visits to friends and relatives, leisure and recreational trips, and personal business trips, were cancelled in many cases. Among the 250 people interviewed, few severe hardships caused by the strike were actually identified. Besides private arrangements, some captive riders were able to rely on social service agencies, which, however, were not able to accommodate all requests for service, because of inadequate supplies of vehicles and staff and strict eligibility requirements.

The impact of the strike on transit ridership and revenue was substantial. The net reduction of revenue from KTC regular routes attributable to the strike is estimated to be in the range of 7.2-16.0 percent. In the case of the express buses, it was estimated that the ridership dropped by 14.9 percent.

With the shift in travel patterns of transit users, downtown merchants, who cater to transit dependents, lost substantial amounts of business. A number of firms reported drops in sales of 50-80 percent, which forced reduced operating hours and layoffs of sales personnel. The downtown business establishments that were affected most seriously were specialty shops, clothing and shoe stores, restaurants, and fast food, drug, and variety stores. Interviews with store managers, however, revealed that sales returned to normal levels within two months. Many CBD merchants felt only minor repercussions that ranged from no loss to a 5 percent decline in sales during the strike. Patrons of many of these merchants were automobile oriented or commuters.

Most of the major Knoxville employers reported little difficulty for their employees in getting to work during the strike. Some special accommodations were required, but, in most cases, these were worked out easily.

No evidence suggested excessive traffic congestion. Only in the CBD area was parking a problem. The addition of an estimated 300 commuter automobiles in long-term lots or in the fringe residential areas made an already tight parking situation worse. It was more difficult for shoppers to find short-term parking spaces. Yet the Coliseum parking garage, which is located near the CBD and charges a third the rate of long-term lots in the CBD proper, recorded no significant increase in use.

The transit system itself felt the most adverse effect from the strike. Although some operating costs were deferred during the strike, the loss of revenue and the subsequent loss of ridership offset any savings. All parties involved with the KTC strike—city officials, operating company, labor union, and consumers—would have benefited more by averting the strike or at least by attempting to shorten its duration. The loss in ridership almost nullified the gain from the fare increase that had been scheduled before the strike. Preventing the work stoppage could have kept many choice regular and express bus transit users from switching to another mode.

The six-week KTC strike showed that transit is a significant public service provided by the community. Most captive and choice riders returned to transit, which suggests that transit was judged superior in terms of cost and convenience to the alternative modes used during the strike. At the same time, the total transportation system showed capability and flexibility in responding to the crisis.

Few severe hardships, apart from minor inconveniences, were reported by former transit users. Most individuals were able to satisfy their travel needs through informal arrangements with relatives and friends. These arrangements were negotiated without the involvement or initiative of any public agency, and it is significant to note that the role and strength of such informal services usually are not recognized. However, the captive riders were less able to participate in these informal transportation arrangements and encountered more difficulty with the strike. It is not clear whether these alternative arrangements would have persisted if the strike had continued even longer.

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Interim Analysis of the Free-Fare Transit Experiments

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This paper summarizes the early results of the two systemwide off-peak free-fare transit experiments being conducted in Trenton, New Jersey, and Denver, Colorado. These experiments, which are sponsored by the Urban Mass Transportation Administration (UMTA) under its Service and Methods Demonstration Program, are the first free-fare programs of such size and comprehensiveness. The demonstrations have already provided a number of interesting, if still tentative, conclusions. The first major conclusion is that, while free fare induces large and sustainable ridership gains (19 percent in Trenton and 34 percent in Denver), the general aggregate behavior of the population in making their modal choices is not significantly different from what it would be with any other absolute change of an equal amount. The price elasticity of

demand for transit implied by the Trenton results was -0.42, which is virtually identical to the transit industry's experience. Saturday evening youth riders and walk trips made up fully 7 percent of the ridership in the free-fare system in Trenton. The demonstration appears to have reduced the peak-load capacity requirements in Trenton's transit system and caused a dramatic shift from the peak to the off-peak. The most surprising finding was that complaints of rowdiness, vandalism, and other incidents increased at both sites to such an extent that some groups called for the abandonment of the experiments.

This paper summarizes early results of the analysis of systemwide off-peak free-fare transit experiments being conducted in Trenton, New Jersey, and Denver, Colorado. The Service and Methods Demonstration Program of the Urban Mass Transportation Administration (UMTA) sponsored the experiments, which are funded by local as well as federal money. These experiments are the first free-fare programs of such size and comprehensiveness and are so costly that they may well be the last. As such, they provide a unique opportunity to examine the efficacy of free transit as a method of alleviating transportation, energy, and pollution problems; they also provide an unusual chance to observe passenger behavior at zero out-of-pocket costs.

THEORETICAL BACKGROUND

The concept of providing transit service as a free or public good has been suggested as a means of solving a number of transportation problems simultaneously. The argument has been that, as the cost of making a transit trip decreases to zero, the mobility of those dependent on transit for transportation will increase. Also, decreasing fares to zero will offset what some have felt to be an unfair cost comparison between transit and the automobile, given the low perceived cost of driving an automobile on a trip and the level of spending on roads and similar automobile-oriented facilities.

The decreased relative cost of transit would attract present automobile users and, by decreasing vehicle kilometers traveled (VKMT), help to ameliorate congestion, energy shortage, and air pollution problems. These positive properties of free-fare transit have been known for quite some time, but little in the way of theoretical or empirical investigation of the concept has been undertaken until the last 10 years. Studies propounding or criticizing free transit have been fairly numerous since then (1-3).

The prevailing conventional wisdom with respect to free-fare transit is that reducing fares is inferior to improving service as a method of increasing the mobility of the transit dependent and attracting people from their automobiles. In their classic study on free transit (4), Domencich and Kraft make this argument from economic theory and existing observed elasticities. Testing their conclusion about zero fares is a major goal of this project.

The object, then, is to improve understanding of the characteristics of demand for an item (to be eventually applied to the case of a ride on a bus) as the price of that item approaches zero.

Traditional economic theory often describes this demand as approaching infinity (in a nonlinear asymptotic way) as the price approaches zero. When the items being sold can be stored for future consumption or possible resale, of course, such a characterization makes sense. In most other cases, however, it seems unlikely that demand would ever even remotely approach the very high levels postulated. One reason is quite simple: Severe constraints on voluminous consumption of particular items will always exist.

In terms of transit, it is difficult to imagine an individual taking or even desiring more than one peak-hour trip to work per day. In addition, even trips for shopping, school attendance, and medical or recreational purposes are basically functions of a derived demand; that is, the demand for transit increases because the demand for some other activity has also increased (possibly because of the decrease in price of the transportation of that activity). Only in the case of joyriding is the transportation likely to be considered an end (or consumption good) in and of itself.

It also seems unlikely that most consumers consider the out-of-pocket price of an item to be the true perceived cost of the purchase. The opportunity cost of the time spent making the purchase, the cost of getting to the market (or bus route), and any other similar costs are quite likely to be incorporated into the decision making of all but the most unsophisticated consumer. Nevertheless, these additional costs can be so low that the purchase price of an item could stand as an excellent proxy for its total perceived cost; in the case of a transit ride, however, most individuals appear to pay more attention to the value of the time lost than they do to the fare (5).

If this is true, then reducing the out-of-pocket cost to zero is unlikely to reduce total cost to zero, and we probably will still be in a fairly linear portion of the demand curve. That is, demand for transportation at a cash price of zero, rather than being infinite, can be analyzed as it is at any other price. Thus, free transit seems quite likely to appeal most to those individuals whose value of time is quite low.

One complicating factor, obviously, is that at zero out-of-pocket costs transit is preferable to walking as a mode for a higher percentage of parallel-route walk trips. For both reasons, not only will it be important to measure the increase in the number of transit riders induced by free fare, it will also be vital to analyze the distribution of ages, incomes, and trip purposes of those riders if we are to properly measure the impact of the program. It may well be that the nonpecuniary costs of riding are so high that the changes in out-of-pocket costs will seem insignificant to a majority of the riders, but this same impact may well be reversed for young, unemployed, or retired individuals.

THE DEMONSTRATION PROGRAM

What is difficult about obtaining solid empirical data needed for conclusions about free transit is that, until the Denver and Trenton programs, no large systemwide free systems were in operation. Previous forecasts of zero-fare ridership were obtained from extrapolations of existing elasticities, from studies of small fare-free zones in the shopping and central business districts of a number of cities, and from other limited observations of free-fare behavior (6-8).

Domencich and Kraft, among others, pointed out that it would be possible "to perform experiments to generate observations for analysis by conducting demonstration projects, rather than by relying on the observations given the existing environment" (4). The authors go on to warn, however, that, unless the time frame of the experiment were long and careful attention were given to planning, it would be impossible to obtain useful analytical results from the projects.

To meet this need, Congress authorized, in Title 2 of the National Mass Transportation Act of 1974, the "research and development, establishment, and operation of demonstration projects to determine the feasibility of free-fare urban mass transportation." This assignment was given to the UMTA Service and Methods Demonstration Program.

In its first annual report on the program in 1975, UMTA echoed Domencich and Kraft's concern by stating that "answers about the costs and efficacy of fare cuts in achieving their objectives . . . can only be achieved if a strong emphasis is placed on matters of experimental design." At present, the demonstration program aimed at meeting this research goal consists of the two fare-free off-peak experiments in Trenton and Denver.

Trenton Demonstration

In the Trenton (more technically Mercer County), New Jersey, demonstration fares are reduced to zero from a previous level of 15 cents for the hours of 10 a.m. to 2 p.m. and after 6 p.m., Monday-Saturday and all day on Sundays and holidays. Other fares varied from 5 cents for a senior citizen State Complex Shuttle ticket to 50 cents for particularly long express routes. The typical peak fare is 30 cents.

The free service was begun on March 1, 1978, and was scheduled to run for a full year. Free off-peak service is provided on all intracounty routes, including 10 regular fixed routes and 3 small shuttle loops.

The project was funded by a $500 000 grant from UMTA, but the total cost of the demonstration, including evaluation, may reach $750 000. Trenton, despite being the state capital, is experiencing many of the difficulties that inner cities around the country have been facing. Its population is diminishing at the rate of almost 1 percent a year (to 104 000) (9), and much of the remaining populace is low-income, elderly, and/or carless. The rest of Mercer County is twice as populous as Trenton, growing, and fairly affluent. However, most of the bus lines are concentrated inside Trenton, so the demonstration is at least partly aimed at helping to revitalize the downtown area.

Extensive pre-implementation planning and data collection, followed by comparable "during" data, will allow accurate and comprehensive measurement of those changes that take place. Level-of-service (schedule or route) changes in Trenton will be limited to "trailer" buses handling excessive loads, which will further isolate the effects of the demonstration.

Denver Demonstration

The Denver demonstration, in contrast to that of Trenton, includes a much larger system with a greater variety of route and service types and is not limited to the fare reduction; during the course of the demonstration, the Denver Regional Transportation District (RTD) system will undergo major route restructuring.

On February 1, 1978, the RTD, which includes several counties, initiated a one-month experiment entitled "transit awareness month." Weekday fares in the district were reduced to zero (from previous levels averaging 25 cents) for all hours except 7-9 a.m. and 4-6 p.m. An UMTA grant provided for approximately half of the nearly $7 million necessary to continue the program for a full year, and data were to be collected during and after the demonstration. On May 1 the morning peak period was redefined as 6-8 a.m.

Denver is a large, vital, growing city of a million and a half people. One of the main reasons for the experiment was to measure the city's potential to counter growing air pollution and energy worries. Thus, this experiment is different enough from the one in Trenton to offer opportunities to learn about varying free-fare impacts in alternate settings.

In addition, the larger fare change in Denver and the liberal defintion of the off-peak increased the potential for major ridership impacts. The lack of pre-implementation data, the midcourse service changes, and changing ridership estimation techniques, however, complicate the Denver evaluation.

EVALUATION METHODS

The differences in availability of before data have resulted in different evaluation approaches for the two demonstrations. In Trenton, direct comparisons between before and during free fares can be made. In contrast, the main analysis of impacts of the demonstration in Denver will come from a comparison of during and after data and from free-fare program riders' recollections of pre-free-fare behavior.

The major pre-implementation data collection in Trenton took place during the fall of 1977 and included a 300-household random telephone survey, interviews at two major activity centers (a downtown shopping mall, the Commons, and a major suburban regional shopping center), two ridership counts, a 4000-person on-board survey, and a follow-up telephone survey of 150 bus users. Post-implementation data collection has included five ridership counts, a 2000-person on-board survey, and a round of surveys matching those administered in 1977. Numerous other observations and interviews have either already been or will be made to address specific issues in greater detail.

The analyses conducted to date for Trenton are not based on the full evaluation's data. Data taken from the fall 1977 surveys were analyzed to estimate before conditions. However, in some cases those data are not completely adjusted and weighted and therefore may be modified in subsequent analyses. The after data are taken from an interim on-board survey conducted in May 1978. The analyses of these data have the same adjustment shortcomings described for the before data.

In addition, there are two inherent limitations to the use of the May data. First, the sample size is less than half as large as that of the fall 1977 on-board survey, and, second, the effects of seasonality (i.e., May versus November) are unaccountable. Therefore, the analyses and findings presented here are tentative and subject to revision as dictated by continuing analysis.

The Denver results presented here are also tentative. They are gleaned for the most part from September 1978 on-board survey results of approximately 8000 riders. Data from a July 1978 2000-person on-board survey are used to supplement September figures in the estimation of off-peak ridership increases attributable to free fares. Other on-board surveys were being conducted in November 1978 and April 1979. Also, three rounds of telephone surveys are being used to identify rider reactions to the program over time and to follow public attitudes toward the program. Transportation supply and cost data are being collected on a monthly basis. In addition, Denver Regional Transportation District monthly and average weekday ridership estimates and information from staff interviews are used to describe free-fare impacts. As mentioned, the usefulness of the data will be diminished by changes in a number of transit system parameters, including ridership counting techniques, route structures, and bus kilometers of service offered.

TOTAL RIDERSHIP IMPACT

In both Denver and Trenton, increases in overall ridership have been strong and sustained at levels above what might have been predicted from previous experience. Figure 1 presents a graphic picture of ridership change.

A comparison of before ridership estimates and four during counts indicates a 24 percent average monthly ridership increase in Trenton (542 000 riders to 672 000 riders). Seasonality differences and the inherent growth trend can account for about five percent of the increase. Therefore, the net ridership impact of the demonstration appears to be 19 percent.

In Denver it is also estimated that from 1977 to 1978 (using adjusted mean ridership estimates for February and August) average monthly ridership increased by about 49 percent from 2 667 600 to 3 973 300 riders. (Figures are adjusted for an estimated 5 percent overestimate in 1977 monthly ridership figures and an 8 percent underestimate in 1978.) However, it is likely that 15 percent of the increase from 1977 to 1978 is due to service expansion and secular growth. Therefore, it is estimated that the

Figure 1. Total monthly ridership trends.

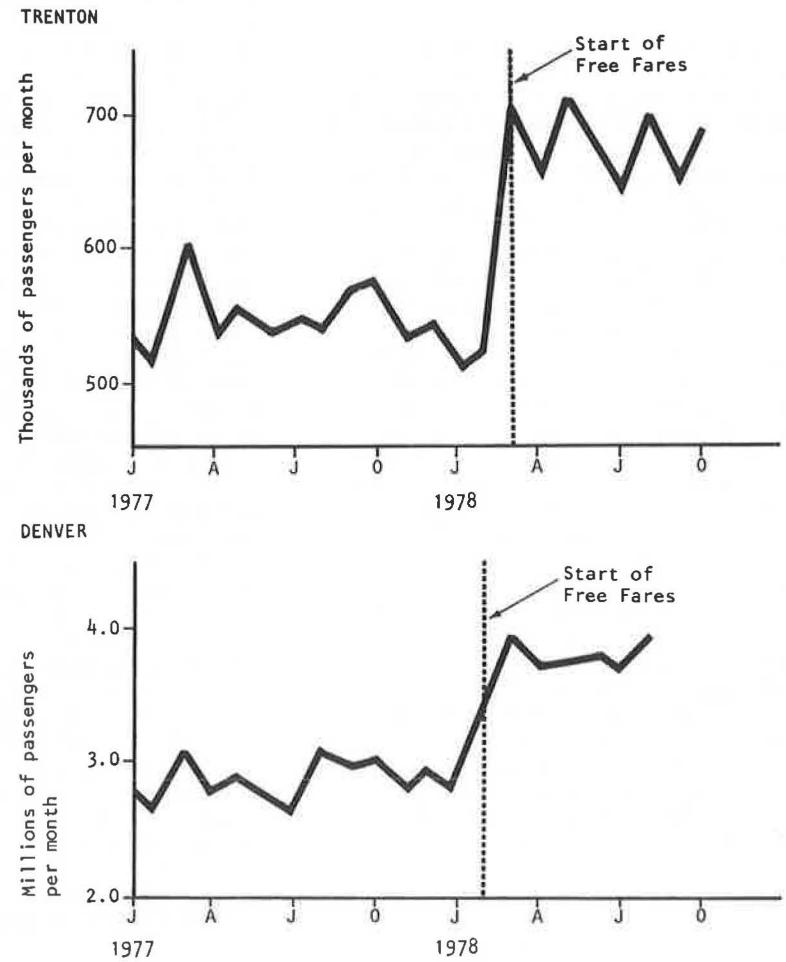
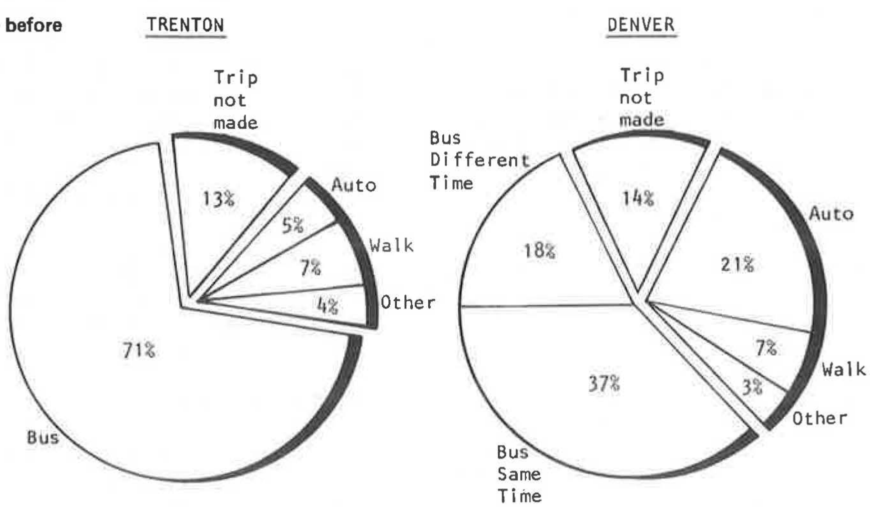


Figure 2. How trips were made before free fares.



net increase caused by free fares is about 34 percent.

EFFECTS ON OFF-PEAK RIDERSHIP

In Trenton, the estimated average weekday off-peak ridership increase from free fares appears to be about 45 percent. The magnitude of change in Denver's off-peak ridership from free fares is less exact at this stage in the data analysis. Average weekday off-peak increases are between 74 and 155 percent. This translates to between 41 000 and 61 000 new off-peak trips, which include trips switched from peak to off-peak because of free fares. The variation in estimates can be attributed to two differing estimates of average weekday pre-free-fare off-peak riders that come from different response patterns on two transit on-board surveys.

A comparison of the Trenton before and four during ridership counts adjusted for seasonality and secular growth indicates approximately a 45 percent increase in weekday off-peak ridership (7200 riders to 10 500 riders). It is not yet known what percentage of this increase is trips shifted from peak to off-peak.

Estimates of average weekday off-peak ridership in Denver are based on several assumptions. First, it is assumed that, like monthly ridership, weekday ridership underestimates actual ridership by 8 percent. This assumption is based on a comparative analysis of observed weekday patronage versus driver's use of farebox counters. In addition, 1977-1978 secular growth is approximately 15 percent, as stated earlier. This assumption is based on a comparison of bus-kilometers. Finally, current average weekday off-peak ridership is about 70 percent of total weekday ridership, according to an all-day sample ridership count taken in September 1978.

OFF-PEAK TRAVEL BEHAVIOR CHANGES

As derived above, free fares appear to have increased Trenton off-peak travel by 45 percent, while in Denver estimated increases are from 74 to 155 percent, depending on the estimated pre-free-fare ridership. (A more meaningful range of percentages for Denver is that 39-57 percent of current off-peak trips are new bus trips plus bus trips switched from the peak period because of free fares.) The following paragraphs describe two of the characteristics of off-peak travel: automobile-to-bus mode shift and generation of new travel (latent demand). September on-board survey data are used to describe Denver traveler characteristics.

In Denver, 21 percent of current off-peak riders surveyed in September stated that the trip at hand was made by automobile before free fares, while in Trenton this percentage was only 5 percent (see Figure 2).

To determine what percentage of these trips were shifted to bus because of free fares, secular growth must be accounted for. Adjusting for this growth results in an estimated 21 300 weekday automobile trips switched to bus because of free fares in Denver and about 500 trips in Trenton. The number of automobile-switched trips in Denver represents 35 percent of the new off-peak bus trips, i.e., new bus trips plus bus trips shifted from peak period, attributable to free fares. For Trenton, about 17 percent of the off-peak trips not previously made by bus were trips formerly made by automobile.

The number of new trips made because of free fares appears to be significant in both Denver and Trenton. As shown in Figure 2, 13 percent of current off-peak riders surveyed in Trenton and 14 percent of the free-fare off-peak riders in Denver identified the surveyed trips as trips not made before.

Adjusting for secular growth, it appears that in Denver 13 000 new trips were made because of free fares; this represents 21 percent of the new and peak-to-off-peak switched bus trips attributable to free fares. In Trenton, approximately 1300 trips, 45 percent of new bus trips caused by free fares, are trips not made before.

FREE-FARE USER CHARACTERISTICS

Some useful findings can be drawn from a comparison of characteristics of pre-free-fare trip makers versus those of the free-fare trip makers. A comparison of rider ages and trip purposes helps indicate whether a new market has been drawn to transit because of free fares.

Generally, the distribution of trips by purpose did not change with free fares, as shown in Figure 3. However, it appears that in both Denver and Trenton the percentage of discretionary trips increased. These trips, which form the "other" trip-purpose category, are mainly personal business trips and some joyriding trips. In Trenton, unlike Denver, the percentage of social and recreation trips dropped from 21 percent of pre-free-fare trips to 14 percent during free fare.

A comparison of the overall age distribution before and after the inception of free fares gives an indication of the way in which the benefits are distributed by age group. These distributions are shown in Figure 4.

In both Denver and Trenton, the percentage of youth (less than 16 years old) riders increased slightly with free fares, while the proportion of older riders dropped. Trenton-Denver differences in pre-free-fare and free-fare age distributions are most marked for the 17- to 24-year-old age group. In Denver this group took 26 percent of the pre-free-fare riders and increased this to 31 percent with free fares. For Trenton, both before and during free fares, the 17-24 age group is the most populous group. During free fares, the proportion of riders in this age group dropped slightly.

In response to comments about perceived increased youth ridership and increased harassment by youths in Trenton, the change in youth ridership by time of day was examined. Results showed that youth ridership understandably decreased as a share of ridership during school hours but tended to rise during the free-fare evening hours.

QUALITY OF SERVICE

Interviews with staff and drivers of both bus companies and a review of Trenton and Denver media indicate that there has been a decline in the quality of some aspects of transit service since free fares. In both demonstration projects, problems with vandalism and youth harassment, schedule reliability, and crowding have been noted.

Vandalism and Youth Harassment

In Trenton, perhaps the most surprising result of the project was a groundswell of driver and media reaction to an increase of rowdiness, vandalism, and harassment on the buses and in a suburban shopping mall served by the demonstration's free rides. All these difficulties were attributed to juveniles attracted to the buses and mall by the free fares; newspaper articles, county-sponsored open hearings, and irate letters to the editor all called for action: increased security forces, reduced evening free-fare hours, or the denial of free-fare rights to certain groups of individuals.

To evaluate this problem, summaries of reported disruptive incidents for the past year and a half were collected from the transit operator, from the mall, from police, and from drivers. Moderate increases in the number of some kinds of incidents, for instance, on-bus vandalism, can be discerned. In addition, the percentage of incidents reported in the free-fare period also increased for some type of difficulties, for instance, operator abuse. The incidence of such problems appeared to ease by summer.

In Denver, as in Trenton, the introduction of free fares created increased driver and patron harassment by youths and annoyance of patrons by drunks in the off-

Figure 3. Trip purposes.

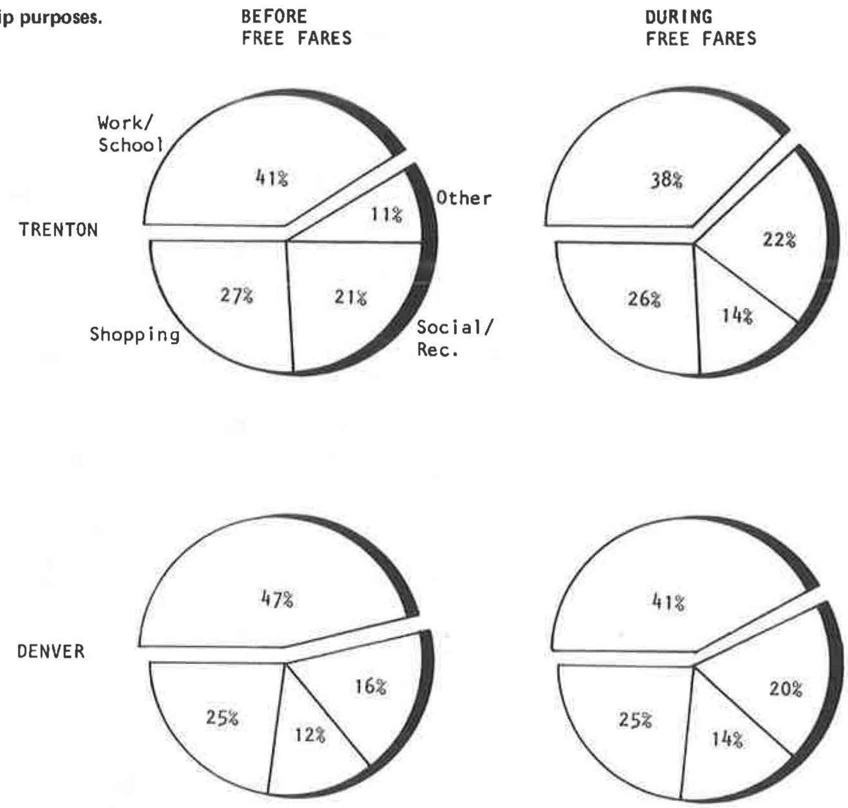
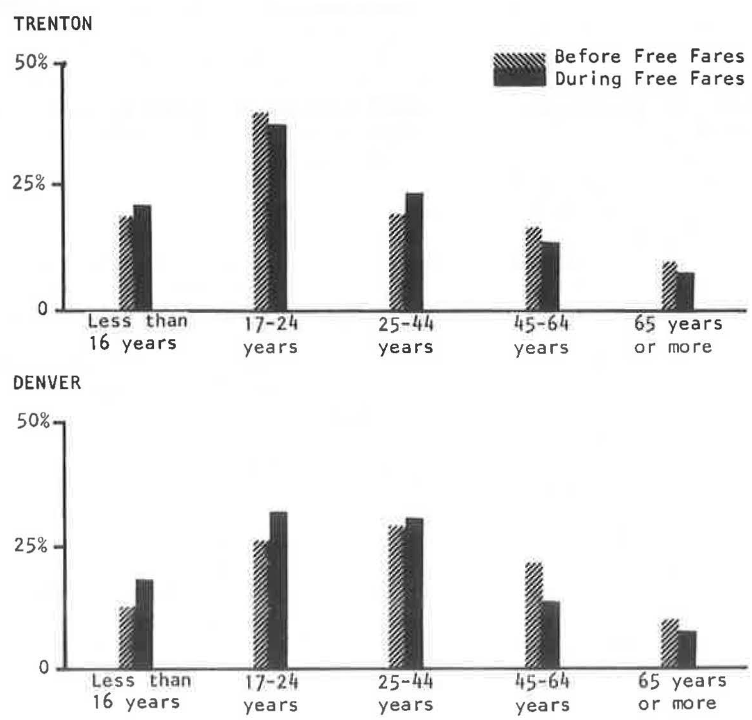


Figure 4. Rider ages.



peak hours. Increases in vandalism have been noted by RTD staff; however, incidents declined during summer. News articles, editorials, and interviews with RTD staff indicate that youths and drunks were causing problems with regular riders and drivers during the first few months. Nineteen percent of the riders surveyed in July responded that passenger politeness had declined since free fares.

Crowding

In Trenton, driver comments and load-factor counts taken near the central business district indicate that seat availability has been significantly reduced during the free-fare period. The most dramatic change occurred in the morning off-peak. The following shows before and during percentages of capacity-loaded buses based on corner-count observations.

Period	Percentage of Observed Buses At or Above Capacity: Before Free Fares	During Free Fares
6-10 a.m.	15	12
10 a.m.-2 p.m.	2	25 (free fares)
2-6 p.m.	16	19
6-10 p.m.	1	9 (free fares)

So far, there are three indicators that crowding on buses is a problem in Denver. News media have reported driver and rider complaints about crowding. Also, from January to March, the number of complaints about crowding to RTD increased dramatically. Thirty-four percent of surveyed bus riders (July 1978 survey) responded that seat availability was worse since free fares. Seat availability was checked as a problem more often than any other service quality listed on survey forms. Load-factor data are being collected, as a part of the evaluation, to permit more definitive findings.

Schedule Reliability

In both Denver and Trenton, there appears to be an increase in late bus arrivals during the off-peak. Comparison of a measure of schedule adherence indicates significant decreases in schedule adherence during free-fare periods in Trenton, as shown below.

Period	Average Delay per Scheduled Bus: Before Free Fares (min)	During Free Fares (min)	Percentage Change
6-10 a.m.	3.3	3.7	12
10 a.m.-2 p.m.	2.8	4.9 (free fares)	75
2-6 p.m.	5.0	5.7	14
6-10 p.m.	2.9	5.5 (free fares)	95

A survey of bus drivers provides additional evidence of schedule adherence problems. A majority of a sample of Mercer Metro drivers interviewed during the fall stated that free fares had negatively affected operating times and ability to maintain schedules or have layovers.

In Denver, crowding appears to be contributing to a reduction in schedule reliability. RTD staff members interviewed in June noted that, because of more frequent stopping, buses often ran late, particularly during the transition period between the afternoon peak and off-peak hours. Time checks are now being analyzed to determine the extent of the problem.

TRANSIT OPERATIONS

In both Denver and Trenton, the demonstrations appear to have increased fleet and driver requirements slightly. In addition, the programs have had a generally adverse effect on driver morale.

Fleet and Driver Requirements

In an April Denver RTD staff memo it was stated that passenger and running time checks indicated that additional midday service was necessary to eliminate passenger pass-ups and severe running-time problems that affected schedule reliability. A need for 13 extra weekday buses and 8 additional Saturday buses was shown. Additional service need was estimated at 40 bus-hours on weekdays and 56 bus-hours for Saturday; corresponding bus-kilometer increases were shown as 747 and 906 km (458 and 563 miles) for weekdays and Saturday, respectively. This amounts to an increase of about 1 percent in RTD's service.

Almost all of this required service has been added since April. All of the needed weekday buses have been added, and most of the Saturday requirements have been met. Trenton experienced minor increased fleet requirements early in its demonstration program. Trailer buses were added to serve a temporary increase in shopping-center trips.

Driver Morale

In both Denver and Trenton, driver morale has declined. News articles, comments from drivers and driver representatives, and RTD staff memos indicate that, since free fares began in Denver, driver morale has declined and complaints against drivers have increased.

Of the drivers sampled in Trenton, 92 percent said the free-fare program has made their jobs less enjoyable. Nearly all of the interviewed Mercer Metro drivers (95 percent) reported having received negative comments regarding the free-fare program; 89 percent said they frequently received negative comments.

Financial Impacts

As expected, revenue losses from free fares were substantial, but increases in operation costs appear to be insignificant in both Trenton and Denver.

Revenue Loss

RTD estimated that operating revenue loss resulting from Denver's free-fare program was of the order of $3.7 million for 1978. This represents approximately a 37 percent decrease from RTD's estimate of 1978 operating revenues if normal fares had been charged based on a projection of 1977 trends. During 1977, revenue levels remained fairly stable at $0.249 per passenger. January 1978 fare increases resulted in an average revenue of $0.282 per passenger. With free fares, the average has dropped to $0.122 per passenger, a 51 percent drop from January 1978.

For Trenton, the projected annual operating revenue loss due to free fares has been estimated at $340 000. This is a 25 percent drop from Mercer Metro's estimate of annual revenues if regular fares had been charged. Current average revenue per passenger is estimated at $0.135. Before free fares, this estimate was $0.205; since free fares, average annual revenue per passenger has dropped by 44 percent.

Operating Costs

It appears that in Denver the demonstration resulted in a slight increase in transit operating costs; the additional costs for service to accommodate the increased free-fare riders were projected to total about $250 000 for April-December 1978, or about $28 000 per month. This amounts to an estimated increase of total operating costs of less than 1 percent. These slightly higher costs have resulted from (a) extra drivers and bus trippers deployed to improve schedule reliability and reduce crowding, (b) increased maintenance (mainly resulting from vandalism), and (c) increased public information needs.

Higher costs did result in Trenton when trailer buses were added to accommodate more trips to shopping centers, but no permanent service additions have been made because of free fares. Costs resulting from increased vandalism and additional wear and tear on buses have not yet been estimated.

CONCLUSIONS

Off-peak ridership gains from free fares are estimated at 45 percent for Trenton and 74-155 percent for Denver. Disaggregate data from both Trenton and Denver demonstrations will be analyzed to form estimates of elasticities for different market segments. However, in the absence of such data, a functional form relating the absolute amount of initial transit price to the percentage change in patronage caused by free fares was derived.

A parabolic curve that is a variation of Scheiner's (8) demand curve was formed. There are two assumptions associated with this curve that differ from Scheiner's. First, demand reacts differently depending on whether fares are increased or decreased; somewhat larger percentage changes are expected as fares are reduced. Second, ridership gain can exceed 100 percent. The equation of the parabolic curve is

$$y = kx^{1/2} \tag{1}$$

where

- y = percentage of off-peak patronage gain from free fares,
- k = a constant, and
- x = the average off-peak fare prior to free fares.

Applying the equation to estimated Trenton off-peak rider increases (55 percent) and the midpoint of the range for Denver (114 percent) results in elasticities of -0.42 for Trenton and -0.64 for Denver. This result indicates a greater response to free fares in Denver than in Trenton. This is likely to be due to the greater opportunity for potential riders to make use of free fares in Denver. RTD free-fare hours are longer than those in Trenton, and overall RTD service frequency is greater.

Results from both demonstrations do indicate support for the notion that, for a substantial percentage of riders in both cities, the movement to zero out-of-pocket costs is not equivalent to a movement to zero total perceived costs and that, while free fare induces large and sustainable ridership gains, the behavior of much of the population in making their modal choices is not significantly different at zero than it would be with any absolute fare change of an equal amount.

There is apparently no significant psychological "free-ride" behavioral change. There are two exceptions to this conclusion: parallel-route walk trips and trips made by youths (and presumably others with similar characteristics). The Trenton results summarized in this paper show that free transit attracts a large proportion of walkers; this result is also partially supported by the Denver results.

The trend of youthful riders is in itself an important consideration. Overall in both Denver and Trenton, the share of youth riders increased slightly. When the concentrations of young riders at particular times are examined, a clearer picture of their demand is obtained. In Trenton, young ridership understandably decreased as a share of ridership during school hours but tended to rise during those times when bus rides were an alternative for transportation to entertainment. In some cases bus rides were entertainment in and of themselves.

This leads to the conclusion that free transit attracts far more riders than might be expected in given subsets of the ridership. The theoretical reason for the discontinuous demand characteristics of these groups is that their nonmonetary costs are at or near zero, so that unlike many other riders the out-of-pocket cost of riding transit is a good proxy for the perceived cost.

Free fares also appear to cause some adverse changes in transportation supply. In both Trenton and Denver, crowding increased and schedule adherence was reduced. Incidents of rowdiness and vandalism also increased. But available documentation indicates that the increases in reported vandalism are not beyond what might be expected, given the ridership increases. Quite naturally, however, the situation of regular riders avoiding transit because of the perceived crowding and hassle is a distinct possibility.

Since most of these riders appear to make modal decisions based more on nonmonetary costs than on dollar costs, it seems that an increase in discomfort could offset the value of decreased fares. Perhaps the most negative conclusion of the study to date is that free fare has the potential to disrupt the typical social balance of a transit system; whether the future will show this to be a temporary condition is impossible to say.

One of the most severe impacts of free fares appears to be a drop in driver morale. Increased ridership has added to the responsibilities of drivers and affected their run times. In addition, drivers appear to be receiving the brunt of negative patron comments about the program and are having to deal with increased harassment and vandalism by youths on the buses.

As was expected, transportation costs were adversely affected. Revenue losses in both demonstrations are in the 30-40 percent range. But it is important to note that operations costs increased only slightly.

In conclusion, it should be reiterated that these results are interim; final project results should be available within a year.

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Operating Assistance for Public Transportation Systems: A Survey of State-Level Programs

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A survey of several state-level programs of operating assistance for public transportation systems was undertaken early in 1978 by the New York State Department of Transportation as part of its annual evaluation of the impact and effectiveness of its statewide aid program. Only three states did not respond, but they were subsequently determined not to have such programs. This paper describes existing programs in terms of eligible operations, local sponsorship, relationship to Urban Mass Transportation Administration funding programs, ability to use funds for capital purposes, sources of program funds, and the scope of services assisted. Finally, it proposes a more in-depth review of the effectiveness of the programs designed to aid in policy development and implementation at both the state and the federal levels.

In recent years the role of the state in transit planning has expanded. A number of states have become involved in capital and technical assistance to local transit, and some of them now provide operating assistance to a variety of public transit services.

The New York State Department of Transportation (NYSDOT) was particularly interested in investigating other states' operating-assistance programs because of its own commitment in this area. New York's operating-assistance program was initiated in 1974 with the stated object of maintaining both fares and current levels of service.

In state fiscal year 1977/78, $104.5 million of state funds were made available to transit operators for the provision of commuter rail, rapid rail, fixed-route bus, demand-responsive bus, and commuter ferry services. During 1978-1979 that amount was increased to $110.6 million. NYSDOT annually evaluates the success of its program in meeting objectives as well as the broader social, transportation, and economic objectives of the state.

Operating and financial information is collected annually from all transit operators receiving state funds; this information is used to estimate future financial needs and to make recommendations for changes in the program to help better achieve its goal. As part of its information-gathering process and to provide comparative information for use in developing its recommendations, NYSDOT decided to investigate transit operating-assistance programs administered by other states. None of the similar surveys conducted in recent years have focused on operating assistance. The recent growth of this type of program and approval of the Surface Transportation Act of 1978 have increased the importance of this activity.

METHODOLOGY

Copies of the 1977 Annual Report on Public Transportation Operating Assistance Programs in New York State (1) were distributed to appropriate officials in state departments of transportation or highways in the 49 other states in January 1978. Along with the report, these officials were sent a survey form requesting information on the existence of public transit operating-assistance programs in their states and asking a series of questions about the programs.

PREVIOUS RESEARCH ON STATE ASSISTANCE TO LOCAL TRANSIT

In 1975 three studies were conducted on state transit funding, all of which discussed capital and technical assistance as well as operating assistance. Bair and McKelvey (2) conducted a study for the Institute of Urban and Regional Research of the University of Iowa on current state practices in transit funding. They surveyed the 22 states with departments of transportation to identify state assistance to local transit in the areas of capital expenditures, technical studies, operating costs, demonstrations, planning, evaluation, and promotion. Carstens, Mercier, and Kannel (3) of Iowa State University conducted a study of the current status of state-level support for transit. They collected information from each state and looked at all types of financial assistance for local transit in 24 states. The third study of state expenditures for local transit, part of the investigation into 13 small city systems conducted by the Transportation Systems Center (4), also covered both capital and operating programs but focused on small cities, i.e., those with less than 200 000 people.