

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

Of course, there can be no guarantees that if an agency does a certain number of things, then a successful time-of-day fare program will result. Numerous factors, many of which are uncontrollable (e.g., changing gasoline prices and regional economic conditions), have varying degrees of influence on the outcome of any fare reform. But among the factors

that a transit agency can directly control, run-based collection, inventive marketing, and the careful designation of time bands all appear to be important ingredients of successful time-of-day fare programs.

ACKNOWLEDGMENT

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

REFERENCES

1. Transit Fact Book. American Public Transit Association, Washington, D.C., 1985.
2. R. Cervero. Evidence on Time-of-Day Transit Pricing in the United States. Vols. I and II. UMTA, U.S. Department of Transportation, 1984.
3. R.L. Oram. Peak-Period Supplements: The Contemporary Economics of Urban Bus Transport in the U.K. and U.S.A. In Progress in Planning, A.D. Diamond and J.B. McLoughlin, eds., Pergamon Press, Oxford, England, 1979, pp. 83-154.

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

Abridgment

Distance-Based Fares on Express Bus Routes

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ABSTRACT

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

During the 1960s and early 1970s, many transit operators switched from some form of distance-based fares to a flat fare. This trend occurred both in the United States (1) and worldwide (2) for two reasons: (a) to establish low, stabilized fares, and (b) to ease collection. As more systems adopted a

flat fare structure, a smaller percent of the operating expenses was paid from passenger revenue. Consequently, increased subsidies from local, federal, and to a lesser extent, state levels, were required for this trend to occur.

Statistics indicate that the goal of stabilized

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

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

Public transit, however, is different from the postal service. Although the argument of the lower overall cost of 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 uncomprehensible zonal fare system Drake and Guenther (4) concluded that the flat fare was easier to present, to understand, and to use.

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

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

Altshuler (10) summarized the equity problem by stating:

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

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

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

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

METHODOLOGY

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

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

TABLE 1 Analysis of Time Series Model

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

^aVariables 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

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.

TABLE 2 Existing System

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

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:

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

where

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

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

For an inelastic demand elasticity, no change in fare policy would result in both a ridership and a

RESULTS

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

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

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

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

TABLE 3 New Fares to Equalize Revenue

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

TABLE 4 New Fares to Equalize Ridership

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

TABLE 5 Specified Percent Increase in Revenue

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

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

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

TABLE 6 Minimum Fare Level

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

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 dis-

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

ACKNOWLEDGMENTS

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

REFERENCES

1. R.B. Cervero, M. Wachs, R. Berlin, and R.J. Gephart. Efficiency and Equity Implications of Alternative Transit Fare Policies. Urban Planning Program, University of California, Los Angeles, Sept. 1980.
2. R. Gutknecht. Alternative Approaches to Public Transit Fares with Their Traffic and Revenue Implications. International Union of Public Transport, 40th International Congress, The Hague, Netherlands, 1973, pp. 3-43.
3. Transit Fare Summary. American Public Transit Association, Washington, D.C., Oct. 1981.
4. J.W. Drake and R.P. Guenthner. Feasibility of and Design of Cost Effective Computer-Based Information Systems to Increase Productivity of Present and Future Urban Transportation Systems. U.S. Department of Transportation, Aug. 1979.
5. W.R. Ugolik and C.B. Leutze. Who Pays the Highest and the Lowest Per-Kilometer Transit Fares? In Transportation Research Record 719, TRB, National Research Council, Washington, D.C., 1979, pp. 32-34.
6. H.G. Wilson and G.J. Kurgan. Some Implications of a Flat Bus Fare Structure. Proc., Transportation Research Forum 15, 1974, pp. 160-165.
7. J.W. Bates and N. Anderson. Average Transit Trip Lengths by Racial and Income Classes in Atlanta: Equity of Flat Fares Based on Trip Length. In Transportation Research Record 857, TRB, National Research Council, Washington, D.C., 1982, pp. 60-63.
8. J.A. Hefner. Efficiency, Equity, and Pricing of Mass Transit Systems. Atlanta Economic Review, Vol. 22, No. 3, March 1972, pp. 14-17.
9. J.R. Pucher. Discrimination in Mass Transit. Journal of the American Planning Association, Vol. 48, No. 3, Summer 1982, pp. 315-326.
10. A. Altshuler. The Urban Transportation System: Politics and Policy Innovation. The MIT Press, Cambridge, Mass., 1979.
11. Transit Fact Book. 1978-1979 edition, American Public Transit Association, Washington, D.C.

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

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