a parent (parents) possessing a family pass and paying full price. In order to simplify the processing of the tickets, the family card is valid for an entire year and costs 60 German marks. The time limits that were in effect (no reduced rates from Monday through Friday from 6:00-8:30 a.m.) remain in effect.

## SUMMARY OF RESULTS

Public opinion, which represents the social point of view, and monetary considerations (increasing use of public transportation during slow hours) cause the family tariff to remain in the limelight. A social-scientific study oriented to individual behavior can be an important aid in forecasting the potential demand that might be reached. On the other hand, a market strategy that tries to deduce potential demand from secondary statistics cannot usually be used for forecasting. The situational analysis of the target group for a family tariff (i.e., households with children) shows that individual options are limited and that the introduction of different measures would have different effects on increased ridership. Since most of the households that use the family tariffs also previously used public transportation to make family trips, the increased number of family tariff users might actually represent a revenue loss. Only a small number of households can be expected to switch from private transportation to the use of public transportation. Thus, the ridership generated by the family passes is minimal.

Although the potential number of persons taking advantage of the family tariff can more likely be increased by public relations work aimed at improving the general image of public transportation than by optimally improving the special offer, the greatest number of persons can be induced to use the special family tariff if both information strategies and the family offer itself are improved.

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# Efficiency and Equity Impacts of Current Transit Fare Policies

ROBERT CERVERO

**Over the past decade, most transit operators in this country have switched from graduated and zonal pricing to predominately flat fares. Many have hypothesized that flat-fare systems are both inefficient and regressive. This paper statistically tests several hypotheses related to the redistributive effects of three California transit operators' current fare structures. Disparities between users' fares and trip costs were found to be greatest as a function of trip distance. Those traveling less than 2 miles tended to pay inordinately high fares per unit of service. Trips beyond 6 miles were generally cross-subsidized by short-distance users. Moreover, off-peak patrons were found to return between one-quarter and one-half more of their costs through the farebox than peak-hour riders. On the whole, redistributive effects of current pricing appeared to be only modestly regressive. Lower income, transit-dependent, and minority users tended to return a higher share of their costs than the average passenger, although equity impacts varied appreciably among study sites.**

Virtually every U.S. bus system today charges most of its customers a single, flat fare. Since the mid-1960s, graduated and zonal fares have been largely abandoned in response to users' demands for simple and convenient services. The availability of federal operating assistance added impetus to the flat-fare renaissance, providing some compensation for revenue losses incurred in eliminating distance surcharges. Simple pricing approaches have also gained steady support from labor unions over recent years, largely because they relieve drivers of major responsibilities in collecting fares.

Despite their growth in popularity, flat-fare structures can be attacked on both efficiency and equity grounds. Transit costs are markedly higher during peak periods and for long trips because additional employees must be hired to accommodate rush-hour loads and driver tours must be extended to serve outlying areas. By charging a constant fare regardless of when or how far one travels, uniform pricing forces the five-block, off-peak rider to offset the high costs of serving the 15-mile rush-hour commuter.

Many have hypothesized that the incidence of fare cross-subsidization is regressive since those with lower incomes are commonly thought to travel shorter distances and more often during off-peak periods (1, p. 284; 2). Not only do simple pricing systems possibly benefit the rich, some argue, but they potentially deprive needy persons the opportunity to even make a trip. Many journeys that would be worthwhile at a fare approximating the cost of providing service are frequently not justifiable at the cost plus the price of subsidizing longer, peak-period trips (3). Transit operators, in turn, lose the opportunity to bring in more revenues from these latent trips and to make efficient use of excess off-peak seating capacity.

This paper examines the efficiency and equity implications of current fare policies. Hypotheses regarding the redistributive impacts of current pricing are tested statistically by using revenue, cost, trip-making, and demographic data from three California transit properties. The intent is to shed light on the structure of mispricing under flat-fare systems as well as to identify the incidence and severity of fare cross-subsidization.

## EFFICIENCY AND EQUITY CONCEPTS

Efficiency and equity are dual criteria used frequently in evaluating the policy implications of public decisions. Together, they provide a basis for probing the question, What is a fair fare? This study views efficiency in terms of what welfare economists call the benefit principle: Users should contribute to the costs of services in line with the benefits they receive. Accordingly, price efficiency is achieved when transit users are assessed the marginal cost of their services. Equity, on the other hand, can be viewed in terms of the ability-to-pay principle: Users should contribute to the costs of services according to their income capacities. At minimum, then, any redistributive impacts of pricing should not be advantageous to those most able to afford and least dependent on transit services. It follows that the fairest fare would be one that eliminated transfer effects altogether by charging users the marginal costs of serving them.

Measuring the true marginal cost of individual transit trips is an exceedingly difficult task. Public transportation confers many tangible benefits on society (e.g., cleaner air and energy conservation) that effectively reduce the true marginal cost imposed by each patron. Placing a precise monetary value on such noncommensurable benefits as reduced pollution and improved land development complicates an analysis greatly. Consequently, this study considered only direct (vis-à-vis social) costs and benefits as reflected by transit managers' expense ledgers and users' fares. Second, the pure marginal cost of accommodating one additional passenger or of providing slightly-longer-distance service is in most cases so negligible as to defy measurement. Yet, we know that peaking and service expansion increase transit operating costs appreciably. The most theoretically satisfying way to conceptualize units of transit costs is in incremental terms. Larger unit measures of transit output, such as trip-distance increments and separate time periods of service, provide pragmatic yardsticks for gauging relative cost differences among trips. By comparing the unit cost of serving patrons traveling different increments of distance or during different times of day, reasonable approximations of marginal costs can be attained.

In light of these arguments, this study evaluates efficiency by comparing mean ratios of revenue and cost per passenger mile (hereafter abbreviated RPM/CPM) among various categories of trip distance and between periods. The RPM/CPM index can be thought of as a farebox recovery ratio computed for each transit user (i.e., a unit measure of the ratio of each patron's fare to the cost of his or her trip). The fairest price system, then, would produce a similar RPM/CPM ratio for all users, regardless of how far or when they traveled. The first two hypotheses of this study test whether the study sites' current fare structures embody disparities as functions of trip distance and time period of use. Thus, they analyze price efficiency in both a spatial and a temporal context. The final hypothesis assesses the equity repercussions of current pricing by comparing RPM/CPM discrepancies among various income, vehicle-availability, ethnicity, sex, and age categories.

## STUDY SITES

Fare policies of three California transit properties were studied (4): the Southern California Rapid Transit District (SCRTD) serving the Los Angeles area, the Alameda-Contra Costa Transit Authority (AC Transit) serving the Oakland area, and the San Diego Transit Corporation (SDTC). The analysis was conducted by using recent revenue and cost data from each property; in the case of SCRTD and AC Transit, data were from FY 1978/1979 while for SDTC the analysis time frame was FY 1977/1978

The SCRTD, AC Transit, and SDTC represent interesting case-study sites because of their varying scales of operation and their contrasting financial positions. During calendar year 1979, SCRTD served 334 million passengers compared with 52.6 million and 36.6 million for AC Transit and SDTC, respectively. Efficiency levels also differed, ranging from an average cost per service hour of $23.60 for SDTC to $30.65 for SCRTD. During their respective analysis period, AC Transit and SDTC recovered approximately one-third of their costs through the farebox whereas SCRTD's operating ratio was slightly higher--40 percent.

Since the early 1970s, each property has initiated essentially a flat-fare structure, collecting distance surcharges on only a handful of freeway express services. Both AC Transit and SDTC priced basic services at $0.35/ride during 1978 and 1979 while SCRTD charged most users $0.45/ride. Each agency also offered an assortment of prepayment programs as well as special elderly and youth discount arrangements.

## RESEARCH METHODOLOGY

The basic framework of analysis involved a crosssectional comparison of revenues and costs among a sample of users. Thus, the study was conducted at a disaggregate level, employing individual passengers as units of analysis. User responses to on-board surveys provided data on each passenger's fare, trip length, time period of travel, and demographic characteristics. Cost data were obtained from internal accounting records and apportioned at the passenger level on the basis of each user's particular bus route and time period of travel.

The first step of the analysis entailed choosing a representative sample of each property's bus lines among those surveyed. Proportional random sampling was used to select data cases among sampled routes, producing more than 10 000 sample cases for each study site. Due to variations in the response rates among user groups, systems of weights were developed to reduce undersampling biases.

Next, an RPM/CPM estimate was assigned to each surveyed passenger. By using fare and trip-distance data from completed questionnaires, revenue per passenger mile (RPM) estimates were calculated. In cases where patrons boarded with passes, cash-fare equivalents were computed based on known use rates per month for the particular pass type. Since the estimation of the cost per passenger mile (CPM) for each sample trip was a fairly complex task, this step of the analysis is discussed separately in the next section.

## COST ESTIMATES

The estimate of each sampled user's cost per passenger mile evolved from a multistage process of refining cost-allocation models and apportioning expenses between time periods. Initially, systemwide equations were derived for each agency that linked specific cost categories (e.g., driver wages) to various explanatory factors (e.g., vehicle hours). Referred to as the unit-cost method (5), this allocation approach produces multivariable equations that can be used to estimate daily operating expenses on any particular bus route. The unit-cost formulas employed by the three properties during the fiscal periods corresponding with this analysis were

$$\text{SCRTD: } OC = 0.41(VM) + 16.44(VH) + 17.57(PO) + 107.77(PV) \quad (1)$$

$$\text{AC Transit: } OC = [0.47(VM) + 13.56(VH)]\ 1.298 \quad (2)$$

$$\text{SDTC: } OC = 0.43(VM) + 20.76(VH) \quad (3)$$

where

- OC = operating cost (dollars),
- VM = vehicle miles (total vehicles miles covered during revenue service),
- VH = vehicle hours (total vehicle hours during revenue service),
- PO = pull outs (sum of the morning and evening buses less the number of midday vehicles), and
- PV = peak vehicles (largest number of buses in operation at any point in time, whether the morning or evening period).

Thus, inserting data on a particular bus route's daily bus miles, hours, and so forth into the appropriate equation produces a daily cost estimate for that route.

The use of systemwide data to apportion operating costs among lines is a major drawback of these equations. Realistically, cost characteristics among routes would be expected to differ as surrounding surface street congestion, frequency of passenger boarding and alighting, and so forth varied among lines. The concept of cost centers offers a way to capture the individual expense characteristics of bus routes. Cost centers can be defined as homogeneous units within an organization that represent natural divisions for cost-finding purposes (6). In the transit industry, these homogeneous units are best represented by operating divisions--i.e., facilities from which groups of bus lines operate, drivers receive specific work assignments, maintenance activities are conducted, and specific accounting records are maintained. To the extent that routes operating from each division are relatively homogeneous in terms of service type, ridership makeup, and geographic area of service, cost estimates of these lines can be refined by respecifying unit cost formulas at the division level.

In the case of both SCRTD and AC Transit, routes within divisions were found to be quite similar in terms of their operating characteristics; separate unit cost equations were consequently computed for AC Transit's and SCRTD's 4 and 11 divisions, respectively. (SDTC operates as a single division, thus precluding any cost center breakdown.) These refinements gave rise to significant differences in the factor coefficients of divisional equations. In the case of SCRTD, divisional coefficients varied around the systemwide coefficients shown in Equation 1 by between 10 and 12 percent, while for AC Transit coefficient differentials were slightly smaller.

Daily cost estimates of sample routes derived from cost center equations were next factored on the basis of passenger miles and regressed to determine whether they declined as a function of various distance indicators. Unit cost estimates were found to decline nonlinearly with distance (Equations 4 through 6), suggesting that routes serving longer trips and covering more miles generally reaped some economies (* = significant at the 0.05 level, and ** = significant at the 0.01 level):

$$\text{SCRTD } (n = 29)\text{: } CPM = 0.16 + 1.17(ATD)^{-2**} - 0.0065(PASS)^{**} + 10\,160(ABM)^{-2**} \quad R^2 = 0.91 \quad (4)$$

$$\text{AC Transit } (n = 19)\text{: } CPM = 0.62 - 0.66(LF)^{**} + 0.76(ATD)^{-2**} \quad R^2 = 0.64 \quad (5)$$

$$\text{SDTC } (n = 9)\text{: } CPM = 0.23 - 0.0086(ATD)^{**} + 1.90(PASS)^{-2**} \quad R^2 = 0.96 \quad (6)$$

where

- ABM = average daily in-service bus miles during typical weekday;
- ATD = average trip distance on route (miles);
- CPM = cost per passenger mile (dollars);
- LF = load factor, representing average ridership divided by average seating capacity of vehicles assigned to the route;
- PASS = daily passengers (thousands) over average 24-h period, representing a proxy for the relative service density of a route; and
- n = number of routes (note: one route with outlier data was removed from the analysis of each property).

With the exception of SDTC's data, CPM declined as a hyperbolic function of distance. That is, CPM estimates were generally high for routes characterized by short-distance travel and comparatively low for those serving moderate- to long-haul journeys.

The next step in the allocation process involved dividing cost estimates into peak and base period components. Estimates produced by unit cost models represent weighted averages of peak and off-peak conditions. However, it is widely accepted that stipulations in most labor contracts that prohibit the hiring of part-time drivers, limit split shifts, and spread time duties have increased the cost of transit services appreciably. The effects of these restrictions are particularly important because transit is a labor-intensive industry, with wages and fringe benefits typically accounting for 80 percent of all costs. Previous studies report that labor union influences may increase the unit costs of peak services anywhere between 10 and 100 percent about those of the base (7; 8; 9, pp. 52-74).

A procedure developed by Cherwony and Mundle (7) was adopted in this study to reflect the cost impacts of restrictive labor agreements. Their approach adjusts the vehicle hour coefficient upward for the peak model and downward for the base model. These adjustments rely on a ratio comparison of pay hours to vehicle hours during the peak and base periods (i.e., the relative number of hours drivers are paid to the hours they actually serve revenue passengers for both time periods). When applied to cost-center equations, this labor productivity index respecifies the vehicle hour coefficients by time of day. Applying rules for attributing pay hours between time periods, similar to those employed by Reilly (8), peak ratios of pay hours to vehicle hours were found to exceed base ratios by 33.7 percent for SDTC, 30.2 percent for SCRTD, and 14.2 percent for AC Transit.

The final stage in the allocation process involved incorporating capital depreciation expenses into peak and base period cost estimates. Based on previous research (10), 85 percent of each property's annual depreciation was apportioned to the peak period. Factoring the total (i.e., operating plus depreciation) cost estimates by passenger miles in each respective time period produced fairly small differences: SCRTD's average peak CPM of 17.6 cents exceeded that of the base by 10 percent, while for the other two agencies time-of-day differentials in CPM were less than 0.5 percent. Generally, the higher costs of peak services were countered by higher ridership levels and longer trips, producing CPM estimates only slightly above those of the base period. However, to the extent that revenues per passenger mile are relatively lower during the peak (due to longer trips), current fare policies would be embodying price inefficiencies and possibly inequities. This possibility is explored next.

## FINDINGS

Revenue and cost estimates assigned to each sample passenger were combined to form the criterion variable RPM/CPM. As mentioned previously, RPM/CPM estimates approximated the farebox recovery ratios associated with specific trip distance, time period, and user group categories. To facilitate comparisons among study sites, these ratios were also expressed in graphic form as proportions of each property's mean RPM/CPM estimate (i.e., as a proportion of each system's farebox recovery ratio). This provided a comparable basis for assessing relative levels of fare cross-subsidization among properties.

It should be noted that the tests of significance presented in this section were hypersensitive to sample sizes. Since each property's sample size exceeded 10 000 cases, differences in RPM/CPM were magnified by both t- and F-tests [see Blalock (11, p. 162)]. It follows that the statistical importance of these hypothesis tests lies not so much with reported significance levels but rather with the directions and magnitudes of differences in RPM/CPM.

### Trip-Distance Analysis

The following null and alternative hypotheses were tested: (a) $H_0$--transit services are efficiently priced with respect to trip distance and (b) $H_1$--estimates of RPM/CPM are significantly lower for long-distance trips (exceeding 6 miles) than for short-distance ones (under 6 miles). The test results in Table 1 indicate that the null hypothesis was easily rejected for all study sites. Those traveling less than 6 miles were generally paying between 2.7 (for SDTC) and 5.2 (for SCRTD) times as much per mile of service as those traveling beyond 6 miles.

The structure of mispricing as a function of trip distance is even more clearly revealed in Figure 1. Here, RPM/CPM estimates were stratified into 12 categories of trip distance and then expressed as a proportion of each system's mean RPM/CPM, i.e., as a proportion of each system's overall farebox recovery ratio. (For example, the adjusted RPM/CPM of 1.5 for SCRTD's 2-mile trips is equivalent to an actual RPM/CPM of 1.5 x 0.463 = 0.695, a recovery ratio of nearly 70 percent.) The horizontal line in Figure 1 serves as a subsidy threshold--those traveling distances with RPM/CPM estimates above it were, in effect, cross-subsidizing those riders from distance categories below the line. For SCRTD and AC Transit, the 2-mile mark separated trips into gainer and loser categories. SDTC's subsidy threshold was somewhat longer--approximately 3 miles.

Price inefficiencies were most prominent between trips of less than 1 mile and all others. For all three operators, those riding less than 1 mile returned more than twice as much through the farebox as those traveling 2 miles. Disparities were most perverse between distance extremes. The most striking differential was among SCRTD trips, where the mean RPM/CPM of the shortest trips was 35 times that of the longest ones. On average, trips beyond 10 miles in length returned less than one-half of each system's mean recovery rate, which means they generally met less than 10 percent of their costs.

The marked decline in revenue productivity as a function of distance can be mathematically expressed in terms of exponential decay or hyperbolic relationships. Equations 7 through 9 indicate that price discrepancies were far greater between short- and mid-distance travelers than beteen mid-distance and long-haul patrons. These nonlinear relationships suggest that current disparities in pricing could be reduced by setting low base fares and assessing distance surcharges with declining steps (i.e., pricing as a logarithmic function of distance). In Equations 7-9, TL equals trip length in miles:

$$\text{SCRTD: } RPM/CPM = 0.539e^{-0.095(TL)} \qquad r^2 = 0.66 \tag{7}$$

$$\text{AC Transit: } RPM/CPM = 0.072 + 1.31(TL)^{-1} \qquad r^2 = 0.46 \tag{8}$$

$$\text{SDTC: } RPM/CPM = 0.512e^{-0.079(TL)} \qquad r^2 = 0.72 \tag{9}$$

### Time-of-Day Analysis

A second set of hypotheses tested was (a) $H_0$--transit services are efficiently priced with respect to time of day and (b) $H_2$--estimates of RPM/CPM are significantly lower for peak-period trips than for nonpeak ones.

Whether peak services return a higher proportion of their costs through the farebox than base services has been a subject of spirited debate within the transit industry. Several analysts (7; 12, pp. 83-154; 13, pp. 14-30) have argued that higher peak-period revenues are overshadowed by comparatively higher peak costs. Others (8, p. 3), however, have asserted that "the transit industry's prevailing opinion has been that the (peak's) revenue effect exceeds the cost effect. That is, peak service has better financial performance in terms of the ratio of revenue to costs than the base service." Perhaps transit managers tend to view the peak's financial performance favorably because of the longstanding industry practice of apportioning expenses on an average cost basis. Whenever the true cost of peak demand is overlooked, "the peak usually does show more favorable revenue-to-cost ratios than off-peak periods and ... is fully exploited as the high-yield market" (12, p. 138). To the extent that the cost models of this study captured the true incremental costs of peak services, the following test results should provide a reasonable basis for comparing efficiency levels between time periods.

Table 1 indicates that off-peak users were generally found to subsidize their rush-hour counterparts. Off-peak patrons returned between one-quarter and one-half more of their costs through the farebox than peak users. This translated into an estimated loss per trip among the three properties of $0.61 during the peak compared with $0.41 during the base. These disparities were statistically significant, confirming the alternative hypothesis that rush-hour commuters benefit the most under flat pricing.

**Table 1. Test of differences in RPM/CPM means by trip distance and time of day.**

| Analysis | SCRTD | AC Transit | SDTC |
|---|---|---|---|
| Trip distance | | | |
| Mean RPM/CPM for trips <6 miles | 0.637 | 0.574 | 0.492 |
| Mean RPM/CPM for trips ≥6 miles | 0.122 | 0.139 | 0.183 |
| t-value | −17.673 | −62.811 | −65.104 |
| Degrees of freedom | 12 408 | 44 305 | 19 154 |
| One-tailed probability | 0.000 | 0.000 | 0.000 |
| Time of day | | | |
| Mean RPM/CPM for base period | 0.555 | 0.437 | 0.418 |
| Mean RPM/CPM for peak period | 0.367 | 0.352 | 0.323 |
| t-value | −5.389 | −14.255 | −18.010 |
| Degrees of freedom | 11 640 | 47 145 | 19 154 |
| One-tailed probability | 0.000 | 0.000 | 0.000 |
| Mean RPM/CPM (all sampled trips) | 0.463 | 0.397 | 0.354 |

As with the trip-distance variable, RPM/CPM estimates were further disaggregated into time-period categories and expressed as a proportion of each system's recovery ratio. Figure 2 indicates that midday services generally returned the highest share of unit costs through the farebox. Evening services were found to match each system's overall recovery rate while the productivity of owl-period service appeared to deviate markedly among properties. These periods accommodated less than 6 percent of each system's daily ridership, however, and therefore played a small part in the overall cross-subsidy picture. In contrast, morning and evening services were by far the least efficient, generally recovering less than one-third of their costs. On average, peak-period subsidies were between 17 and 20 percent higher than each system's average recovery rate.

A reasonable query at this point would be, Which pricing approach could reduce overall inefficiencies to a greater extent--distance-based or time-dependent fares? Since peak trips were generally found to be 1-2 miles longer than each agency's average trip, time-of-day fare differentials could incorporate the distance factor into the pricing structure. Likewise, distance-graduated fares could capture some of the differentials between peak and off-peak costs. For all study sites, the difference in RPM/CPM between trips less than 6 miles and those greater than 6 miles was more than 2.5 times as great as differences between peak and base periods. In the case of AC Transit, the differential was more than five times as large. Since both the 6-mile mark and the peak-base dichotomy generally divided each property's total number of trips into almost equal halves, it follows that disparities were a much stronger function of distance than time period of travel. Distance-based fares, therefore, would seem to hold a clear advantage over time-differentiated fares for improving the efficiency of all three properties' pricing policies.

## Equity Analyses

The following hypotheses were tested to probe the equity implications of current pricing: (a) $H_0$--transit services are priced equitably among user groups and (b) $H_3$--estimates of RPM/CPM are significantly higher for users who have lower incomes, own fewer cars, represent an ethnic minority, are female, and are not at a nonworking age.

The tests of RPM/CPM differences on the basis of each sample respondent's family income produced mixed results among the three study sites (Table 2). Only in the case of AC Transit and SDTC were flat fares found to be regressive. Disparities were small, however, with the differential in RPM/CPM no

**Figure 1. Price disparities among trip-distance categories.**

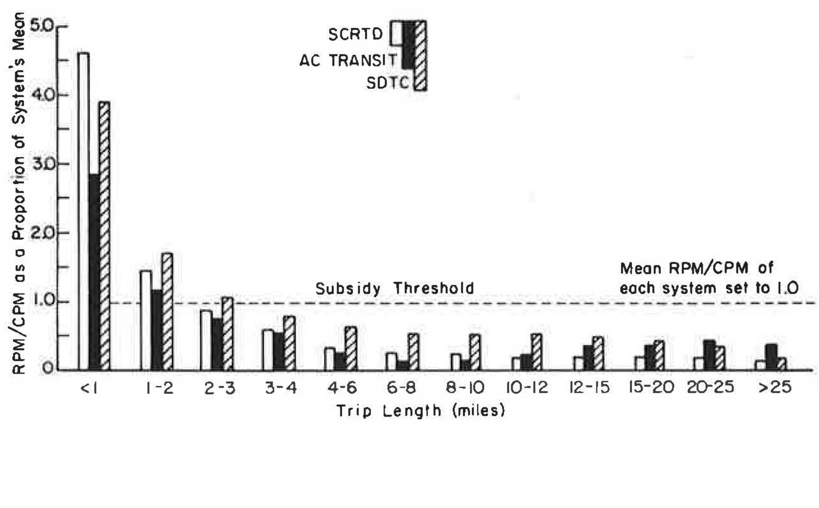


**Figure 2. Price disparities among time periods.**

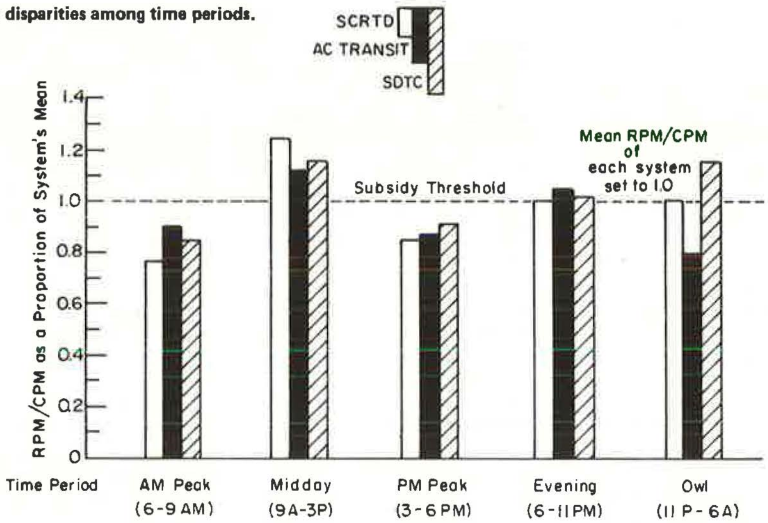



**Table 2. Test of differences in RPM/CPM means by income, vehicle availability, and ethnicity.**

| Analysis | SCRTD | AC Transit | SDTC |
|---|---|---|---|
| Income | | | |
| Mean RPM/CPM for annual family income | | | |
| <$15 000 | 0.458 | 0.404 | 0.365 |
| ≥$15 000 | 0.480 | 0.370 | 0.327 |
| t-value | -0.390 | -4.379 | -5.702 |
| Degrees of freedom | 7 393 | 34 148 | 15 092 |
| One-tailed probability | 0.348 | 0.000 | 0.000 |
| Vehicle availability | | | |
| Mean RPM/CPM for those with | | | |
| No vehicle available | 0.472 | 0.393 | 0.401 |
| ≥1 vehicle available | 0.459 | 0.400 | 0.335 |
| t-value | -1.090 | -0.919 | -7.531 |
| Degrees of freedom | 9 462 | 40 814 | 17 380 |
| One-tailed probability | 0.181 | 0.333 | 0.000 |
| Ethnicity | | | |
| Mean RPM/CPM | | | |
| Asians | - | 0.466 | - |
| Blacks | - | 0.400 | - |
| Hispanics/Spanish-speaking | 0.477 | 0.463 | 0.287 |
| Whites | - | 0.382 | - |
| English-speaking | 0.460 | - | 0.356 |
| Between-group mean square | 1.213 | 26.598 | 7.481 |
| Within-group mean square | 12.194 | 1.715 | 0.270 |
| F-ratio | 0.099 | 13.553 | 27.920 |
| F-probability | 0.752 | 0.000 | 0.000 |
| Mean RPM/CPM (all sampled trips) | 0.463 | 0.399 | 0.354 |

greater than 6 percent for those riders with annual family incomes below and above $15 000. Surprisingly, the net transfer effect of SCRTD's fares were found to be mildly progressive, although the relationship was statistically insignificant. Thus, the null hypothesis was rejected only with respect to the pricing policies of the two smaller transit properties.

The degree of access transit users had to an automobile served as a direct measure of transit dependency. Table 2 indicates that only SDTC's fare structure led to a significant difference in RPM/CPM estimates among those with and without vehicle access. SDTC's transit-dependent patrons were generally found to travel predominantly during off-peak hours when service costs were relatively low. For the other two properties, virtually no price disparities emerged with respect to the vehicle-availability variable.

Equity was also analyzed in terms of either the ethnicity or primary language of survey respondents. The analysis-of-variance (ANOVA) results in Table 2 reveal that RPM/CPM estimates varied significantly between minorities and whites. AC Transit's Asians and Hispanics were major cross-subsidizers, on average generating farebox recovery rates 22 percent higher than whites. The most surprising finding was that SDTC's English-speaking patrons paid higher fares per mile in relation to costs than Hispanic passengers, in spite of the earlier evidence that the system's price structure embodied some regressivity. SDTC's Hispanic users were generally found to pay lower average fares and to patronize those sample routes that were the least profitable.

Finally, RPM/CPM rates were analyzed according to users' gender, age mixes, and trip purposes. In all three study cases, females traveled comparatively shorter distances and more frequently during the midday than male passengers. Female patrons generally returned a larger share of their trip costs through the farebox, although disparities were significant only for SDTC operations. The incidence of cross-subsidization was more sensitive to users' ages. SCRTD's and AC Transit's college-age passengers paid comparatively high fares for their trips, most of which occurred during the midday. The major beneficiaries of fare cross-subsidization were senior and handicapped patrons. In general, the farebox recovery rates generated by elderly users' trips were less than one-half of each property's average (i.e., less than 20 percent), indicating that current pricing policies satisfy the Urban Mass Transportation Administration's Section 16 mandate calling for substantial senior-citizen fare discounts. With respect to trip purpose, work and school journeys were cross-subsidized, reflecting the concentration of these trips during peak hours. Among all trip purposes, medical journeys produced by far the highest revenue returns. AC Transit's medical trip makers generally paid 25 percent more per mile than other travelers. For SCRTD, the differential exceeded 100 percent.

## SUMMARY AND CONCLUSIONS

Current fare policies of three California transit operators were analyzed by comparing differences in the fares paid and costs imposed by various user groups. A multistage cost-allocation procedure was used in apportioning system costs among sampled users. By factoring revenue and cost estimates on the basis of passenger miles, current price disparities were analyzed by using both efficiency and equity criteria.

All three transit properties' fare structures were found to embody considerable inefficiencies with respect to users' distance and time period of travel. By assessing uniform charges against all users, current fare practices seemed to operate on a compensatory basis: Short-distance, off-peak patrons paid inordinately high fares to offset losses incurred in serving long-haul, peak-hour trips. Disparities between fares and costs were greatest as a function of trip distance. Among all three operators, those traveling less than 2 miles generally met their costs through the farebox while also cross-subsidizing others. Patrons traveling beyond 6 miles were generally found to return less than 20 percent of their trip costs through fares. In terms of time period of travel, off-peak patrons appeared to return between 25 and 45 percent more of their costs than did their peak-hour counterparts.

Equity impacts were found to vary appreciably among properties. The net redistributive impact of SCRTD's fare structure appeared relatively neutral; only those patrons below 22 years of age and those making medical trips paid significantly more than the average user. In contrast, the redistributive effects of both AC Transit's and SDTC's pricing exhibited some regressivity. Those losing from fare cross-subsidization included AC Transit's ethnic minorities, low-income patrons, and college-age passengers as well as those SDTC users who were carless, female, unemployed, and from low-income families.

Figures 3 through 5 summarize these findings by ordering efficiency and equity variables in terms of relative RPM/CPM differentials. Clearly, the two efficiency indicators--trip distance and time of day--dominated all other factors. Disparities in RPM/CPM were generally more than three times as great when expressed in terms of trip distance as with any of the equity variables. It seems apparent that discrepancies in RPM/CPM were much more closely related to the characteristics of trips than the characteristics of travelers. In general, equity impacts seemed incidental to the larger problem of inefficient pricing. Maldistributive effects of the three study sites' price policies were generally less pervasive than what might have been expected based on the literature. Indeed, there actually appeared to be a progressive side to some of the subsidy transfers. Overall, however, those who were transit-dependent and captive users were still found to lose more from fare cross-subsidization than others.

To summarize, short-distance users are being hurt the most by current transit fare policies. Off-peak riders also suffer under current pricing programs, but to a lesser extent than short-distance users. Trip distances and time periods of travel vary so much within all classes of users that no particular socioeconomic group stands out as the major cross-subsidy loser. Rather, it is the short-distance, non-rush-hour traveler who pays an excessive and unjust fare, with his or her race, income, and degree of transit dependency being of largely secondary importance.

These findings suggest that changes in current pricing practices should be directed toward correcting price inefficiencies. There also appear to be opportunities for improving the distributional equity consequences of current fare policies through more differentiated pricing of services (but probably only to a modest extent). Graduated fare structures with declining steps seem to offer the greatest potential for eliminating current disparities in pricing. Through current subsidy programs, governments should play a more active role in encouraging pricing innovations that embrace both efficiency and equity principles. Subsidy programs that reward operators for introducing differentiated pricing could not only improve overall efficiency, but could probably improve the industry's financial performance. The success of any transit fare innovation also rests to a large extent on pricing improvements made in other competing transport sectors. As long as highway use is underpriced and parking is subsidized by employers, for example, efficiency-based fare reforms could prove counterproductive. Therefore, transit fare innovations should be part of a larger effort to correct pricing distortions found throughout the transportation system.

Some observers discount the feasibility of major transit fare reforms on both technological and political grounds. Collecting finely graduated fares on conventional bus transportation poses a range of logistical problems. Moreover, opponents

**Figure 3. Ordering of SCRTD efficiency and equity factors.**

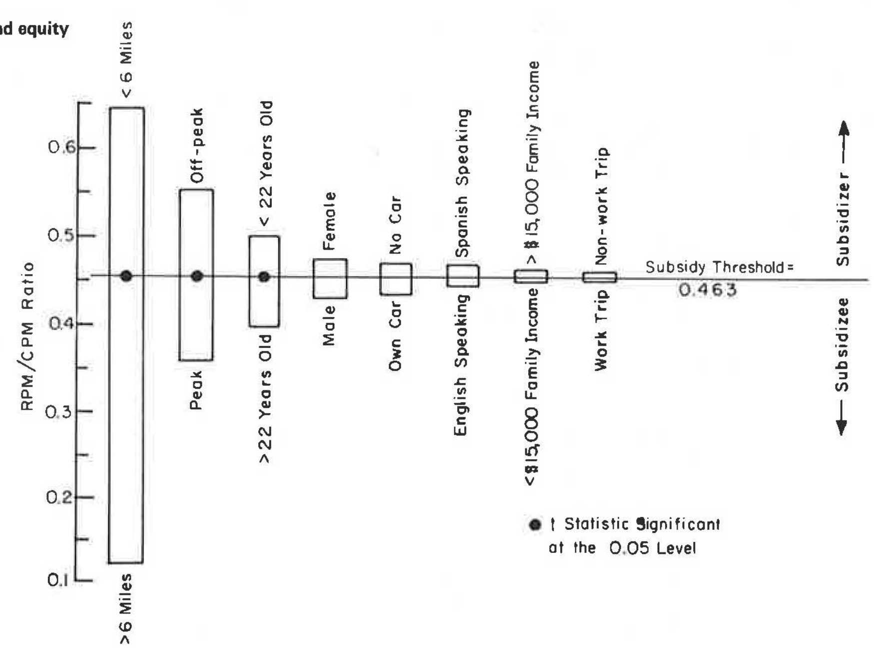


Figure 4. Ordering of AC Transit efficiency and equity factors.

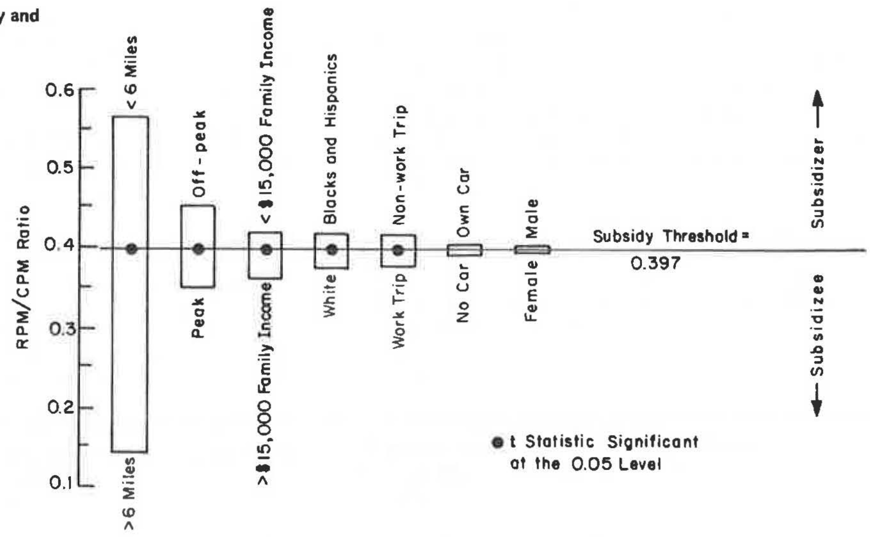
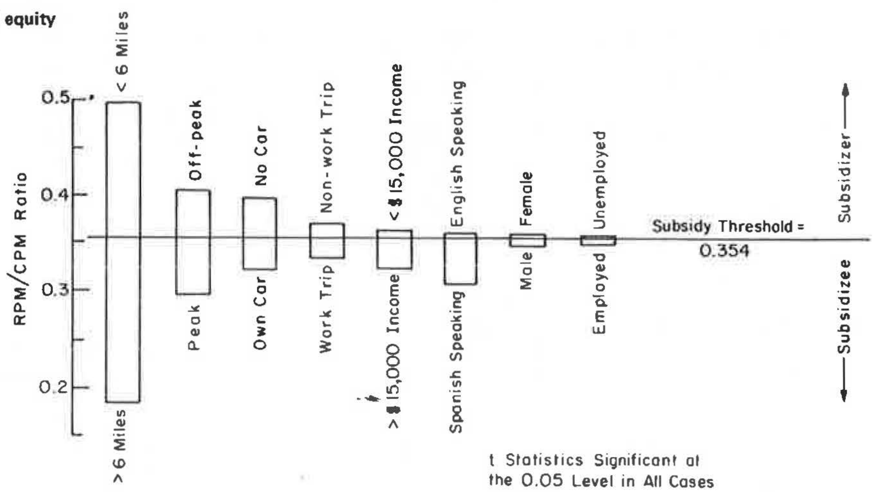



Figure 5. Ordering of SDTC efficiency and equity factors.




of differentiated transit pricing maintain that the riding public will never accept anything other than simple fare concepts. Clearly, the development of a mechanized fare-collection analog to San Francisco's Bay Area Rapid Transit and Washington, D.C.'s subway systems for use on rubber-tired vehicles will test our ingenuity. Europe's success with differentiated pricing of bus services provides the U.S. transit industry with a rich exemplar of possible fare-collection innovations. There, transit agencies have pioneered the use of on-board ticket dispensers and cancellers, curbside ticket-issuing automats, and roving fare-inspection programs to institute and enforce graduated pricing of transit services. Perhaps U.S. attitudes toward differentiated pricing of bus services will improve as consumers grow accustomed to the automated fares of rapid rail transit in large cities and as such pricing arrangements as weekend car rental discounts, night-coach airline saver fares, and reduced long-distance telephone rates during nonbusiness hours gain acceptance in other industries. With transit costs steadily increasing in the wake of possible government cutbacks in subsidy programs, more than ever, it is incumbent on today's transit officials to develop necessary fare-collection systems and marketing programs that will accommodate and promote more-efficient pricing structures.

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# Transit Fare Prepayment Innovations in Sacramento

MICHAEL HOLOSZYC AND BETH F. BEACH

**In October 1977, the Sacramento Regional Transit District received a demonstration grant from the Urban Mass Transportation Administration to expand its monthly-pass program to include employer sales outlets. Although employers showed little interest initially, a temporary promotional discount and a general advertising campaign eventually induced more than 60 firms to sell passes to their employees. The program generated modest increases in pass use and transit ridership. Other benefits included improved cash flow, relatively low administrative costs for both the transit operators and participating employers, and a possible enhancement of ridership retention and commitment. Both the employer program and the general fare prepayment concept became very popular with the Sacramento Regional Transit District. The district has since increased the relative discount of monthly passes compared with daily cash payment and has proposed a new 2-year demonstration to determine which fare prepayment methods are most cost effective.**

Transit fare prepayment--the purchasing of transit rides prior to using the service--is offered by almost every transit system in the country. The most common prepayment techniques are passes, allowing unlimited transit use during a specified period of time, and tickets (or tokens) that are valid for individual rides. These prepayment instruments are usually sold by the transit operator and sometimes at government offices, banks, and retail stores. Transit operators offer fare prepayment programs because they enhance the convenience of using transit and their administrative costs are relatively low.

Recently, there has been a growing interest among transit operators in expanding their fare prepayment programs. An important innovation has been the sale of monthly passes or tickets by employers, paralleling the emphasis that carpool programs have placed on employer promotion. Four years ago, there was only a handful of employer pass programs, but a survey conducted by the American Public Transit Association (APTA) in April 1980 disclosed more than 30 such programs today.

One of the pioneers in this field has been the Sacramento Regional Transit District (RT). Assisted by service and methods demonstration funding from the Urban Mass Transportation Administration (UMTA), RT began an employer pass program in 1978 that today includes more than 50 employers. Other innovations involving monthly passes were also implemented, and a follow-up demonstration has recently been proposed. During the next 2 years, RT will introduce new prepayment instruments and several new distribution systems, including mail and telephone ordering, vending machines, credit card sales, and direct account transfers through banks. Each of these will be evaluated to determine their relative cost-effectiveness.

## INITIAL DEMONSTRATION

The first demonstration's primary objective was to get public and private employers to sell monthly transit passes to their employees, thereby increasing pass use. RT had already been selling the monthly pass to the general public at 35 locations, including 2 outlets operated by RT, 4 government office buildings, 6 retail stores, 20 banks, and 3 colleges. Since a fare change in September 1976, the monthly pass has offered a substantial discount over on-board cash payment for the daily commuter (14 percent between 1976 and 1979, and 20 percent after September 1979 based on 40 rides/month). Consequently, about 20 percent of all riders (and 60 percent of the daily bus commuters) were already using monthly passes when the demonstration began.

Preliminary demonstration activities began in November 1977, and employers were actively solicited to sell passes from March through October 1978. The first employer began selling passes in May 1978, with most employers beginning pass sales in the fall of 1978. During the demonstration, employers promoted pass sales in various ways. RT encouraged employers to sell passes through payroll deduction and to subsidize the cost of passes for their employees.

## IMPLEMENTING EMPLOYER PASS SALES

### Employer Solicitation

Initial employer contact was done with an introductory letter from the RT general manager. This was followed by a telephone call from an RT representative during which more information on the program was supplied. If an employer expressed interest, a meeting was arranged. At this meeting, the project