service level causes some previous transit trips to be lost, while the increase in gasoline prices generates a net gain in total transit trips. The increase in trips, however, more than likely represents diversions from the automobile and may well occur principally during the peak periods. The overall result is an increased burden on current transit-dependent riders and a relative increase in peak-period transit use, which might cause operating costs to increase more rapidly. The social as well as the financial implications of this condition should be carefully considered.

Rational fare policy is essential if the competitive position that transit has established over the past several years is to be maintained and, it is hoped, improved. The 1970s saw a recapitalization of transit systems that strengthened the competitive position. Increasing gasoline price alone is a major factor that favors transit, as are increasing costs for dispersed housing and automobiles. The situation is much different from that in the postwar era when the combination of release from shortages, increasing real incomes, subsidized suburban housing, cheap gasoline, and deteriorated capital structure of transit was overwhelming in its bias for increased automobile travel and decreased transit travel. Pricing the improved transit product in line with the competition will allow increasing fares to match increasing costs. However, the fare increases imposed must be incrementally small, regularly instituted, and anticipated. Planning for fare changes, operating costs, and service levels must extend beyond the current budget year if this is to be accomplished. The process described here is one approach to doing this.

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Examining Likely Consequences of a New Transit Fare Policy

ROBERT CERVERO

An evaluation model is presented for examining the likely consequences of implementing alternative transit fare policies. The model weights responses to on-board ridership survey responses based on disaggregate fare elasticity estimates in projecting future patronage levels and revenue income. Revenue and cost data associated with specific users' trips are also combined in comparing the farebox recovery levels among various categories of trip distance, time of day, and user demographics. The functional components of the model are described and its use is demonstrated. Fare, cost, and travel data from the Southern California Rapid Transit District are used to examine the current fare policy of the system. Uniform fares are found to be both inequitable and inefficient. Both distance-based and time-of-day fare scenarios are designed and tested in terms of their ability to correct some of the problems associated with flat fares. Finely graduated fares are found to be best suited for mitigating inequities, and stage fares seem to be a more cost-effective pricing strategy. As transit funding sources continue to shrink, it is imperative that analytic tools be developed for examining the full range of impacts of alternative fare systems.

The American transit industry today finds itself in a financial stranglehold. The nationwide transit deficit stood at $4 billion in 1980, the product of precipitous cost increases and declining real dollar fares during the 1970s (1). The Reagan Administration's planned phase-out of federal operating subsidies portends a future of major fare increases and service cutbacks. As the going rate for a bus ride threatens to reach the $1 mark in Los Angeles, Chicago, and other major cities in the not-too-distant future, transit managers are scrutinizing current fare practices and pricing rationales more closely. More finely graduated, distance-based pricing and peak/off-peak fares, in particular, may become prevalent during the 1980s as operators attempt to capture some of the differential costs of providing services. During the past several years, more than 20 American transit properties have introduced some form of time-of-day pricing; Tri-Met in Portland, Oregon, and several other operators have recently expanded their zonal fare systems (2).

Understanding the likely effects of alternative transit fare systems is essential to effective ongoing transit planning. Not only is it necesssry to examine the likely ridership and fiscal impacts of a proposed fare change, but one must also be able to discern the distributional consequences. Citizens' groups and minority organizations are increasingly becoming outspoken and militant in their opposition to unilateral fare hikes, as demonstrated by recent court challenges charging violation of Title VI requirements of the Civil Rights Act of 1964 in such places as Dallas, Pittsburgh, and Memphis. Recent evidence suggests that today's reliance on predominantly flat fares is grossly inequitable in that short-distance, midday, and lower-income users typically cross subsidize the long-distance, usually more affluent, rush-hour commuter (3,4). Mitigating any maldistributive effects of a fare change is particularly important because of transit's universally accepted role in providing mobility opportunities to disadvantaged persons.

This paper presents a model originally used in examining the likely consequences of proposed fare changes for three California transit properties (5). In addition to estimating the revenue and ridership impacts of a fare change, equity consequences were assessed. The criterion variable used in evaluating equity impacts was a farebox recovery ratio disaggregated at the level of the individual user (i.e., a ratio of what share of a user's trip costs is met through the farebox). Trip costs were estimated by using a multistage cost allocation technique that is described in detail in a companion paper in this Record and elsewhere (6). Fare revenue and patronage information was gathered from on-board ridership survey responses. The use of passenger-level data enabled the analysis of distributional impacts to be performed at a fairly disaggregate level. The remainder of this paper describes the analytic model in greater detail and demonstrates its possible use in examining alternative fare scenarios for the Los Angeles area.

ANALYSIS OF RIDERSHIP AND REVENUE IMPACTS

In forecasting the likely ridership and fiscal effects of a fare proposal by using disaggregate ridership information, it is necessary to weight individual survey responses based on the fare elasticity estimate associated with each user's trip. Weighted responses can then be aggregated over the entire sample to estimate the anticipated overall patronage response to a fare change.

The arc measure of fare elasticity was chosen for modeling purposes because it produces a nonlinear relation between fares and ridership and seems to best approximate past, empirically derived utility-maximizing models (7,8). Kemp (9) defines arc elasticity as

$$\eta_a = (\log Q_b - \log Q_a)/(\log P_b - \log P_a) \qquad (1)$$

where

Q = ridership,
P = price, and
b,a = respective ridership and price before and after a fare change.

From Equation 1, the "frequency of use" (Q_{a_i}) associated with each passenger's trip is estimated on the basis of the new fare (P_{a_i}), as follows:

$$Q_{a_i} = \text{antilog}(\eta_i \log P_{a_i} - \eta_i \log P_{b_i} - \log Q_{b_i}) \qquad (2)$$

where

Q_a = relative frequency of use after a fare change,
i = individual passenger (survey response),
η_i = arc elasticity associated with passenger i's trip,
P_a = price after a fare change,
P_b = price before a fare change, and
Q_b = relative frequency of use before a fare change.

This equation projects future use on the basis of disaggregate arc elasticities associated with the trip of passenger i. Since each record from an on-board survey typically represents a single passenger, Equation 2 can be reexpressed in terms of a weight (WT_i) by setting Q_{b_i} equal to 1:

$$WT_i = \text{antilog}(\eta_i \log P_{a_i} - \eta_i \log P_{b_i}) \qquad (3)$$

where WT_i is the ridership response weight for a new fare policy.

The model then measures aggregate ridership impacts of a new fare policy in terms of the percentage change in initial patronage by summing over all observations:

$$PCRID = 100 \left[\left(\left\{ \sum_{i=1}^{n} [\text{antilog}(\eta_i \log P_{a_i} - \eta_i \log P_{b_i})] \right\} /n \right) - n \right] \qquad (4)$$

where PCRID is the percentage change in system ridership under the new fare policy and n is the initial sample size from the on-board survey.

The revenue impact of a new pricing policy is next computed as the product of the proportional change in ridership and the proportional change in average fare:

$$PCREV = 100 \left[\left([1 + (PCRID/100)] \left\{ \left[\left(\sum_{i=1}^{n} P_{a_i} \right) /n \right] \div \left[\left(\sum_{i=1}^{n} P_{b_i} \right) /n \right] \right\} \right) - 1 \right] \qquad (5)$$

where PCREV is the percentage change in system revenue under the new fare policy. As the equation shows, new fare systems can be expected to generate higher-revenue returns whenever price increases are relatively greater than patronage losses.

ANALYSIS OF EQUITY IMPACTS

The potential distributional impacts of a fare proposal can be examined by comparing farebox recovery rates among various categories of users' trip distances, time periods of travel, and socioeconomic characteristics. Farebox recovery rates can be measured by using a ratio of the fare revenue per mile of travel paid by a surveyed passenger to the cost per passenger mile associated with the passenger's particular bus trip (RPM/CPM ratio). Equity impacts can be assessed as follows. New fares are initially assigned to sampled users based on the proposed pricing structure. Under a graduated fare proposal, for instance, each sampled passenger's new fare would be estimated by multiplying the updated price rate times the length of the passenger's trip. Trip costs are also adjusted to reflect the additional expenses incurred in collecting differentiated fares. Adjusted RPM/CPM estimates are then compared among trip distance, time period, and demographic categories to fully examine possible equity impacts. Equation 6 summarizes the computation of the mean RPM/CPM of a fare proposal, which can then be disaggregated in analyzing equity impacts:

$$RPM/CPM = \left[\sum_{j=1}^{n} \sum_{k=1}^{n} \sum_{i=1}^{n} (R_{ijk}/PM_{ijk} \div C_{ijk}/PM_{ijk}) \right] /(n_a \cdot n_t \cdot n_r) \qquad (6)$$

where

R = price paid by rider i under the new fare policy,
C = cost of rider i's trip on route j during time period k (including additional collection costs) under the new fare policy,
PM = passenger miles traveled by rider i,
i = individual passenger,
j = route surveyed,
k = time period,
n_a = weighted sample size for route r and time t,
n_t = number of time periods, and
n_r = number of routes surveyed.

ASSESSING FARE-POLICY IMPACTS

The analytic model just described was used in evaluating fare scenarios written for the Southern California Rapid Transit District (SCRTD), which serves the Los Angeles metropolitan region. The use of this model is now demonstrated by presenting the ridership, revenue, and equity impacts projected for finely graduated, stage, and time-of-day fare scenarios proposed for SCRTD.

Prior to testing alternative SCRTD fare programs, SCRTD fare policy at the time of the research (FY 1978/79) was examined. Problems associated with the SCRTD flat $0.45 fare have been described previously (3) and are only briefly summarized below.

Tremendous differences were found in the share of costs recovered from the farebox between short and long trips. The following estimated RPM/CPM averages for six different categories of trip distance reveal this:

Trip Distance (miles)	Avg RPM/ CPM
<1	2.22
1-2	0.66
2-6	0.28
6-10	0.16
10-20	0.12
>20	0.08
System average (all trips)	0.46

SCRTD users making bus trips less than 6 miles in length--79 percent of all trips on the system--met more than five times as much of their costs as those traveling more than 6 miles. Those riding less than 1 mile actually paid an average of $0.17 more than it cost to carry them. In striking contrast, those taking trips more than 25 miles in length paid an average of $3.17 less than it cost to serve them. Most of the SCRTD subsidy, then, went to help the few people taking the longest trips.

When the fare policy was analyzed by time of day, similar disparities were found. The following estimated RPM/CPM averages broken down by time period show that farebox revenue generated by rush-hour services covered a much smaller proportion of operating costs than did revenue generated by off-peak services:

Time Period	Avg RPM/CPM
Morning peak	0.38
Midday	0.68
Evening peak	0.42
Evening	0.48
Late night	0.47
System average (all trips)	0.46

Midday and other nonpeak services were found to cover 56 percent of SCRTD costs compared with a recovery rate of only 40 percent for rush-hour services. In absolute terms, SCRTD lost $0.63 for every rush-hour passenger served compared with $0.37 for every nonpeak customer served.

In terms of differences in RPM/CPM averages among socioeconomic classes, Table 1 suggests that the results were mixed. Surprisingly, the net transfer effect of SCRTD fares was found to be mildly progressive, although the relation was statistically insignificant. With regard to riders' "vehicle availability" status, those without access to an automobile were found to cross subsidize users with other travel options only to a small extent. In general, cross subsidization also hurt those who were college age, female, and making medical trips. On the whole, however, the fare penalties imposed on these groups were quite modest.

In sum, the SCRTD flat-fare structure was found to be largely inefficient in that long-distance and peak-period users paid extraordinarily low fares. From a distributional standpoint, the incidence of cross subsidization did not appear regressive; however, those traditionally thought to be most dependent on transit were found to lose more under current pricing than other user groups, although the overall transfer effect tended to be modest.

TESTING ALTERNATIVE FARE SCENARIOS

In response to the inefficiencies and inequities of the SCRTD fare structure, several alternative fare policies were designed and tested. In addition to current ridership data and information about the proposed price structures, two other data inputs were required in evaluating fare scenarios. For one, disaggregated fare elasticities were computed by using a systemwide long-run elasticity estimate of -0.1 and adjusting it to reflect the sensitivity of specific user groups to fare changes. The various elasticity estimates used incorporated findings from past empirical research that found short-distance, older, higher-income, and male tripmakers to be somewhat more price sensitive than the average user (11,12). Sensitivity testing on low to high ranges of elasticity estimates was used in the modeling of scenarios; however, since the results were found to be quite robust (i.e., generally invariant to specific elasticity figures used), only midrange estimates of long-run responses to fare changes are presented here. In addition, fare-collection costs associated with more complex, graduated pricing were projected and incorporated into the model. Table 2 gives the combined annual depreciation and operating cost estimates of operationalizing three alternative fare systems. A finely graduated fare system was assumed to require ticket-issuing machines and cancellers aboard most of SCRTD's 2600 vehicles as well as curbside automats and a corps of roving inspectors to implement and enforce proper fare payment. Other incidental costs related to maintenance, operations, fare-handling, and retrofitting vehicles were also assumed. Graduated pricing could be expected to raise SCRTD current fare-collection costs by more than 700 percent, which would result in an increase in system total annual operating cost of 2.4 percent. Accordingly, the cost-per-mile estimate of each trip was increased by a factor of 1.024 to incorporate the transactive costs of instituting graduated pricing. More coarsely graduated systems, such as stage or time-of-day fares, were assumed to require less expensive fare-collection technologies and thus provide considerable cost savings over the graduated-fare proposals. Both stage and time-of-day fares were projected to increase system total operating cost by less than 1 percent annually.

Table 1. Equity impacts of current SCRTD fare structure among socioeconomic classes.

Item	Group RPM/CPM	Item	Group RPM/CPM
Annual family income ($)		Age (years)	
≤15 000	0.45	≤17	0.50
>15 000	0.48	18-30	0.56
Vehicles owned		31-62	0.42
None	0.47	>62	0.19
≥1	0.45	Trip type	
Language background		Work	0.45
English-speaking	0.46	Nonwork	0.46
Spanish-speaking	0.48	Medical	1.04
Gender		Total sample	0.46
Female	0.48		
Male	0.44		

Graduated Pricing

One of the scenarios tested in response to the deficiencies of the SCRTD flat fare involved pricing services as pure linear functions of distance. This scenario called for pricing all services at a base fare of $0.10 and $0.08/mile surcharges for journeys beyond 1 mile except for students and elderly passengers, who would pay distance increments of $0.06 and $0.04/mile, respectively. A regular user traveling 8 miles would therefore pay around $0.70, and a 25-mile journey would cost more than $2.

The ridership and revenue impacts of this sce-

Table 2. Fare-collection cost estimates of alternative SCRTD fare scenarios.

Scenario	Fare-Collection Cost Component	Cost Estimate ($)
Finely graduated fare system	On-board ticket dispensers and cancellers at $8500/vehicle (including farebox costs)	17 000 000
	Curbside automats at $10 000 each	16 000 000
	Total capital costs	33 000 000
	Annual depreciation at 8 percent interest and 15- to 20-year service life	3 615 250
	Annual inspector cost at $17 000/inspector	1 700 000
	Other annual operating and maintenance costs at 25 percent of capital depreciation	903 930
	Projected annual total collection cost	6 219 180
	Current annual collection cost	980 000
	Difference between projected and current costs	5 239 180[a]
Stage or zonal fare system	On-board dispensers and cancellers at $8500/vehicle (including farebox costs)	17 000 000
	Annual depreciation at 8 percent interest and 15-year life	1 986 100
	Annual operating and maintenance costs at 35 percent of capital depreciation	695 140
	Additional driver wages due to enforcement responsibilities at 0.25 percent of current wage bill	212 500
	Projected annual total collection cost	2 893 750
	Current annual collection cost	980 000
	Difference between projected and current costs	1 913 750[b]
Peak/off-peak fare system	On-board time-monitoring equipment and fareboxes at $3700 each	7 400 000
	Annual depreciation at 8 percent interest and 15-year service life	864 540
	Annual operating and maintenance costs at 50 percent of capital depreciation	432 270
	Additional driver wages due to enforcement responsibilities at 0.25 percent of current wage bill	212 500
	Projected annual total collection cost	1 509 310
	Current annual collection cost	980 000
	Difference between projected and current costs	529 310[c]

[a] Equals 2.4 percent of total system costs. [b] Equals 0.89 percent of total system costs. [c] Equals 0.24 percent of total system costs.

Table 3. Ridership and revenue impacts of alternative SCRTD fare scenarios.

Impact	Graduated Fares	Stage Fares	Time-of-Day Fares
Change in ridership (%)	+0.1	−2.4	+0.4
Change in revenue income (%)	+11.3	+30.8	+13.5
Mean RPM/CPM[a]	0.50	0.60	0.53
Change in farebox recovery ratio (%)	+8.7	+29.7	+14.3

[a] Estimate of systemwide farebox recovery ratio.

Table 4. RPM/CPM by trip distance under alternative SCRTD fare scenarios.

	Avg RPM/CPM			
Trip-Distance Category (miles)	Current Fares	Graduated Fares	Stage Fares	Time-of-Day Fares
<1	2.22	0.59	0.95	1.42
1-2	0.66	0.47	0.65	0.68
2-6	0.28	0.52	0.59	0.34
6-10	0.16	0.49	0.46	0.25
10-20	0.12	0.50	0.44	0.20
>20	0.08	0.49	0.44	0.15
All trips	0.46	0.50	0.60	0.53

Table 5. RPM/CPM by time of day under alternative SCRTD fare scenarios.

	Avg RPM/CPM			
Trip Time-of-Day Category	Current Fares	Graduated Fares	Stage Fares	Time of-Day Fares
Morning peak	0.38	0.46	0.51	0.54
Midday	0.68	0.62	0.67	0.55
Evening peak	0.42	0.48	0.53	0.56
Evening	0.48	0.47	0.49	0.46
Late night	0.47	0.45	0.48	0.42
All trips	0.46	0.50	0.60	0.53

Table 6. RPM/CPM by demographic characteristics and trip type under alternative SCRTD fare scenarios.

	Avg RPM/CPM			
Item	Current Fares	Graduated Fares	Stage Fares	Time-of-Day Fares
Annual family income ($)				
≤15 000	0.45	0.50	0.60	0.52
>15 000	0.48	0.50	0.62	0.55
Vehicles owned				
None	0.47	0.51	0.58	0.53
≥1	0.45	0.50	0.60	0.52
Language background				
English-speaking	0.46	0.49	0.59	0.52
Spanish-speaking	0.48	0.52	0.67	0.59
Gender				
Female	0.48	0.50	0.59	0.55
Male	0.44	0.50	0.61	0.51
Age (years)				
≤17	0.50	0.46	0.58	0.56
18-30	0.56	0.55	0.68	0.64
31-62	0.42	0.50	0.61	0.55
>62	0.19	0.31	0.25	0.26
Trip type				
Work	0.45	0.49	0.61	0.55
Nonwork	0.46	0.50	0.58	0.51
Medical	1.04	0.66	0.85	1.12
Total sample	0.46	0.50	0.60	0.53

nario were estimated by using Equations 4-6. Table 3 reveals that overall ridership levels would probably remain virtually the same and revenue income could be expected to increase by more than 11 percent. Moreover, the system overall recovery rate could be expected to rise to 50 percent, a growth above the present recovery rate of almost 9 percent.

From Table 4, it is apparent that pure distance-based pricing could virtually eliminate current SCRTD fare disparities. Under this scenario, the RPM/CPM ratio of trips of less than 1 mile could be expected to fall by 275 percent and the recovery rate for journeys of more than 25 miles would likely increase more than 700 percent. Finally, a pure distance-based pricing arrangement could be effective in neutralizing current RPM/CPM differences among time periods as well as among socioeconomic classes of riders (see Tables 5 and 6). In particular, graduated fares would appear advantageous to SCRTD's female passengers and those taking medical trips.

Stage Pricing

Stage fare structures aim to capture some of the costs incurred in serving long-haul journeys, yet without the expense of elaborate distance-monitoring collection equipment. Typically, major interchanges, activity centers, and natural boundaries serve to demarcate each step in a stage price system. An ideal stage system would exact equal fares from those traveling the same approximate distance and systematically varying fares from patrons journeying different distances. In SCRTD's proposed stage fare structure, basic fares would be $0.15-$1.70 and each hypothetical distance step would increase the cost of a trip by $0.10-$0.25.

From Table 3, SCRTD could be expected to lose a margin of riders under stage pricing; nonetheless, significant revenue gains could be expected. Merging the collection costs of stage pricing into the analysis, the system recovery ratio could be expected to rise to 60 percent, nearly a 30 percent increase above the current cost recovery rate. Thus, stage pricing was found to have considerable potential for substantially increasing SCRTD revenue yield and operating efficiency.

Tables 4 and 5 indicate that RPM/CPM difference between trip-distance and time-of-day categories could be substantially reduced, although not to the degree predicted under pure distance-based pricing. For instance, recovery rates would drop by perhaps as much as 230 percent for trips of less than 1 mile but rise nearly 500 percent for trips in excess of 25 miles in length. Finally, Table 6 reveals that stage fares could also mitigate some of the maldistributive effects of current pricing practices. In particular, carless, female, and younger tripmakers would materially benefit from a conversion to stage fares. However, stage pricing could be expected to retain SCRTD's slightly progressive transfer incidence.

Time-of-Day Pricing

Peak-period fares of $0.55 versus off-peak fares of $0.35 (in 1979 dollars) were assumed under this scenario. Again, an assortment of senior citizen, student, and pass-user discounts were assumed under this scenario, which is consistent with current SCRTD policies calling for reduced rates for these groups.

The data given in Table 3 show that a minute increase in overall ridership could be expected; base-period fares, however, could be expected to increase off-peak patronage so as to more than compensate for peak-period ridership losses. Higher-revenue yields could also be anticipated with peak/off-peak fares. Time-based fares do not, however, appear to match the revenue productivity of stage fares. Still, when the relatively lower collection costs associated with time-of-day fares are considered, the scenario recovery ratio would likely rise above that of graduated-fare policies.

Table 5 indicates that the tested fare program would equalize RPM/CPM levels among time periods and recovery rates would generally converge toward the system average during both peaks and the midday period. Table 4, on the other hand, reveals that a marginal equalization of RPM/CPM ratios between short and long trips would likely emerge under time-based pricing. However, the relative reduction in distance disparities projected under peak/off-peak differentials appears less than the relative reduction of temporal disparities projected under graduated pricing. In general, time-of-day fares were found to hold less potential for improving overall price efficiency in comparison with distance-based fares.

Equity implications of time-of-day pricing are summarized in Table 6. Compared with the other two scenarios tested, few discernible changes in the distributive effects of current pricing were projected. The only perceptible change in the current equity impacts predicted under time-of-day fares involved a neutralization of RPM/CPM levels among work and nonwork tripmakers that reflects the concentration of higher-priced commuter bus trips during peak periods.

In sum, it is apparent from these scenarios that, as fare structures begin to approximate marginal cost pricing, significant fiscal, efficiency, and equity benefits can be expected. In particular, pure distance-based pricing seems to hold the greatest promise for eliminating the maldistributive effects and inefficiencies of current flat-fare systems, and stage fares and time-of-day pricing seem to offer the greatest potential for increasing revenue productivity and cost-recovery levels. If one ignores questions regarding user receptiveness, automated fare-collection systems would appear to be cost-effective investments in the case of SCRTD in that the system's overall farebox recovery ratio could be expected to increase significantly under all three scenarios. Collectively, these findings offer compelling grounds for opting for more differentiated pricing structures as preferred fare policies.

SUMMARY

With transit managers increasingly turning to the farebox to reduce soaring deficits, a better understanding of the full consequences of instituting a new fare system is essential. In particular, a disaggregate analytic structure is needed for identifying who the gainers and losers will be under different pricing systems. This paper presents an analytic model for probing the likely ridership, revenue, and equity impacts of a fare change. The model examines a fare proposal by weighting sample cases from passenger surveys based on estimates of disaggregate arc fare elasticity. The model encapsulates information about the additional costs of collecting differentiated fares into the analysis and can be used to analyze changes in the average farebox recovery ratio of different types of trips and services.

Possible uses of the model were demonstrated by examining the likely consequences of three radically different fare structures designed for the SCRTD system in Los Angeles. SCRTD's predominantly flat-fare structure was found to be quite inequitable and inefficient, particularly with respect to its inability to capture the higher cost of serving long-distance trips. System users taking short trips were found to pay on the order of 12 times as much per mile of service as the average rider. Price disparities were also quite severe between peak and off-peak periods. Overall, the redistributive consequences of the current SCRTD fare system appeared most harmful to those traditionally considered most dependent on transit.

The three scenarios studied for remedying the current problems associated with uniform pricing involved differentiating fares as pure linear functions of distance, varying fares with distance steps, and bifurcating fares by peak and nonpeak time periods. All three proposals seemed quite responsive to current fare deficiencies, though to different degrees. The scenario calling for a finely graduated fare seemed best able to eliminate current inequities, whereas stage and time-of-day pricing seemed to hold greater promise for improving the fiscal condition of the system. Of course, any pricing structure chosen should support the specific policy objectives of transit decisionmakers. Given a policy mandate to implement distance-based fares, for example, stage pricing seems most promising in terms of revenue productivity whereas graduated structures appear particularly suited to eliminating inequities. Another trade-off might involve the apparent ridership advantages of time-of-day pricing versus simplicity and user comprehensibility of flat rates. Given the almost inherent conflicts among various pricing objectives, it is imperative that the relative advantages and disadvantages of alternative pricing approaches be confronted through informed public discussion and debate.

The analytic model presented in this paper is intended to serve as a decisionmaking guide in assisting transit officials in probing the policy implications of alternative fare programs. As with any model, it represents only an abstraction of reality and must rely on managerial judgment and insight as well. Given the relative uncertainties about disaggregate fare elasticities of different ridership groups, the model is perhaps best suited for sensitivity testing and quick-response analysis. The model structure is also easily adaptable to interactive computer programming, which might prove quite useful in providing real-time output and graphic displays of the impacts of alternative fare policies. As adjustments in fare policies become more prevalent during the 1980s, such capabilities could serve to facilitate public input into the transit pricing decisionmaking process and also enhance an agency's ongoing financial planning efforts.

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Analysis of a Fare Increase by Use of Time-Series and Before-and-After Data

JOY L. BENHAM

On October 1, 1978, the Jacksonville Transportation Authority (JTA) increased fares on almost all bus routes in the system. The impact of the fare increase on transit ridership is analyzed. Two complementary techniques are examined: (a) estimation of a ridership model based on time-series JTA operating data and (b) estimation of fare elasticities for market segments based on before-and-after on-board survey data. By using monthly operating data for JTA from January 1976 through June 1979 and multiple regression techniques, the elasticity of demand with respect to basic fare in real terms is estimated. The elasticity with respect to bus miles of service and the cross elasticity with respect to gasoline price are also estimated. The nonlinear, constant-elasticity model is found to best represent changes in travel behavior for the observed data. In addition, long-run elasticities are not significantly different from the one-month short-run elasticities over the time for which data were available after the fare increase (9 months). An on-board survey, administered slightly less than 6.5 months after the fare increase, is used to analyze the impact of the fare increase on market segments. Reliable estimates of market segment elasticities could not be obtained because the assumptions required for application of this method were violated. Sampling designs are required that provide more precise estimates of market segment ridership and disaggregate data by which to examine the impacts of all factors that affect transit use by market segments so that reliable estimates of market segment elasticities can be obtained.

On October 1, 1978, the Jacksonville Transit Authority (JTA) of Jacksonville, Florida, introduced a fare increase for almost all bus routes in the system. This paper presents the results of an analysis of the impact of the fare increase on transit use by the general population and by market segments. The analysis uses two approaches. Based on time-series operating data for the JTA system, a transit ridership model is estimated by using multiple regression techniques. The time-series analysis provides estimates of direct demand elasticities with respect to fare and service and the cross elasticity with respect to gasoline price. The second approach involves the use of on-board survey data collected before and after the fare increase.