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

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

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REFERENCES


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Abridgment

Distance-Based Fares on Express Bus Routes

RICHARD P. GUENTHNER and SHAU-NONG JEA

ABSTRACT

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

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

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

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

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

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

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

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

Altshuler (10) summarized the equity problem by stating:

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

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

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

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

**METHODOLOGY**

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

The results of the better fit exponential model are given in Table 1. In addition to the fare, fuel prices, snowfall, and vehicle-hours, time trends were found to affect significantly the monthly ridership as judged by the 95th percentile t-values. Both exponential and linear time trends were also considered.

The overall model was significant as explained by the high adjusted R-squared value of 0.917. The overall F value of 203.48 was significant to the 0.95 level. The elasticity with respect to fare was determined to be -0.58 as indicated in Table 1. This

<table>
<thead>
<tr>
<th>Variables in the Equation</th>
<th>Coefficient</th>
<th>t-Value</th>
<th>Elasticity</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>1.835</td>
<td>7.92</td>
<td>+0.734</td>
<td>+0.550 to +0.919</td>
</tr>
<tr>
<td>Fare</td>
<td>-1.769</td>
<td>-6.12</td>
<td>-0.561</td>
<td>-0.379 to -0.743</td>
</tr>
<tr>
<td>Month</td>
<td>0.0043</td>
<td>8.50</td>
<td>+0.791</td>
<td>+0.462 to +1.120</td>
</tr>
<tr>
<td>Vehicle-hours</td>
<td>0.0051</td>
<td>4.78</td>
<td>+0.791</td>
<td>+0.462 to +1.120</td>
</tr>
<tr>
<td>Snow</td>
<td>0.0054</td>
<td>4.77</td>
<td>+0.791</td>
<td>+0.462 to +1.120</td>
</tr>
<tr>
<td>(constant)</td>
<td>7.359</td>
<td>32.35</td>
<td>+0.791</td>
<td>+0.462 to +1.120</td>
</tr>
</tbody>
</table>

*Variables are defined as follows: dependent variable = log (ridership), fare = regular fare per rider corrected for inflation, fuel = average gasoline price per gallon corrected for inflation, vehicle-hours = vehicle-hours traveled, month = month (January 1976 = 1), and snow = monthly snowfall in inches.*
value, although steeper than traditionally accepted values, can be justified by a high percent of choice riders found on the express routes. Also indicated in Table 1 are the elasticities with respect to fuel price and service. The 95 percent confidence intervals for each are also given.

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

\[ Q_{\text{new}} = Q_{\text{old}} \times (1 + SR \times \Delta F/F) \]  

(1)

where

- \( Q_{\text{new}} \) = ridership after the increment,
- \( Q_{\text{old}} \) = ridership before the increment,
- \( SR \) = shrinkage ratio, and
- \( F \) = fare.

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

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

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

### RESULTS

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

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

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

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

### TABLE 2 Existing System

<table>
<thead>
<tr>
<th>Route</th>
<th>One-Way Revenue 1983 Ridership</th>
<th>1983 Pass-Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>50,819</td>
<td>553,660</td>
</tr>
<tr>
<td>40</td>
<td>127,449</td>
<td>1,274,490</td>
</tr>
<tr>
<td>41</td>
<td>71,109</td>
<td>568,872</td>
</tr>
<tr>
<td>42</td>
<td>212,652</td>
<td>2,977,128</td>
</tr>
<tr>
<td>43</td>
<td>154,685</td>
<td>2,242,933</td>
</tr>
<tr>
<td>44</td>
<td>152,121</td>
<td>1,447,525</td>
</tr>
<tr>
<td>45</td>
<td>177,595</td>
<td>2,219,938</td>
</tr>
<tr>
<td>46</td>
<td>93,162</td>
<td>1,024,782</td>
</tr>
<tr>
<td>Total</td>
<td>1,364,709</td>
<td>16,967,282</td>
</tr>
</tbody>
</table>

### TABLE 3 New Fares to Equalize Revenue

<table>
<thead>
<tr>
<th>Route</th>
<th>Low Scenario</th>
<th>Medium Scenario</th>
<th>High Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fare ($)</td>
<td>Ridership</td>
<td>Revenue ($)</td>
</tr>
<tr>
<td>Shortest (41)</td>
<td>0.70</td>
<td>81,565</td>
<td>57,005</td>
</tr>
<tr>
<td>Longest (43)</td>
<td>1.30</td>
<td>140,016</td>
<td>182,021</td>
</tr>
<tr>
<td>Total</td>
<td>1,381,931</td>
<td>1,351,852</td>
<td>1,394,694</td>
</tr>
</tbody>
</table>

### TABLE 4 New Fares to Equalize Ridership

<table>
<thead>
<tr>
<th>Route</th>
<th>Low Scenario</th>
<th>Medium Scenario</th>
<th>High Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fare ($)</td>
<td>Ridership</td>
<td>Revenue ($)</td>
</tr>
<tr>
<td>Shortest (41)</td>
<td>0.75</td>
<td>79,457</td>
<td>59,592</td>
</tr>
<tr>
<td>Longest (43)</td>
<td>1.35</td>
<td>137,831</td>
<td>166,072</td>
</tr>
<tr>
<td>Total</td>
<td>1,355,464</td>
<td>1,394,582</td>
<td>1,355,494</td>
</tr>
</tbody>
</table>
losses of 4.7 to 23.1 percent could be expected while retaining a 10 percent increase in revenue. Drops in ridership of 9.2 to 40.3 percent might be experienced in the quest for a 20 percent revenue increase.

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

**CONCLUSIONS**

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

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

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

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

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**REFERENCES**


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