Transit Fare Elasticity: Role in Fare Policy and Planning

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With the planned phaseout of federal operating assistance over the next five years, transit managers across the country are looking to the farebox to raise the necessary revenues to maintain current levels of service. Since raising fares is a necessary but politically sensitive means of boosting operating revenues, much more attention is being placed on developing accurate ridership and revenue models and on identifying fare policies that will increase revenues with minimal effect on ridership. Fare elasticity of demand and its role in ridership and revenue planning and in developing fare policy are discussed. The fare elasticity is a useful concept because it provides information on how riders respond to fare changes. Since fare elasticities usually vary significantly by trip distance, time of day, and quality of service, transit managers can take advantage of these differences by differentially pricing their services in order to increase revenues and ridership. Differential pricing, however, does have its political and monetary cost. Whether the revenue-generation advantages as indicated by the variation in fare elasticities are worth the increased administrative costs will be answered by each system in the next few years as the financial pressures increase and when the revenue-generation potential of differentially priced transit service becomes of paramount importance.

The reasons behind the current financial problem in transit are very clear. Between 1975 and 1980, total transit operating expenses increased at an average annual rate of 11.8 percent while farebox revenues increased at only half that rate, or 5.8 percent annually (1, pp. 46-47). This in itself has not been a problem, since operating subsidies grew at a much faster annual rate of almost 21 percent over this same five-year period; the largest growth in operating assistance came from the federal government. Now, however, the federal government is planning to eliminate all operating assistance in the next five years.

Fortunately, the federal government's share of total operating revenue is only 17.3 percent, or slightly more than the level contributed by the states. If we assume that state and local contributions to transit service operations will continue to grow but at slightly slower rates, the loss in federal operating dollars will have to be met by higher farebox revenues and/or reductions in operating costs in order to maintain the balance between revenue and cost. Typically in the wake of subsidy shortfalls, fares are arbitrarily increased and service levels are reduced so that available revenues cover the operating expenses after all remaining operating subsidies are committed. Although such decisions can provide temporary solutions to financially troubled transit companies, more rational short-range policies that fit into a long-term approach to transit financial planning should be adopted soon if transit companies are going to remain solvent in the near future and maintain the political support they require.

Aside from determining how high the fares should be with respect to the subsidy level (i.e., what percentage of total operating revenues should come from the farebox), the principal problem with transit planning today is that fare and service-level decisions are hardly ever jointly planned and considered despite the fact that fares and service levels are intrinsically related. If a greater proportion of operating revenues is going to have to come out of the farebox with minimum losses of ridership, these fare levels will have to be determined in conjunction with the quantity, quality, and cost of the service provided. In addition, less-traditional fare and service concepts should be given serious consideration when major policy changes are under review. The financial crisis and high inflation we all face today should not divert our attention from the need to choose wisely and from a wide range of alternatives. In fact, the current financial situation should highlight the importance of making the right decision as a result of a careful analysis of choices in relation to specific operating objectives.

This paper focuses on one particular element or factor that enters into the equation when making the range of important trade-offs suggested above--the fare elasticity of demand. It is an important concept because it describes how individuals or groups of individuals react to fare changes. In a more generalized sense, the fare elasticity of demand also tells us something about how important the fare level is with respect to the total cost of travel (i.e., including wait, walk, and in-vehicle time costs). This paper presents new information on the fare elasticity of demand and suggests how the elasticity can be used in ridership and revenue analysis and for developing fare policy.

FARE ELASTICITY OF DEMAND: A DEFINITION

The demand for public transit is influenced by many factors, including the level of transit fares, the quality and quantity of service provided, and other factors outside the control of the transit company. The elasticity of demand is a convenient measure of the relative responsiveness of transit ridership to changes in these individual factors. As a quantitative measure of relative change, the elasticity of demand is defined as the ratio of the proportional change in transit demand to the proportional change in the factor being observed. Thus, the transit fare elasticity will indicate the percentage change in transit ridership resulting from a 1 percent change in fares. Since the percentage change in ridership, fares, and services is independent of the units in which each is measured, the ratio of percentage changes--the demand elasticity--is also dimensionless. Therefore, one may compare, for example, the fare elasticities observed in England with those observed in the United States.

Transportation analysts have used several methods for computing the elasticity of demand; each results in slightly different numerical values. It is obviously beyond the scope of this paper to provide a detailed review of the four principal mathematical relationships used to compute a fare elasticity, and the reader is referred to Grey (2) or to Mayworm, Lago, and McEnroe (3) for a more comprehensive discussion. Nevertheless, it is relevant to at least identify the four measures that appear most often in the literature:

Point elasticity:

$$\eta_{pt} = (\partial Q/\partial F) \cdot (F/Q)$$

Shrinkage ratio:

$$\eta_{sr} = [(Q_2 - Q_1)/Q_1] \div [(F_2 - F_1)/F_1] = (\Delta Q/Q_1)/(\Delta F/F_1)$$

Midpoint elasticity:

$$\eta_{mid} = \{(Q_2 - Q_1)/[(Q_2 + Q_1)/2]\} \div \{(F_2 - F_1)/[(F_2 + F_1)/2]\} = [\Delta Q/(Q_1 + Q_2)]/[\Delta F/(F_1 + F_2)]$$

Arc elasticity:

$$\eta_{arc} = (\log Q_2 - \log Q_1)/(\log F_2 - \log F_1)$$

where

Q_1 = initial level of ridership,
Q_2 = new level of ridership,
F_1 = initial fare level, and
F_2 = new fare level.

The point elasticity is derived from the actual transit ridership demand curve and can be evaluated at any point along the curve. Although it is perhaps the most useful measure for ridership planning, since it is derived from the demand model, many transit analysts do not have enough information from which to develop such functions for groups of riders let alone for the system as a whole.

The three remaining measures, therefore, are used most often to estimate elasticities from ridership and fare-level data corresponding to periods before and after a fare change. Of these, the shrinkage ratio or loss ratio is perhaps the most common measure. Although there are numerous advantages and disadvantages to using all three elasticity measures, the midpoint and arc elasticity definitions will yield more consistent results both for a transit company and across sites, especially for large fare changes such as those occurring today.

NEW INFORMATION ON FARE ELASTICITIES

During the year after Ecosometrics published its compilation of demand elasticities (3), several studies were released that added to the body of literature on this subject. Perhaps the most comprehensive and professional study on the demand for public transportation was recently published by the Transport and Road Research Laboratory (TRRL) in 1980 (4). This international collaborative study reviews all the factors affecting public transit demand, including fares. Based on a wide variety of studies from all over the world, this study reconfirms the fact that fare elasticities are low; they range from -0.10 to -0.60. Thus, increases in fare levels will almost always lead to increases in revenues. Off-peak travel is about twice as elastic as peak travel and those with an automobile available are more sensitive to fare changes than those captive to the public transit system for most of their travel needs. In addition, persons traveling short distances are more responsive to fare changes than those traveling long distances. However, there is some evidence to suggest that the fare elasticity will once again rise with very long trips as passengers have the opportunity to find alternative destinations.

In addition to this excellent document, several British analysts have recently published results of studies on passenger demand. Oldfield and Tyler (5) and Stark (6) looked at passenger response to changes in suburban rail fares by using time-series data from the 1970s. Stark analyzed passenger response in the suburbs of Glasgow, Scotland, during this period and estimated a fare elasticity of -0.45. Oldfield and Tyler looked at British Rail fares on services connecting London to its suburbs and found that commuters were less responsive than reduced-fare patrons to fare changes and that there was no systematic variation in the fare elasticity for commuters according to distance. The fare elasticity for reduced-fare riders, however, grew as the trip distance increased. The general results of Oldfield and Tyler's study of the elasticity of medium-distance rail travel are presented below (5):

Fare Category	Fare Elasticity ± Standard Error
Full fare	-0.20 ± 0.04
Pass	-0.50 ± 0.07
Reduced fare	-0.65 ± 0.06

Another fare study from England was performed by Urquhart and Buchanan and published by TRRL in 1981 (7). This study focused on the effects of fare and service changes on shopping and nonshopping travel in Telford, England. Although there are questions surrounding the methodology used to measure passenger response to the fare change while extensive management and service changes were taking place, the analysts were able to conclude that the fare elasticity for shopping trips was between -0.58 and -0.80; the mean for three model formulations was -0.65. Nonshopping travel was found to be less elastic; the fare elasticity varied from -0.32 to -0.46. The mean fare elasticity for nonshopping trips computed from six model formulations was -0.40. This study also found that many shopping trips taken by bus were redistributed among various shopping centers in the Telford area in response to the fare changes.

Very few new studies have been published in the United States presenting new evidence on transit fare elasticities of demand. Although based on fare changes that occurred in 1976, two studies by Knudson and Kemp provide reliable evidence of how transit riders respond to fare changes (8,9). In September 1976, the Erie Metropolitan Transit Authority (EMTA) raised the cash fare and adult and student tokens. The study results indicate that adult token riders are less elastic than cash users and that students are very sensitive to fare increases, as shown below. The systemwide point elasticity was calculated to be -0.33 (8):

Fare Category	Fare Change ($)	Point Elasticity
Adult token	0.28-0.31	-0.25
Cash	0.30-0.35	-0.38
Student token	0.20-0.25	-0.72
Systemwide	0.29-0.34	-0.33

In a second study performed by Knudson and Kemp (9), fare elasticities were estimated following a November 1976 systemwide fare change in the Kentucky suburban counties of Cincinnati. The base fare on the Transit Authority of Northern Kentucky (TANK) system increased 60 percent from $0.25 to $0.40, which resulted in a fare elasticity of only -0.15. A summary of the fare elasticities by fare category is presented below (9):

Fare Category	Fare Change ($)	Point Elasticity
Base	0.25-0.40	-0.15
Elderly and handicapped off-peak	0.10-0.20	-0.26
Student cash	0.20-0.25	-0.63
Systemwide	0.23-0.37	-0.12

Although the results are in general agreement with other studies, the very low aggregate fare elasticity indicates that riders were very insensitive to the large fare increase. Knudson and Kemp attribute this low response to the captive nature of the riders (i.e., generally low-income commuters, females, and the elderly) and the timing of the fare change (i.e., just before Thanksgiving and the Christmas season). These two studies as well as other studies performed by Kemp (10) and by Goodman, Green, and Beesley (11) should be read by all transit-pricing analysts because of the careful methodology used in attempting to isolate the effects of fares on transit ridership levels.

Other studies have also been published that have computed fare elasticities; they are not discussed here because they add little to what is already known. Unfortunately, there has yet to be published any information on how riders are reacting to the massive and frequent fare changes that have occurred during the past two years. There is very little empirical evidence to suggest that these fare increases would result in significantly different elasticities than those already reported. There are, however, theoretical arguments purporting that indeed ridership becomes more sensitive to fare changes as the fare increases. This is discussed in more detail later in this paper.

FARE ELASTICITY IN RIDERSHIP AND REVENUE PLANNING

In the past few years there has been a resurgent interest in the concept and use of the elasticity of demand--specifically, the fare elasticity of demand. Although the values obtained from quantitative analyses or borrowed from the analyses performed on other systems are an important factor in ridership and revenue planning, the amount of information that they can provide is limited. As briefly mentioned earlier, the demand for transit is affected by a large number of factors, of which fares is only one. Service quality, wait and walk time, and reliability are a few additional factors that are known to influence ridership levels. Moreover, there are factors beyond the control of a transit manager that will influence the number of people using transit and their frequency of use. In a recent paper, for example, Ulberg (12) found that the supply of gasoline and the level of employment in the Seattle metropolitan area were very important factors influencing ridership on the Seattle Metro transit system. Fare levels, therefore, can only give us part of the information we need for accurate ridership and revenue analysis.

It is important to note this limitation of the fare elasticity and of the overall influence of fares on ridership. During the two-year period 1977-1979, fares were being increased in transit systems across the country while ridership was also increasing. Many people, in fact, felt the fare increases had little or no impact on ridership. In the last two years, however, ridership has fallen dramatically as fares continued to increase. Obviously other factors, such as the level of employment and gasoline prices and supply, played important roles in influencing ridership. Thus, there is no reason to suspect that the ridership response due to the fare increase alone differed during these two periods. For an excellent summary and guide in understanding and interpreting fare elasticity information, the reader is referred to a recent working paper by Kemp (13).

It is also important to recall that given the same conditions, ridership response will be different in different cities, for different transit services and levels of service, for different periods of the day, for different trip lengths, and perhaps for different fare levels. All of this suggests that a single fare elasticity value is of little use to most transit companies if accurate ridership and revenue forecasts are required. The fare elasticity will not only differ by user group (e.g., commuter), but it may also change within the same ridership group as other factors change; that is, the fare elasticity is most likely not constant as is often alleged in much of the modeling work done.

Finally, as pointed out by Kemp (13), fare elasticities alone should not be used for forecasting ridership and revenues. Instead, revenue or ridership models should be developed that incorporate the fare variable and its elasticity as well as the other variables that influence ridership. The elasticities used in these models should in fact be derived from these models if sufficient data are available. If not, elasticities, especially elasticities for specific user groups or time periods, can be borrowed from other systems for this purpose if attention is paid to the values selected (14). Although usually enough data are available at most transit companies to develop simple models and compute elasticities based on aggregate ridership data, such information is of little use in serious ridership and revenue forecasting since most transit companies have multiple fare categories. Thus, aggregate elasticities computed from an analysis of fare changes occurring within one's own transit system can be modified for initial modeling purposes by using the relative values of fare elasticities observed in other locations. Moreover, with the advent of the microcomputer, there is little reason why most transit companies cannot begin to develop data-base monitoring systems and ridership models that are dynamic, that is, models wherein the elasticities and other parameters can be recalibrated as conditions change or better information is provided.

FARE ELASTICITY IN DEVELOPING FARE POLICY

Although the fare elasticity plays a limited but nevertheless important role in ridership and revenue planning, it does provide us with very useful information on how responsive riders are to fare changes. Since many ridership groups respond differently faced with the same fare change, the fare elasticity becomes a useful measure for comparison purposes. For example, the fare elasticities computed in one transit system can be compared with those observed in other systems for the purpose of gaining credibility of one's modeling results. Similarly, fare elasticities can be used to compare recent fare adjustments with fare changes that occurred in the past. Most importantly, however, the fare elasticity can be the measure used to compare different user groups or markets within the same transit system. This last role is perhaps the most important role the fare elasticity can play since it can and should influence fare policy.

Fare policy in the broadest sense refers to the level of fare charged and how that fare varies by distance, time of day, user group, or other classification. What fare structure to adopt and how high the fares should be are difficult decisions that must be made in consideration of the specific objectives of the transit company, the levels of service provided and their costs, the political and subsidy constraints, and the characteristics of the transit system and its users. The fare elasticity enters into the decisionmaking process since it tells us something about the characteristics of the users. It is in this way that the fare elasticity can influence or guide fare policy.

Setting Fare Level

The reactions of many citizens to the large and frequent fare increases that have taken place in many cities across the country have caused many managers and administrators to question whether the actions being taken are the best, given the objective of raising needed revenues. If we had raised the fare higher, what would have been the ridership and revenue impacts? Have we reached the point where future fare increases will not lead to increases in revenues? Should we be implementing small, frequent fare increases or should we hit the public with one large fare increase every two years? These are important and legitimate questions of policy for which there are economically and politically correct answers. Unfortunately, there is no research completed or currently being performed that directly addresses these issues. There are, however, some guidelines that can be presented based on theory and a few empirical findings related to the fare elasticity of demand.

How High Can We Raise Fares?

Fare elasticities estimated in the past have usually been based on relatively small fare changes, both in percentage and absolute terms. For example, the highest fare level for an urban bus system evaluated by Mayworm, Lago, and McEnroe (3) was $0.65 for New York City. Today, this is a typical fare level and many cities charge $1.00 or more for a one-way transit trip. Consequently, the very low fare elasticities computed in the past may not be appropriate for the fare levels being implemented today. What is being suggested is that the fare elasticity may increase with the level of the fare. In fact, many analysts have argued that the higher the fare level, the greater the ridership response to subsequent fare changes.

To date, however, the empirical work on fare elasticities has not found evidence to support this view. Dygert, Holec, and Hill (15) reviewed the data reported by the American Public Transit Association and concluded that the magnitude of the average fare before the fare increase did not affect the size of the fare elasticity. Bly (16) also could find no significant relationship between fare level and size of the fare elasticity.

There is, nevertheless, theoretical support for this hypothesis since the elasticities derived from many models are themselves functions of the fare level and other variables in the model. The findings of several demand analysts of the London Transport (17) suggest that the demand for transit is nonlinear with respect to fares. In all these cases, the fare elasticity rises with fare level. What, then, is the revenue-maximizing fare level? Where is the point at which further increases in fares will lose so many riders that the net result will not be an increase in revenues? This point is reached when the fare elasticity reaches -1.0.

Following the formulation of their model of transit demand based on the TANK base-fare increase from $0.25 to $0.40, Knudson and Kemp (9) computed the level of the fare that would have maximized gross revenues in 1976, holding all the remaining variables constant. The model predicted a fare on the order of $1.30 to $1.35 compared with the $0.40 fare that riders were paying.

Finally, the concept of generalized cost suggests that the fare elasticity will increase as the fare proportion of the total travel cost increases (assuming the generalized cost elasticity remains constant).

Mathematically, the fare elasticity is related as follows:

$$\eta_f = (F/GC)\,\eta_{GC} \qquad (1)$$

where

$$GC = F + \sum_i v_i t_i$$

and

η_f = fare elasticity of demand,
F = fare level,
GC = generalized cost,
η_{GC} = generalized cost elasticity,
v_i = value of time associated with time component i, and
t_i = time spent during trip in time component i.

Thus, if our current fare is $0.40, which represents 30 percent of total generalized cost [see the report by Oldfield (18)], and the initial fare elasticity of demand is -0.40, then the fare would have to rise to $2.82 in order to reach the point where further fare increases would result in revenue losses (i.e., where $\eta_f = -1.0$). The relationship between fare level and fare elasticity for this example is presented in Figure 1.

The actual value of the revenue-maximizing fare will change significantly as the assumptions change. For example, if the value of time in transit is greater than originally assumed, then the generalized cost will be larger, all other factors remaining constant. Thus, by using the same assumptions identified above but with a larger value of time component and a generalized cost elasticity of -2.0, the revenue-maximizing fare would be $1.60, a much smaller figure. However, even at this fare level, off-peak and short-distance travel would disappear. If higher fares are going to be charged, then distance-based or time-of-day fare structures should be adopted.

Although there is no evidence to suggest that any transit company in this country has reached the point where the fare elasticity is equal to unity nor is it possible to tell where that point may lie, it is clear that the economic limits to raising fares are beyond the political limits, except perhaps for very long-distance trips where the fare elasticities and fares are already very high. In Chicago, for example, I am told that we are already beginning to see many commuters switching from commuter rail lines to less expensive private paratransit and subscription-bus operations.

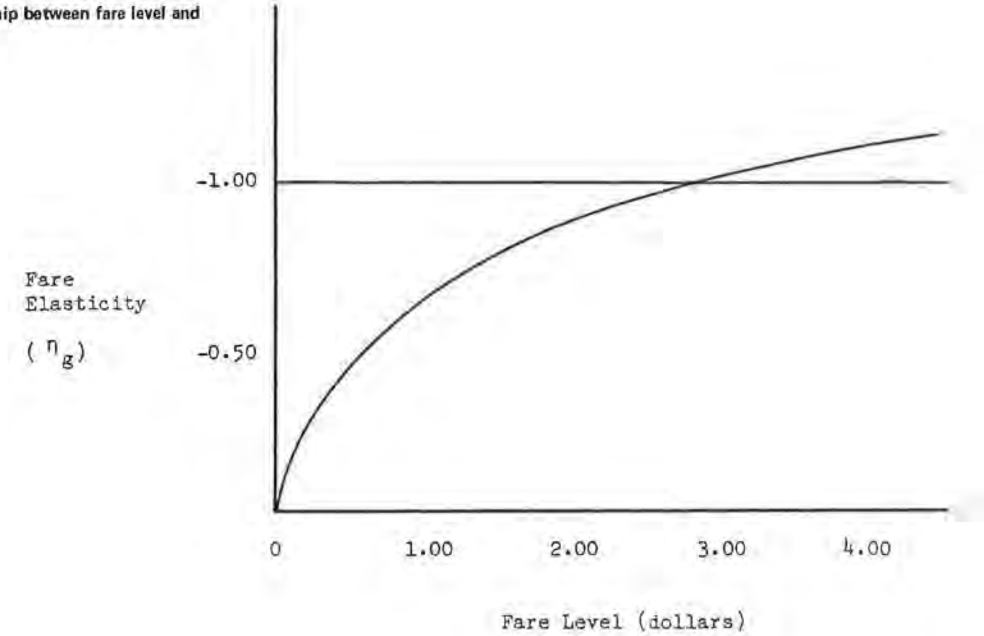
How Frequently Should We Raise Fares?

Another issue facing many transit managers concerns the size and frequency of fare changes. During the 1970s, many transit companies did not raise fares for five or six years; most, in fact, reduced their fares. Today, however, inflation is taking a heavier toll on costs, and the growth in deficits is not being offset by the subsidies provided. Since the fare level is being reviewed more frequently to fill this gap, is there any evidence that would favor semiannual, annual, or biannual fare reviews? Do riders respond differently to frequent small fare increases than to infrequent large fare increases?

Many analysts again argue that the greater the fare increase, the greater the rate of decline in transit riding. As in the case described above, the fare elasticity should increase as the fare increases to become a large portion of the total generalized cost. Since the value of time should increase over time with inflation, small fare increases that keep up with the value of time components should result in no significant change in the fare elasticity over time. Similarly, Bly (16) contends that even the large but infrequent fare changes should not affect the elasticity over time since most large fare increases are only imposed when the initial fare has become a relatively small fraction of the generalized cost. Thus, the fare is perhaps the same proportion of total generalized cost when viewed over entire periods of constant fares.

Very frequent fare changes, however, should be

Figure 1. Relationship between fare level and fare elasticity.



avoided, since most of the evidence on fare elasticities suggests that it takes six to nine months to feel the full effect of a fare change. In general, transit riders will not change their travel habits in the very short term. Thus, fare elasticities can be expected to increase slightly over this six- to nine-month period. Hensher and Paterson showed in a 1972 study (19) that the elasticity for work trips by rail in Sydney, Australia, jumped from -0.30 three months after the fare change to -0.60 six months after the fare change.

In the analyses performed by Knudson and Kemp (8,9) and by Kemp (10), the fare elasticities differed only slightly over time; most of the final ridership response occurred within six to nine months of the fare change. In the case of the 1976 fare increase in Erie, Pennsylvania, however, the analysts found that the fare elasticity was smaller in the long term. They account for this fact by suggesting that some of the ridership lost as a result of the initial impact of the fare increase may have been recaptured. Results of all three studies are presented below (8-10):

Months After Fare Change	Atlanta, GA (1972)	Northern Kentucky (1976)	Erie, PA (1976)
3	-0.16	-0.08	-0.37
6	-0.17	-0.11	-0.32
9	-	-0.12	-0.32
12	-0.18	-0.12	-0.32

Although many factors will affect the decision on when to implement a fare change, this short analysis suggests that time is not a major factor. Fares should not be changed more frequently than every six months, since it takes at least that long for the impact of the previous fare change to be realized. Transit managers should also rule out biannual or very long periods between changes since inflation is so high today. Moreover, most transit riders understand that fares have to keep up with inflation and would accept an annual fare review and adjustment period.

Designing Fare Structure

Perhaps the most important role the fare elasticity can play is with regard to developing and designing the fare structure of a transit system. It is important and useful because it indicates the way and the degree to which we should differentially price our services. Although we should be setting different prices for different services based on the costs of providing the service, by comparing fare elasticities of demand, we can determine whether we are taking full advantage of what individuals are willing to pay.

Designing fare structures is essentially a task of determining the degree to which we should differentially price. For economic efficiency arguments, this essentially involves equalizing the fare elasticities of demand for the specific markets in question. Since differential pricing results in higher revenues with no net loss in ridership, a transit manager should weigh these higher revenues against the costs incurred in creating a zone system, peak-period surcharge, or whatever differential pricing scheme is under consideration. Thus, fare elasticities are very useful because they tell us how much we can expect to gain.

There are many different types of fare structures that can be designed and each transit system will have its own combination. However, the three most common forms of differential pricing are distance-based fares, time-of-day fares, and quality-based fares. These methods are the most common forms of differential pricing for three reasons. First, the cost of providing transit service differs significantly for short and long trips, by time of day, and by service quality. Second, these forms of pricing are relatively easy to administer. Finally, the fare elasticities differ significantly within each group so that we can charge riders higher fares for long-distance, peak-period, and express service without affecting overall ridership levels.

Revenue generation is the main purpose for differentially pricing transit service, and revenues will only be generated if there are significant differences in the fare elasticities. Express-bus riders are known to place a higher priority on travel time, safety, and comfort than on the fares paid. Thus, the fare elasticities calculated for express-bus and local service users should be significantly different and different fares can be charged.

Table 1. Elements in fare structure trade-off analysis.

				Effect on Costs		
Fare Structure	Revenue Efficiency	Equity	Passenger Convenience	Collection Costs and Complexity	Effect on Operating Costs and Boarding Times	Fraud Avoidance
Flat	Poor	Poor	Excellent	Excellent	Excellent	Excellent
Time of day	Excellent	Good	Good	Good	Good	Good
Distance based	Excellent	Excellent	Poor	Poor	Poor	Poor
Quality based	Excellent	Fair	Good	Good	Excellent	Excellent

Similarly, peak-period riders are known to be less responsive to fare changes than off-peak riders. Although there is little evidence to suggest that peak-period demand will shift to the less expensive off-peak period by differentially pricing peak and off-peak service, such a pricing scheme can lead to higher revenues with no net loss in ridership.

Perhaps the most important differential pricing option open to a transit company concerns how the service is priced by trip distance. When British Rail fares were examined during the 1970s, Oldfield and Tyler (5) found that the fare elasticities for full-fare and pass riders did not vary by trip length. Since fares are graduated on the suburban London service, the fact that there was no systematic variation in the fare elasticity may suggest that the fare portion of the users' total generalized cost increases proportionally with distance. They did find, however, that the fare elasticities for reduced-fare riders increased with distance, which suggests that the fares are perhaps increasing too rapidly with distance for this group. Since the rail lines included in the study extend as far as 72 miles from London, many reduced-fare riders can obviously find alternative destinations for their trips.

In a recent study on intercity bus demand, Burkhardt and Riese (20) found that the fare elasticity decreased with distance as shown below:

Route Length (miles)	Fare Elasticity
20-60	-0.645
20-120	-0.352
120+	-0.268

Since the average fare paid per mile did not differ significantly for each group, the longer-distance routes perhaps provided service for individuals for whom alternative modes of travel are not available.

For any type of transit system, the choice and appropriateness of some form of distance-based fares will depend on the distribution of trip lengths and the variations of fare elasticities by trip length. Small transit systems without major differences in fare elasticities by trip distance should opt for flat fares. Under these conditions, the gains in revenue as well as equity [see report by Cervero and others (21)] are simply not worth the extra cost and inconvenience of distance-based fares. Experiments conducted on London's suburban routes in Harrow and Havering as reported by Richardson and Fairhurst (22) and by Fairhurst (23) concerning conversion back to flat fares resulted in both greater revenues and passenger miles of travel. These experiments showed that complex fare systems create opportunities for fraud and that if the differential between fare elasticities for short and long trips is not large, then flat-fare systems are relatively efficient. Based partly on these experiments, London Transport is converting to flat fares in some of its suburban bus systems. However, this scenario is by no means representative of all American settings where significant differences in fare elasticities exist.

The role of the fare elasticity in fare structure design is to provide information on the revenue-generation potential of alternative schemes so that important trade-offs can be made between revenue generation and equity on one side and convenience and cost on the other (Table 1). In large systems where peak-period travel is important and fare elasticities vary by trip length, distance-based and time-of-day fare structures are probably superior to flat fares in terms of revenue generation. Whether this advantage in revenue generation as well as equity is worth the increased administrative cost will be answered in the immediate future as the financial pressure on transit increases and when the revenue-generation potential of alternative fare structures becomes of paramount importance.

CONCLUSIONS

With subsidy shortfalls predicted for the next few years, transit managers across the country are looking to the farebox to raise the required revenues to keep their services operating. The political sensitivity of fares as a means of boosting operating revenues has caused many managers to require their staffs to provide more accurate ridership and revenue projections and to present a wider range of choices on different fare structures that are designed to increase revenues. This paper has presented a discussion of the fare elasticity of demand in terms of its role in ridership and revenue planning and in fare structure design.

Although the fare elasticity of demand is a useful concept because it provides information on how riders respond to fare changes, ridership and revenue planning must acknowledge the myriad factors that affect patronage, of which fare is only one. The fare elasticity, however, is an extremely useful measure that can provide information and guidance in developing fare policy so that we can begin to capture the farebox revenues we need with minimal effect on ridership levels. As noted in this paper and in other studies (3,4), fare elasticities often vary significantly by trip distance, time of day, and quality of service. If we are going to take advantage of the increased revenue and ridership opportunities afforded by the differences in fare elasticities across transit markets, the reliance on flat fares will have to be abandoned and more attention will have to be placed on how we price transit services.

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Scheduling-Based Marginal Cost-Estimating Procedure

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With changing policies regarding transit funding at all levels of government, transit planners will be required to more carefully monitor existing bus systems as well as intensively examine the net cost or savings of proposed service changes. In the past, research has focused on only one side of the equation—demand, hence revenue estimation. In the near future, more effort will be directed to operating-cost estimation and the underlying relationships that impact expenditures. Although a variety of cost-estimation techniques have been developed, there is little agreement as to which one best estimates cost. The purpose of this project was to develop a technique that is complex enough to capture the salient cost characteristics of a change in transit service. The cost model presented here is sensitive only to those line items that typically vary in response to changes in the scale or characteristics of fixed-route service. These are termed variable costs. A major variable cost component is driver cost, which is treated by the model in some detail. Driver cost is assumed to be a function of the number of drivers required to operate scheduled service, along with exceptions that normally occur in daily operations. These perturbations are captured through simulations of scheduling and dispatching processes. These are described as a set of calibrated ratios and percentages that assume no dramatic departure from the norm. Other variable costs (e.g., fuel and insurance) are estimated through a typical cost-allocation approach. This model is currently being tested along with several other prominent costing approaches. A variety of small service changes are being used as the basis for comparison. No results on the models' comparative performances are available at this time.

The current decade will represent a period of dramatic change for most transit agencies as they respond to an era of limited resources. Many systems, facing severe financial constraints, have already made substantial service changes to balance transit costs with available funds. This new direction in the transit industry will place greater demands on transit planners to forecast, with reasonable accuracy, the financial implications of service changes. Unfortunately, no single technique or procedure has been established that transit planners can readily use. Recognizing this deficiency, the Urban Mass Transportation Administration (UMTA) has commissioned a research effort to develop a bus-route costing procedure.

This study has consisted of several interrelated steps. The initial step was to review techniques now used in the industry as well as procedures identified in the technical literature. Following an assessment of these procedures and the requirements of transit planners, a proposed method was design-