present an attractive price to the employee. The employer contribution can thus help to improve the overall revenue position of the transit agency.

SUMMARY

With reductions in public funding for transit service, increased involvement on the part of employers will be important to the viability of transit service. For employees, benefits are in the form of reduced commuting costs, whereas employers can either cancel or defer plans for costly new parking facilities.

For transit agencies, the cost-benefit issues are more complex. Many programs have been initiated with a pure marketing focus and with little concern for revenue impacts. With fare revenues likely to become a larger portion of total revenues, these programs will come under increased scrutiny, especially concerning the level of discount provided to regular riders. The continued existence of employer-based transit pass programs will rely heavily on rigorous analysis of their financial impacts on the transit system.

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Average Transit Trip Lengths by Racial and Income Classes in Atlanta: Equity of Flat Fares Based on Trip Length

JOHN W. BATES AND NORRIS ANDERSON

Transit fares that are the same for all trips made regardless of trip length have decreased in favor recently. New preference is being given to distance-based fares, which offer potential to financially pressed transit operators for increasing revenues without increasing all riders' fare payment. One argument that has been advanced favoring distance-based fares is that flat fares are not equitable. Since low-income riders generally make shorter trips than do high-income riders, high-income riders receive more benefit for the same fare payment. This generalization is based on the presumption that all transit trips are radial to and from the central area and that low-income riders live within or close to the central area, whereas high-income riders live in suburban areas. This presumption is based on a concept of urban development patterns and transit service distribution that may or may not be true in all urban areas. An analysis of trip-length patterns for low- and high-income minority and nonminority riders in Atlanta, Georgia, shows that there is no significant variation in trip-length distribution by race and income class, except that high-income minority riders generally make shorter trips than do both groups of low-income riders as well as the high-income nonminority riders. The generalization that low-income and nonminority riders make shorter trips than high-income nonminority riders is shown to be not valid in this one case and therefore may not be used as a general basis for supporting distance-based fare systems. Distance-based fare systems may be desirable in many instances but must be justified on individual merits and not as a general rule.

During the 1970s, transit fare policies were often guided by the following two basic precepts:

1. Fares should be stable; that is, they should be held at nearly constant levels over long periods of time; and
2. Fares should be low, both absolutely and relative to the cost of the service provided and to the cost of the competing mode.

These precepts were sometimes translated into practice, in part through systemwide flat fares with free transfer.

More recently these precepts have been more likely to be questioned. Rising costs, real and inflationary, have increased the necessity of generating more revenue through fares. A fixed amount of net revenue increase may be obtained by raising all fare payments by X amount or by raising some proportion of fare payments by an amount n*X. Distance-based fares are an example of this latter approach.

The distance-based fee approach has certain apparently logical imperatives. Generally (but not necessarily always), it costs more to provide for a long trip than it does for a short one. Also, the long trip must be worth more than the short one, since the rider is willing to spend more time making it. Extending this argument, some analysts have also supported distance-based fares vis-à-vis flat fares on the basis of equity, maintaining that wealthier riders make long trips (suburban trips to work), whereas low-income riders make short trips (within the central city). If this is true, then the high-income rider receives more value for the fare than does the low-income rider paying the same amount.

A general statement that flat fares are inequitable, for the above-stated reasons, carries certain presumptions about the income distribution of residents of urban areas. The presumptions are that what might be called the classical ring form of urban development is commonplace. This form of urban development is described simplistically as a central core in which all nonresidential activity takes place, an inner ring containing the residences of all low-income citizens, and an outer ring containing all the high-income residents. (There is also often a presumption that low income is synonymous with minority racial groups.) In this situation, on every working day all the high-income residents will pass through the low-income ring on the way to and from work and will make trips about twice as long, on average, as those by occupants of the inner ring.

Although this type of development is very illustrative in theoretical discussions, whether it actually exists is debatable. Yet transit-pricing theorists are apparently assuming that it does exist to suggest that distance-based fares should be more commonly applied.

This analysis examines the average trip lengths for different classes of riders in Atlanta, Georgia, to determine whether the presumption is borne out in that one instance. If it is not, the presumption does not hold true in this specific case, and then it therefore cannot be assumed to hold true in all cases.

ANALYSIS PROCEDURE

The procedure selected for analysis to determine whether there is a difference in the trip lengths between various population groups of riders of the Metropolitan Atlanta Rapid Transit Authority (MARTA) is as follows:

1. Selection of small sample of MARTA riders (100 trips) and stratification into four population groups: (a) low-income minority riders (incomes less than $10 000/year), (b) high-income minority riders (incomes equal to or greater than $10 000/year), (c) low-income nonminority riders, and (d) high-income nonminority riders;
2. Location of origin and destination for each sample trip and measurement of airline distance between;
3. Calculation of arithmetic mean and standard distribution for each of four subsamples (population groups);
4. Comparison of arithmetic means and standard deviations by statistical tests to determine whether there is statistical probability that sample means are different [note that a determination of similarity based on a comparison of sample means only is not conclusive; a sample mean is a measure of the midpoint of a statistical distribution; two samples may have the same sample mean but have wide variations in the distribution of individual cases making up the sample; for example, a sample of 100 cases each having the value of 50 will yield a sample mean of 50 but a standard deviation of zero; in this sample it may be concluded that the probability of any value in the universe other than 50 is very small; in another sample of 100 cases, however, if the 50 cases have a value of zero and the remaining 50 have a value of 100, the sample mean will also be 50, but the standard deviation will be very high; in this sample it may be concluded that the probability that any value in the universe is equal to 50 is very high; therefore, a determination of similarity between two sample distributions cannot be made on the basis of sample means alone but also must consider the dispersion of sample values about the mean value, measured by the standard deviation for the sample];
5. Selection of second sample independent from the first and repetition of analysis process (if subsample distributions are similar between two samples, samples are accepted as valid representations of total population); and
6. If comparison of sample distribution between subsamples shows that distributions are similar with reasonable statistical confidence, rejection of the presumption that high-income riders always make longer trips; if comparison shows that distributions between some subsamples are not similar but that changing MARTA fare structure from flat to distance-based fare could create inequities (i.e., give one population group preferential economic treatment that does not now exist at the expense of another group), the presumption may be accepted in theory but rejected in this case as trivial in practice.

SELECTION OF SAMPLES

Two samples of 100 transit trips each were selected on a random basis from interviews conducted by the Atlanta Regional Commission (ARC) in a survey of MARTA riders during October and November 1980. The ARC survey, conducted as part of the Transit Impact Monitoring Program, interviewed bus and rail passengers separately. From a random listing of bus interviews, 81 were taken for each of the two samples for this analysis, and 19 interviews were taken for each of the samples from a similar listing of rail interviews, reflecting the proportions in daily boardings for bus and rail services. Only those interviews that included information on origin, destination, income, and minority/majority classification were accepted for the sample listings.

STATISTICAL TESTING

After means and standard deviations had been calculated for each of the subsamples in both samples, a standard statistical test was applied to determine whether for all possible comparisons within each sample, the basic hypothesis for the analysis should be accepted or rejected. This basic hypothesis is that there is no statistical difference between the mean trip length of subsample A compared with the mean trip length of subsample B.

This statistical test is performed by comparing the value of a parameter Z calculated from the means and standard deviations of two subsamples to a standard value that implies a certain level of confidence. For a 95 percent level of confidence in the conclusion to accept or reject the basic hypothesis, the value of Z must be less than or equal to 1.96 to accept the hypothesis (equality) or greater than 1.96 to reject the hypothesis (difference). The value of Z is calculated by the following expression:

$$Z = (\bar{X}_1 - \bar{X}_2)/[(s_1^2/n_1) + (s_2^2/n_2)]^{1/2} \quad (1)$$

RESULTS OF ANALYSIS

The mean trip lengths and standard deviations calculated for each subsample in the two samples are shown below:

Sample	No. of Cases	Mean Trip Length	SD
Sample 1:			
Entire sample	100	6.55	4.31
Subsample			
Low-income minority	30	5.83	4.49
High-income minority	27	5.61	2.44
Low-income nonminority	16	7.49	4.20
High-income nonminority	27	7.75	5.23
Sample 2:			
Entire sample	100	6.53	5.15
Subsample			
Low-income minority	28	5.32	3.55
High-income minority	25	5.14	2.99
Low-income nonminority	17	8.34	6.33
High-income nonminority	30	7.01	6.53

Note that although there are arithmetic differences in the values for mean trip length comparing the two minority subsamples to the two nonminority subsamples in both samples, the differences are relatively small, and the standard deviations are very large relative to the mean in all cases. This implies that the individual trip lengths vary widely and the mean trip length alone is not necessarily a good measure for comparison.

The results of the statistical test for comparison of subsample means for the first sample are shown in Table 1. In all cases the value of Z calculated is less than the critical value for the hypothesis that there is no statistical difference in the values of the means to be accepted. Therefore, the findings from analysis of the first sample tested do not infer that differences exist in trip lengths for different population groups, and an allegation that such differences do exist is not supported. In one comparison, that of high-income minority riders with high-income nonminority riders, the value of Z calculated is very close to the critical value, and this is noted as a borderline case. However, the allegation of inequity speaks to a difference between the trip lengths of low-income riders compared with those of high-income riders, so this borderline case, even if it were not still in the acceptance range, is not necessarily pertinent.

A second sample was also analyzed. The potential exists for any small sample to be not representative of the entire population, so the second sample provides a basis for verification of the findings from the first sample. The first test made for the second sample provides a basis for verification of the findings from the first sample. The first test made for the second sample was a comparison of sample means from each sample separately. It was found that the Z values for comparison of subsample means from one sample to another were all small and well below the critical value. This comparison shows consistency between the two samples, from which it may be inferred that both samples are representative of the total population.

The results of the statistical test for comparison of subsample means for the second sample are shown in Table 2. In all cases the value of Z calculated is less than the critical value for the hypothesis that there is no statistical difference in the values of the means to be accepted. Therefore, the findings from analysis of the second sample tested do not infer that a difference exists in the average trip length for different population groups, and an allegation that such differences do exist is not supported.

FURTHER ANALYSIS

The large values of standard deviations relative to arithmetic means for each of the classes within both samples indicate a wide dispersion of trip lengths within each group. To consider what this dispersion might be, the two samples were combined into a single sample and frequency distributions for each of the groups in the larger samples were determined. These distributions are shown in Table 3. Here we see that for the combined samples, high-income minority riders actually have the shortest trip lengths. Distance-based fares would give this high-income group a price advantage over the other groups, including both low-income groups of riders.

Table 1. Conclusions from analysis of sample 1.

Hypothesis	Z-Value	Conclusion
Mean trip length for low-income minority group is not statistically different from that for high-income minority group	0.23	Accept
Mean trip length for low-income minority group is not statistically different from that for low-income nonminority group	-1.25	Accept
Mean trip length for low-income minority group is not statistically different from that for high-income nonminority group	-1.48	Accept
Mean trip length for high-income minority group is not statistically different from that for low-income nonminority group	-1.63	Accept
Mean trip length for high-income minority group is not statistically different from that for high-income nonminority group	-1.93	Accept
Mean trip length for low-income nonminority group is not statistically different from that for high-income nonminority group	-0.18	Accept

Table 2. Conclusions from analysis of sample 2.

Hypothesis	Z-Value	Conclusion
Mean trip length for low-income minority group is not statistically different from that for high-income minority group	0.22	Accept
Mean trip length for low-income minority group is not statistically different from that for low-income nonminority group	-1.08	Accept
Mean trip length for low-income minority group is not statistically different from that for high-income nonminority group	-0.90	Accept
Mean trip length for high-income minority group is not statistically different from that for low-income nonminority group	1.18	Accept
Mean trip length for high-income minority group is not statistically different from that for high-income nonminority group	-1.05	Accept
Mean trip length for low-income nonminority group is not statistically different from that for high-income nonminority group	0.35	Accept

Table 3. Distribution of trip lengths by rider classification (N = 200).

Trip Length (miles)	Low-Income Minority		High-Income Minority		Low-Income Nonminority		High-Income Nonminority	
	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum
<2	20.7	20.7	11.6	11.6	15.1	15.1	10.5	10.5
2 to <4	19.0	39.7	25.1	36.7	12.1	27.2	24.4	33.9
4 to <6	22.5	62.2	23.0	59.7	21.3	48.5	14.0	48.9
6 to <8	12.0	74.2	23.0	82.7	6.1	54.6	7.1	56.0
8 to <10	8.6	82.8	13.5	96.2	12.1	66.7	14.0	70.0
10 to <12	13.8	96.6	3.8	100.0	12.1	78.8	8.7	78.7
12 to <14	1.7	98.3	-	-	9.1	87.9	10.5	89.2
14 to <16	-	98.3	-	-	-	87.9	-	89.2
16 to <18	-	98.3	-	-	9.1	97.0	3.6	92.8
18 to <20	1.7	100.0	-	-	-	97.0	1.8	94.6
20 to <22	-	-	-	-	-	97.0	-	94.6
22 to <24	-	-	-	-	3.0	100.0	3.6	98.2
24 to <26	-	-	-	-	-	-	-	98.2
26 to <28	-	-	-	-	-	-	1.8	100.0
$\bar{X}$	5.58		5.39		7.93		7.77	
s	4.03		3.09		5.33		5.94	