tribution is warranted to disseminate the findings of these study efforts to the transit community. Just as UMTA has offered training sessions for existing and potential users of the UTPS software packages, a similar effort could be undertaken by either the Transportation Research Board, UMTA, or the American Public Transit Association for the short-range demand estimation planners.

Transit Fare Development Procedures and Policies

EDWARD M. ABRAMS

Transit properties throughout the country will be facing difficult policy decisions in the next several years, principally due to the phasing out of federal Section 5 funds (Urban Mass Transportation Act of 1964, as amended). Furthermore, local communities have shown a strong resistance for further increases in their tax assessments. Although in the past transit was heavily subsidized by public funds, these shifts are causing more of the financial burden of transit to be placed on user charges. Fares, however, are a sensitive and visible element of transit services. The transit rider is constantly reminded of the cost of the journey each time he or she boards a bus. These riders will be hard pressed to accept the reasons for the shift in the financial burden for transit. Therefore, a fare-pricing policy must be cognizant of this attitude and attempt to mitigate it through innovative approaches and marketing programs. In the past, transit properties generally increased their fares by a uniform increase throughout the fare structure. Little attention was paid to each element of the structure in terms of effect on ridership and revenue. However, recent research has found that fare-change impacts are not uniform throughout the various submarkets within a transit property. Therefore, transit properties are faced with initiating a high level of fare increase more frequently and without a complete understanding of how the various submarkets will be affected. This paper presents an approach for addressing this problem by delineating a comprehensive development process for making transit fare changes. The process has at its foundation the development of policy guidelines to identify what is expected from the fare change. Two major analysis procedures are defined. First, a technique is presented whereby individual submarket elements of the fare structure can be changed and their ridership and revenue impact readily determined. Second, the development process relies on a building-block approach, whereby changes to each unit of the structure are tested with respect to ridership and revenue impacts and then combined into overall fare-structure alternatives. The procedures contained in this paper were developed as part of a study sponsored by the Pennsylvania Department of Transportation to offer guidance to small and medium-sized transit properties in making service and fare-structure changes.

This paper contains a suggested approach for making fare-structure changes in order to deal with the different ways each submarket of a system is affected by the change. It relies on the process developed as part of the Transit System Performance Evaluation and Service Change Manual for the Pennsylvania Department of Transportation (PennDOT) (1). The process of fare-change development suggested here contains seven major steps, as listed below:

1. Define evaluation procedures,
2. Develop analytical tools,
3. Describe fare actions,
4. Determine ridership and revenue impacts,
5. Develop alternative fare structures,
6. Evaluate alternative structures, and
7. Select and implement preferred alternative.

The procedures suggested for each, as well as how each works together to form a total fare-structure development program, are described in detail below.

DEFINE EVALUATION PROCEDURES

In planning for fare-structure changes, the first and perhaps most important step is to determine what are the objectives to be accomplished by the changes. Is it to increase revenue by a certain percentage? Is it to simplify the structure? These and other questions must be answered to guide the transit fare-development process.

The process for answering these questions could involve the delineation of criteria that have significance levels assigned to each. Such criteria may involve local priorities with respect to six factors associated with transit fares, such as the following:

1. Fiscal integrity: With cutbacks in federal operating support and with the general concern to minimize local financial support, fiscal integrity is probably the most important priority. It describes the financial objectives to be achieved by the fare changes that may be measured by the amount or percentage of a revenue increase, or the percentage of expenses recovered by the farebox.
2. Fare-structure simplification: A major advantage of transit is its low cost. In order to market this advantage, the fare structure should not be overly confusing to hinder its use.
3. Fare promotion programs: Other things being equal, the fare structure that can attract the most transit trips is preferred. Fare promotion programs, at relatively little revenue loss, can be designed to draw attention to new or improved services and also try to establish a transit riding habit.
4. Passenger equity: Although transit fare equity is hard to define, it generally can be considered in three categories: riding distance, quality of service, and patron's ability to pay. A zone structure is usually established to equalize the patron fare based on distance traveled. Premium services, which offer the patron a higher standard of dependability, speed, comfort, or convenience, may command a higher price. Finally, the relative importance of the fare to different user groups should be considered before setting the same price for everyone.
5. Ease of administration: A fare structure must lend itself to easy (low administrative cost) collection of, and accounting for, route revenues. Security of revenues is also a consideration.
6. Effect on energy and the environment: Transit can play a major role in energy conservation and in improving the environment. Therefore, the fare structure may be a key element to influence a modal shift from private automobile to transit.

What is probably most obvious from these six criteria is that they do not work together; that is, a change to enhance satisfaction of one criterion may affect another criterion detrimentally. Thus, there are trade-offs to be made, so that a balance may be struck between the different criteria. These trade-offs can be made by assigning significance levels to each by ranking each as to its relative importance in making fare changes.

DEVELOP ANALYTICAL TOOLS

Use of mass transit service is a function of several factors, including demand characteristics (such as population density and socioeconomic characteristics of the area residents) and supply characteristics (such as route spacing, headways, area coverage, type of service, price of service, etc.). Demand for transit service, however, is closely related to two important supply characteristics--price and level of service. Variation in price, level of service, or both generates change in the use of transit.

An increase in price causes a decrease in ridership. The relation between price and transit use is known as the demand function and is measured by a price-elasticity formula. The literature on transit price elasticity generally refers to two elasticity measures--arc elasticity and shrinkage ratio--although others are mentioned. Historically, the shrinkage ratio was the most commonly used price-elasticity tool (2). However, as a result of extensive research in this field, the arc-elasticity method appears to be more accurate. It is calculated as a ratio of the percentage change in transit use divided by the percentage change in price when the base of the price percentage change is the average of the before and after values. For small changes in ridership, the arc-elasticity formula can be expressed as follows:

$$\text{Arc elasticity} = [(R_2 - R_1)/R_1] \div \{(F_2 - F_1)/[(F_1 + F_2)/2]\} \quad (1)$$

where

R_1 = average daily ridership before fare change,
R_2 = average daily ridership after fare change,
F_1 = average fare before fare change, and
F_2 = average fare after fare change.

The wide range of elasticities reported in the literature points out that riders in different cities and among various transit submarkets within the same city react differently to pricing (3). This evidence leads to the conclusion that ridership and revenue impacts should be accomplished on a disaggregate level. During the preparation of the fare-change manual for PennDOT, data were collected on elasticity values for different fare categories. The values from this research of medium-sized properties located in cities in Pennsylvania indicated that variations in elasticity values can be significant, as seen below:

Item	Elasticity Values
Local routes	-0.20 to -0.30
Express routes	-0.30 to -0.40
Elderly and handicapped riders	-0.30 to -0.35
Student riders	-0.30 to -0.40
Peak ridership	-0.10 to -0.20
Off-peak ridership	-0.30 to -0.40
Transfer riders	-0.30 to -0.40

For these elasticity factors, ridership and revenue estimates were developed in graphic form and are shown in Figures 1 and 2, respectively. These charts are applicable to fare changes that use the arc-elasticity method when they are keyed to the local elasticity values.

DESCRIBE FARE ACTIONS

A transit fare structure is a composite of a number of elements, including various levels of fare with respect to types of service, various methods of payment of fare, and various procedures used to identify eligibility of a passenger to use a given type of fare.

A transit fare structure generally consists of a variety of programs that include fares for the elderly during off-peak periods, reduced fares for handicapped persons, weekly passes, a transfer fee, etc. In theory, revisions to the fare structure could involve almost limitless permutations. At the same time, consideration must be given to the effect of revisions on individual user groups, not only the bottom line, since various combinations of changes may yield similar ridership and revenue total results.

To analyze potential revisions to a fare structure, a building-block approach is suggested. In this way, alternative revisions are evaluated, one by one, as discrete actions; these revisions are changes that might be made to individual elements of the fare structure. The emphasis should be placed on formulating numerous individual or discrete actions for altering the fare, each of which can be analyzed independently. Examples of discrete actions would include items such as peak pricing, off-peak pricing, zone fares, transfer fees, express surcharges, multiride tickets, changing pass discounts or multiples, and promotional activities.

The final step would be to construct an array of potential changes by each fare category. For example, a hypothetical array of fare-change actions is given in Table 1. For each type of fare category, the existing fare structure is described along with several alternative ways the category could be changed.

DETERMINE RIDERSHIP AND REVENUE IMPACTS

Fare revisions must be evaluated to determine their impacts on different rider groups and on systemwide revenue. This step, therefore, involves using the elasticity formulas to determine the ridership and revenue impacts of each discrete action.

Of course, the completion of this process requires additional data to perform the analysis. These would primarily include existing ridership levels by each discrete-action category. For example, if a fare change to increase the transfer fee is contemplated, it is necessary to know the number of transfer passengers before the fare change can be properly evaluated. Results from this step will be an array of changes in ridership and revenues due to each discrete action.

DEVELOP ALTERNATE FARE STRUCTURES

Once discrete actions for fare revisions are identified, fare-structure alternatives can be formulated to fulfill wide-ranging objectives. This can be accomplished by combining the most attractive building blocks into the overall fare programs.

Alternative fare structures might embrace concepts such as fiscal integrity, simplicity, or equity. Each fare program may also contain elements that are not exclusive to a particular structure. For example, Table 2 sets forth three hypothetical alternative structures, which in several instances have the same discrete fare change for more than one alternative.

Figure 1. Percentage of fare increase versus ridership loss.

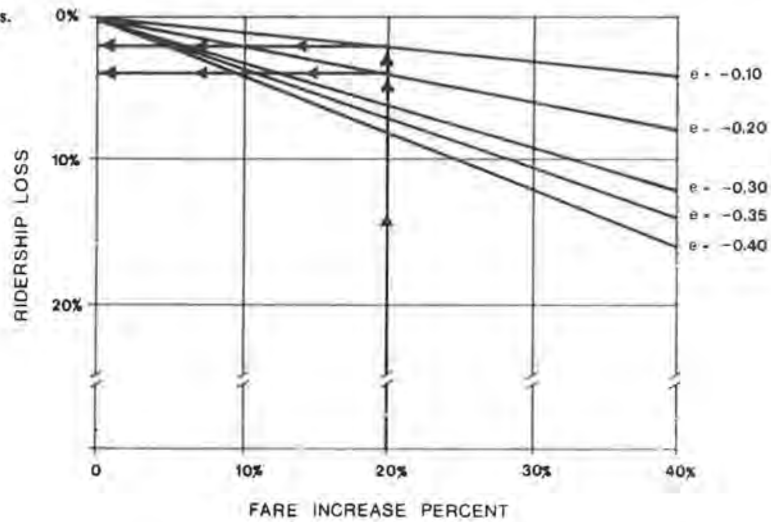

Figure 2. Percentage of fare increase versus revenue gain.

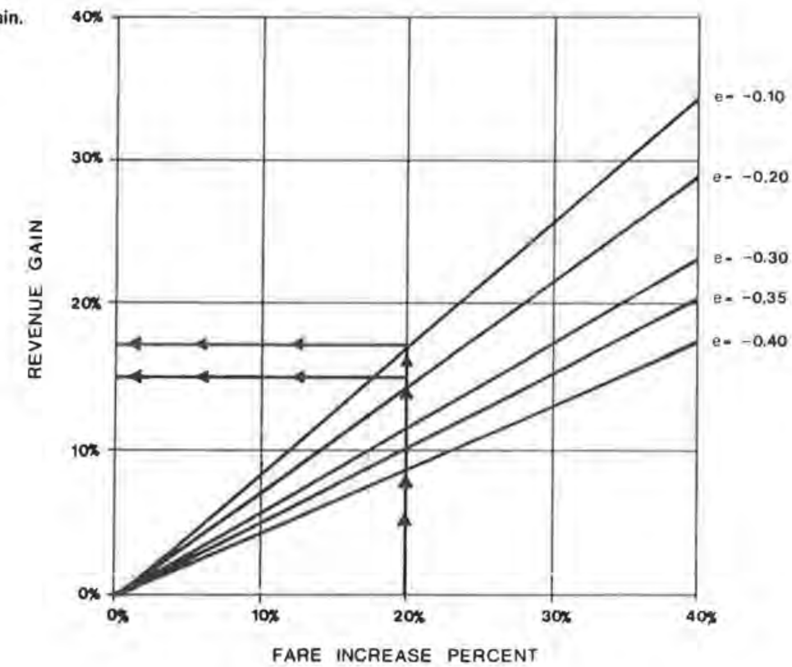

Table 1. Hypothetical array of discrete fare-change actions.

Item	Current Hypothetical Fare Structure	Revenue Impact of Discrete Fare-Change Actions		
		Minimum	Intermediate	Maximum
Peak adult fare ($)	0.45	+0.05	+0.10	+0.15
Off-peak adult fare ($)	0.35	Existing	+0.05	+0.10
Zone fare (per zone) ($)	0.30	Existing	+0.10	+0.20
Transfers ($)	Free	Free	+0.05	+0.10
Express surcharge ($)	0	0	+0.05	+0.10
Student fares ($)	0.35	Existing	+0.05	+0.10
Monthly pass discount (%)	10	Existing	5	0

EVALUATE ALTERNATIVE STRUCTURES

Evaluation criteria were established earlier to set the policy guidelines for making a fare-structure change. In this step, those criteria would be used to assess each fare-structure alternative to determine which alternative should be selected.

The process of evaluating the alternative structures is fairly straightforward. It involves multiplying the relative importance score for each of the six criteria (i.e., fare structure simplification, fiscal integrity, fare promotion programs, passenger equity, ease of administration, and effect on energy and the environment) times the degree to which the alternative satisfies those specific criteria to equal a weighted score. (Note that the score for relative importance and for degree of satisfaction is between 0 and 5, where 0 represents the least satisfaction and 5 the greatest.) The weighted score for each criterion would be summed to arrive at the composite score for the particular alternative being evaluated.

SELECT AND IMPLEMENT PREFERRED ALTERNATIVE

The final step in the development process of fare changes is the ranking of alternatives by their respective scores obtained in the prior step. At this

Table 2. Example of fare program alternatives: fiscal integrity focus.

Item	Alternative A: Minimal			Alternative B: Selective			Alternative C: Major		
	Fare	Ridership Change	Revenue Change	Fare	Ridership Change	Revenue Change	Fare	Ridership Change	Revenue Change
Peak period adult ($)	+0.05			+0.15			+0.15		
Off-peak adult ($)	+0.05			+0.05			+0.10		
Zone fare ($)	Existing			Existing			+0.20		
Transfers ($)	Existing			+0.05			+0.10		
Express surcharge	+0.05			Existing			+0.10		
Student fares ($)	+0.05			Existing			+0.10		
Monthly pass discount (%)	Existing			5			0		

Note: This table is set up as a guide for transit property administrators. The ridership and revenue columns are left blank to show the items to be completed by administrators, so as to see how each fare alternative would alter both ridership and revenue.

point, the fare alternative that has the highest score should be reviewed to ensure that it satisfies the overall objectives. If it does not, then it may be changed by adding or deleting certain elements. If it does, it should be moved forward to implementation.

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Pennsylvania's Urban Operating-Assistance Grant Formula Methodology

JOHN DOCKENDORF

The Pennsylvania Department of Transportation (PennDOT) has provided state transit operating assistance since 1968. For many years, the Bureau of Mass Transit Systems, PennDOT, managed this activity as a discretionary grant program. However, due to the growth of the program and the increasing complexity of these grants, the Bureau determined that a better grant methodology was needed to ensure that state operating-assistance grants were adequate, equitable, and predictable. In FY 1976-1977, the Bureau began experimenting with a formula grant methodology that was based on financial need and system performance. After two years of experimentation and refinement, the Bureau developed a formula grant methodology that it believed achieved the objectives of predictability, equity, and adequacy. This concept was accepted by the state's transit industry as a reasonable and fair method to determine state operating-assistance grants, and efforts began in FY 1979-1980 to achieve passage of state transit legislation based on this grant methodology. This effort was successful and culminated in the passage of the Pennsylvania Urban Mass Transportation Law (Act 101) on July 10, 1980. The key elements of Act 101 and how they are applied to state operating-assistance grants are described. PennDOT believes this methodology has application for other transit funding programs and hopes other agencies can use the concepts in administering their transit programs.

Ever since the passage of Act 8 (Pennsylvania Urban Mass Transportation Assistance Law of 1967), Pennsylvania has participated in providing transit operating assistance to urban and nonurban transit systems. Originally, this program was administered by the Department of Community Affairs. However, in 1970 this function was transferred to the newly created Bureau of Mass Transit Systems when the Pennsylvania Department of Transportation (PennDOT) was established.

Act 8 authorized the state to fund up to two-thirds of operating losses, and localities were responsible for providing the remaining one-third match. With the introduction of the federal Section 5 operating-assistance program in 1974-1975 (Urban Mass Transportation Act of 1964, as amended), this policy was modified to authorize the state to fund up to two-thirds of the nonfederal share of operating deficits. State funds were allowed as matching funds for Section 5 grants.

This policy remained in effect until FY 1980-1981, when Act 101 (Pennsylvania Urban Mass Transportation Law) was passed. This legislation authorized PennDOT to provide a state subsidy of at least two-thirds, but not more than three-quarters, of its constrained deficit. The constrained deficit was defined as an amount equal to constrained operating cost reduced by assumed revenues and federal operating subsidies. These concepts are defined and discussed later in the paper.

Until the passage of Act 101, the Bureau determined operating-assistance grants in a discretionary manner by relying on rules of thumb, past state funding experience, and anticipated budgets. In the early years of the program, there were not a large number of program applicants, so it was possible to review projects on a line-item, as well as an overall, basis. The Bureau developed an extensive transit data-reporting system, which included an annual questionnaire, a detailed project application, and quarterly progress reports. Therefore, the staff had reasonably good knowledge of the participating transit systems, and the discretionary grant program worked fairly well for many years.