Effect of Fares on Transit Riding

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•FARES are perhaps the most sensitive aspect of transit service—balancing uneasily between political pressures and the need for operating revenue. Political campaigns in major American cities have been won and lost over transit fare issues, and there is substantial evidence that patrons react to fare increases at the turnstiles as well as at the polls.

The correlation of price increase with loss of transit riding has been well established. Most utility commissions use a variation of the "shrinkage formula" devised by our firm more than 20 years ago when pressures of inflation first became manifest in fare increase proposals by transit companies.

But the corollary questions of price differential among competing transit services, and the effect of joint fares in coordinated transit operations, have not been so well explored. What is the "sub-modal split" of riding between surface and rapid transit connecting two points, when the fare is 15 cents on one and 25 cents on the other? How much added traffic is attracted to rapid transit when the feeder bus fare is dropped from 20 cents to 10 cents? When feeder and trunk lines are separate operations, how should the feeder line discount in the combination fare be shared between them?

These are fundamental questions of revenue and cost apportionment in developing coordination between surface and rapid transit systems. Auto travel switches freely between systems—from county roads to city streets to state highways—without motorists' awareness; division of motor fuel revenues among these systems is accomplished by legislative standards with varying degrees of sophistication. Transit, however, is more like a barrier-type toll highway; each link of the trip is a new fare confrontation—whether the journey fare is paid at one point or piecemeal. The mechanics of collection become involved, therefore, as well as price discount and revenue yield.

These considerations were a major part of the Northern California transit coordination study (NCTDP) recently completed for transit services in the San Francisco Bay Area. This HUD-sponsored analysis explored correlations among community goals, traffic, population, auto ownership, transit routes, operating costs and vehicle requirements, as well as single-vehicle and combination fares, for their influence on transit riding. The transit systems involved are the two present surface operations—San Francisco Municipal Railway (Muni) and Alameda-Contra Costa Transit District (AC Transit)—in conjunction with the Bay Area Rapid Transit District (BARTD), the 75-mile rapid transit network now under construction (Fig. 1).

PRESENT FARE STRUCTURES

The fare structures of these operating systems are quite dissimilar and not readily adaptable to coordination.

Muni has one of the lowest and simplest transit fare plans in the nation—a citywide 15 cent fare for adults, 5 cents for children and students, free transfer, no tokens and no zones. This fare has been in effect since 1952.

AC Transit has zone fares, but the first zone is so large as to approach an areawide flat fare plan. More than 80 percent of East Bay journeys are one-zone rides. The basic adult fare is 25 cents with a 20 cents token rate. Zone increments for the four additional zones are 5 and 10 cents each. Transbay fare between the central East Bay zone and downtown San Francisco is 50 cents cash or 45 cents on a commute ticket.

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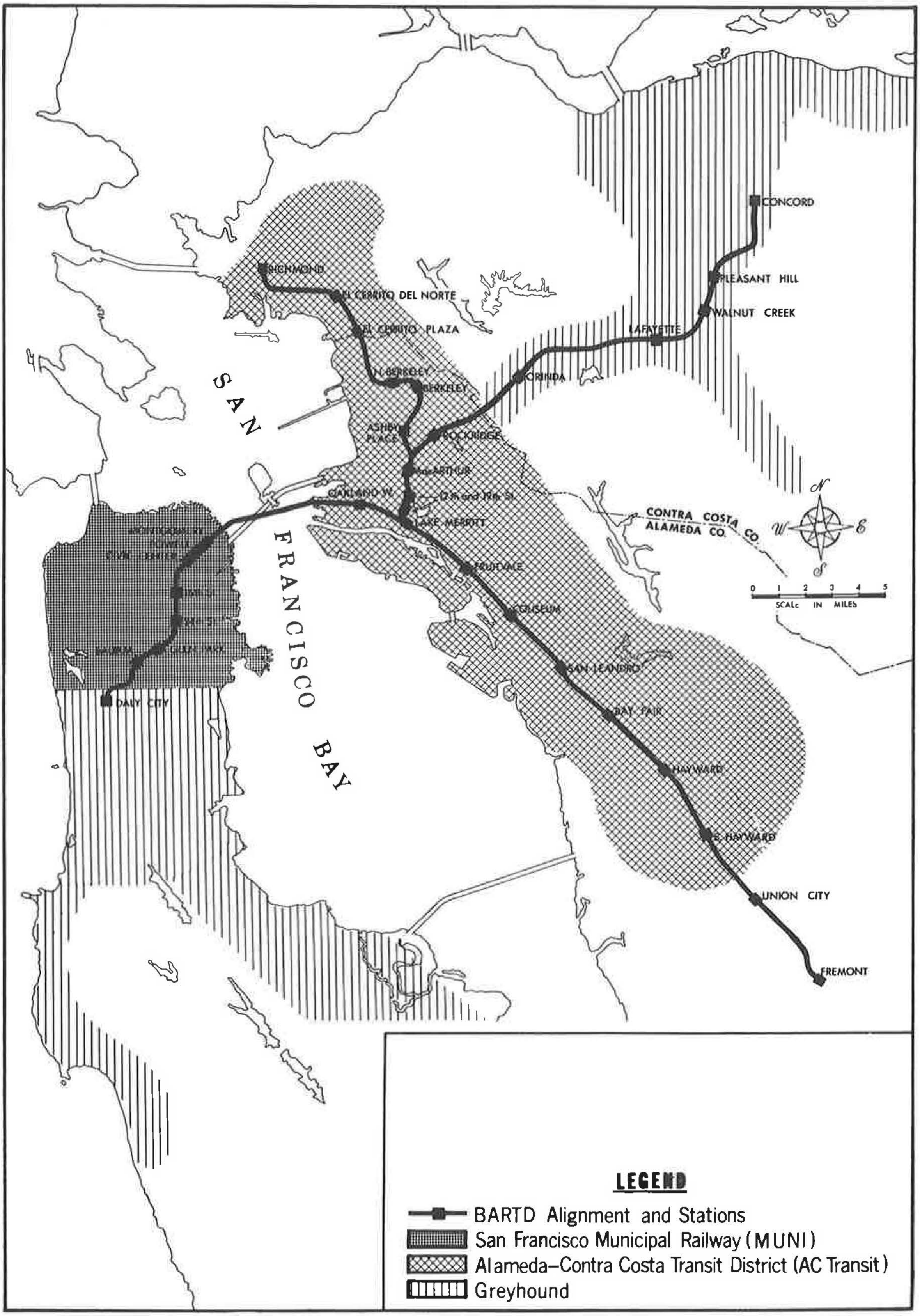

Figure 1. Transit services—San Francisco Bay Area.

BARTD will have a range of station-to-station rates based on distance, varying from 25 cents to $1.00.

Both Muni and AC Transit have pay-enter fare box collection on vehicles; BARTD is designing an automated system, based on stored-value or stored-trip tickets which are magnetically encoded and inserted by passengers in entrance and exit turnstiles.

There are no joint fare arrangements between Muni and AC Transit. O-D studies reveal a substantial interchange of passengers between the two, particularly at the San Francisco Transbay Terminal. Combination fares for multi-vehicle journeys between systems will become particularly significant when BARTD is superimposed on them.

Among the 22 largest metropolitan areas in the country, only Philadelphia and Washington have combination fare arrangements between suburban and local transit systems to any significant degree. In both cities, joint fare tickets are sold by drivers manually; neither the sale nor collection is automated.

TRANSIT TRAVEL IN 1975

Conventional systems techniques for traffic forecasting were utilized to develop a potential volume of 253,353 adult BARTD passengers on the average weekday in 1975, prior to adjustment for fare differentials. Similarly, AC Transit's AADT is projected at 57,485—down 54 percent from 1965—while Muni is expected to carry 353,377 adult riders, a drop of 8 percent from 1965 levels. The latter two figures for 1975 do not include feeder trips to BARTD stations, which are estimated at another 65 percent of BARTD's daily volume. When these are added, AC Transit is expected to carry a total of 12 percent more than its 1965 daily volume, but for trips of considerably shorter length. Muni system riders are also forecast to rise 22 percent overall, divided among Muni surface vehicles, a new Muni rapid transit system and feeder passengers to BARTD in San Francisco.

These projections of 1975 transit riding were calibrated from existing transit use, which is a product of the fare structure on the present carriers. These estimates of future travel, therefore, presupposed continuation of existing fare policies. To the extent that alternative fare plans developed for 1975 will result in higher or lower fares than now exist for comparable journeys, it was necessary to alter projected transit travel to reflect that change in travel costs.

ALTERNATE FARE PROPOSALS

Alternate fare proposals were considered first from the standpoint of public acceptance and policy considerations, then tested for their influence on traffic generation and revenue production. With several choices of fares on each of the three transit systems—as well as inter-system alternatives and possible variations in parking charges—it is evident that 500 or more combinations could be devised. The initial problem was to narrow the choice to those which might have greater public appeal, then determine the effectiveness of components in attracting passengers and revenue. Following this, the cost side of the equation was introduced and the iterative process of revenue and cost projections repeated until a reasonable balance was achieved to satisfy fiscal requirements for the three transit systems.

Several fare schedules for surface and rapid transit lines in the Bay Area were machine-tested by bracketing the range of acceptable alternatives, then narrowing the choice within that range. Four alternate fare plans were reviewed by BARTD, as summarized in Table 1, together with two alternatives for AC Transit and three for the Muni system.

BARTD Plans B-1 to B-4 were tested for previously determined station-to-station volumes on the BARTD system, in combination with various feeder surface fares. Each of these tests involved separate consideration and subdivision of BARTD patronage among single-vehicle BARTD trips, journeys on which passengers will come to BARTD by a Muni route (Muni-BARTD), by an AC route (AC-BARTD) and in various other combinations (i.e., Muni-BARTD-Muni, AC-BARTD-AC, Muni-BARTD-AC, AC-BARTD-Muni, BARTD-Muni, and BARTD-AC).

TABLE 1

ALTERNATE FARE PROPOSALS, BAY AREA TRANSIT SYSTEMS

(a) Alternate Fare Plans Considered for BARTD

Fare Category	Plan B-1	Plan B-2	Plan B-3	Plan B-4
Minimum adult fare (cents)	25	25	25	25
Minimum fare applicable to non-transbay trip of (miles):	8	8	5	4
Maximum adult fare ($)	1.00	1.00	1.00	1.00
Minimum transbay fare (cents)	35	50	50	50
Fare increment for transbay trip (cents)	10	10	4 miles added	4 miles added
Adult fare within San Francisco (cents)	25	25	25	25
Maximum fare on peninsula (Daly City-San Francisco) (cents)	25	25	30	35

(b) Alternate Fare Plans Considered for AC Transit

Fare Category	Plan A-1	Plan A-2
Adult single zone cash fare (cents)	25	25
Adult token fare (cents)	20	None
Transfers	Free	Free
Minimum transbay fare—cash/commute (cents)	50/45	50/45
Surface feeder to BARTD (cents)	10	25/round trip
Student and child fare (cents)	15	15

(c) Alternate Fare Plans Considered for Muni

Fare Category	Plan M-1	Plan M-2	Plan M-3
Adult surface fare (cents)	15	20	25
Surface transfers (cents)	Free	5 for first transfer only	Free
Adult Muni rapid fare (cents)	25	25	25
Adult combination surface rapid fare (cents)	25	30	30
Surface feeder to BARTD (cents)	5	10	25/round trip
Student and child fare (cents)	5	10	15

BARTD Fare Plans B-1 to B-4 were analyzed in combination with AC Transit alternate Plans A-1 and A-2, as well as Muni Plans M-1 to M-3—making a total of 24 complete multi-system analyses.

SUB-MODAL SPLIT BETWEEN SURFACE AND RAPID TRANSIT

New rapid transit systems in Toronto, Montreal and Chicago opened in the past two decades reveal that an overwhelming majority of the users of these systems are not new to transit. Studies on the Yonge Street Subway in Toronto show that 86 percent of the riders were previously surface transit users. Similarly, on the Congress Street rapid transit and the Skokie Swift demonstration in Chicago, diversion studies show the proportion of previous transit users at 85 percent on Congress Street and 75 percent on the Skokie Swift. These indications do not lessen the importance of rapid transit in terms of its primary task of winning people over from auto travel; however, they do point up the need for careful analysis of sub-modal split—the distribution of transit users between rapid and surface lines.

Some further attention has been given to transit diversion in Philadelphia where estimates have been made for distribution of transit riders between surface and grade-separated lines reflecting the relative convenience of surface transit for short trips and passenger reluctance to go down into a subway or up to an elevated structure (1).

The gross transit market in San Francisco derived for 1975 was developed initially on the basis of factors which affect total transit use and assigned to specific transit

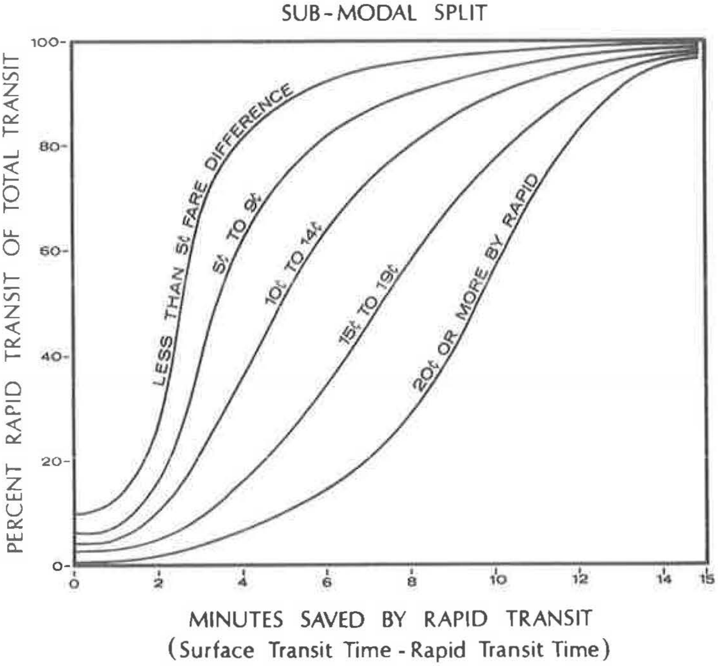

Figure 2. Effect of fare and time differentials on rapid transit use.

lines on the basis of the route or combination of routes representing the minimum time path from origin to destination. Thus, for example, a short trip of a mile or mile and one-half was originally assigned to the rapid transit system as opposed to a surface alternative whenever the trip time on the rapid transit line was slightly less than the surface route, regardless of fare differences.

However, diversion studies reveal that an important element of the "sub-modal split" equation is the fare differential between rapid transit and surface lines. With rapid transit fares higher than surface travel, a significant group of rapid transit patrons will prefer the slower surface alternative. Only when time savings on rapid transit are large (15 minutes or more) do most riders prefer that service to the alternative surface lines, despite a fare differential.

Based on experience in other cities with rapid transit, a family of time differential diversion curves was developed, stratified by fare differences between rapid and surface transit (Fig. 2). Each curve represents a 5-cent fare difference and expresses the proportion of rapid transit usage in relation to time savings by rapid transit over surface alternates. Thus, a trip which had a 5-minute saving on rapid transit with 10 cents additional fare was analyzed differently from a trip with the same time saving but with a 20-cent fare differential.

This process resulted in a series of internal redistributions of traffic between rapid transit and surface routes. While the aggregate volume of riding on the Bay Area transit systems in 1975 was not affected, there was some shifting to surface lines of trips which, strictly on a time comparison basis, had been assigned to the rapid transit system.

Traffic Reduction Due to Fare Increase

As previously indicated, the effect of fare increase (and of fare decrease) on transit riding has been analyzed periodically over the past two decades. Figure 3 illustrates the experience of 77 bus fare changes, revealing a high correlation coefficient ($R = 0.92$).

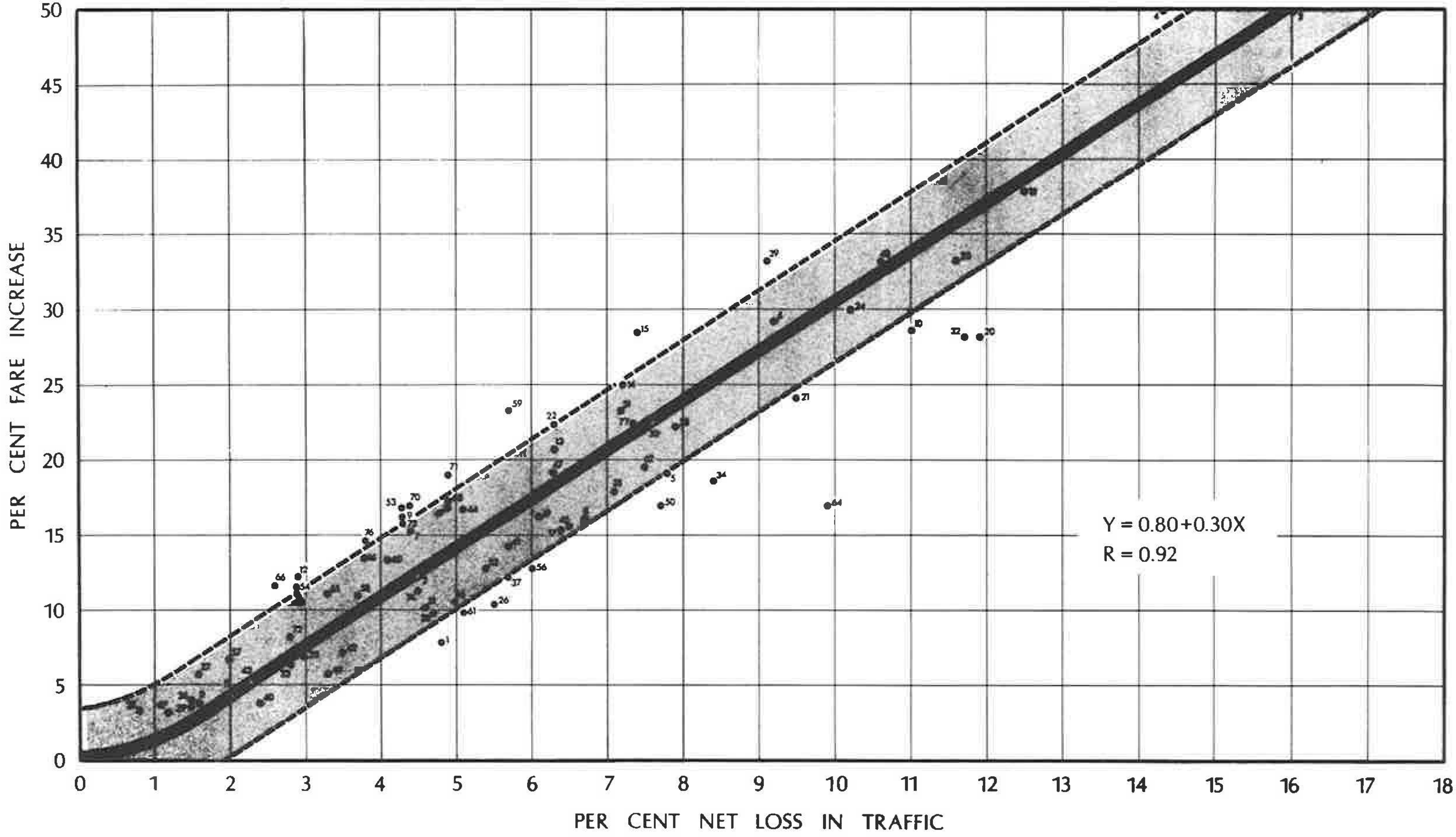

Figure 3. Shrinkage in passenger traffic due to fare increases—transit systems throughout the United States.

Universally, fare increases in the range here being considered for the Bay Area systems have produced revenue gains for the transit systems involved. It is not until the minimum or basic fare level reaches 30 to 35 cents that diminishing returns may offset the revenue yield. But it is also a universal phenomenon that some passenger riding is lost due to each fare increase, no matter how nominal that increase may be.

The factor expressing the rate of passenger loss attributable to fare increase is known among utility commissions as "loss ratio" or "shrinkage ratio." It is applied to the percentage increase in fare to determine the rate of passenger loss as a result of the higher price.

The loss ratios for fare increases in a group of representative cities are given in Table 2. The last fare change in San Francisco, which occurred in June 1952, raised the adult rate from 10 to 15 cents. Prior to the fare increase, traffic had been declining slowly at a rate of 1.87 percent; this drop was accelerated after the fare increase to a rate of 11.04 percent. The net traffic decline due to the 50 percent fare increase, therefore, was 9.17 percent, resulting in a loss ratio of 0.18.

In light of prior experience in San Francisco and other fare changes throughout the United States, it was estimated that a loss ratio of 0.20 would be applicable in the Bay Area for fare increases establishing a minimum fare of 25 cents or less.

There was an additional element to be considered in predicting the impact of fare changes on the BARTD and Muni rapid transit systems. For those particular facilities, a lower shrinkage loss was anticipated because of the superior quality of service and passenger amenities represented in rapid transit compared to existing forms of transit in the Bay Area. Patrons will be required to pay more than they do now, but they will be getting a faster and more comfortable journey in more attractive vehicles. While an increase in fares for rapid transit journeys above existing surface fares can be expected to have some effect on riding, it will be less than the passenger loss which would result from a higher fare on existing routes and service. In calculating the impact of a rate increase from the existing surface transit fare to a proposed higher rapid transit fare, therefore, a loss ratio of 0.10 was applied.

Rapid transit journeys in many cases will involve access by surface transit vehicles to rapid transit lines and/or the use of surface lines for reaching the final destination after leaving rapid transit. These surface feeder legs were treated as a part of the rapid transit trip, and the loss ratio of 0.10 was applied to the entire journey. The 0.20 loss ratio was used only for journeys completed entirely on surface routes.

TABLE 2

PASSENGER "LOSS RATIO" RESULTING FROM FARE INCREASES ON MAJOR TRANSIT SYSTEMS INCREASING FARES TO LEVELS UP TO 25 CENTS

Date	City	Cash Fare Increase (cents)		Loss Ratio
		From	To	
June 1952	San Francisco	10	15	0.18
July 1953	New York	10	15	0.20
July 1966	New York	15	20	0.18
Oct. 1955	Boston (surface)	13	15	0.19
	(rapid transit)	18-20	20	
Feb. 1958	Portland	20	25	0.28
Dec. 1963	Salt Lake City	20	25	0.12
June 1958	Connecticut Co.	15	20	0.28
Oct. 1963	Atlanta	20	25	0.28
July 1957	Cincinnati	20	25	0.24
Jan. 1954	Philadelphia	15	18	0.14
Oct. 1958	Baltimore	20	25	0.08
Jan. 1954	NYC omnibus	10	13	0.30
July 1957	Chicago	20	25	0.30

	Daly City	24th Street	Downtown San Francisco	Downtown Oakland	MacArthur	Orinda	Walnut Creek	Concord	Berkeley	El Cerrito	Richmond	Fruitvale	San Leandro	Hayward
24th Street	$0.25													
Downtown San Francisco	0.35	$0.25												
Downtown Oakland	0.75	0.60	$0.55											
MacArthur	0.75	0.70	0.60	$0.25										
Orinda	0.90	0.80	0.75	0.40	$0.35									
Walnut Creek	1.00	0.90	0.85	0.65	0.60	$0.25								
Concord	1.00	1.00	1.00	0.75	0.75	0.55	$0.35							
Berkeley	0.85	0.75	0.70	0.30	0.25	0.55	0.75	$0.85						
El Cerrito	0.90	0.80	0.75	0.40	0.30	0.65	0.80	0.95	$0.25					
Richmond	0.95	0.90	0.85	0.55	0.50	0.75	0.90	1.00	0.35	$0.25				
Fruitvale	0.80	0.70	0.60	0.25	0.30	0.60	0.75	0.85	0.40	0.55	$0.65			
San Leandro	0.90	0.80	0.75	0.40	0.50	0.65	0.85	0.95	0.60	0.70	0.75	$0.30		
Hayward	1.00	0.90	0.85	0.60	0.65	0.80	0.95	1.00	0.75	0.80	0.85	0.50	$0.30	
Fremont	1.00	1.00	1.00	0.85	0.85	1.00	1.00	1.00	0.95	1.00	1.00	0.75	0.65	$0.50

FARE PLAN FORMULA

25¢	First 4 Miles
25¢ +4¢/mile	4 to 10 Miles
50¢ +3¢/mile	10 to 15 Miles
65¢ +2¢/mile	over 15 Miles
$1.00	Maximum Fare

TRANSBAY – Mileage plus 4 Miles with 50¢ Minimum

PENINSULA – 25¢ Fare within San Francisco 35¢ Maximum Fare

Figure 4. Fare Plan B-4—prospective BARTD fares, typical stations.

SUMMARY OF PASSENGERS AND REVENUE FOR 1975

The passenger and revenue volumes projected for the three Bay Area transit systems on the machine run of fare schedules ultimately recommended are summarized in Tables 3 and 4. Table 3 deals solely with adult riding and revenues, while Table 4 includes child and student riding and advertising income, as well as adult patronage.

The BARTD operation, based on Fare Plan B-4 (Fig. 4), is forecast to carry 53.9 million adult riders, of whom 36 percent will be transbay passengers, about 40 percent San Francisco riders and the balance—approximately 24 percent—riders on the East Bay portion of the BARTD system.

In terms of adult patronage, the Muni system is expected to carry two-thirds of 1957 Bay Area transit patrons. Under the

TABLE 3

BAY AREA TRANSIT SYSTEMS
(1975 Annual Adult Passengers and Revenue Under Machine Run VI)

System (Fare Plan)	Passengers	Revenue ($)
BARTD (B-4):		
Transbay	19,419,900	14,014,305
East Bay	12,643,740	5,041,365
San Francisco	21,796,200	5,678,400
BARTD total	53,859,840	24,734,070
Muni (M-3):		
Richmond rapid	17,245,559	4,311,390
Sunset rapid	14,377,088	3,594,273
Twin Peaks rapid	10,886,684	2,721,672
Muni rapid total	42,509,331	10,627,335
Surface only	57,848,190	14,357,921
Surface—BARTD	43,234,124	5,045,329
Surface—Muni rapid	45,705,200	2,048,610
Muni surface total	146,787,514	21,451,860
Muni system total	189,296,845	32,079,195
AC Transit (A-2):		
Surface only	18,614,044	4,952,517
Surface—BARTD	24,621,170	2,973,321
AC system total	43,235,214	7,925,838
Total	286,391,899	64,739,103

TABLE 4

BAY AREA TRANSIT SYSTEMS
(1975 Annual Adult, Child and Student Passengers, Passenger and Advertising Revenues Under Machine Run VI)

System (Fare Plan)	Adult, Child and Student Passengers	Passenger and Advertising Revenue ($)
BARTD (B-4)	56,552,832	25,723,433
Muni rapid (M-3)	44,634,798	11,052,428
Muni surface (M-3)	163,862,047	24,253,232
Muni system total	208,496,845	35,305,660[a]
AC Transit (A-2)	60,414,714	10,607,791[b]
Total	325,464,391	71,636,884

[a] It is estimated that special and charter revenues will add $300,000 annually to the line passenger and advertising revenues shown here.

[b] It is estimated that charter revenues will add $800,000 annually to the line passenger and advertising revenues shown here.

projected arrangement, Muni will operate its own surface and rapid transit service, as well as feeders to BARTD.

Derivation of passenger and revenue estimates for AC Transit were based on the techniques previously described, using a loss ratio of 0.20 for AC Transit riding under Fare Plan A-2 and a corresponding ratio of 0.10 for combination journeys with BARTD.

JOINT FARE DISCOUNT

Serious consideration was given to the added volume of riding induced by offering a fare discount for combination journeys. Six discount proposals were analyzed for joint fare reductions ranging from 5 to 12½ cents on the surface systems (Table 5). The revenue yields to feeder line and trunk route under various amounts of discount were readily determinable. Derivation of passenger volumes and revenue yield under these combination proposals was based on the two adjustments previously described: (a) a shift of passengers among alternate routes of BARTD and the surface systems on the basis of passenger convenience, time and fare differentials, followed by (b) shrinkage or increase of passenger volumes in combination journeys as a result of the discount in fare.

It was in devising an acceptable formula for sharing the fare discount among affected transit systems that the fare analysis became obscured. The amount to which a surface system is entitled for carrying a joint fare rider may be developed in relation to the length of ride and fare charged for non-feeder trips on that particular local system.

TABLE 5

SURFACE AND BARTD-FEEDER FARES AND DISCOUNTS UNDER SEVERAL FARE PLANS

Fares and Discounts	Fare Plan					
	A	B	C	D	E	F
(a) BARTD-Muni						
Fare (cents):						
Muni surface	15	15	20	20	25	25
Single-vehicle BARTD	25	25	25	25	25	25
Muni-BARTD	35	35	35	35	40	37.5
Muni-BARTD-Muni	35	40	35	45	50	37.5
Discount (cents):						
Muni-BARTD	5	5	10	10	10	12.5
Muni-BARTD-Muni	5	0	10	0	0	12.5
Payment (cents):						
BARTD to Muni	2.5	2.5	2.5	2.5	0	2.5
(per passenger)	2.5	0	2.5	0	0	2.5
Total annual discount on surface feeders ($)	1,884,698	1,669,777	3,922,932	3,462,165	3,377,730	4,839,600
BARTD to Muni discount share ($)	946,648	834,889	985,340	865,541	0	972,437
(b) BARTD-AC Transit						
Fare (cents):						
AC surface	–	–	20	20	25	25
Single-vehicle BARTD	–	–	25	25	25	25
AC-BARTD	–	–	35	35	40	37.5
AC-BARTD-AC	–	–	35	45	50	37.5
Discount (cents):						
AC-BARTD	–	–	10	10	10	12.5
AC-BARTD-AC	–	–	10	0	0	12.5
Payment (cents):						
BARTD to AC	–	–	5	5	0	2.5
(per passenger)	–	–	5	0	0	2.5
Total annual discount on surface feeders ($)	–	–	2,166,510	1,955,550	2,024,930	2,817,690
BARTD to AC discount share ($)	–	–	1,083,250	977,770	0	565,620

An alternate approach would relate the amount to be received by the local system for carrying the feeder line passengers to the average cost per passenger on the entire surface operation. Another fundamental approach would be to relate the average length of ride for feeder passengers on a particular local system to the length of ride on the rapid transit line to which feeder passengers are delivered.

While surface feeder legs will ordinarily involve short rides, a higher than normal proportion of BARTD feeder trips will be peak-hour travel—trips occurring at a period of the day when it is necessary for the surface systems to add manpower and vehicles in order to take care of BARTD patrons. On the basis of cost of service, therefore, it may be held that the surface lines are entitled in many instances to full fares for feeder patrons carried to rapid transit.

These basic elements—length of haul on the one hand and proportion of peak-hour traffic on the other—are important counterbalancing considerations. A wide variety of formulas can be devised provided there is agreement among the carriers on objectives. In this instance, the three transportation agencies will have to give more detailed study to policy on feeder service and its several complexities before a formula can be evolved. To a considerable degree, the final arrangement will depend on how much feeder surface operation to BARTD is required and how much is realized in fare-box revenue in the aggregate from that service.

In order to complete the fare analyses and revenue yield calculations, an arrangement was tested whereby the discount represented in the surface feeder fare to BARTD below the present fare levels on each surface system would be divided equally between BARTD and Muni or AC Transit, as the case may be. Thus, using existing fares as the basis, a passenger riding a Muni surface line to reach BARTD and/or after leaving BARTD would pay 10 cents to Muni. BARTD would pay Muni an additional 2½ cents for each such rider, representing 50 percent of the discount in the feeder fare below the present 15 cent fare level on the Muni system. On AC Transit, the basic fare is 20 cents while the feeder patron to BARTD would pay 10 cents. This discount of 10 cents would be borne equally by AC Transit and BARTD, requiring a payment of 5 cents per passenger by BARTD to AC Transit.

The effect of this discount-sharing proposal is pointed up in the six fare plans summarized in Table 5. In this series, Plans A and B were not applied to AC Transit, since they involved a 15 cent minimum fare—5 cents below the present AC Transit rate.

As shown in Table 5, the amount of payment from rapid transit to the feeder systems varied from nothing under one proposal to more than $2 million on two others, offset to a substantial degree, however, by higher gross revenue on the rapid transit line.

As ultimately worked out, a 25 cent minimum fare for adult riders was recommended on all three systems. Further, the recommended amount which the passenger would pay for feeder surface ride to BARTD would be 12½ cents, or one-half the basic adult fare on either of the surface operations. In another phase of the NCTDP study dealing with fare collection, it was recommended that this be accomplished by selling the feeder transportation on the basis of 25 cents for a surface round trip.

OPERATING COST ANALYSIS

The end result of the foregoing fare analyses was a distribution of riding and revenue among the three Bay Area transit systems in 1975. To evaluate the proposed fare structures, singly and in combination, it was necessary to determine their sufficiency in meeting projected operating expenses. This was accomplished by projecting the cost of carrying prospective passenger volumes under each fare plan—first, by determining the amount of service required for that patronage, and then by estimating the cost of that service. Various methods were developed for determining both of these sets of facts.

The number of adult passengers by lines under each projected fare plan served as the basis of deriving vehicle-miles and hours of service to be operated on each surface route in 1975. Service levels on existing routes were analyzed by class of lines to determine the mileage provided in relation to riding volumes.

TABLE 6

PROJECTED 1975 RESULTS OF OPERATIONS
(Three Bay Area Transit Systems)

Category	1965	1975	Percent Change
Revenue passengers:			
BARTD	–	56,552,832	–
Muni	141,724,908	208,496,845	+ 47.1
AC Transit	52,905,464	60,414,714	+ 14.2
Total	194,630,372	325,464,391	+ 67.2
Passenger & advertising revenues ($):			
BARTD	–	25,723,433	–
Muni	19,820,932	35,605,660	+ 79.6
AC Transit	13,268,079	11,407,791	- 14.0
Total	33,089,011	72,736,884	+119.8
Cost of operations ($):			
BARTD	–	13,596,360	–
Muni	27,966,377	43,525,177	+ 55.6
AC Transit	14,827,112	17,055,659	+ 15.0
Total	42,793,489	74,177,196	+ 73.3
Net Revenues ($):			
BARTD	–	10,589,016	–
Muni	- 7,991,711	- 6,947,080	+ 13.1
AC Transit	- 1,463,421	- 5,082,248	-247.3
Total	- 9,455,132	- 1,440,312	+ 84.8

Future surface transit costs were then determined by calibrating cost allocation models on the basis of the three independent variables developed—vehicle-miles, vehicle-hours and passenger revenue—as follows:

Muni bus:

$$C = 3.359H + 0.3862M + 0.11456R$$

Muni trolley coach:

$$C = 6.108H + 0.3803M + 0.09462R$$

Muni cable car:

$$C = 11.058H + 2.461M + 0.19624R$$

AC Transit bus:

$$C = 6.209H + 0.2541M + 0.03865R$$

Sensitivity tests on cost allocation formulas revealed a satisfactory level of accuracy for planning purposes. The result was to produce individual route cost figures for the AC Transit and Muni surface systems in arterial, cross-town and feeder service.

The projected results of operations for the three systems in 1975 under the recommended fare structures are summarized in Table 6. The influence of the proposed fare increases is revealed by relative gains estimated for revenue passengers and passenger revenue. The latter is projected to increase by nearly 120 percent, while revenue passengers are expected to rise more than 67 percent. As shown, high costs due primarily to more extensive operations will require this entire increase, leaving the three systems in a slight deficit position overall.

As a final step, the future cost/revenue margin for each of the 120 surface routes, as well as for the several rapid transit trunk lines, was derived. This important measure will enable system managers to analyze the prospective operations of each route in terms of its own self-liquidating capabilities, its contribution to feeding rapid transit and other arterial lines, as well as less tangible warrants of cost effectiveness.

REFERENCE

1. Mass Transportation Diversion Curves, Subway-El vs. Surface Lines (RR Excluded). Penn Jersey Tech. Memo. Series TM 14-9, 1960.

Discussion

R. L. CARSTENS, Associate Professor, Department of Civil Engineering, Iowa State University—The author's report on methodology employed to forecast modal choice is a helpful contribution to the understanding of travel characteristics in urban areas. This very complex decision-making process is even more difficult to quantify when a choice of alternative forms of transit is available.

The writer would agree that the fare charged for transit service influences a choice among alternative travel modes. Examples reported by the author and shown in Figure 3 indicate that the percent loss in patronage resulting from a fare increase is about one-third of the percent fare increase. Stated otherwise, this experience has indicated a shrinkage ratio of about 0.33 or a price elasticity of -0.33 for transit patronage. The author states quite correctly that this correlation has been well established.

The writer has investigated transit operating experience in 13 cities in Iowa starting with 1950 but covering shorter time periods (depending upon the availability of data) in most cities. These 13 communities vary in size from about 20,000 to more than 200,000 population. In most of them, particularly in recent years, the quantity of transit service has been quite low. For comparisons among cities, the quantity of service is expressed as a service factor, S, as follows:

$$S = \frac{\text{Annual revenue miles of transit service}}{\text{Population in transit service area}}$$

There have been frequent changes in the quantity of service afforded by the transit operations studied, and these changes often have occurred concurrently or nearly concurrently with fare changes. Since previous research had established a relationship between the level of service and transit patronage, it was possible to isolate the probable effect of service changes. Having done this, elasticities were then calculated to relate changes in transit patronage with fare changes. These were found to vary widely for the 30 substantial fare changes that occurred in 12 cities during the period studied. A median elasticity was -0.67, or about twice that developed from the author's data.

Although the pattern of variation in elasticities was very scattered, at least one relationship was evident to help explain the differences among cities. The level of service appears to exert a most important influence on price elasticity in that the effect of a fare increase upon patronage was found to be markedly more pronounced when the level of service was low. Various other factors, many of which it was not possible to identify, undoubtedly were of importance in particular cities. The writer believes, however, that the low levels of service common in cities in Iowa account primarily for the fact that elasticities are so much higher than those encountered in other studies.

Several specific examples of extremely elastic behavior of transit patronage were noted in the study, most of these occurring when the service level was quite low. Recent experience in Iowa City is an example. Here, the average fare had been about $0.20 with a $0.25-base fare and a substantial number of reduced-rate school fares. Then, in November 1966, a uniform fare of $0.10 was introduced. Patronage immediately nearly doubled and continued to gain gradually until the increase in ridership amounted to more than 100 percent after the reduced fare had been in effect for a year. A comparison of patronage during the fourth quarter of 1967 with the same period in 1965 indicates an increase of 127 percent in patronage. Some increase in service occurred during the intervening period with the service factor changing from about 5.4 in 1965 to approximately 5.8 in 1967. Discounting the probable effect of the added service and comparing these two quarterly periods, a decrease of 48 percent in fare apparently induced an increase of 98 percent in patronage.

An implication of shrinkage ratios greater than 1.0 is that, depending on the magnitude of the change, a fare decrease might increase revenue while a fare increase may actually result in a decline in passenger revenues. In general, however, the considerable price elasticity of transit patronage when levels of service are low has resulted in changes in passenger revenues that were quite small following fare changes in most cities in Iowa.

Elasticities on the order of those presented by the author were encountered in Iowa only when service factors were about 20 or higher. Service at this level would probably be limited today to large transit-oriented urban centers or those smaller cities with a large number of captive riders. It would appear that some reevaluation may be in order for our understanding of the correlation between price increases and loss of patronage.

EUGENE L. GRANT, Professor of Economics of Engineering, Emeritus, Stanford University—An important aspect of the choice of a passenger fare schedule on an urban mass transit system is the total amount of revenue that must be secured from the passengers. The aimed-at total passenger revenue objectives differ considerably among different publicly owned transit systems. Fares may be intended merely to cover current out-of-pocket outlays for operation and maintenance with the remainder of the costs to be met from general taxation or other sources. Or they may be set to cover part or all of the capital costs as well.