of transit marketing evaluation activities. However, additional efforts to determine the cost effectiveness of individual marketing techniques and mechanisms for sharing the results of research and evaluation activities among the agencies in the transit industry are also needed.

Market Research

Market research is widely recognized as the pivotal component of transit marketing; however, marketing departments generally lack the financial and staff resources to conduct market research studies on a consistent and timely basis. What is needed, then, are ways to make existing market research techniques more cost effective.

Service Development and Pricing

This is acknowledged to be an area in which marketing should play a major role, but this is rarely the case in actual practice. Activities in this area have mainly focused on fare prepayment and fare-free zones. Evaluation indicates that these programs are more effective in attracting existing users than in increasing ridership. Although these programs have significant administrative costs and result in reduced revenues, offsetting cost savings can be realized through savings from advanced collection and reduced loading times. These activities often provide opportunities for collaboration with the private sector that can maximize the effectiveness of marketing resources.

Consumer Information

Consumer information is generally the first marketing element developed by a transit agency. Regardless of the level of marketing activity, each transit agency interviewed believed that good consumer information services were the most necessary marketing element. Transit agencies spend a significant portion of their marketing budgets on user aids, and more needs to be learned about how to maximize the cost-effectiveness of their design and distribution. Trip planners and tourist information aids are relatively new concepts that show promise in transit marketing, particularly for attracting off-peak ridership.

A significant portion of marketing resources are devoted to responding to telephone inquiries. Evaluation evidence is limited but suggests that automation of telephone responses can reduce costs and increase productivity when the level and cost of automation is matched with local needs and resources. Techniques to make the telephone inquiry response function as a sales tool as well as an information tool also show promise.

Public Relations

Public Relations activities rely heavily on the effective use of local media to keep the public up-to-date on transit agency activities. Transit agencies take advantage of the arrival of new equipment and the implementation of new services to capture media coverage of activities. Community service activities by the agency or by transit employees are effectively publicized to demonstrate agency commitment to the community.

Advertising and Promotion

Advertising and promotion activities are focusing more on target marketing techniques and less on a "shot gun" approach. The limited evidence available suggests that advertising is most effective for generating broad-based support and enhancing transit's image and least effective for increasing revenue from passengers (i.e., getting more riders). Advertising resources can often be stretched through tradeouts and joint promotions with retailers and businesses. Direct contact marketing is seen as an effective marketing tool, but more rigorous evaluation of its cost-effectiveness is needed.

Nonfare-related incentives, such as merchant discounts, are popular among transit users but appear to be more effective in increasing pass sales than in attracting new riders. Free or reduced fares are also commonly used, primarily to increase off-peak ridership. Both programs are cost-effective ways to involve the private sector in agency activities. The full cost of these programs is generally not well documented and little is known about their impact on ridership over the long term.

Most transit agencies evaluate at least a portion of their marketing activities and programs, but few take a consistent approach to evaluation. A strategy for evaluation is rarely considered in the planning stages of a specific marketing activity, and resources are seldom available to conduct a thorough evaluation of a single activity. Because marketing activities are often difficult to evaluate in terms of cost-effectiveness, evaluation tends to rely more on measures of perceived rather than quantified effectiveness.

Although experiences reported by other transit agencies are helpful in assessing the cost-effectiveness of a particular marketing technique, comparative data have limited usefulness. Local evaluation of marketing activities is an important activity because the cost-effectiveness of any particular technique will depend on local objectives, needs, operating characteristics, and staff capabilities.

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Publication of this paper sponsored by Committee on Public Transportation Marketing and Fare Policy.

A Special Event Parking and Transit Pass System Using Ticketron: The Rochester, New York, Tall Ships Experience

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ABSTRACT

Ticketron is a well-known advance reservation and ticket sales system that is seldom used in the field of transportation. Although Ticketron could be used more fully in many transportation situations, one of the best applications is for special event, park-and-ride shuttle bus ticket sales. The use of Ticketron in such a situation by the transportation system in Rochester, New York, for a 4-day Tall Ships Festival in July 1984 is described. More than 29,000 parking tickets for 94,000 bus passengers were bought through Ticketron. The event and the transportation system worked well owing in part to the Ticketron sales. The costs and benefits of using Ticketron in Rochester is described along with general transportation characteristics in which Ticketron sales would be most beneficial. Although not applicable in all situations, the use of Ticketron can greatly improve the allocation of scarce transportation resources, and it is especially applicable for special-event transportation. The successful Rochester experience also demonstrates that the use of Ticketron in special-event transportation need not be limited to large cities, but its use is also justified in medium-sized cities as well.

THE CONCEPT

Advance sales of tickets by Ticketron for concerts, camp sites, and other activities is well known in the United States. Such sales involve multiple-event scheduling using decentralized computer terminals connected to a central mainframe computer. Event information is often provided to remote terminal outlets using microfilm. The system is nationwide, thus event reservations can be made from anywhere in the United States. This nationwide sales network is important for events that draw from more than a local market.

Only a few applications of Ticketron sales can be found in the field of transportation. Several colleges such as Pennsylvania State University and the University of Wisconsin, Madison, include the presales of reserved parking spaces as part of their football ticket system. Bus and airline reservations are also provided as part of tours that are scheduled through Ticketron. It has also recently been learned that the 1984 Summer Olympics issued more than 200,000 Ticketron tickets for some of its transportation services. No other Ticketron transportation applications are known by the author. In cases in which Ticketron is used, transportation is generally included as part of the event and not as a separate transportation space reservation.

However, it is possible to use more fully the Ticketron computer technology and nationwide sales structure in transportation. Applications could include any situation in which reserved space (seats, parking spaces, road space, etc.) is needed, especially when the transportation capacity is limited, when there is a premium price for premium service, when the transportation demand is regional or nationwide, or when the service is used so infrequently so as not to justify its own computer reservation equipment. Other situations would be instances in which large sales volumes would justify the centralized computer reservation system, as well as make fare collection extremely slow or difficult for the transportation system.

One of the best transportation applications of Ticketron is prepaid transit passes and/or parking tickets to large-scale special events. The concept presented in this paper is to use the Ticketron centralized computer technology and nationwide sales structure in a special event, prepaid parking and transit pass system. The implementation of such a concept in Rochester, New York, during July 1984 is described in the remainder of this paper.

THE ROCHESTER EXPERIENCE

The Event

Rochester, New York, is a medium-sized city of 241,000 located in upstate New York along Lake Ontario. Its regional population of 971,000 ranks 39th in the United States. Last year, Rochester was 150 years old and the city celebrated with a year-long community birthday party. One of the many events of the year was a Lake Ontario-Tall Ships Festival held during July 1984.

The Lake Ontario Festival was composed of numerous activities including the arrival and display of 21 Tall Ships, a Rochester Philharmonic concert, giant firework displays, aerial plane displays, parades, a picnic for 3,000 senior citizens, and other entertainment. The festival, held July 12 through 15, 1984, was expected to attract 250,000 people with a peak demand expected on Saturday night for the Rochester Philharmonic concert and fireworks display.

Event financing was important. There was no charge for admission to the Tall Ships site. Because the general sesquicentennial budget could not absorb a potential transportation cost of $250,000, the transportation system would require a major fare collection effort--a factor that greatly influenced the decision to use Ticketron.

The Site

The Tall Ships Festival was held at Ontario Beach Park along the lake and on the vacant Port of Rochester land along the Genesee River. The site of approximately 50 acres was devoted almost entirely to festival activities with little room for parking. Parking was so limited that most entertainers, concessioners, and staff had to be shuttled to the site.

Access to the site was also extremely constrained. Because of its location along a lake, river, and a set of railroad tracks, only two streets provided access to the site. One access street was a 4-lane principal arterial with numerous traffic signals, and one was a 2-lane local collector. The nearest freeway was 4 mi to the west of the site; however, a 4-lane, limited-access parkway did connect the freeway to the principal arterial approximately 1 mi south of the site.

A rock concert held at the Tall Ships site in 1982 drew an unexpected crowed of 25,000 people. Because of the limited site parking and limited access, this crowd caused complete gridlock. Emergency vehicles were completely blocked from the site. The memory of this experience was fresh in the community's mind as planning for the Tall Ships event began. As many as 100,000 people were expected at the Saturday night activities, or four times more people than at the rock concert. Based on a concern for public safety, a decision was made to restrict all automobile access to the site. A cordon line was established on local streets approximately 3 mi from the festival site. The only automobiles allowed within this special-event, automobile-free zone were those of local residents or workers who obtained access permits. More than 25,000 such permits were issued through local police departments and community associations.

The Access System

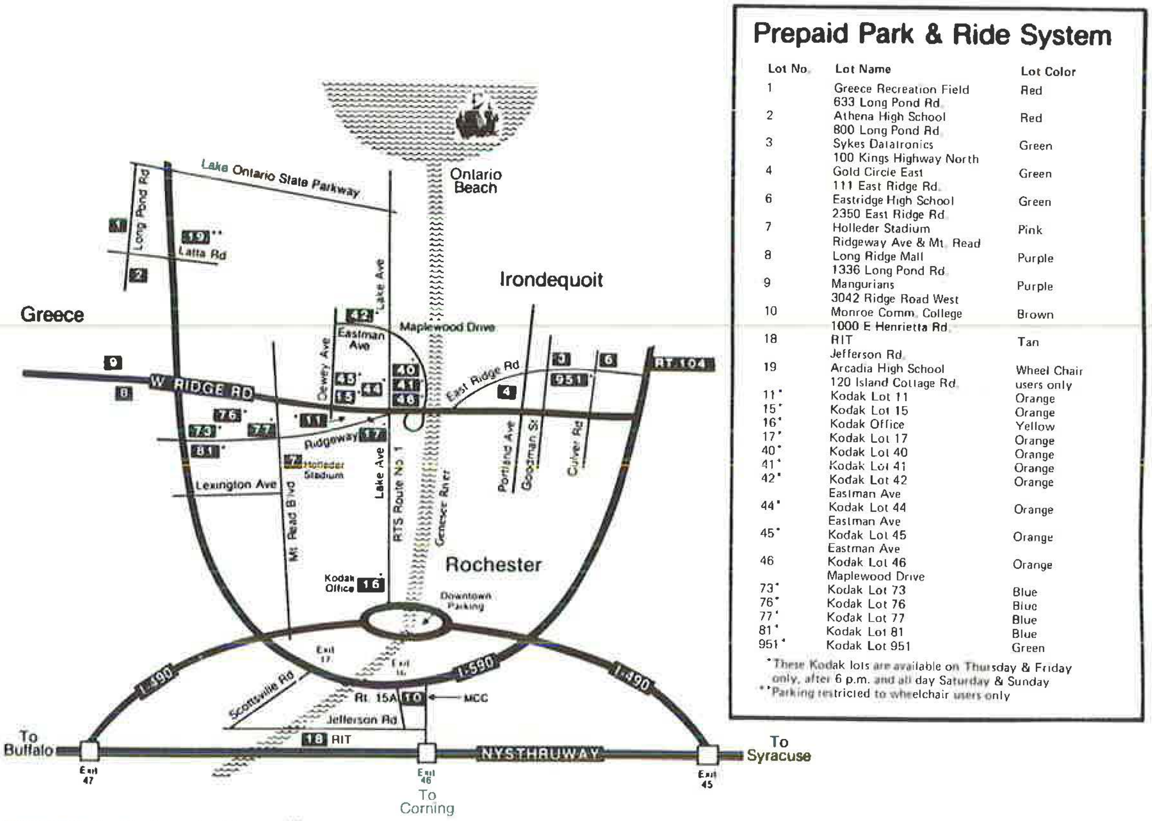
With the exception of the automobiles mentioned in the preceding paragraph, access to the site was limited to buses, bicycles, or pedestrians. Although an amazing number of people did bicycle or walk, the vast number of people took a bus to the event. Several types of buses were used. First, more than 230 private charter buses were driven to the site during the 4 days. This does not include the 73 charter buses that carried more than 3,000 senior citizens to the site on Friday. Second, three internal shuttle systems served the site. One shuttle bus served citizens within the automobile-free zone, a staff-press shuttle served a remote parking lot, and the police operated a separate shuttle for law enforcement personnel. Third, the regular 100 lines of the local transit authority directly served the site. This transit service was the major access for those who did not buy the park-and-ride tickets. Seventeen thousand more people rode the 100 line during the 4-day festival than during a typical Thursday through Sunday period. The last bus access provided to the site, and the subject of this paper, was the park-and-ride shuttle system.

Park-and-Ride Shuttle System

An elaborate park-and-ride system shown in Figure 1 was established to serve the site. Nine separate color-coded transit routes served 26 parking lots. Each lot was numbered and color coded according to the transit line it served. The lots ranged in size from 100 to 3,500 spaces and were from 4 to 19 mi from the site. The large number of parking lots was required to handle the 100,000 Saturday evening peak and also serve a potential 50,000 Thursday and Friday daytime crowd. This latter group caused some of the longest bus trips because two distant colleges had to be used for weekday, daytime parking.

The parking scheme was further complicated by the fact that some lots, mostly Eastman Kodak lots, were not available during the day on weekdays, but were available after 6:00 p.m. Thus, the parking system had a large number of lots with variable capacities (depending on both the day and time of day). Ticketron is very attractive in such a system because of the information that can be printed on the ticket for parking lot control.

The weekday-weekend event pattern also caused problems for the shuttle system. The local public transit authority could only promise 10 buses for the weekday daytime shuttle; thus, this service had to depend on the major private school bus provider in Rochester. On Saturday, up to 300 buses were com-



Prepaid Park & Ride System

Lot No.	Lot Name	Lot Color
1	Greece Recreation Field 633 Long Pond Rd.	Red
2	Athena High School 800 Long Pond Rd.	Red
3	Sykes Datatronics 100 Kings Highway North	Green
4	Gold Circle East 111 East Ridge Rd.	Green
6	Eastridge High School 2350 East Ridge Rd.	Green
7	Holleder Stadium Ridgeway Ave & Mt. Read	Pink
8	Long Ridge Mall 1336 Long Pond Rd.	Purple
9	Mangurians 3042 Ridge Road West	Purple
10	Monroe Comm. College 1000 E Henrietta Rd.	Brown
18	RIT Jefferson Rd.	Tan
19	Arcadia High School 120 Island Cottage Rd.	Wheel Chair users only
11*	Kodak Lot 11	Orange
15*	Kodak Lot 15	Orange
16*	Kodak Office	Yellow
17*	Kodak Lot 17	Orange
40*	Kodak Lot 40	Orange
41*	Kodak Lot 41	Orange
42*	Kodak Lot 42 Eastman Ave	Orange
44*	Kodak Lot 44 Eastman Ave	Orange
45*	Kodak Lot 45 Eastman Ave	Orange
46	Kodak Lot 46 Maplewood Drive	Orange
73*	Kodak Lot 73	Blue
76*	Kodak Lot 76	Blue
77*	Kodak Lot 77	Blue
81*	Kodak Lot 81	Blue
951*	Kodak Lot 951	Green

*These Kodak lots are available on Thursday & Friday only, after 6 p.m. and all day Saturday & Sunday
**Parking restricted to wheelchair users only

FIGURE 1 Park and ride parking.

mitted to the park-and-ride shuttle--200 from the school bus operator and 100 from the local transit authority. Actual use, of course, varied according to the demand.

Two separate shuttle load-unload areas were established on the site, each with 10 to 12 bus gates. The school bus operator was assigned the western load area and the transit authority was assigned the eastern load area on the basis of the parking lots they had to serve. This separation of the mixed fleet worked very well from a management control and physical dimension standpoint. The color-coded routes were each assigned one or more gates depending on Ticketron sales for the day.

Charter buses were given a separate loading area, but were not allowed to wait at the site because of lot capacity restrictions. The Liftline, a wheelchair-accessible transportation service provided by the transit authority, was also given a separate gate area along a street with newly installed sidewalks.

Prepaid Ticketron System

Thus far a complicated park-and-ride shuttle system to a special event has been described. It would be possible to run such a system without an advance ticket sale system or, specifically, without a Ticketron prepay system. On-board or on-site bus fare collection could be used, or tickets could be sold at banks, retail outlets, or city-town clerks' offices. However, given the complexity of the park-and-ride system, the expected patronage volumes, and the fact that fare collection on school buses is illegal in New York State, it became apparent that Ticketron was the only rational way to handle the Tall Ships transportation fare collection system.

Because of the computer, the Ticketron system is extremely flexible. Parking lot and other transportation priorities and capacities can be established and the tickets can be issued by priority or can be printed with any combination of transportation information. If needed, the system can be used to collect information about each consumer (for example, when the consumer needs wheelchair-accessible transportation service). Summaries of ticket sales can be obtained quickly at any time to give advance estimates of the size of the crowd at the special event. Knowing the transportation demand in advance is extremely important in planning for the transportation system. The Ticketron sales network also relieves the organization of the event from the problems of cash collection, cash control, and security, which is a major problem at any special event.

In Rochester, the Ticketron tickets served two separate purposes: to reserve a parking space at one of the 26 lots and to provide access to a bus for a particular day of the event. In effect, the ticket represented a vehicle or parking space, and the number printed on the ticket represented bus passengers. This relatively simple concept created some confusion for the public, particularly because the price of the ticket was based on the number of bus passengers and the Ticketron surcharge to the consumer was based on the ticket or vehicle ($2 per passenger and $1 per ticket, respectively). For example, the cost of a ticket for three people in one vehicle would be $7 (3 times $2 plus $1 ticket surcharge).

The Ticketron system also provided direct parking control. Ticketron allowed selected close-in parking lots to fill first. A two-tiered parking lot sales hierarchy was used to accomplish this parking priority scheme. Upper limits on vehicles' capacities were established for each lot and ticket sales could not exceed these limits. Time-of-day limits were also established. Certain lots were not available before 6 p.m. on weekdays (a zero lot capacity), and in one lot the capacity increased from 550 to 800 spaces after 6 p.m. This represented not only an upper lot capacity by time of day, but also a crude estimate of time of arrival at the event.

Another limit was also imposed--a maximum daily bus passenger limit. Due to the limited site size, it was believed that only 50,000 to 60,000 park-and-ride bus passengers could safely be on the site in any one day (in addition to those who came by other modes). Fortunately, these upper ticket sales were never reached, although the Saturday limit of 50,000 was nearly reached at 49,814.

The two-part ticket was also used to provide consumer information about the transportation system. The color code of the parking lot-transit route was printed, as was the parking lot number. As mentioned previously, the number of bus passengers was printed up to a maximum of nine people per vehicle (to represent a van). Also printed was the day of the event. All tickets were sold as day-long passes to the event. There was no overbooking of parking lots to account for parking turnover, a conservative decision that should be evaluated by others who use the Ticketron park-and-ride system.

One of the parking lots was reserved for wheelchair-bound or other handicapped passengers. A policy was set whereby up to four family members could travel in the Liftline wheelchair bus with the handicapped person. More than 400 people in 125 vehicles used this lot. Thus, it is possible to obtain information about the traveling consumer through the Ticketron system, for example, compact versus full-sized car users, and so forth.

The park-and-ride tickets were marketed through the local media who were more than eager to provide the information to the public. Ticket information was mentioned in all press releases and in the information packets sent to media and travel agents within 400 mi of Rochester. Thousands of park-and-ride system maps were sent to all Ticketron outlets within the same region. Color-coded maps were published several times as news items by the local daily newspapers. The message was clear: "If you want to see the Tall Ships, buy a park-and-ride ticket and take the bus." The public gracefully accepted this requirement.

Cost

The cost of the Ticketron system had two parts. Ticketron charged the ticket buyer $0.11 to $1 per person service charge depending on the number of bus passengers per ticket. (The charge was $1 per ticket with up to nine bus passengers per parking ticket). Persons who used the city-owned Community War Memorial were not charged the ticket surcharge. The second cost was a charge to the event sponsor for each ticket sold. Charges generally ranged from $0.10 to $0.25 per ticket depending on sales volumes and other factors. Building owners that generated Ticketron sales generally received the lower rates when the sales occurred at their building box offices. In Rochester, sales occurred at both remote Ticketron outlets and the Community War Memorial. The total Ticketron bill to the city was approximately $7,000.

Although the cost of setting up an alternative transit fare collection system was never fully analyzed in Rochester, there was no doubt that Ticketron was the least expensive and least burdensome administrative system considering the complex parking scheme. Computerized ticket control was a necessity. The Ticketron sales also totally relieved the bus drivers from the job of fare collection, thus enabling more efficient use of the buses, particularly with large volume movement of people.

It should be noted that some lines of people waiting up to an hour did develop at Ticketron outlets during the last week of ticket sales. Although tickets went on sale a month in advance, a considerable number of Rochester skeptics did not buy tickets until the last moment, apparently believing the Tall Ships would either not arrive or Rochester's weather would not allow viewing of them. More than 28 percent of the ticket sales occurred during the last 4 days before the event. This waiting, while considered an inconvenience by the public, was inevitable under any system, whether at a central distribution site, on the buses, or at the parking lots themselves.

Results

In two words: it worked. Despite some minor problems, the event was extremely successful. An estimated 240,000 people safely visited the site during the 4 days. Access to the site was maintained for public safety vehicles at all times. Although transportation could only be considered one factor in the success of the event, it had to be considered an important factor. The Ticketron prepaid park-and-ride shuttle ticket system was an important part of the success of the transportation.

Table 1 gives total Ticketron sales by lot with the lot location, lot color, transit provider (GA is the school bus provider and RTS is the local transit authority), and the lot capacity given on the left. Percent capacity (automobiles per lot capacity) is given for both the peak day and during the 4 days. Subtotals for each color-coded bus line and the two transit providers are also given. More than 94,000 people in 29,000 vehicles attended the Tall Ships event.

Another result of interest to planners was the actual vehicle occupancy, 3.21 persons per car was the actual rate versus the 3.20 rate used for planning the park-and-ride services. Special event automobile-occupancy estimates found in the literature ranged from 3.25 used for the Seattle World's Fair up to 4.0 for some other special events. A low automobile occupancy was used in Rochester because the event was on a smaller scale and involved less long-distance driving than the World's Fairs. This actual vehicle occupancy may be useful to others planning special-event transportation systems in medium-sized cities.

Mode split statistics are not readily available and may not be relevant to other cities given the automobile-free zone established in Rochester. However, for those interested, estimates of mode split are: 45 percent park and ride, 7 percent number 1 transit line, 7 percent private charter bus, 32 percent walk, and 9 percent bicycle. One surprise was the thousands of people who walked or bicycled many miles to the event. Planners of special-event transportation need to consider these normally overlooked transportation modes as well.

One of the most difficult tasks was to predict total attendance and shuttle bus demand during the 4-day period. Attendance at longer-term World's Fairs and Tall Ships' visits to large cities, such as Boston, New York, and Philadelphia with their 250,000 to 1 million per day attendance figures, did not apply in Rochester. In the end, high, medium, and low guesses were made. Estimates ranged from 275,000, 184,000, and 103,000 for total attendance and 220,000, 143,000, and 63,000 for park-and-ride buses. The actual total attendance of 240,000 was, thus,

TABLE 1 Tall Ships Travel Demand

					FOUR DAY TOTALS				PEAK DAY
PARKING LOT:	#	LINE COLOR	BUS OPER.	DAILY LOT CAP.	TOTAL VEHICLES	TOTAL PERSONS	AVG. VEH. OCC.	% CAP. USED	% USED
GREECE RECREATION	1	RED	GA	2,050	3,761	11,801	3.14	46%	100%
ATHENA H. S.	2	RED	GA	350	1,208	4,078	3.38	86%	100%
HOLLENDER STADIUM	7	PINK	GA	1,300	3,194	10,292	3.22	61%	100%
LONG RIDGE MALL	8	PURPLE	GA	850	2,466	7,813	3.17	73%	100%
GOLD CIRCLE EAST	4	GREEN	RTS	200	800	2,798	3.48	100%	100%
SYKES DATATRONICS	3	GREEN	RTS	800	1,826	6,019	3.30	57%	100%
MANGURIANS	9	PURPLE	GA	200	643	2,067	3.21	80%	100%
EASTRIDGE H. S.	6	GREEN	RTS	200	800	2,678	3.35	100%	100%
MONROE COMM. COLL.	10	BROWN	GA	3,500	6,631	21,158	3.19	47%	97%
ROCH. INST. TECH.	15	TAN	GA	800	1,634	5,198	3.18	51%	99%
KODAK LOT#	42	ORANGE	RTS	2,500	1,932	5,952	3.08	19%	65%
KODAK LOT#	41	ORANGE	RTS	300	345	1,156	3.35	29%	100%
KODAK LOT#	44	ORANGE	RTS	300	324	1,008	3.11	27%	100%
KODAK LOT#	45	ORANGE	RTS	300	135	422	3.13	11%	39%
KODAK LOT#	73	BLUE	GA	300	166	541	3.26	14%	44%
KODAK LOT#	76	BLUE	GA	100	35	94	2.69	9%	31%
KODAK LOT#	77	BLUE	GA	200	81	245	3.02	10%	34%
KODAK LOT#	951	GREEN	RTS	300	470	1,655	3.52	39%	100%
KODAK LOT#	40	ORANGE	RTS	600	735	2,412	3.28	31%	100%
KODAK LOT#	46	ORANGE	RTS	400	495	1,659	3.35	31%	100%
KODAK LOT#	81	BLUE	GA	800	84	309	3.68	3%	9%
KODAK LOT#	11	ORANGE	RTS	300	114	369	3.24	10%	29%
KODAK LOT#	15	ORANGE	RTS	100	92	256	2.78	23%	76%
KODAK LOT#	17	ORANGE	RTS	300	230	716	3.11	19%	63%
KODAK OFFICE	16	YELLOW	RTS	2,500	1,019	3,116	3.06	10%	28%
ARCADIA H. S.	19	HANDI-CAPPED	LIFT-LINE	100	125	410	3.28	31%	53%
		RED	GA	2,400	4,969	15,879	3.20	52%	100%
		PINK	GA	1,300	3,194	10,292	3.22	61%	100%
		PURPLE	GA	1,050	3,109	9,880	3.18	74%	100%
		BROWM	GA	3,500	6,631	21,158	3.19	47%	97%
		BLUE	GA	1,400	366	1,189	3.25	7%	22%
		TAN	GA	800	1,634	5,198	3.18	51%	99%
		GA-SUB	TOTAL	10,450	19,903	63,596	3.20	48%	88%
		GREEN	RTS	1,500	3,896	13,140	3.37	65%	100%
		ORANGE	RTS	5,100	4,402	13,950	3.17	22%	72%
		YELLOW	RTS	2,500	1,019	3,116	3.06	10%	28%
		RTS-SUB	TOTAL	9,100	9,317	30,206	3.24	26%	65%
		HANDI-CAPPED	LIFT-LINE	100	125	410	3.28	31%	53%
		GRAND	TOTAL	19,650	29,345	94,212	3.21	37%	77%

near the high estimate of total attendance, and the actual park-and-ride bus users of 94,000 was near the low end. These estimates are so dependent on the local event and the site that no conclusions should be drawn for other cities. However, they do provide an order of magnitude for special event attendances.

The last result that should be mentioned is the actual and perceived control that Ticketron sales allow. As stated previously, more than 94,000 people bought park-and-ride tickets and they arrived in 29,000 vehicles.

The advance knowledge of these ticket sales greatly reduced the uncertainty in planning for transportation and other event support services. With advance ticket sales, scarce transportation resources such as bus drivers and loading gates can be allocated more efficiently. Ticketron sales also provided a public image of event control and professionalism. Indeed, the advance sale system provide real control by distributing only a limited number of people to each parking lot and by giving priority to certain lots. It is this control whether real or perceived that is perhaps the most important result of the Rochester Ticketron park-and-ride system experience.

APPLICATION TO OTHER CITIES

Ticketron can be used more fully in transportation, especially in special-event transportation, in any location in the United States. However, the benefits and costs of its use obviously depend on the unique circumstances of the local event. Questions to be considered include:

1. Are there general admission charges or an event budget line for transportation that could avoid a separate transportation fare collection effort?
2. Are there many or only a few parking lots that serve the event (on-site fare collection would be easier at a few lots)?
3. Do all the buses have on-board fare collection equipment, generally meaning is the event held in the evening or on weekends when school buses do not have to be used?
4. Does the event have adequate on-site parking and/or access so as not to require separate transit service?
5. Is the event demand local or regional in nature?, and

6. Are the ticket sales volumes for the expected event high enough to justify the computerized Ticketron system?

In general, the use of Ticketron is more justified in situations in which ticket sales volumes are high; the demand is, at least, regional; there is a premium price for a premium transportation service; the transportation demand occurs infrequently, as in special event transportation; and the park-and-ride system is relatively complex.

Publication of this paper sponsored by Committee on Public Transportation Marketing and Fare Policy.

Experiences with Time-of-Day Transit Pricing in the United States

ROBERT CERVERO

ABSTRACT

Evidence on time-of-day transit pricing in the United States is examined in this paper, particularly in terms of ridership, fiscal, and equity impacts, as well as with respect to various implementation issues. Thirty-two time-of-day fare programs have been initiated in the United States since the early 1970s, of which 22 currently exist. These are about evenly split between off-peak discounts, peak-period surcharges, and programs involving differential rates of fare increases between peak and off-peak periods. Most fare differentials have been fairly modest to date (i.e., around $0.10 to $0.15), although there have been several cases in which peak exceed off-peak surcharges by $0.35. From interviews, it was found that the most prevalent reason for adopting time-of-day pricing was to encourage ridership shifts to the off-peak. Unfortunately, there was little empirical evidence to suggest that time-of-day fare programs to date have accomplished just that, although in most cases the proportion of total ridership during off-peak periods rose. Off-peak users were found to be more sensitive to differential fare changes than peak riders, with midday discount programs demonstrating the most prolific ridership impacts. Before-and-after analysis generally showed that time-of-day fare programs have had fairly inconsequential effects on efficiency and equity, ostensibly because of the nominal size of most differentials. Cost recovery rates did increase significantly for most peak surcharge programs, however. The most successful programs have been those that collect fares on the basis of run direction (rather than exact time) and that aggressively market their programs.

Since 1970, more than 30 areas in the United States have introduced adult transit fares that vary by time of day. Of these, 12 programs were eventually discontinued, leaving some 23 areas in the United States with time-of-day pricing as of late 1983.

These programs have ranged from additional surcharges for rush-hour services to fare discounts during the midday and bargain passes limited to off-peak periods. Time-of-day fares have been implemented on conventional bus, rapid rail, and demand-responsive (i.e., dial-a-van) modes of public transportation and in metropolitan areas as small as 25,000 and as large as 5 million persons. Fare differentials have ranged from $0.05 to more than $1, and have been as large as 300 percent in relative terms.

Interest in time-of-day transit pricing has been prompted largely by the U.S. transit industry's worsening financial situation over the past several decades. Nationwide, deficits rose from under $300 million in 1970 to more than $4.4 billion in 1982. Despite a massive infusion of government aid to cover these deficits, nationwide ridership increased only marginally, from 5.93 billion annual trips in 1970 to only slightly more than 6 billion in 1982 (1).

With operating subsidies becoming less certain, fare structures that attempt to approximate the costs of providing different types of services are gaining increasing popularity. In contrast to the more common practice of uniform pricing, time-of-day differentials attempt to encapsulate the higher overhead and staffing costs of accommodating rush-hour loads while charging non-peak users a fare reflective of basic level services. Charging more for peak period use can increase farebox returns because rush-hour transit commuters tend to be less sensitive to higher prices than other patrons, mainly because they are locked into a fixed work schedule and are making essential trips. On the other hand, giving a break at the farebox to non-peak users can significantly increase patronage. Differential fares can also serve to efficiently ration capacity--relieving overcrowding during morning and evening rush hours while helping to fill empty seats during off-peak periods. A more even distribution of demand throughout the day can ultimately mean a substantial cash savings to transit properties. In addition, given that rush-hour commuters generally have higher incomes than off-peak customers, peak-period surcharges are considered to be an equitable alternative to across-the-board fare increases.

Recent research on time-of-day fare programs in the United States is summarized in this paper. Included in this summary is an examination of how such programs vary, the motivations behind them, the range of impacts experienced to date, and various implementation issues that have surfaced (2). Particular attention is given to the effects of time-of-day pricing on ridership levels and composition, farebox recovery, and operating performance. Emphasis is also placed on highlighting exemplary cases of these fare programs. The paper concludes with specific recommendations for improving the effectiveness of time-of-day pricing.

FEATURES OF TIME-OF-DAY FARE PROGRAMS

Types of Fare Programs

An assortment of terms are currently used to describe how transit fares can be varied between peak and off-peak periods. Perhaps the most generic is peak and off-peak pricing, which refers to the variation in fares between high demand and base or low demand periods. Peak and off-peak fares can involve charging different rates during rush hours and nonrush periods of the day, between weekdays and weekends, or even over different seasons of the year. Thus, at least three versions of peak and off-peak pricing are time-of-day fares, day-of-week fares, and seasonal fares.

This paper concentrates solely on peak and off-peak fares, which vary by hours of the weekday (i.e., time-of-day pricing) primarily because this represents the most significant form of differential in terms of efficiency potential. A number of American transit properties do offer weekend fare breaks, even though the average costs of these services are probably even higher than those during weekday rush hours. Seasonal fares are less common, although they would appear appropriate when significant cost increases are incurred over several months of the year, as in the case of a summer resort area.

Figure 1 shows a number of possible varieties of time-of-day pricing in terms of changes from the base or average fare level. More than 10 U.S. transit properties have introduced peak surcharges since 1970, increasing fares only during morning and evening rush hours. At least one instance of a non-midday surcharge (Akron, Ohio), whereby fares were raised for all periods of the day except during the interpeak, has been recorded. A number of discount possibilities also exist. The most common has been midday discounts in which fares between peak periods are lowered with the hope of filling up empty bus seats. The discount arrangement can also be extended to early morning, late evening, and weekend periods, and combinations of all three.

Rather than have the fare change be one-sided, more than 10 American properties have inaugurated time-of-day pricing by increasing charges during both peak and off-peak periods, at different rates, however. Although a differential increase effectively results in a higher peak versus off-peak fare, this approach implies different ridership and financial impacts than other options because base fares are increased at all times. The differential change can also be in the opposite direction, involving decreasing off-peak rates faster than peak rates, although there have been no instances of this. Neither have there been any cases of a combined peak surcharge-off-peak discount; that is, a raising of peak period fares coupled with a lowering of off-peak fares.

Finally, several pass possibilities exist for differentiating fares throughout the day. At least three U.S. cities have implemented prepaid passes sold at a discount and restricted to off-peak use. Several cities (e.g., Bridgeport and Tallahassee) have pass programs restricted to peak hours, although the existence of discounted express service-only passes has effectively lowered rush-hour commuting costs in many other cities.

It should be noted that time-of-day fare differentials currently exist in almost every American city for special ridership markets, namely, elderly, handicapped, and student passengers. Monthly unlimited-ride passes, often priced at 40 times the base period fare, yet used upwards of 60 times per month, also end up providing regular, usually peak period, users with a discount. Given the prevalence of student discounts and regular pass programs in the United States, it is probably the case that average peak-period fares are actually lower than those in off-peak periods, at least among markets that do not include the elderly.

Chronology and Setting of Fare Programs

The data in Table 1 chronicle the evolution of time-of-day transit fare programs in the United States since 1970. Based on available records, more than 30 programs have been introduced between 1970 and 1983, including a 1-month experiment with midday discounts on San Francisco's BART rapid rail systems. At least 12 of these programs were subsequently discontinued, and in 2 of these cases (Akron and Youngstown), the differential was eventually reinstated.

The cumulative total column in Table 1 reveals that except for a small drop-off in 1980, the annual count of properties with time-of-day fares has increased steadily since 1970. By 1977 there were eight cases of time-of-day transit pricing, with only Boston having abandoned its differential on rail services. It is noteworthy that all of the pre-1977 programs involved off-peak discounts. It is probably no coincidence that the growth in fare discounts paralleled a period when operating subsidies from all levels of government were increasing by leaps and bounds. The rate of growth in time-of-day pricing slowed by the late 1970s to be followed by a second surge in the early 1980s. Of the 17 programs initiated during 1981 and 1982, 14 involved either peak-only surcharges or differential increases (peak fares rose more than off-peak ones). Clearly, the trend has been more toward time-of-day differentials that add on charges rather than deduct them. This reorientation suggests that threats made during the early 1980s to eliminate operating subsidies, particularly at the federal level, may have prodded some systems to initiate time-of-day fares as a means of generating revenue.

Where time-of-day fare programs have been implemented a wide variety of settings have been found. Twelve programs have been implemented in areas with

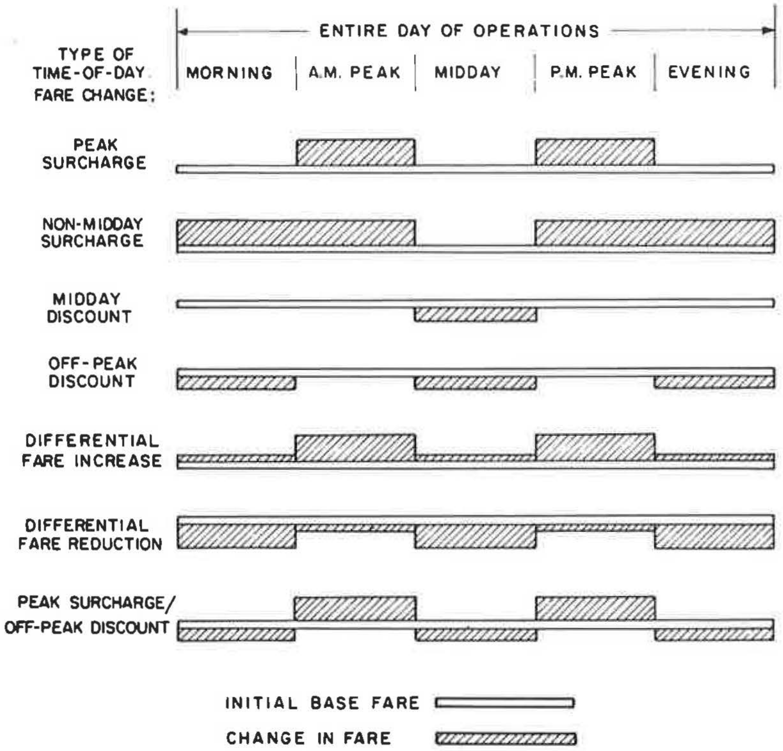


FIGURE 1 Time-of-day pricing options: ways of varying fares from the base level.

metropolitan populations above 1 million, whereas seven have been implemented in areas with populations below 100,000. Besides rail (San Francisco; Washington, D.C.; and Boston) and dial-a-ride (Orange County) applications of time-of-day pricing, bus systems that have nearly 3,000 active vehicles (Washington, D.C., Metrobus) and as few as 5 (Chico) have differentiated fares between peak and off-peak periods.

One statistic particularly relevant to this research is the ratio of peak-to-base vehicles among systems that have priced transit services by time-of-day. A high ratio would generally be associated with large cost differences between peak and off-peak periods; thus, systems that have high ratios can be expected to be likely candidates for time-of-day differentials. The mean peak-to-base ratio of 23 of the 30 nonrail systems that have used time-of-day pricing, and for which data were available, was 2.30 (standard deviation = 0.92). On average, more than twice as many vehicles were being deployed during peak as off-peak periods when time-of-day fares were introduced. This figure is higher than the national average peak-to-base ratio of 2.04 during the late 1970s (when most of the differentials were initiated) (3). Compared to the average U.S. property, systems that introduced time-of-day fares generally appeared to be good candidates in terms of the degree of peaking.

Description of Fare Programs

The absolute size and type of time-of-day differential for programs existing as of 1983 are given in Table 2. Differences between peak and nonpeak adult cash fares have been as small as $0.05 (in Baltimore and Washington, D.C.) and as large as $0.35 (in Columbus, Denver, and Palm Springs). The average differential has only been around $0.15. In relative terms, Columbus currently has the largest differential--base period fares are 140 percent higher than midday fares. The average differential is 40 percent, and the most frequently occurring differential is 25 percent (seven cases). Moreover, in some areas that have both zonal and time-of-day differentials, fares between peak and off-peak periods currently vary by as much as $0.85, in the case of Wilmington, and $1.30, in the case of the Washington, D.C., Metrobus. Overall, 12 of the 32 systems that have introduced time-of-day fares have also used distance pricing.

For almost all systems studied, the time-of-day differential that was initially set has eroded in real dollars' terms because of inflation. Only Denver, Burlington, and Cincinnati have increased their time-of-day differentials since its inception--Denver, from $0.10 to $0.35, Burlington from $0.10 to $0.15, and cincinnati, from $0.05 to $0.10.

Although most systems rely on cash payment to collect differentials, several rely solely on passes, whereas others use combinations of cash, passes, and ticket prepayment. Seven properties offer off-peak discounts ranging from 12 to 100 percent to passholders, whereas in four cases (Denver, Minneapolis, Orange County, and Washington, D.C.), peak surcharges ranging from $0.25 to $1.55 are tacked onto peak pass usage. These prepayment provisions are particularly noteworthy in that off-peak users are receiving fare incentives comparable to those enjoyed by rush-hour passholders.

The designated hours of peak and off-peak periods for systems that have implemented time-of-day pricing are given in Table 3. Fairly wide time bands have often been set, particularly among larger transit properties. In the case of the Washington, D.C., Metrobus and Metrorail, the designated morning and evening peak spans 7 hours. For most other properties, 6-hr peak periods have been designated; although there have been five different versions,

TABLE 1 Chronological Listing: Systems with Time-of-Day Pricing *(2,4)*

Year	Property	Number Implemented	Property	Number Discontinued	Cumulative Total
1977 or before	Erie (1970) Allentown (1972) Boston (1973) (rail) Denver (1973) Louisville (1974) Akron (1974) Rochester (1975) Baltimore (1976) Washington, D.C. (bus) (1975) (rail) (1976)	9	Boston (1975) (rail)	1	8
1978	Burlington Cincinnati Spartanburg/Anderson Walnut Creek	4		0	12
1979	Youngstown	1		0	13
1980	Albuquerque Duluth	2	Akron Baltimore Youngstown	3	12
1981	Chico Columbus Kansas City Orange County Palm Springs Sacramento Salt Lake City St. Louis	8	Albuquerque	1	19
1982[a]	Akron (reinstated) Chapel Hill Binghamton Kansas City Minneapolis Seattle Tacoma Wilmington Youngstown (reinstated)	8	Duluth Kansas City Palm Springs Rochester St. Louis Walnut Creek	6	21
1983	Wichita	1		0	22

[a] A 1-month experiment with time-of-day pricing by San Francisco's BART rail system during the month of February 1982 is not included in this chronology.

the most common is 6:00 to 9:00 a.m. and 3:00 to 6:00 p.m. Midday discount programs by comparison generally involve 5- to 6-hr discount periods that concentrate on lunchtime.

Although a wide time band can increase revenue yields, it also discourages shifts in ridership between periods because the number of potential beneficiaries becomes small. On the other hand, too narrow a band might result in excessive loss of passenger revenue and higher incidences of fare disputes at time-breaks. Indeed, some of the most vocal protests against time-of-day fare programs to date have been about the duration of the designated peak; some patrons charge that agencies are only interested in collecting more money from customers rather than encouraging shifts. In that most shifts could be expected to occur from the shoulders instead of the heart of the peak, transit managers counter that the cost savings of this redistribution in demand would be minimal. The original designated peak period was extended by 1 hr in the case of Orange County and 2 hr in the cases of Denver and Washington for these reasons.

Rationales for Adopting Time-of-Day Pricing

From extensive one-site and telephone interviews, information was elicited on why properties introduced time-of-day fare programs. The most frequently cited reason (21 of 31 systems) was to encourage increases in off-peak ridership through shifting. This was usually the primary motivation behind off-peak discount programs. The next most frequently cited reason (11 of 31 systems) was to increase farebox returns, promoted mainly by areas introducing peak-period surcharges. Other justifications were to effectuate cost-based pricing, to minimize ridership losses (through peak-only price increases), to help the disadvantaged, and to strengthen downtown areas. Several site-specific rationales were also cited; for example, in Minneapolis the regional transit authority was practically forced to institute a peak surcharge because the Minnesota Legislature precluded the raising of base period fares as a precondition to the receipt of state operating assistance. In general, all time-of-day programs were the products of many different stimuli as opposed to any one factor and usually took their form as a result of hard political bargaining and compromise.

Interviews also revealed reasons for discontinuing time-of-day pricing in some areas. In Akron, Baltimore, Boston, Palm Springs, Rochester, St. Louis, and Youngstown, excessive revenue losses prompted the return to flat fares. In Albuquerque, Kansas City, and Walnut Creek (California), increases in fare disputes and other implementation problems led to the abandonment of the differential. Moreover, there appeared to be an absence of direct beneficiaries of lower off-peak fares in many areas, ostensibly because senior citizens, who often pre-

TABLE 2 U.S. Time-of-Day Fare Programs in Existence from 1980-1983 by Size of Differential and Type of Fare Change

Transit Property	Size of Differential Between Peak and Nonpeak Periods ($)	Type of Fare Change[a, b]
Columbus	0.35	Midday discount
Denver[c]	0.35	Differential increase
Palm Springs[d, e]	0.35	Midday discount
Chico	0.25	Peak surcharge
Louisville	0.25	Off-peak discount
Tacoma	0.25	Peak surcharge
Walnut Creek[f]	0.25	Peak surcharge
Albuquerque[g]	0.20	Midday discount
Rochester[g]	0.20	Midday discount
Minneapolis	0.15	Peak surcharge
Orange County	0.15	Differential increase
Wichita	0.15	Differential increase
Youngstown	0.15	Midday discount
Akron	0.10	Nonmidday surcharge
Allentown	0.10	Off-peak discount
Binghamton	0.10	Peak surcharge
Burlington	0.10	Midday discount
Cincinnati	0.10	Differential increase
Chapel Hill	0.10	Peak surcharge
Erie	0.10	Midday discount
Kansas City[g]	0.10	Peak surcharge
Sacramento	0.10	Peak surcharge
St. Louis[g]	0.10	Peak surcharge
Salt Lake City	0.10	Differential increase
Seattle[h]	0.10	Peak surcharge
Wilmington[i]	0.10	Differential increase
Baltimore[g]	0.05	Differential increase
Washington, D.C.[j]	0.05	Differential increase
Spartanburg/Anderson	–	Off-peak pass
Duluth[g]	–	Peak-restricted pass

[a] Refers to version of time-of-day pricing in existence or first introduced between 1980-and 1983. Types of fare change are: differential increase (raising the peak fare higher than the off-peak); midday discount (lowering fares only during midday hours); nonmidday surcharge (increasing fares only during nonmidday hours); peak surcharge (increasing fares only during peak hours); off-peak discount (lowering fares for all nonpeak hours, whether morning, midday, or evening); off-peak pass (discounted pass only for use during off-peak periods); and peak-restricted pass (discounted pass restricted during narrow peak time span).

[b] San Francisco's BART experiment with time-of-day pricing in February 1982 is not included. The differential amounted to a 20 percent discount below the regular fare during the midday period; the exact amount varied by distance traveled.

[c] Denver's local differential is $0.35 ($0.70 versus $0.35) in the city proper and $0.15 ($0.50 versus $0.35) in the city of Boulder.

[d] Subsequently discontinued time-of-day pricing.

[e] For intercity routes the differential was $0.50 in Palm Springs.

[f] Seattle's time-of-day fare differential widens to $0.15 for trips between two zones.

[g] Wilmington's time-of-day fare differential is only $0.10 for travel within any one zone, but is as large as $0.85 for travel between four zones.

[h] Washington's Metrobus time-of-day fare differential is only $0.05 within the District, but is as large as $1.30 for interjurisdictional trips between outer zones in Maryland and Virginia.

TABLE 3 Comparison of Time Period Intervals Among Transit Properties with Time-of-Day Fares Since 1970

Transit Property	Designated Peak/Off-Peak Hours	Duration (hr)
Properties with Designated Peak Hours		
Washington, D.C.	6:00-9:30 a.m., 3:00-6:30 p.m.	7.0
Baltimore[a]	6:00-9:00 a.m., 3:00-6:00 p.m.	6.0
Cincinnati	6:00-9:00 a.m., 3:00-6:00 p.m.	6.0
Denver	6:00-9:00 a.m., 3:00-6:00 p.m.	6.0
Kansas City[a]	6:00-9:00 a.m., 3:00-6:00 p.m.	6.0
Orange County	6:00-9:00 a.m., 3:00-6:00 p.m.	6.0
St. Louis[a]	6:00-9:00 a.m., 3:00-6:00 p.m.	6.0
Seattle	6:00-9:00 a.m., 3:00-6:00 p.m.	6.0
Minneapolis	6:00-9:00 a.m., 3:30-6:30 p.m.	6.0
Binghamton	6:15-9:15 a.m., 3:15-6:15 p.m.	6.0
Chapel Hill	6:30-9:30 a.m., 3:00-6:00 p.m.	6.0
Tacoma	5:00-9:00 a.m., 4:00-6:00 p.m.	6.0
Seattle[b]	6:00-8:45 a.m., 3:15-6:00 p.m.	5.5
Sacramento	6:30-9:00 a.m., 3:30-6:00 p.m.	5.0
Louisville	6:30-8:30 a.m., 3:30-5:30 p.m.	4.0
Salt Lake City[c]	6:30-8:30 a.m., 3:30-5:30 p.m.	4.0
Duluth[a]	7:30-8:00 a.m.	0.5
Properties with Designated Off-Peak Hours		
Albuquerque	9:00 a.m.-3:00 p.m.	6.0
Spartanburg/Anderson	9:00 a.m.-3:00 p.m.	6.0
Wilmington	9:00 a.m.-3:00 p.m.	6.0
Burlington	9:15 a.m.-3:15 p.m.	6.0
Wichita	9:45 a.m.-3:45 p.m.	6.0
Columbus	9:30 a.m.-3:00 p.m.	5.5
Youngstown	9:30 a.m.-2:30 p.m.	5.0
Allentown	10:00 a.m.-3:00 p.m.	5.0
San Francisco (rail)[a]	10:00 a.m.-3:00 p.m.	5.0
Rochester[a]	10:00 a.m.-2:30 p.m.	4.5
Akron	10:00 a.m.-2:00 p.m.	4.0
Erie	10:00 a.m.-2:00 p.m.	4.0
Palm Springs[a]	10:00 a.m.-2:00 p.m.	4.0
Boston (rail)[a]	10:00 a.m.-1:00 p.m.	3.0

Note: This comparison of time period intervals among transit properties with time-of-day fares since 1970 is the latest version of time-of-day pricing for those properties that revised designated hours.

[a] Discontinued time-of-day differential.

[b] Seattle's actual hour intervals are 6:00 to 9:00 a.m. and 3:30 to 6:00 p.m. for inbound trips and 6:00 to 8:30 a.m. and 3:00 to 6:00 p.m. for outbound trips. Hours shown are on average of this range.

[c] Designated peak hour is actually from the first bus in the morning to 8:30 a.m., which, for most runs, is from 6:30-8:30 a.m.

dominated off-peak patronage, were already receiving substantial discounts anyway. In general, users were indifferent to the elimination of off-peak pricing. This was reflected by the paucity of formal protests lodged at public hearings.

IMPACTS AND TRENDS ASSOCIATED WITH TIME-OF-DAY PRICING

Data limitations, stemming from the fact that this research was conducted "after-the-fact," restricted the analysis of ridership, financial, and equity impacts. Nevertheless, the examination of "before" and "after" data provided a basis for attributing various trends to time-of-day pricing.

Ridership

Both before-and-after comparisons and econometric analyses were conducted in examining the ridership implications of time-of-day pricing (2). The data in Table 4 summarize the measured ridership impacts grouped in terms of the type of fare program initiated. Most areas that introduced off-peak discounts experienced significant gains in ridership; the average increase (from 1 yr before to 1 yr after the fare change) was about 10 percent. In Burlington, Columbus, and Erie, riders appeared to have been more sensitive to fares than is typical for cities of comparable size; estimated fare elasticities from the introduction of time-of-day fares were about

TABLE 4 Apparent Impacts of Time-of-Day Pricing on Total Ridership, Controlling for Average Fare and Level of Service

Type of Fare Change	Increase	Decrease	Little or Uncertain
Off-peak or midday discount	Burlington Columbus[a] Erie	Allentown[a] Boston	Akron[a] Louisville
Peak surcharge or differential increase	Chapel Hill Cincinnati[a] Salt Lake City Tacoma	Akron[a,c] Baltimore Wilmington	Denver[a] Minneapolis Orange County[a] Sacramento Seattle[a]

[a] Based on ridership model.

[b] Initial implementation October 1972.

[c] Reimplementation February 1981.

-0.80 to -0.90. This suggests that the discounts were more effective in boosting ridership than a uniform lowering of fares (which produced the same average fare) would have been.

With peak surcharges and differential increases, ridership consistently declined an average of about 10 percent in the case of peak surcharges and 15 percent in the case of differential increases. Users in Baltimore and Wilmington appear to have been most sensitive to the initiation of a differential increase. Time-series analysis revealed that Cincinnati's off-peak users were more than twice as sensitive to the area's 1980 simultaneous increase in peak fares (by $0.15) and off-peak fares (by $0.10) as their peak-period counterparts. Fare elasticities were estimated to be -0.31 for peak periods and -0.69 for off-peak periods. Among systems that introduced peak surcharges, the largest ridership decrease occurred in Sacramento, an area that initiated extensive service cuts at about the same time as the 1981 fare change. Overall, however, the patronage losses from both peak surcharge and differential increase programs were generally less than what would have been expected from an across-the-board fare hike that yielded the same average fares.

Unfortunately, attempts to gauge the degree of across-period shifting induced by time-of-day pricing and to compute temporal cross-elasticities were unsuccessful because of data limitations. It bears repeating that the main impetus behind most properties introducing time-of-day pricing was to bring about shifts in use from the peak to off-peak hours. The data in Table 5, which summarize changes in the distribution of ridership from before and after the introduction of fare differentials in 17 areas, does provide some insight in this regard, however. There is some evidence that the off-peak share of ridership rose in about one-half of the areas that introduced midday or off-peak discounts. Areas with the largest relative discounts and the longest designated midday periods appeared to enjoy the greatest increases in off-peak shares. In Columbus, for example, a $0.35 discount extended over the midday hours of 9:30 a.m. to 3:00 p.m. was followed by a midday increase in the share of total ridership from 36 to 44 percent. In contrast, peak surcharge programs appeared to have had an imperceptible influence on ridership distribution. Thus, peak ridership generally held its own in areas introducing peak surcharges; the one notable exception was Chapel Hill, North Carolina, where the off-peak share increased by almost 40 percent 1 year after the 1982 adoption of a $0.10 peak surcharge. Although these findings fail to disclose whether off-peak ridership gains came from the ranks of former peak period users, there is, nonetheless, ample evidence that time-of-day differentials have at least helped fill up underutilized off-peak buses.

TABLE 5 Trends in Ridership Distribution Between Peak and Off-Peak Periods Associated with Time-of-Day Pricing

		Fare Differential			
Type of Fare Change	Transit Property	($)	(%)	Lower Fares in Effect	Evidence of Change in Ridership Distribution Between Peak and Off-Peak
Midday or off-peak discount	Akron	0.05	9	10:00 a.m.-2:00 p.m.	One-day, on-board passenger counts before and after adoption of differential indicate no shift.
	Boston	0.15	60	10:00 a.m.-1:00 p.m.	Passenger counts indicate percentage of riders during discount period increased from 12.4 percent the week before the fare change to an average of 13.3 percent the first 5 weeks after the change.
	Burlington	0.25	33	9:00 a.m.-3:00 p.m.	88 percent of midday riders surveyed report they plan trips to take advantage of discount.
	Columbus	0.35	58	9:30 a.m.-3:00 p.m.	Midday ridership from 36 percent of 44 percent of total. Staff estimates 10 percent shift from peak to midday.
	Duluth[a]	2.00	21	All except 7:30-8:00 a.m.	Passenger counts and surveys indicate no shift.
	Rochester[a]	0.15	58	10:00 a.m.-2:30 p.m.	Anecdotal evidence of significant shifts from peak to off-peak.
	San Francisco[a] (BART)	0.10-0.35	20	10:00 a.m.-3:00 p.m.	During 1-month experiment, 37 percent of average weekday passengers rode during midday as compared with 36 percent in 3-month period before and after experiment.
	Spartanburg/ Anderson,	—[b]	60	9:00 a.m.-3:00 p.m.	Off-peak pass sales increased 100 percent over 3-year period while overall ridership held steady.
Differential increase	Orange County	0.15	20	9:00 a.m.-3:00 p.m. After 6:00 p.m.	Passenger counts indicate an increase in off-peak share of total ridership from 44 percent to 46 percent.
	Wilmington	0.10-0.70[c]	17-42[c]	9:00 a.m.-3:00 p.m.	Passenger counts indicate increase in midday share of total ridership from 28.5 percent to 29.3 percent.
Peak surcharge	Chapel Hill	0.10	20	9:30 a.m.-3:00 p.m. After 6:30 p.m.	Passenger counts indicate increase in off-peak share of total ridership from 33 percent to 46 percent.
	Minneapolis	0.15	20	9:00 a.m.-3:30 p.m. After 6:30 p.m.	Responding to ridership surveys, 18 percent of users report they have shifted usage to off-peak.
	Sacramento	0.10	17	Before 6:00 a.m. 9:00 a.m.-3:30 p.m. After 6:00 p.m.	Passenger counts indicate off-peak share of total ridership was 63.9 percent in year before differential and 55 percent in year after differential was adopted.
	Seattle	0.10	17	Before 6:00 a.m.[d] 9:00 a.m.-3:00 p.m. After 6:00 p.m.	Ridership survey indicates a 4 percent shift of discretionary trips from peak to base period.
	St. Louis[b]	0.10	17	Before 6:00 a.m. 9:00 a.m.-3:00 p.m. After 6:00 p.m.	Passenger counts indicate off-peak share of total ridership was 43.3 percent before differential, 43.8 percent when differential was in effect, and 43.1 percent after differential was abandoned.
	Tacoma	0.25	50	Before 5:00 a.m. 9:00 a.m.-4:00 p.m. After 6:00 p.m.	Increase in off-peak share of total ridership from 44.6 percent to 47.5 percent.
	Washington Metrobus	0.05	7	9:30 a.m.-3:00 p.m. After 6:30 p.m.	Increase in off-peak share of total ridership from 33.3 to 36.8 percent.

[a] Time-of-day pricing subsequently abandoned.
[b] Discount applies to monthly passes only.
[c] Differential depends on number of zone boundaries crossed.
[d] Hours differ slightly for morning outbound and afternoon inbound trips.

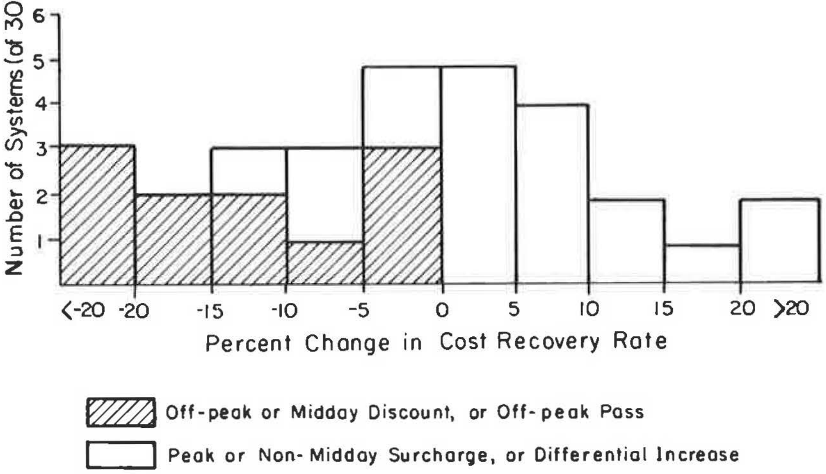


FIGURE 2 Distribution of percent change in cost recovery rates, by type of time-of-day differential.

Efficiency

Besides stimulating shifts in ridership, many time-of-day programs were also initiated with the objective of upgrading financial and operating performance. Figure 2 shows the superior financial performance of surcharge programs by comparing changes in cost recovery rates (passenger revenues and operating expenses) for 30 properties. In all cases, off-peak discount programs experienced a decline in the share of expenses recovered from fares; in seven cases rates fell by more than 10 percent within 1 yr. By comparison, cost recovery rates generally increased by 5 to 10 percent for most systems that introduced either peak surcharge or differential fare increases. The range in the percent change in cost recovery was from -33 percent in the case of Albuquerque's 1980 $0.20 discount to +62 percent in the case of Orange County's 1981 $0.25 peak and $0.10 off-peak fare increase. Although numerous other factors have undoubtedly affected systems' financial performances, it was nonetheless clear that fiscal improvements have generally accompanied peak surcharge programs whereas with off-peak discounts, cost recovery rates have consistently declined.

A common argument in favor of time-of-day transit pricing is that unit costs can be lowered by more efficiently allocating both capital and labor throughout the day. However, the data in Table 6, reveal that there were no significant changes in peak-to-base period ratios of vehicles or employees. Only in the case of off-peak discount programs did there tend to be a slight reduction in this ratio. However, for four larger areas--Minneapolis; Orange County; Sacramento; and Washington, D.C., the ratio of peak-to-base buses did decline by more than 7 percent within 1 yr of the introduction of surcharges. Based on discussions with local transit officials in all four communities, time-of-day pricing appeared to be only one of a number of other efficiency and cost-savings improvements that helped shave peak-to-base ratios.

Moreover, the sizes of properties' labor forces were generally found to be unaffected by time-of-day pricing. By shaving peak services in response to ridership shifting to the off-peak, it is hoped that both overhead expenses and workforce size can be trimmed under time-of-day pricing. Moreover, labor productivity, as reflected by vehicles and vehicle-miles per employee, generally declined by about 2 percent among systems using time-of-day pricing, regardless of the version used. There were notable variations in these trends, however. In Akron and Orange County, for example, vehicle miles per employee increased by more than 10 percent within 1

TABLE 6 Percent Change in Several Efficiency Indicators Following the Introduction of Time-of-Day Pricing by Type of Fare Change

	No. of Systems	Average Peak-to-Base Ratio for the Year Time-of-Day Pricing Was Introduced[a]	Average Percent Change[b]			
			Peak-to-Base Ratio of Vehicles	Employees[c]	Vehicle Miles per Employee	Vehicle Hours per Employee
Systems that currently have time-of-day pricing	22	209.3	−0.2	+2.6	−2.1	−2.8
Surcharge or differential increase	15	197.2	+0.2	+2.3	−2.1	−2.5
Off-peak or midday discount	6	241.2	−1.4	+3.5	−2.1	−3.6
Off-peak pass	1	200.0	0.0	–	–	–
Systems that abandoned time-of-day fares	6	226.2	–	–	–	–
Surcharge or differential increase	4	274.0	–	–	–	–
Off-peak or midday discount	2	130.5	–	–	–	–
All systems combined	28	217.0	–	–	–	–

Note: Dash means data not available.

[a] Two current surcharge programs and two current discount programs are excluded due to unavailable data. Peak-to-base ratio equals number of peak vehicles divided by number of off-peak, or base, vehicles times 100.

[b] Each case is weighted the same regardless of property size. Only non-rail systems are analyzed.

[c] Computed only for 14 surcharge and 4 discount programs; other cases were missing.

year of adopting time-of-day pricing, whereas the same indicator dropped by a comparable rate in Tacoma and Wilmington.

Individual case studies revealed more positive efficiency impacts of time-of-day pricing. For example, Rochester's transit authority redeployed 10 of its peak-hour runs to off-peak hours and shaved its peak fleet following its 1975 lowering of midday fares. Columbus's bus system also reassigned numerous driver tours. There, seat occupancy during the midday increased from 40 to 63 percent, to the point where load factors are now the highest during the noontime. Columbus's $0.25 midday fare, coupled with free midday downtown services, has led to an oversubscription problem, however. Because of excessive noontime crowding, the incidence of scheduled buses running 3 min late or more increased by 22 percent following Columbus's initiation of a combined midday discount-free downtown service.

In terms of other efficiency trends, there was an average decline in revenue passengers per mile following time-of-day pricing among the systems studied, although this did vary markedly among properties. Notably, in Denver and Columbus, two areas that have the largest absolute differentials, this measure increased by 10 percent 1 yr after time-of-day pricing was introduced.

There is also anecdotal evidence that midday discounts have had positive impacts on downtown retail activities in several areas. The most impressive results have been in Columbus where daily ridership to downtown increased by one-third during the first month of the city's $0.25 midday discount program. One year later, sales tax revenues dedicated to the local transit system increased by $2 million more than had been expected, effectively reducing Columbus's need for state and federal operating assistance. Local officials attribute the boom in sales volumes to the multiplier effect of stimulating downtown business activities through the promotional fares. Columbus officials proudly note that sales tax revenues increased 14 percent during the first month of the fare program, whereas for the same period during the previous year they decreased 10 percent. However, any sales tax gains can be expected to be related to larger regional economic forces. That is, in the absence of a growing economy, any increases in downtown business sales would be purely redistributive--that is, taking away retail transactions from areas not in the central business district. Nonetheless, Columbus is in a financially more viable position than several years ago (because of tremendous gains in dedicated tax receipts), lending some credence to the contention that more efficient pricing yields important secondary community benefits.

Equity

This research also included an examination of the effects of time-of-day pricing on ridership composition to determine whether fare differentials would benefit the poor and disadvantaged groups the most (as evidenced by their increased use). The distributional effects of time-of-day pricing were found to be quite modest. This was probably because most time-of-day fare differentials were so small as to diffuse impacts among user groups. Among six properties for which data were available, only in Columbus and Minneapolis did the differential appear to influence ridership mixes to any noticeable extent. In Columbus, the share of older, minority, and low-income users increased overall; however, the proportion of choice riders increased markedly during the midday. In Minneapolis, some shifting of lower income, school-aged and captive users to off-peak periods was found following the add-on of a 25 percent peak surcharge.

IMPLEMENTATION AND POLITICAL ISSUES

Making time-of-day pricing work, both logistically and politically, is a major hurdle to overcome in the minds of many. Several important strategies that facilitated the implementation of time-of-day pricing deserve particular attention.

Fare Collection

Foremost among the successful implementation strategies have been innovative approaches designed for collecting differential fares. In particular, nonobtrusive ways have been devised for coping with the boundary problem; that is, collecting fares at the changeover point from the off-peak to peak period and vice versa. Nearly one-third of all properties collect their differentials on the basis of individual bus runs or arrival at a major activity center rather than according to the specific hands on the clock. Run-based collection virtually eliminates fare disputes, more closely approximates cost variations, and provides the flexibility needed to make differential pricing manageable. In Binghamton, Columbus, Erie, Orange County, Sacramento, Seattle, and Wichita, managers claim that user-driver confrontations have been substantially reduced because everyone boarding a bus from the beginning to the end of a regularly scheduled run pays the same fare as opposed to the fare changing, for example, midway along a route. In instances where run-based collection is used, individual bus schedules have been shaded or printed in boldface letters to highlight exactly where, rather than when, fare rates change.

Special signage (e.g., flip signs and decals) and pulse scheduling have also been used to facilitate the differential fare collection process. Moreover, coinage was chosen in Columbus ($0.25) and Denver ($0.35 token) to reduce change handling in order to expedite the boarding process during high-volume midday hours. In addition, in almost every case studied, drivers were encouraged to exercise discretion when collecting differentials. Although there was some indication of fare evasion in several areas following the introduction of time-of-day pricing; overall there appeared to be a collective spirit of cooperation among users and drivers in enforcing the fare programs.

Reactions to Time-of-Day Pricing

Another important aspect of implementing time-of-day pricing is the general receptiveness of different groups and special interests to fare reform. Numerous individuals were polled about their reactions as well as the reactions of others to the fare changes. In general, most groups appeared fairly indifferent toward time-of-day pricing. Interviews with transit managers indicated that board members of more than three-quarters of all areas were supportive of time-of-day pricing, considering it a more business-like practice. In most of these cases, agency staffers aggressively promoted the idea of time-of-day pricing through special workshops and other efforts designed to explain the rationales behind peak and off-peak differentials. In those areas where board members were initially skeptical, apprehensions tended to wane within several months of implementation.

In most areas, drivers have been fairly ambivalent toward time-of-day pricing. Interviews with rank-and-file representatives in a number of areas indicated that the fare programs themselves were far down the list of priority concerns among drivers. Most drivers indicated that complaints about fare collection generally were related more to matters such as exact payment, multiple passes, and zonal charges than to the time-of-day differential. Some found time-of-day pricing to be a simplification of previous fare practices. No instances were found in which drivers used the differential program and its greater likelihood for fare disputes as a bargaining chip during wage negotiations.

Although there were scattered incidences of user complaints immediately following the introduction of peak surcharges in several areas, acceptance generally came quickly. Aggressive marketing and educational programs certainly had something to do with this. However, the fact that differential pricing was already institutionalized in several areas and that time-of-day fares were actually simplifications of earlier fare practices in others also worked in the transit properties' favor. Moreover, in that the vast majority of users ended up paying the same fare regularly, the differential itself became a nonissue. There were few instances of peak-period customers complaining about unfair treatment. Apparently, the adoption of fairly small differentials helped to assuage potential ill-feelings. A number of transit managers interviewed volunteered that a small differential was consciously chosen initially to guard against disenfranchising any one group, though they had the intention of eventually widening the differential. As mentioned earlier, few properties have actually widened the differential.

Perhaps the most vocal user protests concerned the specific designation of the peak time bands instead of the fare rates. In Denver; Washington, D.C.; and several other areas; users openly complained at public hearings that the designated peak hours were too long, thus limiting their ability to take advantage of lower fares. Although longer peak hours enhance revenue returns and perhaps reduce the incidence of fare disputes, the discouragement of shifting is perceived by many to be a major drawback. Finally, there were a few instances in which certain groups of users were intimidated by fare differentials. In Orange County, for example, bus drivers have reported a high incidence of overpayment during off-peak periods among non-English-speaking patrons, primarily southeast Asians and Latinos, who simply do not understand the differential and are fearful of being accused of cheating.

Marketing and Other Implementation Factors

The general public receptiveness to time-of-day pricing was unquestionably due, in large part, to ambitious marketing and user information programs. Many systems launched aggressive promotional campaigns using extensive media coverage, newspaper advertisements, radio announcements, on-vehicle brochures, educational films, and areawide postering to inform the public about time-of-day pricing. When Columbus initiated its $0.25 midday discount program, for example, an extensive $40,000 promotional effort and media blitz was undertaken. Moreover, merchants gave away more than 200,000 free ride coupons and store prizes as a goodwill gesture during the opening week of the fare program.

A particularly useful marketing ploy adopted by a number of properties was to sell the fare program to the public as a discount fare rather than a peak surcharge, regardless of whether it was or not. Most off-peak discounts were marketed as bargain and incentive fares, rather than peak and off-peak differentials. This tended to cast each program in a positive light and also avoided any hint of discriminatory pricing between peak and off-peak users. In the cases of peak surcharge and differential increase programs, the marketing tactic usually chosen was to emphasize the benefits of off-peak travel instead of the higher cost of peak-period usage. These marketing strategies parallel those currently being used by many oil companies whereby emphasis is placed on receiving cash discounts rather than any mention of credit card surcharges.

An investigation of the role of the private sector in promoting time-of-day pricing revealed that most of the involvement was limited to business merchants giving away free bus tokens and promotional prizes during the first week or more of some programs. The giveaways were linked to service improvements as much as the fare programs in most areas, however. Few instances in which time-of-day pricing was implemented as part of a flextime or staggered work-hour program were found. In the one case where time-of-day pricing was introduced specifically in combination with flextime (Duluth) the demonstration was discontinued after 1 yr because virtually no employers participated. In the absence of joint public and private coordination of work schedules and fare policies, it is perhaps no great surprise that the level of ridership shifting found was fairly inconsequential. It is probably the case that private interests need to believe that there is something in it for them, such as in the case of Columbus, if they are to actively promote and support time-of-day pricing or any other fare innovation.

CONCLUSION

Although it is hoped that some new insights into time-of-day pricing have emerged from this research, knowledge regarding possible ridership and financial effects of such fare reforms remains incomplete. In particular, the ability of time-of-day fares to bring about significant temporal shifts in ridership remains unclear, even though this was the intended result of most programs. Data limitations are partly to blame. But the fact that most of the differentials implemented to date have been fairly nominal, along with the absence of a true peak-increase and off-peak-decrease fare change, have been limiting factors as well. Moreover, because many differentials have been eroded by inflation since they were first introduced, the dearth of significant ridership and performance findings perhaps could have been expected. It is probably also the case that the wide time bands chosen by many transit properties to represent the peak period effectively prevented many passengers from shifting over to the lower-priced off-peak periods.

If the effects of a substantial peak and off-peak fare differential are to be accurately gauged, a carefully designed and administered demonstration program needs to be launched. A more controlled experimental approach using panel groups is essential if the incidence of ridership shifting induced by time-of-day pricing is to be measured. Ideally, a demonstration program involving a combined peak-increase and off-peak-decrease fare change with a large differential would be designed. In addition, every effort should be made to enlist the support of the private sector in coordinating various flextime and staggered work-hour programs with time-of-day pricing.

This research suggests that both off-peak discounts and peak surcharges, as well as combinations thereof, can yield positive dividends to a transit agency as long as they are carefully implemented and other reinforcing factors accompany them. Run-based fare collection appears to be far superior to time-based approaches. Equally as important, driver-user confrontations can be avoided with a well-planned, run-based collection system. Creative marketing also appears to be an important prerequisite. There appears to be less public resistance, moreover, when differentials are marketed as bargain off-peak fares, without any reference to higher peak-period rates. This marketing ploy can cast the fare program in a more positive light without alienating transit's bread-and-butter customers--peak-hour users. It is also essential that careful attention be paid to the designation of peak and off-peak hours, mindful of the trade-offs involved. Although lengthy peak periods usually generate more revenues than narrower ones, they probably have been major deterrents to significant ridership shifting as well. Peak-period time bands need to be seriously reevaluated in some areas with an eye toward encouraging ridership shifting. Along this same line, every effort should be made to implement time-of-day pricing in conjunction with flextime programs. Both public and private interests could materially benefit by doing so.

Of course, there can be no guarantees that if an agency does a certain number of things, then a successful time-of-day fare program will result. Numerous factors, many of which are uncontrollable (e.g., changing gasoline prices and regional economic conditions), have varying degrees of influence on the outcome of any fare reform. But among the factors that a transit agency can directly control, run-based collection, inventive marketing, and the careful designation of time bands all appear to be important ingredients of successful time-of-day fare programs.

ACKNOWLEDGMENT

This research was funded by the Technical Assistance Program of the Urban Mass Transportation Administration, U.S. Department of Transportation.

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Publication of this paper sponsored by Committee on Public Transportation Marketing and Fare Policy.

Abridgment

Distance-Based Fares on Express Bus Routes

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ABSTRACT

Distance-based fares for bus transit have been previously shown to be more equitable than the widely used flat fares. However, with rising transit costs, an additional source of revenue is often needed. In this paper the possibility of distance-based fares as a source for this revenue is explored. Express bus service in Milwaukee, Wisconsin, was used as a case study. Different fares were proposed for each route based on its length. Alternative methods of implementing distance-based fares were then proposed. The findings revealed that a small revenue gain is possible without suffering a ridership loss. Conversely, slightly lower fares could result in a small ridership increase with no revenue loss. A 10 percent revenue gain would require a fare increase on the longest route of 55 to 90 percent for the low and high scenarios. The corresponding fare change on the shortest route is a 20 percent decrease to a 5 percent increase. A 20 percent revenue gain would require a fare increase of 75 to 170 percent on the longest route and a 5 percent decrease to a 45 percent increase on the shortest route.

During the 1960s and early 1970s, many transit operators switched from some form of distance-based fares to a flat fare. This trend occurred both in the United States (1) and worldwide (2) for two reasons: (a) to establish low, stabilized fares, and (b) to ease collection. As more systems adopted a flat fare structure, a smaller percent of the operating expenses was paid from passenger revenue. Consequently, increased subsidies from local, federal, and to a lesser extent, state levels, were required for this trend to occur.

Statistics indicate that the goal of stabilized fares was reached because during the period from 1972 to 1978, the consumer price index increased by 56 percent while passenger fares increased by only 21 percent (3). By contrast, the change in fares was greater than that of the consumer price index during the previous period from 1950 to 1970 (1).

The idea of a flat fare was used by Benjamin Franklin for setting rates for the post office. Franklin determined that the overall cost of administering the flat rate would be less than that for a graduated rate. The system worked and is still in use. It appears quite inequitable to someone mailing a letter locally. However, that same person will usually also mail a letter to another state, which in the long run will balance the inequity.

Public transit, however, is different from the postal service. Although the argument of the lower overall cost of administrating a flat fare is still true, the self-balancing equity is not. A person living near the edge of the transit service area will undoubtedly ride the system for a longer distance per trip than will someone living near downtown. Consequently, consideration is now being given to returning to a distance-based fare for the main reasons of (a) equity between passengers taking different length trips, and (b) providing additional revenue to meet inflated transit costs.

The cost to graduate fares is high. Cervero (1) determined that a finely graduated fare structure would add about 2.4 to 3.6 percent to the cost of providing the service. Bus speed might be reduced due to more dwell time while collecting fares. From the labor standpoint, more responsibility would be required of the bus operator to collect fares. From a marketing standpoint, by comparing a very simple flat fare structure to a seemingly uncomprehensible zonal fare system Drake and Guenthner (4) concluded that the flat fare was easier to present, to understand, and to use.

The magnitude of the equity problem has been explored. In three California cities with flat fares Cervero (1) found that the short trips were subsidizing the long trips. Ugolik and Leutze (5) found similar results in Albany, New York. Wilson and Kurgan (6) found that trip lengths less than 3.5 mi subsidized longer trips in three small Pennsylvania cities. Using information from Atlanta, Bates et al. (7) stated that passengers making longer trips are generally suburbanites in higher income brackets who are better able to pay a higher fare. Charging a distance-based fare, in this situation, would be more equitable than charging a flat fare.

Suburban expansion has further increased the problem. A combined effect of lower population densities and federal assistance for capital expansion has resulted in low productive service to suburban areas. The operating cost per passenger for providing service to outlying areas far exceeds that of providing service to areas near downtown. Hefner (8) pointed out that new rail systems are being designed primarily to serve suburban areas. Consequently, although these new systems appear to be serving the inner city, they actually intensify the equity issue. Pucher (9) called for "a moratorium on the construction of any more of the proposed new multi-billion dollar rail systems."

Altshuler (10) summarized the equity problem by stating:

> With few exceptions, American transit systems charge flat fares or variable fares that fail to cover the full additional cost of longer trips (bearing in mind both the additional vehicle mileage required to serve them and the reduced load factors at the outer ends of routes).

A recent financial crisis has occurred in the transit industry. During the period from 1972 to 1978, while fares were stabilized, the cost of providing transit service increased faster than the consumer price index. The overall operating ratios decreased from an average of 0.74 to 0.48 (11). The result has been significantly increased fares from 1978 to 1981 [28 percent in only 3 years (3)]. The simple $0.25 fare is no longer possible. As fares approach a level of $1.00, a negative image of the transit system often results. Consequently, in addition to the equity arguments, distance-based fares are being considered a more politically feasible means of obtaining critically needed revenue.

The Milwaukee County Transit System (MCTS) is considering distance-based fares for its 12 express bus routes known as freeway fliers. These routes generally commence from an outlying park-and-ride facility and traverse a freeway to the central business district. They are downtown-oriented routes that serve predominantly suburban areas, and the riders are primarily middle class, white collar workers. A high percentage of the ridership is assumed to be choice riders. The routes operate daily during the morning and evening peaks. Although some of the routes have multiple boarding locations before entering the freeway, a majority of the passengers on each route boards at one or two main locations. Consequently, the length of travel by all of the riders on each route is about the same. Using a different fare for each route based on its length, distance-based fares would be feasible.

Alternative methods of implementing distance-based fares on the freeway flier routes are examined in this paper. A range of projected impacts is presented for each alternative.

METHODOLOGY

Paramount for any revenue projection surrounding a fare change is a reliable value for the demand elasticity with respect to fare. Time series analysis was selected as a method to estimate the elasticity in the Milwaukee case study. The method was chosen because it can account for a number of factors other than fare changes. Both exponential and linear time trends were also considered.

The results of the better fit exponential model are given in Table 1. In addition to the fare, fuel prices, snowfall, and vehicle-hours, time trends were found to affect significantly the monthly ridership as judged by the 95th percentile t-values. The overall model was significant as explained by the high adjusted R-squared value of 0.917. The overall F value of 203.48 was significant to the 0.95 level. The elasticity with respect to fare was determined to be -0.56 as indicated in Table 1. This

TABLE 1 Analysis of Time Series Model

Variables in the Equation[a]	Coefficient[b]	t-Value	Demand Elasticity	95 Percent Confidence of Demand Elasticity
Fuel	1.835	7.92	+0.734	+0.550 to +0.919
Fare	−1.769	−6.12	−0.561	−0.379 to −0.743
Month	.0043	8.50		
Vehicle-hours	.0051	4.78	+0.791	+0.462 to +1.120
Snow	.0054	4.77		
(constant)	7.359	32.35		

[a] Variables are defined as follows: dependent variable—log (ridership), fare = regular fare per rider corrected for inflation, fuel = average gasoline price per gallon corrected for inflation, vehicle-hours = vehicle-hours traveled, month = month (January 1976 = 1), and snow = monthly snowfall in inches.

value, although steeper than traditionally accepted values, can be justified by a high percent of choice riders found on the express routes. Also indicated in Table 1 are the elasticities with respect to fuel price and service. The 95 percent confidence intervals for each are also given.

The 1983 ridership, revenue, passenger miles, and route lengths for each freeway flier route are given in Table 2. The linear distance-based fare for each route is the route length multiplied by the systemwide fare per passenger-mile. Knowing the demand elasticity with respect to fare, a new ridership can be predicted for each route. By evaluating only small increments of fare at a time, the point elasticity can be estimated by a series of shrinkage ratios. Mathematically, this may be represented as follows:

TABLE 2 Existing System

Route	One-Way Length (mi)	1983 Ridership	1983 Pass-Miles
39	11	50,819	553,660
40	10	127,449	1,274,490
41	8	71,109	568,872
42	14	212,652	2,977,128
43	15	154,685	2,242,933
44	10	152,371	1,447,525
45	12	102,121	1,225,452
46	13	177,595	2,219,938
47	11	93,162	1,024,782
49	13	222,746	3,452,563
Total	–	1,364,709	16,967,282

$$Q_{new} = Q_{old} \times (1 + SR \times \Delta F/F) \quad (1)$$

where

Q_{new} = ridership after the increment,
Q_{old} = ridership before the increment,
SR = shrinkage ratio, and
F = fare.

The equation is used by sequentially changing the value of F by ΔF until the new fare is reached. One-half of a cent was used for ΔF as acceptably close to zero.

For an inelastic demand elasticity, no change in fare policy would result in both a ridership and a revenue gain. For the Milwaukee case, the longer routes required an increased fare that resulted in a lower ridership and more revenue. The shorter routes experienced the opposite. The overall ridership increased slightly with an insignificant drop in revenue.

After the fares have been adjusted to equalize fare per mile, by adjusting the fare level, several policy options were evaluated including: maintaining current revenue and current ridership, increasing revenue by a certain percent, and adjusting the lowest fare to a minimum value.

RESULTS

The analysis of the freeway flier routes was conducted by using three values of the fare elasticity. The medium scenario involved the value of −0.56 given in Table 1. Values of −0.37 and −0.74, which were the extremes for the 95 percent confidence interval, were used for the high and low scenarios, respectively.

After the fares were converted to distanced-based, only a minor adjustment was needed to maintain the current revenue. The results are given in Table 3. Because the adjustment was minor, the fares for each of the three scenarios were the same. The ridership has increased from 1.2 percent in the low scenario to 3.2 percent in the high scenario. The fares range from a low of $0.70 (30 percent lower) to a high of $1.30 (30 percent higher). These results indicate that distance-based fares can result in a small ridership gain with no loss in revenue. The same logic should indicate that a gain in revenue is possible without a loss in ridership.

The data in Table 4 indicate the results of the analysis to equalize ridership. Each fare is $0.05 higher than the corresponding fare in the analysis to equalize revenue. The revenue increases of 0.7 percent in the high scenario to 2.2 percent in the low scenario might be considered insignificant to transit operators. More significant revenue gains will be examined.

The data in Table 5 show the required fares to increase revenue by 10 and 20 percent. In the high scenario, the fare for the longest route reached $1.90 for a 10 percent revenue gain and $2.70 for a 20 percent revenue gain. Care should be taken in interpreting the results of these extreme values because the assumption of a constant elasticity is less valid for large changes in fare. Ridership

TABLE 3 New Fares to Equalize Revenue

		Low Scenario		Medium Scenario		High Scenario	
Route	Fare ($)	Ridership	Revenue ($)	Ridership	Revenue ($)	Ridership	Revenue ($)
Shortest (41)	0.70	81,565	57,095	87,115	60,980	93,040	65,127
Longest (43)	1.30	140,016	182,021	133,460	173,498	127,203	165,363
Total		1,381,931	1,351,852	1,394,694	1,354,597	1,408,285	1,358,024

TABLE 4 New Fares to Equalize Ridership

		Low Scenario		Medium Scenario		High Scenario	
Route	Fare ($)	Ridership	Revenue ($)	Ridership	Revenue ($)	Ridership	Revenue ($)
Shortest (41)	0.75	79,457	59,592	83,805	62,853	88,388	66,291
Longest (43)	1.35	137,831	186,072	130,387	176,022	123,335	166,502
Total		1,355,464	1,394,582	1,353,494	1,383,560	1,353,119	1,374,212

TABLE 5 Specified Percent Increase in Revenue

	Low Scenario	Medium Scenario	High Scenario
10 Percent Increase in Revenue			
Fares for shortest route (41)	0.80	0.90	1.05
Fares for longest route (43)	1.55	1.65	1.90
Total ridership	1,300,685	1,222,830	1,049,254
Total revenue	1,498,998	1,498,500	1,495,652
20 Percent Increase in Revenue			
Fares for shortest route (41)	0.95	1.10	1.45
Fares for longest route (43)	1.75	2.00	2.70
Total ridership	1,239,049	1,094,331	814,518
Total revenue	1,633,201	1,631,221	1,633,530

losses of 4.7 to 23.1 percent could be expected while attaining a 10 percent increase in revenue. Drops in ridership of 9.2 to 40.3 percent might be experienced in the quest for a 20 percent revenue increase.

One policy might be to set the minimum freeway flier fare at either $0.80 (current regular fare) or $1.00 (current freeway flier fare). Consequently, the results of these policy options are given in Table 6. Also note that the highest fare was $1.50 for the $0.80 minimum and $1.85 for the $1.00 minimum. The $0.80 minimum fare could increase revenue from 7.5 to 2.7 percent with a ridership drop of 3.4 to 6.3 percent. The $1.00 minimum fare could have a much larger effect--a 23.8 to 8.6 percent revenue increase and an 11.0 to 20.8 percent ridership drop.

TABLE 6 Minimum Fare Level

	Fare, $0.80 Minimum		Fare, $1.00 Minimum	
Scenario	Total Ridership	Total Revenue	Total Ridership	Total Revenue
Low	1,318,710	1,466,477	1,214,247	1,689,303
Medium	1,297,034	1,431,880	1,142,555	1,577,912
High	1,279,226	1,401,890	1,081,445	1,482,304

CONCLUSIONS

Distance-based fares on bus transit have been previously shown to be much more equitable than flat fares. Also, with rising transit costs, distance-based fares can be one possibility for providing additionally needed revenue. This possibility has been explored for the express bus service in Milwaukee, Wisconsin.

The distance-based fares would require lower fares on six routes whereas four routes would have a higher fare. The findings demonstrated that distance-based fares could enable a small increase in revenue without a loss in ridership. Similarly, a small ridership increase could be expected without a loss in revenue.

Policies to increase revenue by 10 and 20 percent were also examined. Fares as high as $1.90 on the longest route might be required for a 10 percent revenue increase. A $2.70 fare might be needed on this same route to afford a 20 percent increase in revenue.

The findings in this paper demonstrate that distance-based fares on express routes in Milwaukee can be feasible. Additional revenue could be generated with only minor drops in ridership. Additional research is required to expand distance-based fares to entire systems. Also needed is more information on implementing distance-based fares such that more operators can consider them as an alternative fare arrangement.

ACKNOWLEDGMENTS

The work for this paper was supported by the Marquette University Committee on Research. Necessary data were provided by the Milwaukee County Transit System.

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The authors are solely responsible for the content of this paper.

Publication of this paper sponsored by Committee on Public Transportation Marketing and Fare Policy.

An Optimizing Model for Transit Fare Policy Design and Evaluation

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ABSTRACT

To support transit agencies in the design and evaluation of more equitable and efficient fare structures, an optimization-based model system has been developed and implemented on a microcomputer. This system seeks distance-based fares of the form: FIXED CHARGE + (MILEAGE CHARGE) (trip distance) + (TRANSFER CHARGE) (number of transfers). It maximizes estimated revenues subject to a minimum ridership constraint and constraints on the attributes of the fare structure, which provide the user with considerable control over the structure of the optimal fare, such that distance-based, zone, and flat fare schemes can be designed and tested. This model can be used to search for fare schemes meeting user-specified requirements, to perform sensitivity studies of fare characteristics, and to test user-supplied price structures. These applications are demonstrated through the use of a data set from part of a large urban transit system.

Among the challenges facing transit operators today is balancing service needs against financial resources. Virtually every U.S. transit system receives large public subsidies. These are justified in terms of the social goals to which transit contributes (e.g., mobility for low income people) and the externalities created by such services, including improved air quality, energy savings, and encouragement of efficient land use patterns.

Although there is support for continued transit subsidies, particularly from those who receive them, there is increasing concern about the magnitude of such subsidies. Federal policy makers have attempted to reduce federal contributions to operating subsidies. Local policy makers, facing many funding requests on limited revenue bases, have also become less inclined to support subsidy increases. Some have argued for increasing fares--and changing fare structures--to allocate a larger share of transit costs to the user. These suggestions are based on both efficiency and equity arguments. An efficient pricing system relates prices to the marginal cost of service; an equitable price structure relates prices to the user's ability to pay and to the amount of service consumed.

Because transit demand is generally inelastic with respect to price (1), fare increases have resulted in increased revenues, but not without significant losses in ridership. Thus, while transit properties have moved toward one of their goals through such actions, they have necessarily moved away from others, including increasing ridership and expanding service.

Farebox revenue generation has been constrained by the abandonment of differentiated pricing (e.g., zone or distance fares and time-of-day surcharges) in favor of flat fare schemes. This has resulted, in part, from a desire to simplify fare collection and reduce passenger confusion. It also reflects an interest in attracting non-central city market segments. Under flat fare schemes used in most U.S. cities, the price for traveling only a few blocks is the same as that for traveling distances in excess of 10 mi.

The era has passed in which transit operators, facing assured subsidies, could turn their concerns toward maximizing service and ridership. The focus of transit policy today is more clearly on revenue maximization or, at least, subsidy minimization. Thus, it appears particularly appropriate to reexamine current pricing policies to ensure the financial viability of transit systems. Although revenue maximization appears to have become a primary objective, other objectives must not be ignored, including increasing ridership (or limiting ridership losses due to price changes) and developing a pricing policy that efficiently and equitably allocates costs to the users. In addition, the pricing policy should be simple enough to be understood by transit operators and passengers and cost-effective to implement and operate.

In this effort, transit operators should look beyond flat fares to consider more creative fare structures, including distance-based fares and time-of-day fares. Such schemes have been proposed and analyzed by researchers in recent years (2-8). Some operators have implemented alternative fare structures either under demonstration projects sponsored by UMTA (9-10), or independently, to achieve some of the objectives mentioned previously (11-13).

Design and analysis of alternative fare structures is not a simple task, particularly if innovative fare options are to be considered. The technical challenge is twofold. First, it is necessary to specify pricing options; second, the effects of these options on transit objectives must be explored. There is no systematic method for specifying pricing options. The approaches for testing different fare proposals range from "back of the envelope" calculations, based on an average price elasticity applied to the aggregate market, to line-by-line short-term travel forecasting methods. The former methods are most commonly used, whereas the latter methods tend to be cumbersome and costly and, thus, are reserved for specialized investigations.

Limitations of fare design and analysis techniques restrict both the range of fare options considered and the comprehensiveness of their evaluation. This is a particular problem for distance and zone fare options. Among the methodological requirements for advanced fare policy design and analysis methods are the following:

- Methods should be responsive to the major issues associated with fare policy revisions (e.g., implications for revenues, ridership, and equity);
- Methods should be well-founded on appropriate theory;
- Methods should have transparent logic and face validity to enhance user comfort and confidence in their use;
- Methods should be compatible with available (or readily acquired) resources for transit planning, including personnel skills, computational facilities, and data; and
- Methods should be simple to apply and should support efficient design and analysis of alternatives.

In this paper, an optimization-based tool is described that meets these requirements and supports the design and analysis of alternative transit fare structures, including, but not limited to, distance and zone-based fares.

In the next section transit pricing issues, options, and methods are reviewed, followed by a qualitative formulation of the model and its solution technique. In the last section examples of applications of the model are given, and the paper ends with summary and conclusions.

TRANSIT PRICING ISSUES, OPTIONS, AND METHODS

Objectives for transit fare structures include revenue maximization, efficient allocation of demand and service resources, price differentiation to reflect costs and service quality, equity in pricing, and minimizing the cost (and/or assuring feasibility) of fare collection itself.

Several studies have concluded that under the common flat fare structure, long-distance and peak-period riders are cross subsidized by short-distance and off-peak riders (14). When efficiency of flat fare pricing is measured in terms of the farebox recovery ratio, or the ratio of revenue per passenger mile to the cost per passenger mile, the conclusion is the same: revenues from short trips pay a greater fraction of their costs than from long trips (3-5, 15). Thus, a flat fare system is considered to be the most inefficient pricing policy; distance or time-of-day based fare structures, or both, have been proposed to remedy the efficiency shortcomings of flat fares.

A primary argument for either time-of-day or distance-based fare schemes is that they may improve the equity of fares. Both user charges and public subsidies should be allocated equitably. Although subsidies have been found to be progressive when compared with flat fare increases (16), certain trips tend to be more heavily subsidized than others; for example, long-distance trips receive greater subsidies than short trips; peak trips are more heavily subsidized than off-peak trips; and suburban trips receive greater subsidies than inner-city trips. All these features of current fare structures and subsidy policies tend to be regressive (16-17).

The importance of minimizing fare collection costs and delays is also clear. The fare structure should be easily understood by fare collectors and passengers. The shift to flat fares has responded to these concerns. Alternative fare structures may demand new technologies to support their implementation. To the extent that schemes involving other than flat fares are attractive for meeting primary operator objectives, incentives for innovation in fare collection and passenger pricing information may be increased (18).

Efforts to evaluate the effects of transit fare changes (either structural changes or changes in the amount paid) have produced important specific results, including elasticity estimates for different services and rider groups, revenue impacts, and distributional consequences (1,9,10,19). The majority of published work assesses the impacts of various fare changes; principally, fare increases, pass programs, and unique concepts such as free fares. A few reports deal with methodologies for evaluating alternative proposed fare policies.

Wilbur Smith and Associates (7) studied existing and proposed pricing policies in the Detroit area, presenting and analyzing three zone pricing schemes that consisted of a flat fare system within the zones with different surcharge rates for crossing zone boundaries. Alternatives were ranked on the basis of financial (net revenue); social (patronage, equity, etc.); and operational (operating needs, enforcement, rider comprehension, etc.) criteria. Although the details of the policies differ, all resulted in increased ridership and decreased revenue due to the reduced average fare and the inelasticity of transit demand with respect to fare changes. No attempt to generate alternatives that reflected a different ordering of objectives was reported.

Cervero et al. (5) analyzed the effects of several pricing schemes on the Los Angeles, San Diego, and Oakland, California, transit systems. The policies included stage (zone) fare pricing and graduated pricing in which the distance-based fares were finely graduated either as a linear or logarithmic function of distance. Joint time-distance pricing policies were also tested. Policies were evaluated in terms of efficiency, equity, and ridership impacts. All of these policies increased the ratio of the revenue per mile to the cost per mile, which means that the more complex fare structures are more efficient in economic terms. It was concluded that more highly differentiated pricing schemes offer the most favorable balance between a modest patronage loss combined with significant revenue, efficiency, and equity gains.

Ballou and Mohan (20) developed a micro-simulation fare evaluation model aimed at evaluating not only systemwide ridership and revenue impacts but also equity impacts on different groups. The model is based on expanding the impacts projected for a sample of riders to systemwide impacts similar to that proposed by Cervero et al. (5). Seven combinations of distance-based and peak-period pricing policies were analyzed. The policies resulted in a range of ridership and revenue increases and decreases.

Both this and the Cervero models take the pricing schemes as a model input. No attempt is made to identify policies that attain specific ridership, revenue, efficiency, or equity objectives. Both models use a sample of transit riders and expand the results to the system's ridership.

Weiss and Hartgen (6,8) examined the financial, ridership, and equity implications of premium rush-hour fares on seven transit systems in New York State. They report that in all of the cities studied, no time-of-day based fare policy increases both revenue and ridership simultaneously. Certain combinations did improve equity while increasing either ridership or revenue with a less than 5 percent loss in the other. Again, fare structures were model inputs in these studies.

Taking fare policy as a model input results in two important shortcomings. First, analyses may fail to identify the policies most likely to attain specific objectives. Second, failing to identify the best alternative, the models cannot assess the opportunity costs associated with particular managerial or political constraints on the fare structures.

A search for the best pricing alternative may be conducted more efficiently and effectively by using an optimization model. Because of the requirements of such models, they will almost certainly be incapable of incorporating all the constraints that determine a viable pricing policy. The modeled policy is likely to be altered in response to these constraints before implementation. However, it is particularly desirable to identify the degree to which objectives can be achieved in the less constrained environment of an optimization model if the opportunity costs associated with imposition of the nonmodeled constraints are to be measured. Only when the opportunity cost of various constraints are known can it be decided whether the benefits of these constraints justify their cost.

In the next section an optimization model is described that determines the fare between any two points on a transit network through maximization of revenue subject to ridership and fare structure constraints. This model can deal with the different time-of-day pricing through the use of different ridership data and elasticity values. The model can produce a distance-based or a zone fare policy and estimates of the optimal transfer charges simultaneously.

MODEL DESCRIPTION

The model system is composed of seven programs designed to determine the optimal fare policy subject to user-supplied constraints, as described next, and to facilitate data input and model output analysis. The structure of the model system, together with the flow of information is shown in Figure 1. The system is designed for the IBM Personal Computer under DOS 1.1.

At the heart of the model system is FWFARE, which determines optimal fare structures by maximizing total revenue, the sum over all origin-destination (O-D) pairs of the fare charged for the O-D pair multiplied by the number of riders between the origin and destination. The fare for each O-D pair is given by the following equation:

Fare from Origin I to Destination J
 = FIXED CHARGE + (MILEAGE CHARGE)
 x (Distance from I to J)
 + (TRANSFER CHARGE)
 x (Number of Transfers from I to J) (1)

The model determines the FIXED CHARGE, MILEAGE CHARGE, and TRANSFER CHARGE that maximize the total revenue subject to the user constraints. The number of riders between each O-D pair depends on the fare charged for trips between the origin and destination, as determined by the following equation:

Ridership from Origin I to Destination J
 = Base Case Ridership from I to J
 x {1 + [ELASTICITY x (NEW FARE
 - BASE FARE)/BASE FARE]} (2)

Equation 2 is a linear approximation to the demand curve at the base case ridership and fare. The NEW FARE is computed using Equation 1 once the model determines the FIXED CHARGE, MILEAGE CHARGE, and TRANSFER CHARGE. The use of this linear approximation results in a quadratic objective function and linear constraints that are easily solved as noted in the following paragraph. Use of a nonlinear demand model would result in nonlinear constraints and would greatly increase the difficulty involved in solving the optimization problem.

Transit demand is fare inelastic; that is, elasticities are negative and between -1.0 and 0.0 (1, 21,22). Therefore, revenue may be increased by increasing the fare. However, fare increases will result in a decrease in ridership. Thus, the first constraint the user can place on the optimization model is a MINIMUM RIDERSHIP CONSTRAINT. This allows

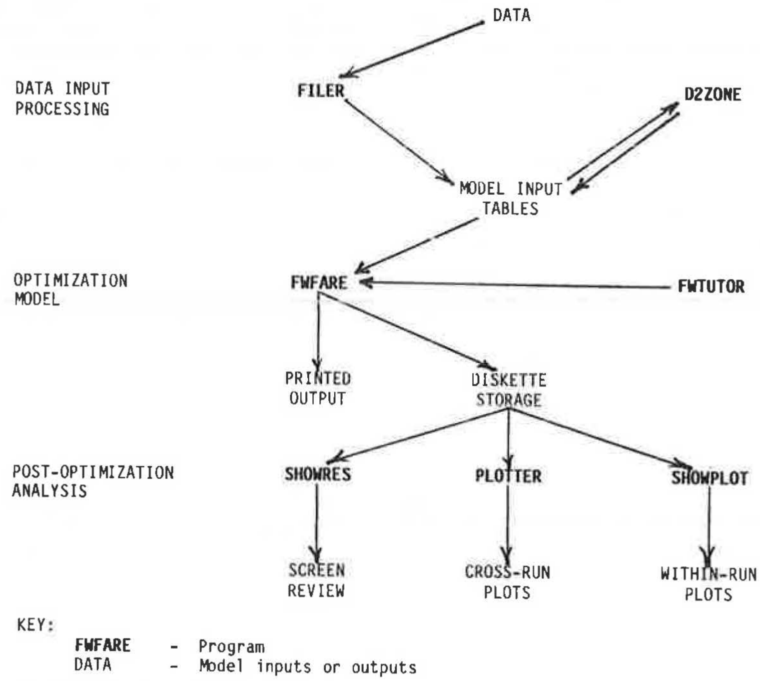


FIGURE 1 Model system structure.

the user to limit the ridership loss if fares are increased. Additional constraints can be placed on the:

1. MINIMUM and MAXIMUM FARE charged between any O-D pair,
2. MINIMUM and MAXIMUM MILEAGE CHARGE,
3. MINIMUM and MAXIMUM TRANSFER CHARGE,
4. MINIMUM and MAXIMUM FIXED CHARGE,
5. MINIMUM and MAXIMUM RATIO of the TRANSFER CHARGE to the FIXED CHARGE, and
6. MINIMUM and MAXIMUM DIFFERENCE between the FIXED CHARGE and the TRANSFER CHARGE.

Mathematically, an optimization model is obtained that maximizes a concave quadratic objective function subject to linear constraints on fixed, mileage, and transfer charges (23).

Model inputs include four tables--(a) the base case ridership (total or for a particular market segment) between each O-D pair, (b) the base case fare between each O-D pair, (c) the number of transfers required between each O-D pair, and (d) the distance between each O-D pair--and an estimate of the systemwide elasticity (for the study market segment). A systemwide elasticity is used to simplify the model inputs. Conceptually, the model may employ more realistic distance-based or origin-destination specific elasticities; however, the use of alternative elasticity measures would require minor recoding of the computer programs and would necessitate the analyst having additional information on the relationship between elasticity and trip length, for example. Model outputs include the optimal values of the FIXED CHARGE, MILEAGE CHARGE, and TRANSFER CHARGE as well as the REVENUE, RIDERSHIP, SMALLEST FARE, and LARGEST FARE.

Two programs facilitate the coding of the model inputs. FILER is a screen-oriented data input program. It allows the analyst to code the four input tables necessary to run the model. D2ZONE will transform these input tables to alternate forms. Thus, the analyst might code the actual number of transfers between each O-D pair and store the information on a diskette file. This matrix can be used if an additional charge is desired every time a transfer is made. If the analyst wants to test a fare policy with only a single charge for a transfer pass, independent of the number of transfers made, an alternate input matrix would be needed. D2ZONE can transform the information in the original file into the requisite input table that could then be stored as a new file. FWTUTOR is a brief tutorial program designed to assist analysts in using FWFARE.

The results of FWFARE, as well as the constraint values and other input information, may be stored on diskette files for future analysis. Three programs may be used to analyze these model outputs. SHOWRES displays the results stored in a results file on the screen for subsequent review and analysis. PLOTTER uses a dot matrix printer to plot any one of 22 variables (such as the total ridership, total revenue, smallest and largest fares, the range in fares, and all 13 constraint values) against any of the other values to allow the analyst to explore trade-offs between policy variables as identified by a series of model runs. Finally, SHOWPLOT allows the analyst to plot performance measures, including the fare, fare per mile, and the difference between the base case fare and the optimal fare, for a given model run.

Once an optimization problem has been solved, the most recently used parameter values become the default values for subsequent runs. This allows the user to perform sensitivity analyses rapidly by changing only one or two values for each subsequent optimization. For example, if the user wants to analyze the trade-off between ridership and revenue, holding elasticity constant and all of the parameters of the fare policy fixed, he need only change minimum ridership and rerun the problem.

The Frank-Wolfe algorithm is used to solve this model (23). This involves maximizing a linear approximation to the objective function at any feasible value of decision variables. Having the solution to the linear program obtained by linearization of the objective function and the current feasible solution to the model, an improved solution is generated by averaging these two solutions through a one-dimensional search process. The algorithm proceeds by generating a sequence of solutions until they converge satisfactorily to the optimal solution. It is well known that when maximizing a concave function subject to linear constraints, this procedure will converge to the optimal solution.

Conceptually, FWFARE performs a form of constrained linear regression with objective function weights that differ somewhat from those used in ordinary least square regression. This is a limitation in the sense that the fare policies designed by the model are not likely to differ in significant structural ways from the current (input) fare policy unless explicitly constrained to do so. For example, in the model tests outlined using data from the Chicago Transit Authority (CTA), which employs a flat fare structure along with a transfer pass charge, the model always found a very small mileage charge unless constrained to do otherwise. On the other hand, this feature allows the user to specify an input fare table that approximates the desired policy. The use of the model system in policy analysis is outlined in the following section.

MODEL USE STRATEGIES AND EXAMPLES

The model system can be used to search for desirable fare policies and test candidate fare structures. Application strategies include (a) an experimental design approach of searching along critical policy dimensions to explore the sensitivity of fare structures and performance measures to key inputs, (b) a decision tree approach in which the user determines input values for subsequent model runs based on prior results, and (c) a policy emulation approach in which the model is constrained to replicate and test specific policies (and derivatives of them).

In the first mode, the analyst generally specifies all model runs to be conducted before the computer work is begun. For example, he might choose to explore the sensitivity of revenue and the structure of the fare policy to changes in (a) the minimum required ridership and (b) the elasticity of demand with respect to fare. To do so, he would specify a range of minimum allowable ridership values, for example, from 30 percent below the current ridership to 20 percent above this value. Similarly, a range of elasticity measures would be specified. The user would then run either all combinations of the minimum ridership and elasticity or selected combinations to cover the options of interest. The results would be stored and evaluated.

In the decision tree approach, the analyst uses the model to search for a fare policy that meets certain criteria, examining the results of each model run together with those of previous runs to select input values for subsequent runs. For example, the results of one test might produce an optimal transfer charge of $0.108 per transfer. Because this is an impractical value, the user might constrain the transfer charge to be less than or equal to $0.10 per transfer in the next model run. This would be a more constrained problem and the revenue would decrease by a magnitude that measures the opportunity cost associated with being unable to charge the "optimal" transfer charge. Next, the user might explore the implications of alternate transfer charge policies by increasing the maximum transfer charge constraint to $0.50 and setting the minimum transfer charge to $0.15 to determine the effect of increasing the charge above its "optimal" value. The process would continue in this way until all options of immediate interest had been explored.

In the policy emulation mode of model use, the analyst attempts to replicate exogenously proposed fare structures in the model. The model system is used (a) to predict key outputs, including ridership and revenue; (b) to explore the sensitivity of these outputs to changes in uncertain input parameters such as the elasticity of demand with respect to fare; and (c) to identify other impacts of the proposed fare structure, including changes in the fare per mile paid by patrons.

To support development of the model system, the research team secured Chicago Transit Authority O-D travel data for parts of two rail transit lines and connecting bus services segmented by trip purpose, time of day, and fare class. Trips were coded into a 47-zone table. These data and the authors' analyses of them cannot be used to evaluate present and proposed CTA pricing policies for several reasons. First, only a portion of the CTA system has been used, and the representativeness of this portion was not tested. Second, CTA fares have changed since the O-D survey was taken, and this and other factors have led to potentially different ridership patterns (as well as levels) from those utilized. Third, a thorough assessment of CTA policy options would require a more extensive and detailed investigation than undertaken and reported here. Finally, transit operators respond to a variety of different goals and objectives; a valid analysis of CTA pricing would demand consideration of other important issues. Despite these limitations on the authors' ability to draw policy-related conclusions, the data set is useful in testing the model and in demonstrating the range of analyses that may be conducted by using the model system.

To illustrate the experimental design approach, runs were conducted to assess the sensitivity of revenue and the fare structure to changes in (a) the elasticity of demand with respect to fare, (b) the minimum allowable ridership, and (c) the time of day. Four elasticity values were used: -0.30, -0.25, -0.20, and -0.15. Three different ridership matrices were used that represented the entire day, the peak period only, and the off-peak periods. In addition to the elasticity and minimum allowable ridership, values were specified for all of the lower and upper bounds on the fare equation. The base case fare matrix corresponded to the fares currently charged; that is, $1.00 and $0.90 for trips with and without transfers, respectively.

The primary output of these analyses is the trade-off between revenue and ridership for different elasticity values. Figure 2 shows this trade-off based on the ridership data for the entire day and for all trips. Two trends are illustrated in this figure. First, revenue increases as the ridership decreases below the base case value of 165,293 and decreases as ridership increases above this value. Second, the sensitivity of revenue to ridership increases as the demand becomes less elastic with respect to fare; that is, as demand becomes

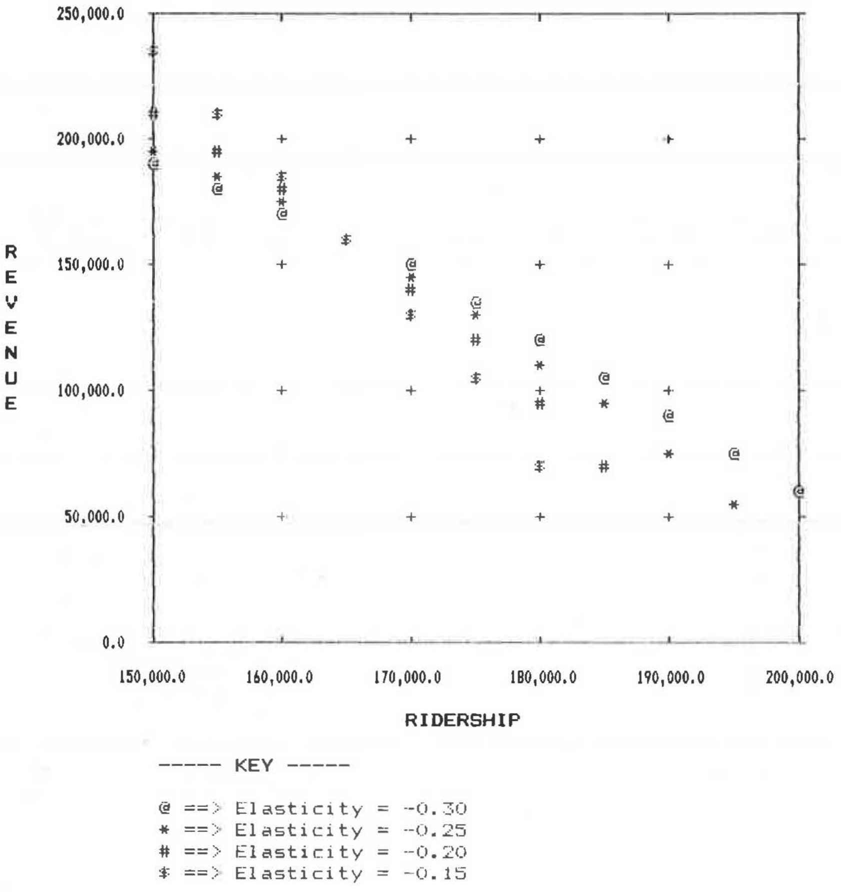


FIGURE 2 Ridership versus revenue by elasticity—all day.

more inelastic, a larger revenue change (reflecting a larger fare change) is necessary to produce a specific ridership change.

As the ridership changes in Figure 2, the coefficients in the fare equation change. In general, the transfer pass charge remains at its maximum allowable value ($0.10) and a nominal mileage charge of less than $0.01/mi is levied in all cases. To allow ridership to increase, the optimal fixed charge decreases until the smallest fare charged falls below the minimum allowable fare of $0.25. At this point, the mileage charge is eliminated and the transfer charge must be decreased to allow further ridership increases. Similar experiments were conducted using the peak period and off-peak ridership data (23); the results showed identical trends.

The sensitivity of the fare structure and the total revenue across different market segments was also explored using appropriate elasticity ranges. The four market segments tested were: (a) all work trips, (b) peak work trips, (c) all nonwork trips, and (d) peak nonwork trips. For each of the work-trip segments, elasticities of -0.2, -0.15, and -0.10 were used. For nonwork trips, elasticities of -0.5, -0.4, and -0.3 were tested. In all cases, the minimum ridership was set at the base case ridership for that market segment.

In all cases, the fixed charge was between $0.79 and $0.90. The transfer pass charge always equaled the maximum allowable value of $0.10. Because of the nominal mileage charges, the fare structure appeared to be nearly identical to the base case fare policy. Finally, the total revenue for any particular ridership matrix was nearly independent of the elasticity used. This is a result of using the base case ridership as the minimum allowable ridership. Figure 2 shows a similar result; the total revenue is nearly identical for all elasticity values when the ridership is fixed at the base case value.

None of the fare structures identified in the analyses outlined in this section exhibited large mileage charges. This is a direct result of (a) the absence of a distance component in the current CTA fare structure and (b) the similarity between the objective function used in FWFARE and that used in regression as discussed earlier. The model will try to find the fare structure that provides the closest fit to the existing fare structure. In this case, this will involve the use of transfer passes in preference to distance charges. From a policy perspective, the absence of a strong distance component in the fare structures identified by FWFARE reflects the fact that revenue maximization--the objective used by FWFARE--may not be consistent with the social and economic objectives that argue for distance-based fares. As a result, there is no cause for alarm by the absence of significant distance charges in the examples discussed previously.

To illustrate the decision tree approach, the model was used to identify a distance-based fare structure. The data matrices used in this analysis were: the network distance matrix; the base case fare charges of $0.90 and $1.00 for nontransfer and transfer trips, respectively; the matrix of the number of transfers between each O-D pair (as opposed to the transfer pass matrix used previously); and the all-day, all-purpose ridership matrix. Throughout this analysis an elasticity of -0.25 was used. A minimum allowable ridership equal to the base case total ridership of 165,293 was used initially.

To obtain a distance-based fare policy, the mileage charge was constrained to equal $0.10/mi by setting the lower and upper bounds on the mileage charge to this value. Because the maximum distance in the base case data was 22.5 mi, the smallest feasible maximum fare would be $2.25 with a $0.10/mi mileage charge. In this example, a range in fares was allowed from $0.25 to $4.50 per trip. In addition, transfer charges up to $0.10 per transfer were permitted, and a maximum fixed charge of $0.25 was tried initially. Finally, the constraints on the ratio of, and difference between, the transfer and fixed charges were set so that they would not be binding. The results are shown in Figure 3. The upper bounds on all three components of the fare equation are binding. The minimum ridership constraint is not binding, because the fare equation results in an estimated ridership of 1,701 passengers in excess of the minimum allowable (base case) value. Revenue declines approximately 7.3 percent when compared with the base case value. Notice that the range in fares has changed dramatically from $0.10 ($0.90 to $1.00) to $2.40 ($0.30 to $2.70).

To allow the ridership to decrease to its base case level, the analyst might next change the constraints on the fare equation coefficients as follows:

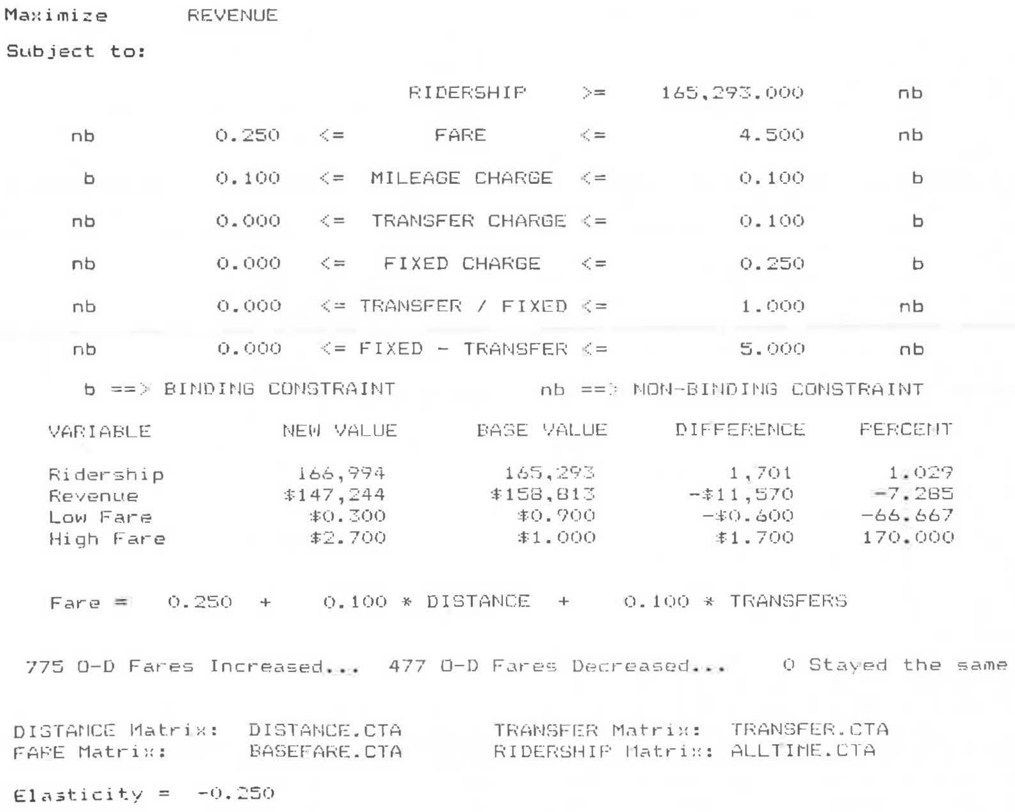
1. Reduce the minimum allowable mileage charge to $0.075,
2. Increase the maximum allowable transfer charge to $0.15, and
3. Increase the maximum allowable fixed charge to $0.50.

These changes allow the optimization program greater freedom in identifying a desirable fare policy. In addition, fares are likely to increase sufficiently to reduce the total ridership to the base case value. Indeed, this is exactly what happens: only the maximum fixed charge, the minimum ridership, and the minimum allowable mileage charge constraints are binding. In the unconstrained cases, the optimal fare policy consists of only a nominal mileage charge and rather large fixed charges. Thus, the model attempts to reduce the mileage charge as much as possible and to increase the fixed charge to the greatest possible extent.

To illustrate the use of the model for analyzing specific policies, again, the CTA sample data are used. One recent proposal for a revised fare structure on the CTA called for the elimination of transfer charges; riders would need to pay a new fare each time they board another service. The proposed fare was $0.50 for bus trips and $0.75 for rail trips. The model system may be used to analyze this policy as well as related policies.

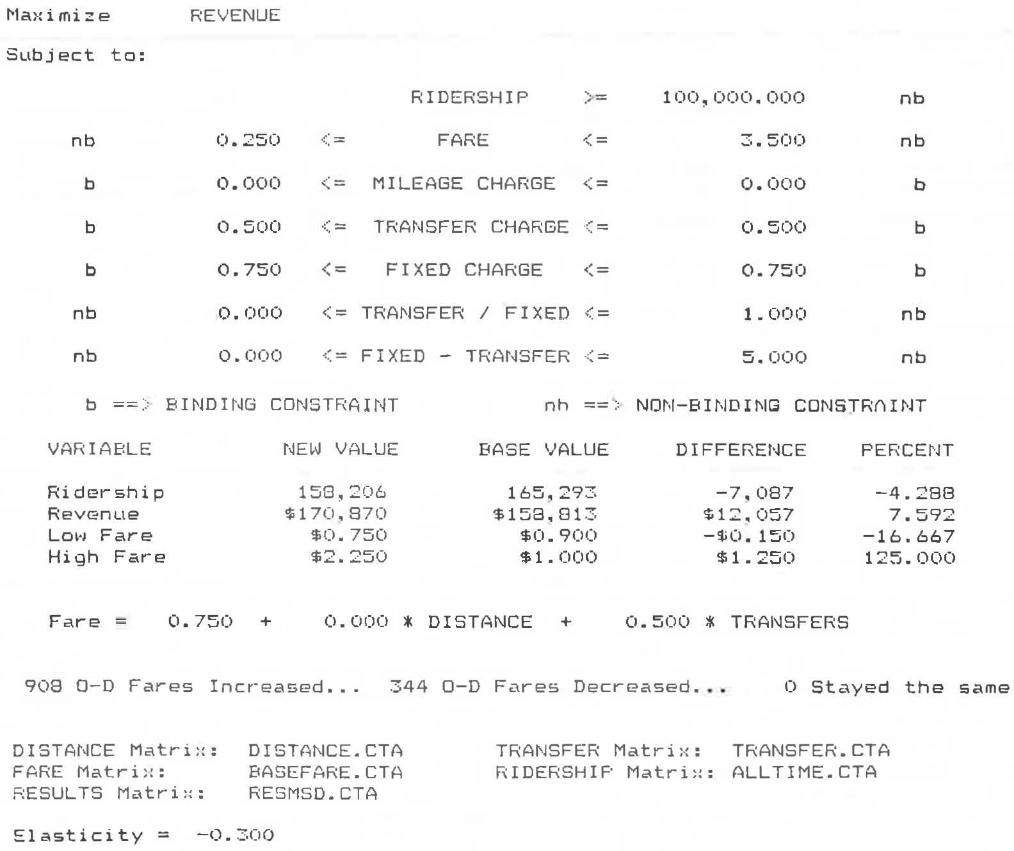
In the data set coded for this work, all riders use at least one rail line. Thus, under the proposed fare structure, all riders will pay a fixed charge of (at least) $0.75, so an approximation of the proposed fare structure was begun by constraining the fixed charge to $0.75. In addition, some riders also use feeder buses to go to and from the rail line. The additional bus fares paid by these passengers were emulated by constraining the transfer charge to $0.50. The number of transfers table (as opposed to the zero/one transfer pass table) was used. The proposed policy does not call for distance-based charges, and so the mileage charge is constrained to $0.00. Finally, because it is uncertain if ridership will increase or decrease under this policy, the minimum allowable ridership must be reduced to ensure a feasible solution. The ridership that results from the proposed policy will be a model output. All other model inputs, including the elasticity of demand with respect to fare, were kept at their default values.

Figure 4 shows the results of this analysis. The model suggests that for the sampled O-D pairs the ridership will decrease about 4.3 percent and the revenue will increase 7.6 percent under the proposed



```
Maximize       REVENUE

Subject to:

                                    RIDERSHIP     >=    165,293.000         nb

      nb           0.250    <=         FARE        <=          4.500         nb

       b           0.100    <=   MILEAGE CHARGE   <=           0.100          b

      nb           0.000    <=   TRANSFER CHARGE  <=           0.100          b

      nb           0.000    <=    FIXED CHARGE    <=           0.250          b

      nb           0.000    <= TRANSFER / FIXED   <=           1.000         nb

      nb           0.000    <= FIXED - TRANSFER   <=           5.000         nb

       b ==> BINDING CONSTRAINT             nb ==> NON-BINDING CONSTRAINT

   VARIABLE             NEW VALUE       BASE VALUE      DIFFERENCE      PERCENT

   Ridership             166,994          165,293          1,701         1.029
   Revenue              $147,244         $158,813       -$11,570        -7.285
   Low Fare               $0.300           $0.900        -$0.600       -66.667
   High Fare              $2.700           $1.000         $1.700       170.000

   Fare =    0.250   +     0.100 * DISTANCE   +     0.100 * TRANSFERS

 775 O-D Fares Increased...  477 O-D Fares Decreased...       0 Stayed the same

DISTANCE Matrix:   DISTANCE.CTA        TRANSFER Matrix:   TRANSFER.CTA
FARE Matrix:       BASEFARE.CTA        RIDERSHIP Matrix:  ALLTIME.CTA

Elasticity =   -0.250
```

FIGURE 3 **Decision tree approach—initial distanced-based fare.**



```
Maximize       REVENUE

Subject to:

                                    RIDERSHIP     >=    100,000.000         nb

      nb           0.250    <=         FARE        <=          3.500         nb

       b           0.000    <=   MILEAGE CHARGE   <=           0.000          b

       b           0.500    <=   TRANSFER CHARGE  <=           0.500          b

       b           0.750    <=    FIXED CHARGE    <=           0.750          b

      nb           0.000    <= TRANSFER / FIXED   <=           1.000         nb

      nb           0.000    <= FIXED - TRANSFER   <=           5.000         nb

       b ==> BINDING CONSTRAINT             nb ==> NON-BINDING CONSTRAINT

   VARIABLE             NEW VALUE       BASE VALUE      DIFFERENCE      PERCENT

   Ridership             158,206          165,293         -7,087        -4.288
   Revenue              $170,870         $158,813        $12,057         7.592
   Low Fare               $0.750           $0.900        -$0.150       -16.667
   High Fare              $2.250           $1.000         $1.250       125.000

   Fare =    0.750   +     0.000 * DISTANCE   +     0.500 * TRANSFERS

 908 O-D Fares Increased...  344 O-D Fares Decreased...       0 Stayed the same

DISTANCE Matrix:   DISTANCE.CTA        TRANSFER Matrix:   TRANSFER.CTA
FARE Matrix:       BASEFARE.CTA        RIDERSHIP Matrix:  ALLTIME.CTA
RESULTS Matrix:    RESMSD.CTA

Elasticity =   -0.300
```

FIGURE 4 **Policy emulation analysis—initial results.**

fare structure. However, these results must be interpreted with caution, not only because of the data limitations outlined previously, but also because the model as currently structured does not accurately reflect the proposed fare structure. Fares range from $0.75 to $2.25 in the model (Figure 4), but passengers using two rail lines as well as bus access and egress routes would pay $2.50 under the proposed scheme--two $0.75 rail fares (free transfers are not now permitted between these rail lines) and two $0.50 bus fares. The model charges such passengers one rail fare of $0.75 and three transfer (bus) fares of $0.50. All passengers using both rail lines are modeled as paying $0.25 less than the proposed fare structure might call for them to pay. Thus, the model is likely to underestimate both the revenue increase and the ridership decrease that would result from such a proposal.

To replicate the proposed fare structure more accurately, the transfer table was used to indicate the number of rail trips needed by an O-D pair in addition to the one rail needed by all riders in the sample. The distance table was used to provide the number of bus trips needed by passengers between each O-D pair. The fixed charge and the transfer charge--now used to capture the second rail trip made by some passengers--were both constrained to equal $0.75. The distance charge, which now reflects bus use, was constrained to $0.50. With these inputs, the model estimates a 7 percent decline in ridership and an 11.5 percent increase in revenue.

Finally, the model can be used to explore variations on the proposed policy using the last two constraints in the model formulation. For example, suppose we wish to identify the optimal rail fare, if the bus fare is held fixed at $0.50 and ridership is to be retained at the current level. By using the constraint on the ratio of the transfer charge to the fixed charge, the two fees were constrained to equal each other, while the model was asked to determine the optimal value of the charge. The model suggests that the rail fare must be reduced to less than $0.60 to maintain the current ridership with an elasticity of -0.3. At this point, the proposed fare structure results in slightly more than 2 percent reduction in revenue.

SUMMARY AND EVALUATION

Alternative price structures, including distance-based and zone fares, as well as time-of-day pricing, offer ways to enhance revenue generation while maintaining greater control of distributional consequences. Such fare structures may also permit increases in efficiency by linking user charges more closely to operator costs. The challenge is to find feasible ways to design, explore, and evaluate alternative fare structures. A microcomputer model system has been described that can support such fare policy studies.

The system is composed of seven programs that support the determination of an optimal fare policy subject to user-supplied constraints on fare characteristics and ridership. The core model maximizes total revenues over all O-D pairs. Fare is comprised of a fixed charge, a mileage charge, and a transfer charge, all internally determined by the model, and all subject to some degree of user control through the constraint specifications. Because it is structured around an optimization formulation, the model system provides strong support for the search for promising fare policies; in response to user-supplied requirements, it designs the best fare policy and provides a variety of evaluation measures. The model system also permits the evaluation of specific, user-defined fare policies.

Because it has been developed for a microcomputer, the model system allows fast and easy user interaction in the search for desirable fare policies. This feature encourages users to test a variety of options in an efficient manner. Outputs from each run guide successive runs, so that a comprehensive and systematic search for promising fares may be carried out.

Even if users do not want to explore fares that are structurally different from current fares, this system supports rapid testing of proposed fares using an analysis process at least as sophisticated as that commonly used by transit properties. The speed of response, and the comprehensiveness of the evaluation measures, suggest that this model system is superior to traditional hand computation or mainframe computer methods. The model system makes it easy to explore and evaluate distance-based and zone fare policies. In addition, with a time-of-day data base, it supports the assessment of time-of-day pricing options if O-D data are available for time-based market segments.

The optimization process at the core of the model system can help the user determine the opportunity costs associated with unmodeled constraints. An understanding of these costs may lead to both better fare analyses and better fare decisions.

The requirement for a recent O-D ridership data base may appear to be a limitation of this model system. However, a reasonable analysis of fare policies cannot be conducted without such a data base, no matter what the approach. Of course, with an aggregate measure of system ridership, simple elasticity methods can be used to estimate revenue and ridership impacts of changes in flat fare schemes. Yet such approaches cannot provide information on distributional implications of fares, nor do they permit evaluation of alternatives to flat fare pricing.

The system utilizes a simple treatment of the travel demand function, approximated as a linear relationship. This, of course, is the same type of assumption that is now made in aggregate, elasticity-based fare policy analysis. It does not reflect the possibility that changes in fares may shift the spatial orientation of trips, nor does it evaluate the impacts on other modes of trips driven off transit. The former is likely to be a long-term effect, better treated through the use of a traditional travel forecasting process. The same is true of mode shifts, although the magnitude of transit ridership is such that this may be a minor issue.

The fare policy design model system presented in this paper represents an important step toward developing efficient, operational strategies for fare policy design and evaluation. The result, ultimately, should be a more powerful capacity on the part of transit managers to identify, evaluate, and implement creative and responsive pricing schemes.

ACKNOWLEDGMENT

This paper was funded by the Urban Mass Transportation Administration, U.S. Department of Transportation. The authors wish to acknowledge Dennis Ryan and Mary Kay Fitzgerald, Chicago Transit Authority Operations Planning Department, who provided the data used in the study.

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The authors are solely responsible for the contents of this paper.

Publication of this paper sponsored by Committee on Public Transportation Marketing and Fare Policy.

Are Transit Riders Becoming Less Sensitive to Fare Increases?

DANIEL K. BOYLE

ABSTRACT

The Simpson-Curtin formula for measuring ridership changes resulting from fare increases, first published in 1968, has recently been confirmed in a study by Ecosometrics, Inc. However, in the wake of the 1979 energy crisis, some observers noted that the impact of fare increases on ridership was less than expected. Examined in this paper is the hypothesis that transit riders have become less sensitive to fare increases in the post-energy crisis period. One hundred seventy-nine instances of fare changes between 1979 and 1982 are analyzed. Several measures of elasticity are calculated, and results are broken down by region, Standard Metropolitan Statistical Area (SMSA) size, year, level of original fare, bus and rail systems, and type of fare change. Results indicate that the hypothesis must be rejected. This conclusion supports the assumption implicit in transportation planning that measures of travel behavior are stable over time and have positive implications for current work on disaggregate elasticities.

Transit companies have long had a natural interest in the reaction of their riders to fare increases. Historically, the demand for transit has been inelastic with respect to price. As a practical matter, this meant that a fare increase would cause some loss in ridership but would bring an increase in revenue. In 1968 Simpson and Curtin measured the elasticity of transit ridership with respect to price as -0.3 (1). This measure has gained widespread acceptance as a rule-of-thumb in the transit industry and has continued to provide an accurate gauge of the aggregate effect of increasing transit fares on ridership.

Recent work on fare elasticity has focused on disaggregate elasticities, or the sensitivity of various groupings of transit riders to fare changes. The most comprehensive work on disaggregate elasticities was performed by Mayworm et al. (2). These authors found interesting differences in response to fare changes among ridership segments. In terms of the aggregate reaction to fare changes, they confirmed the continuing validity of the Simpson-Curtin formula.

Scattered fare increases in the immediate wake of the 1979 energy crisis did not have the expected impact on transit ridership. Mayworm et al. examined fare changes that occurred before 1979, and so there was the possibility that transit riders had become less responsive to fare increases as a result of gasoline supply problems and price increases in 1979 (2). In this paper the hypothesis that transit riders have become less sensitive to fare increases in the post-energy-crisis period is explored. If this hypothesis is correct, the elasticity of ridership with respect to price would be closer to zero.

METHODOLOGY

To test this hypothesis, various American Public Transit Association (APTA) reports were reviewed to identify all fare increases that have taken place between 1979 and 1982 (3,4). A total of 227 instances of fare changes was identified for this 4-year period. APTA monthly ridership reports were then examined to determine ridership changes (5). In 48 cases, ridership data were not available, leaving a usable sample of 179 fare changes.

There are several pitfalls and issues to be considered in calculating changes in ridership in response to fare increases. Seasonal variation, existing ridership trends, and time frame for the effects of the fare change are all addressed here. In order to control for seasonal or month-to-month variation in transit use, changes in ridership were computed by comparing the ridership of the month in question to that of the same month in the previous year. For a given fare change, the change in ridership is measured in this way for the month following the fare change (or the month of the fare change if it took effect in the first 5 days). However, this method of calculating ridership changes requires that existing ridership trends be taken into account. If this is not done, changes in ridership resulting from fare changes (and thus, elasticities) would be overestimated in periods of declining ridership and underestimated in periods of increasing ridership. The existing trend is measured by calculating the change in ridership for the month preceding the fare change (compared to the same month in the preceding year). The third consideration is the possible long-term effects of fare changes; these are examined by calculating the ridership change for the sixth month after the fare change (compared to the same month in the previous year). Thus, three measures of change in ridership are available for each of the 179 fare changes. These three measures provide information on ridership trends before the fare change, immediate impact, and long-term impact.

Four elasticity numbers were calculated from these three measures of change in ridership. Short-term and long-term elasticities, with and without existing trends, were derived using the following equations:

Short term, no trend: $e = R_1/F$
Long term, no trend: $e = R_6/F$
Short term, trend: $e = (R_1 - R_o)/F$
Long term, trend: $e = (R_6 - R_o)/F$

where

e = the elasticity of ridership with respect to fare,
R_1 = percentage change in ridership in the first month after the fare change (compared to the same month in the previous year),
R_6 = percentage change in ridership in the sixth month after the fare change (compared to the same month in the previous year),
R_0 = percentage change in ridership in the month preceding the fare change (compared to the same month in the previous year), and
F = percentage change in fare.

A common criticism of fare elasticity measures is that they assume that ridership changes occur only in response to fare changes. The trend equations are intended to control for existing ridership trends, which reflect changes in service levels and other extraneous factors. Because it measures immediate impact, the short-term trend equation is best in terms of controlling for the effects of nonfare-related changes in ridership.

RESULTS

Mean elasticities calculated by each method are given in Table 1. As may be observed, these are presented along with the standard error of the mean for all systems, and broken down by region, by SMSA size, by year, and by level of original fare. These are also shown separately for bus and rail systems, and for systems with fare increases and with fare reductions.

As noted in the preceding paragraph, elasticities measured without regard for existing ridership trends overestimate the effect of fare changes in periods of declining ridership and underestimate the effect of fare changes in periods of increasing ridership. In approximately two-thirds of the instances of fare changes, the ridership trend was positive in the previous month; thus, the elasticities calculated without regard for ridership trends are generally closer to zero. Short-term elasticities are also closer to zero than long-term elasticities. This may indicate that the full effects of fare changes are not immediately obvious because it takes time for riders to find suitable alternatives. However, there are likely to be many other factors that also affect ridership during the 6-month period, and so the reliability of long-term elasticities for measuring the impact solely of the fare change is reduced.

The breakdowns in Table 1 reveal some differences. Transit riders in the Northeast and the South appear most sensitive to fare changes in the period 1979 to 1982. The elasticity of riders with respect to fare is surprisingly high in very large SMSAs and unexpectedly low in very small SMSAs. The level of original fare may be confounding the SMSA size breakdowns because systems in small SMSAs tend to have low fares. When existing ridership trends are taken into account, bus riders are more sensitive to fare changes than rail riders (commuter rail is not included). The difference between elasticities for bus and rail systems is not as great as expected; Mayworm et al. found that bus elasticities were twice as large as rail elasticities (2). It is interesting that on rail systems, long-term elasticities are lower than short-term elasticities. This suggests that rail transit riders may be attracted back to the system within a few months of a fare increase more readily than bus riders, although as noted earlier there may be many other factors affecting ridership in the intervening months. Most of the fare changes in this 4-year period were increases; there are too few cases of fare reductions to make valid generalizations.

Two points of particular significance stand out in Table 1. The major conclusion concerns the central hypothesis of this paper, that transit ridership has become less elastic with respect to fare. Although the overall elasticities initially appear to support the hypothesis, the yearly breakdown shows that this may have been true only in the immediate wake of the energy crisis, that is, in 1979 and 1980. By 1982 the short-term, no-trend elasticity had returned to the level predicted by Simpson and Curtin. In addition, the short-term trend elasticity has remained relatively constant at a level within range of the

TABLE 1 Mean Elasticities ± Standard Error of the Mean Derived from 179 Cases of Fare Changes Between 1979 and 1982

	N	1 Month No Trend	N	6 Months No Trend	N	1 Month Trend	N	6 Months Trend
All systems	164	−0.05 ± 0.04	169	−0.18 ± 0.03	157	−0.21 ± 0.04	154	−0.32 ± 0.04
Region								
Northeast	37	−0.16 ± 0.08	42	−0.16 ± 0.05	36	−0.28 ± 0.07	37	−0.24 ± 0.09
South	40	−0.08 ± 0.10	42	−0.25 ± 0.10	36	−0.35 ± 0.10	36	−0.57 ± 0.11
North Central	50	−0.08 ± 0.07	46	−0.17 ± 0.06	49	−0.13 ± 0.06	44	−0.22 ± 0.06
West	37	+0.14 ± 0.08	39	−0.12 ± 0.05	36	−0.10 ± 0.07	37	−0.30 ± 0.06
SMSA size								
1 million +	57	−0.14 ± 0.06	57	−0.21 ± 0.05	56	−0.20 ± 0.07	53	−0.26 ± 0.08
500,000-1,000,000	22	−0.07 ± 0.11	21	−0.21 ± 0.07	20	−0.11 ± 0.09	19	−0.28 ± 0.06
250,000-500,000	23	−0.00 ± 0.09	27	−0.24 ± 0.08	21	−0.29 ± 0.09	24	−0.44 ± 0.10
100,000-250,000	37	−0.04 ± 0.09	41	−0.08 ± 0.07	36	−0.21 ± 0.07	36	−0.26 ± 0.05
50,000-100,000	11	+0.06 ± 0.13	11	−0.14 ± 0.06	10	−0.13 ± 0.12	10	−0.31 ± 0.11
Year								
1979	13	+0.30 ± 0.12	15	+0.24 ± 0.12	13	−0.23 ± 0.16	13	−0.33 ± 0.18
1980	59	+0.13 ± 0.06	60	−0.06 ± 0.05	57	−0.21 ± 0.07	57	−0.39 ± 0.07
1981	61	−0.14 ± 0.06	62	−0.21 ± 0.04	58	−0.19 ± 0.06	55	−0.21 ± 0.07
1982	31	−0.35 ± 0.10	32	−0.53 ± 0.08	29	−0.24 ± 0.08	29	−0.42 ± 0.08
Original fare ($)								
30 and below	30	+0.09 ± 0.06	30	−0.05 ± 0.06	30	−0.12 ± 0.08	27	−0.31 ± 0.10
31-40	59	+0.04 ± 0.06	62	−0.10 ± 0.05	57	−0.19 ± 0.05	57	−0.30 ± 0.06
41-50	41	−0.02 ± 0.09	42	−0.21 ± 0.07	38	−0.28 ± 0.09	38	−0.42 ± 0.07
51-60	21	−0.43 ± 0.14	23	−0.41 ± 0.13	20	−0.34 ± 0.13	21	−0.33 ± 0.12
Above 60	13	−0.25 ± 0.19	12	−0.31 ± 0.07	12	−0.03 ± 0.14	11	−0.13 ± 0.23
Bus systems	160	−0.05 ± 0.04	164	−0.18 ± 0.03	153	−0.20 ± 0.04	150	−0.32 ± 0.04
Rail systems	11	−0.26 ± 0.16	11	−0.12 ± 0.10	10	−0.15 ± 0.16	9	−0.01 ± 0.03
Fare increases	161	−0.06 ± 0.04	165	−0.18 ± 0.03	154	−0.20 ± 0.04	150	−0.32 ± 0.04
Fare reductions	3	+0.26 ± 0.20	4	−0.14 ± 0.25	3	−0.31 ± 0.15	4	−0.40 ± 0.44

Simpson-Curtin elasticity. This indicates that fluctuations in the no-trend elasticities are likely due to external events affecting ridership trends. The short-term trend elasticity is the preferable measure: it controls for month-to-month variation and for existing ridership trends, and it measures the immediate impact of a fare change. Taking the annual breakdowns and existing ridership trends into account, then, the hypothesis that the elasticity of ridership with respect to fare has moved closer to zero must be rejected. Although increasing fares may have had little apparent impact on ridership in the energy-conscious years of 1979 and 1980, this appears to have been only a temporary, and perhaps illusory, phenomenon.

A second interesting point concerns the concept of a fare threshold. This concept postulates that as fares rise beyond a certain threshold level, ridership behavior changes significantly. Behavior can change in one of two ways: either a large number of riders will balk at a fare beyond a certain threshold, or they will be relatively immune to fare increases beyond that threshold. The former version is analogous to the situation with gasoline prices. A price of $1.00/gal had been considered a threshold; at this price or beyond, it was thought that automobile users would be seriously motivated to investigate alternative means of travel. This has not happened, nor is there any evidence of a fare threshold of this type in transit. However, the latter version of the threshold concept is supported to some extent by Table 1. Elasticities are increasingly negative at higher levels of the original fare up to the "above $0.60" category. In this category, ridership response becomes less elastic than in the "$0.51 to $0.60" category. The explanation driving this version would be that by the time a relatively high fare level is reached, most of the choice riders have already abandoned transit for another mode, and so further increases have less impact on ridership. Although the data in Table 1 does not provide conclusive proof that a fare threshold of this nature actually exists, further research into this concept would be useful.

SUMMARY

The hypothesis that transit ridership has become or is becoming less elastic with respect to fares must be rejected. In 1979 and 1980, when transit ridership experienced gains due in large part to the effects of the energy crisis, there appeared to be a greater tolerance among riders for fare increases. If this willingness did in fact exist, it was short-lived; by 1982, the short term, no-trend elasticity had returned to the level of the Simpson-Curtin rule. An examination of the short-term trend elasticity, which is the most reliable measure of ridership response, suggests that the response of riders to fare increases was constant between 1979 and 1982 at a level within range of the Simpson-Curtin elasticity. The willingness of riders to tolerate fare increases in 1979 and 1980 was an illusion caused by the dramatic ridership increases occurring before a fare change. These pre-fare-change ridership trends were reduced but were not reversed by the fare increase, thus leaving the impression when raw numbers were examined that ridership was impervious to fare changes. This illusion highlights the importance of considering existing ridership trends when calculating elasticities.

The conclusion that the Simpson-Curtin formula for measuring ridership response to fare changes has remained valid has significance beyond the scope of this study. Transportation planning, particularly in the modeling area, rests on an implicit assumption that measures describing travel behavior are stable over time. This assumption is being examined in various areas. The report by Mayworm et al. (2) is one example; a previous New York State Department of Transportation (NYSDOT) study on the stability of trip rates is another (6). In both examples, the assumption was confirmed. The findings of this paper extend the findings by Mayworm et al. through the 1979 energy crisis, a period in which travel behavior underwent major disruption, and thus provide additional support for the validity of the assumption. Also, the conclusion that the aggregate fare elasticity has remained stable provides a foundation from which important work on disaggregate elasticities may proceed confidently.

ACKNOWLEDGMENTS

Research for this paper was funded by a grant from the Urban Mass Transportation Administration, U.S. Department of Transportation, Project NY-09-8006, Transportation Energy Planning: Procedural Guidance. The author wishes to thank Richard Steinmann, UMTA Project Monitor, and David T. Hartgen, New York State Department of Transportation.

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Publication of this paper sponsored by Committee on Public Transportation Planning and Development.

The views expressed in this paper are the author's and do not necessarily reflect those of the U.S. Department of Transportation, Urban Mass Transportation Administration or the New York State Department of Transportation.