Economics of Transit Fare Prepayment: Passes

ARMANDO M. LAGO AND PATRICK D. MAYWORM

Transit fare prepayment has become widely used by transit operators in an attempt to increase ridership and reduce costs. However, most fare prepayment plans, especially pass plans, are improperly priced, resulting in unnecessary revenue losses. The current knowledge on the economics of fare prepayment is reviewed and summarized. Specifically, start-up and operating costs are presented, as well as the potential returns from dwell-time reductions, savings in coin-handling costs, interest accruals on cash flow, peak to off-peak trip diversions, generated travel, and price discrimination. In addition, the price elasticities of demand for fare prepayment are summarized, a simple model for predicting market penetration rates is presented, and the economics of pass pricing is discussed. Criteria for pass-pricing plans are also presented. It is emphasized that when properly designed and priced, transit fare prepayment can improve a system's performance and operating ratio.

Few transit operators with fare prepayment plans can give explicit reasons why their plans were established. Among the principal reasons (1) given for implementing fare prepayment plans are (a) to increase ridership by making transit service more convenient; (b) to increase revenues, an objective not easily accomplished given the high diversion rates from cash patrons; (c) to reduce operating costs by lowering cash-handling costs, reducing theft, and reducing dwell-time costs; (d) to help meet the Section 5(m) requirements of the Urban Mass Transportation Act of 1964 with regard to off-peak reduced fares for the elderly and the handicapped; (e) to improve the image of the transit company; and (f) a variety of miscellaneous reasons such as providing promotional offers to new residents.

The economic aspects of designing and implementing fare prepayment plans are analyzed with special reference to passes. The focus of this paper is on passes because pass-pricing strategies are the most misunderstood aspect, with the consequence that most operators are facing serious revenue losses through improper pricing.

COSTS AND BENEFITS OF FARE PREPAYMENT PLANS

The evidence presented below shows that fare prepayment plans are cost-effective in the sense of providing benefits in excess of costs if cash revenue losses from improper pricing can be avoided. The costs and benefits of a hypothetical monthly pass summarized below show potential benefit-cost ratios of 1.17-1.57 for typical medium-sized programs with large start-up costs. Note, however, that the potential benefits are three to five times larger than the recurrent costs.

Costs and Benefits	$1980
Costs	
Start-up	0.439
Recurrent operating	0.233
Total	0.672
Potential benefits	
Dwell-time cost savings	0.270
Coin-handling cost savings	0.450-0.720
Interest accruals on cash flow (10 percent borrowing rate)	0.064
Total	0.784-1.054

Needless to say, fare prepayment plans are effective only if improper pricing decisions are avoided. Some evidence on the costs and benefits of fare prepayment plans is presented next.

Costs

The cost figures presented above correspond to those of the Ottawa-Carleton Transpo (OC Transpo) monthly pass program (2). Our analysis of the costs of fare prepayment programs reported elsewhere (3) shows the recurrent operating costs to be as low as $0.14 per instrument sold in the smaller systems to $0.94 in some of the larger, more expensive systems. It is our contention that most transit operators can attain unit costs of between $0.15 and $0.20 if efficient administrative distribution methods are employed.

Benefits from Dwell-Time Savings

Boarding times are significantly reduced as the proportion of prepaid fares increases. Boarding times in the OC Transpo system diminished as much as 25 percent as a consequence of the monthly pass program. The benefit figures given above are based on Wilbur Smith and Associates (4) estimates of savings of 2 s in boarding times between passes, permits, and tickets versus conventional cash fares and a smaller saving of 0.5 s for tokens. The benefits shown correspond to reduced demand for driver hours if bus schedules are revised accordingly. Driver hourly wages and fringe benefits were estimated as $11.37 with potential boarding-time savings estimated as $0.006 per passenger boarding. Forty-five boardings per month were assumed for the monthly pass example given above.

Benefits from Savings in Coin-Handling Costs

Fare prepayment can reduce coin-handling costs, particularly the costs of sorting and counting coins and dollar bills, repairing fareboxes, and reducing theft. According to several studies (5,6), these savings vary from $0.010 to $0.016 per prepaid passenger trip and are reflected in the data given above.

Benefits from Interest on Advanced Cash Flow

One feature of prepaid plans is that fares are collected in advance of services being delivered. This positive cash flow from prepayment reduces the financial requirements of the transit agency, requirements met by a combination of funds from municipal taxes and debt obligations. Assuming a uniform daily trip rate per prepaid user and purchase of prepayment instruments the day before their use, the interest cash accrual may be estimated as follows:

$$I = (1/2) \times (\text{prepayment plan price}) \times [(\text{days covered in plan}) - 1.0] \times (i/365) \quad (1)$$

where i/365 corresponds to the daily interest rate. The estimated benefits shown above assume 10 percent borrowing rates.

EVIDENCE ON RIDERSHIP AND REVENUE IMPACTS

As stated earlier, the attractiveness of fare prepayment plans depends to a great extent on their ability to stem cash revenue losses due to diversion of cash riders to discounted prepayment plans. This section analyzes the evidence on ridership impacts.

Lack of Significant Generation of New Riders

Most of the discussion on ridership impacts fails to

Table 1. Average monthly trip rates for pass holders in selected cities.

City	Pass Type	Avg Monthly Trip Rate (linked trips)
Milwaukee	Weekly	62.4
Chicago		
Chicago Transit Authority	Monthly	59.5
Commuter rail[a]	Monthly	39.0
Honolulu[b]	Monthly	56.5
Ottawa-Carleton[c]	Monthly	55.8
St. Louis[d]	Monthly	53.6
San Francisco	Monthly	51.2
Sacramento (employee)	Monthly	46.4
Oakland		
Alameda-Contra Costa Transit Authority (AC) local	Monthly	45.2
AC Transbay	Monthly	44.0
Duluth (employee)	Monthly	46.9
Tucson		
Adult	Monthly	41.6
College student	Semester/monthly	43.5
High school student	Monthly	37.0
Elderly and handicapped reduced fare	Monthly	52.9

Note: Data on the remaining sites were obtained through conversations with agencies in each city and from unpublished documents.

[a] D. Jhaveri (7).
[b] A. Fujita, T. Hamayasu, P. Ho, and J. Magapdi (8).
[c] Bureau of Management Consulting (2, p. 29).
[d] W.C. Gilman and Co. (13, p. II).

distinguish between new riders and new transit trips by previous transit riders. The generation of new transit riders is rare and hardly ever does it exceed 5 percent of the previous adult cash riders. However, in contrast to the lack of generation of new riders, fare prepayment does significantly increase the number of off-peak transit trips taken by previous cash riders. For example, in the OC Transpo experience (2), only 2 percent of the trips by pass purchasers were trips diverted from other modes and another 2 percent were trips generated by new riders. On the other hand, although peak-period travel by pass purchasers was unaffected, off-peak travel of previous cash riders increased 24 percent. Thus the main effect of fare prepayment is to divert cash riders.

High Trip Rates of Pass Purchasers

A major problem in designing proper pricing policies for time-limited fare prepayment plans such as passes is presented by the high trip rates experienced by pass riders in American cities. In small transit systems such as those operating in Duluth, Tucson, and Sacramento, the average monthly trip rate of pass holders ranges from 42 to 46. In larger systems operating in such cities as San Francisco, St. Louis, Honolulu, and Ottawa-Carleton, the average monthly trip rates of pass purchasers ranges from 51 to 56. Thus, in larger systems in which the opportunities for off-peak and weekend transit travel are the greatest, the average monthly trip rates are more than 50. In Milwaukee and Chicago, the average number of unlinked monthly trips is 91 and 107, corresponding to linked monthly trip rates of 59 and 62, respectively. This means that current practices of offering large discounts to monthly pass riders by pricing passes at under 40 trips per month are self-defeating since they will not encourage a significant amount of new riders and will lead to a diversion of cash riders and therefore to significant revenue losses. A compilation of the trip rates of pass holders in selected American cities is presented in Table 1.

Demand Elasticities of Prepaid Fares

The knowledge of fare elasticities of demand for transit fare prepayment is limited. The scant information available shows that pass riders are more inelastic than cash fare or ticket riders, reflecting the fact that pass users are frequent riders who, like commuters, exhibit low fare elasticities. Examples of pass elasticities that have been estimated include values of -0.36 for Jacksonville (9) and -0.18 to -0.38 for the Sacramento employer-promoted monthly pass program (10). Although these elasticity estimates are reasonable, the econometric demand work conducted on pass programs has failed to analyze passes as rate structures. The result of this improper reflection of the econometrics of rate structures is to confuse the price and income effects of passes on demand.

As an aid in the design of fare prepayment demonstrations, we developed a simple sketch-planning model, presented below. The sketch-planning model is based on information from 62 independent fare prepayment programs. The model was estimated by using regression analysis and predicts the market penetration of a given fare prepayment plan as a function of its effective discount over cash fare, its length or period of validity, and the number of competing plans. Two versions of the sketch model are available and are shown below:

$$\begin{aligned} \text{PEN RATE} = {} & 23.6229 + \underset{(0.1437)}{0.4323}\,(\text{DISC}) - \underset{(0.1172)}{0.2509}\,(\text{TRIPS}) \\ & - \underset{(1.3238)}{2.8006}\,(\text{COMP}) + \underset{(0.1388)}{0.3341}\,[(\text{TRIPS})(\text{DISC})/100] \\ & R^2 = 0.5899 \end{aligned} \tag{2a}$$

$$\begin{aligned} \text{PEN RATE} = {} & 22.6930 + \underset{(0.1363)}{0.5169}\,(\text{DISC}) - \underset{(0.1204)}{0.2217}\,(\text{TRIPS}) \\ & + \underset{(0.000\,25)}{0.000\,52}\,(\text{TRIPS})^2 - \underset{(1.3390)}{2.8572}\,(\text{COMP}) \quad R^2 = 0.5805 \end{aligned} \tag{2b}$$

where the figures in parentheses are the standard errors of the respective regression coefficients and

PEN RATE = market penetration rate expressed in percentage terms (e.g., 20 percent penetration), which denotes the percentage of prepayment plan riders to total transit riders;
DISC = percent discount over base fare (e.g., 5 percent discount); in case of implicit discount plan (e.g., monthly or semester pass), the discount rate is computed based on the average trip rate noted below;
TRIPS = quantity of trips associated with plan; time-limited pass plans have been interpreted as follows for the purpose of quantifying this important variable: semester pass = 140 trips, monthly pass = 40 trips, weekly pass = 10 trips, day pass = 2 trips; and
COMP = number of competing fare prepayment plans offered by the transit agency.

These equations have successfully predicted the penetration rates in several transit agencies not in the original data base. However, they should not be used to test either extremely long-term plans (e.g., annual passes) or very large discounts (i.e., more than 50 percent).

ECONOMIC PRINCIPLES IN DESIGN OF PASS PLANS

Part of the reason why so many fare prepayment plans fail to contribute significantly to revenues is their failure to incorporate economic principles of rate structure design. Weekly and monthly passes, for example, are analogous to two-part tariffs with a fixed charge equivalent to the pass price and a quantity or marginal charge of zero. This section concentrates on the design of pass plans, the most misunderstood of all plans. The pricing of tickets and punch cards is not different from that of regular cash fares and therefore is not discussed here.

Price Discrimination Through Pass Programs

In the context of transit pricing, price discrimination refers to the fact that an identical service may be priced differently to reflect differences in demand characteristics, such as trip rate, trip purpose, and income. This deviation from single-fare pricing requires two main conditions to be effective, namely, the preclusion of resale, since otherwise riders in the low-fare market could resell to those in the high-fare market, and the ability to divide transit riders by their elasticities of demand. Thus, there must be some easily identifiable method by which the transit agency can separate those riders that belong in the high-fare market. Of course, some monopolistic elements must also be present.

The design of price-discriminating pass programs may be approached by applying the principles of rate structure design. The price structure of fare prepayment instruments can be considered similar to a two-part tariff where the consumer pays a certain fixed price (E) as entry into the system, after which as many rides as desired may be purchased at a constant per-unit price (π). The cost (p) of the prepayment instrument to the user may be represented by the following equation:

$$p = E + \pi(q) \tag{3}$$

where q is the number of transit rides.

In the case of weekly and monthly passes, the above expression reverts to the following one:

$$p = E, \text{ since } \pi = 0 \tag{4}$$

whereas for tickets and punch cards the cost to the user becomes as follows:

$$p = \pi(q), \text{ since } E = 0 \tag{5}$$

It is worth noticing the difference in demand impacts between E (the pass price) and π (the quantity or marginal charge). The demand effects of changes in E are analogous to the effects of lump-sum taxes and or income transfers. That is, the effect of changes in E is analogous to income effects. Thus, the demand elasticity of changes in the fixed charges of pass plans is similar to the income elasticity of demand. On the other hand, changes in π are analogous to the price elasticity of demand. This distinction is important because most of the demand work on pass programs conducted to date has confused these two very distinct effects, which, as shown by Taylor (11), should be separated and properly identified in the demand-estimation procedure.

Graphical Exposition

The design principles of pass programs are discussed in a graphical exposition presented in Figure 1a and 1b. The graphical exposition makes extensive use of the concept of consumer surplus. However, as shown by Willig (12), no significant biases occur because of the use of consumer-surplus concepts at the low ratios (i.e., less than 2 percent) of pass expenditures to disposable personal incomes that characterize pass programs. Let Figure 1a portray constant-utility demand curves for transit by two prototypes of transit riders: the demand D_1 of a frequent rider and D_2 of an infrequent rider. If the price per ride for a ticket, punch card, or even cash fare is set at $\pi = p_1$, then the frequent rider takes p_1a_1 rides (i.e., 34 trips), whereas the infrequent rider takes p_1b_1 rides (i.e., 8 trips). The frequent rider's consumer surplus is given by ap_1a_1 and bp_1b_1 is the consumer surplus of the infrequent rider.

Suppose a monthly pass program is introduced at a fixed charge of E = x. The effect of the fixed price is to shift downward the demand curve of the frequent rider to D_1' (this shift being analogous to the income effect of a lump-sum tax, assuming that transit is a normal good). If the frequent rider purchases the pass, a_1' rides will be consumed (i.e., 45 trips) since the quantity charge is $\pi = 0$. That is, once the frequent rider buys the pass, transit use will be expanded until saturation is reached, given the opportunities for making use of transit, especially during off-peak hours. The maximum fixed charge that the transit agency can ask for the monthly pass and still get the frequent rider to purchase it is $E \leq a_1'oa' - a_1p_1a$. Thus, the frequent rider will purchase the pass if the willingness to pay for the 45 trips--denoted in function D_1' by the area $a_1'oa'$--exceeds the previous consumer surplus a_1p_1a by more than the pass price E = x.

However, this maximum pass price that can be extracted from the frequent rider is larger than the one that can be extracted from the infrequent rider reflected by D_2. The infrequent rider will not purchase the pass if the price of the pass is set at the maximum the frequent rider is willing to pay.

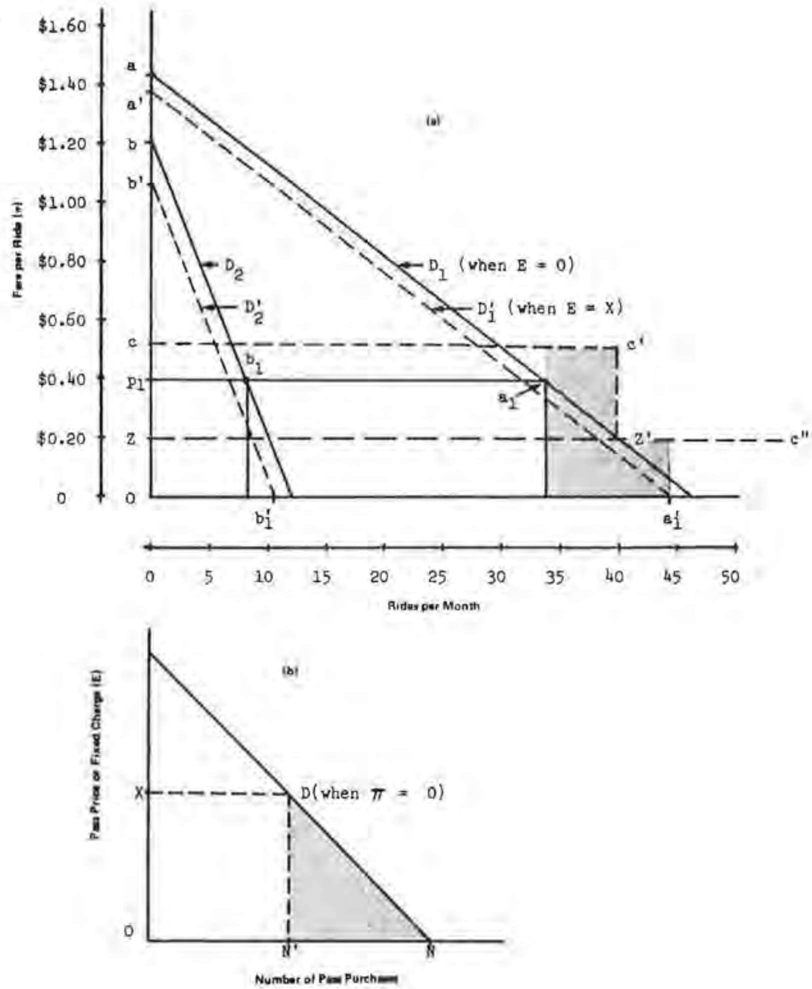
In Figure 1a, the maximum price the infrequent rider is willing to pay is given by $b_1'ob' - bp_1b_1$, which is much less than the amount the frequent rider is willing to pay. Therefore, given the choice of purchasing the pass at a price of E = x or paying cash at p_1, the infrequent rider will opt for the cash fare. This is an important difference between the public utility case and the transit case, since in the case of transit the rider has the choice of self-selection among several possible rate structures. Because of the difficulty in designing one pass program common to both frequent and infrequent riders, the preferred solution is to design a pass program for the frequent rider and a ticket program or cash fares for the infrequent rider.

The design of optimal pass prices or fixed charges also requires consideration of the cost impacts of increased travel by pass purchasers. At cash fares of p_1, the marginal cost function represented by cc'c" in Figure 1a exceeds the fare line p_1. After the frequent rider purchases the pass, monthly rides are increased to a_1', thereby adding extra costs represented by the shaded area in Figure 1a. These extra costs have to be financed by the revenues from pass sales.

Figure 1b shows the demand curve that can be derived by varying the pass price E (for a given level of π). When the pass price is E = 0 (i.e., the free pass), ON consumers will purchase the pass. As the price increases to E = x, fewer passes are purchased, with the infrequent riders (represented by N'N) shifting to cash fares.

As shown in Figure 1a, the lower the initial fare the greater the level of consumer surplus that can be extracted from the pass price or fixed charge.

Figure 1. (a) Demand for transit rides under alternative rate structures. (b) Demand for pass purchases.



The transit rider benefits from the pass in that the quantity or marginal charge is now zero, or below the cash fare. This encourages additional transit rides by the pass purchaser. Through the proper choice of pass prices, losses occurring due to the low variable or quantity charges can be removed. Customers who cannot financially afford the fixed charge of the monthly pass continue to purchase transit rides through the uniform cash fare structure and are therefore not affected.

Numerical Example

A frequent problem encountered in the design of pass plans is underpricing. This underpricing fails to account for the loss of cash fares and the extra costs of new rides. The result is a high revenue loss due to a faulty pricing strategy. Design of optimal pass programs requires information on the trip rate distribution of riders, estimates of demand functions for groups of riders, and estimates of marginal costs. Tables 2 and 3 present a numerical example for a hypothetical transit system with trip rate distribution data from the St. Louis monthly pass study (13).

Table 3 represents the demand functions calibrated for each ridership group. A fare elasticity of -0.30 was assumed in accordance with our previous work (14), while an income elasticity of +0.10 was assumed following Grey (15). Also presented in this table is the trip rate for the pass purchasers and the amount that would make each consumer group indifferent between the pass price and cash fare.

Suppose now that the transit agency prices the pass at 40 rides (40 rides x 0.40 = $16.00), which is the general convention in the industry. In this case all riders taking 36 trips or more would benefit by shifting from cash fares to monthly pass use, with the transit agency losing a significant amount of cash revenue. For example, the riders taking 60 monthly trips are indifferent between paying a monthly pass price of $28.90 or paying cash. Setting the pass price at 40 rides provides them with windfall gains.

As shown in Table 3, as the price of the pass increases, pass penetration decreases and the average trip rate by pass holders increases. The decision on the level of optimal pass price in the example depends on the marginal costs per off-peak ride generated by the monthly pass plan. If off-peak riders can be transported at zero or negligible extra cost, the optimal pass price would be $18.65 or 46 rides, which would generate the most net revenue of the pass price alternatives. However, if the marginal cost of off-peak travel is half the cash fare, only the highest pass price (i.e., $32.65) can be accepted. Thus, the optimal pass price depends on several factors, including the distribution of riders and the marginal costs of off-peak service. However, it is self-defeating to offer the monthly pass at a price level comparable with that of 40 monthly rides or less. The result will be a net revenue loss.

It is important to remember that transit-pass purchasers exhibit diminishing marginal utility or benefit of pass use, especially after 40-45 trips

Table 2. Trip-rate demand functions and willingness to pay for monthly pass on hypothetical transit system.

No. of Monthly Trips	Proportion of Cash Riders (%)	Trip Demand Functions[a] $\ln T = A_0 - b(P) + c \ln (Y - E)$	Trip Rate for Pass Purchasers[b]	Pass Price That Makes Rider Indifferent with Cash Fares[c] ($)
70	0.5	$\ln T = 3.8395 - 0.75(P) + 0.10 \ln (Y - E)$	94	32.65
56	2.0	$\ln T = 3.6164 - 0.75(P) + 0.10 \ln (Y - E)$	75	26.10
50	3.0	$\ln T = 3.5030 - 0.75(P) + 0.10 \ln (Y - E)$	67	22.30
44	4.0	$\ln T = 3.3752 - 0.75(P) + 0.10 \ln (Y - E)$	59	20.50
40	25.0	$\ln T = 3.2799 - 0.75(P) + 0.10 \ln (Y - E)$	54	18.65
36	11.5	$\ln T = 3.1745 - 0.75(P) + 0.10 \ln (Y - E)$	48	16.77
32	12.0	$\ln T = 3.0567 - 0.75(P) + 0.10 \ln (Y - E)$	43	14.92
28	1.0	$\ln T = 2.9232 - 0.75(P) + 0.10 \ln (Y - E)$	38	13.05
24	8.0	$\ln T = 2.7691 - 0.75(P) + 0.10 \ln (Y - E)$	32	11.19
20	7.0	$\ln T = 2.5867 - 0.75(P) + 0.10 \ln (Y - E)$	27	9.32
16	8.0	$\ln T = 2.3636 - 0.75(P) + 0.10 \ln (Y - E)$	22	7.45
12	2.0	$\ln T = 2.0759 - 0.75(P) + 0\ 10 \ln (Y - E)$	16	5.59
8	10.0	$\ln T = 1.6704 - 0.75(P) + 0.10 \ln (Y - E)$	11	3.72
4	2.0	$\ln T = 0.9773 - 0.75(P) + 0.10 \ln (Y - E)$	5	1.84
2	4.0	$\ln T = 0.2841 - 0.75(P) + 0.10 \ln (Y - E)$	3	0.50

[a] The trip demand function was calibrated at a fare elasticity of −0.30 and an income elasticity of +0.10. Fare levels of $0.40 and monthly incomes of $1200 were assumed. In this equation, T represents the monthly transit rides, P represents the cash fare, E represents the pass price or fixed charge, and Y represents the monthly household disposable income. The functional form was selected to represent elasticities that increase as functions of the price level, properly reflecting derived demand considerations.
[b] Calculated at the pass price of $16.00 (E = 16 in the above demand equation).
[c] Calculated by integrating each respective demand curve between the trip rate for regular fares and that of pass riders.

Table 3. Net revenue effects or alternative monthly pass-pricing policies in hypothetical transit system.

Pass Price (or fixed charge) ($)	Percentage of Pass Purchasers[a]	Average Monthly Rides per Pass Purchaser	Pass Penetration Rate (%)	New Monthly Rides Generated	Monthly Revenues from Pass Sales ($)	Monthly Revenue Losses from Cash Fare Diversions ($)	Net Revenue from Pass Sales and Cash Fare Losses ($)
16.77	40.25	56	65.0	580	675.0	672.00	3.00
18.65	22.0	59	20.7	336	410.30	389.20	21.10
20.50	7.5	69	17.1	131	153.75	154.00	(0.25)
23.30	4.0	74	10.1	75	93.20	88.8	4.4
26.10	1.5	81	4.2	31	39.10	36.4	2.7
32.65	0.25	94	0.8	6	8.20	7.0	1.2

[a] The pass purchasers are those whose willingness to pay for the monthly pass (or indifference level in Table 2) exceeds the actual pass price. In trip-frequency groupings where willingness to pay (or indifference level) and the pass price are equal, these riders are shared equally between cash fares and monthly passes.

per month have been taken. The fact that more trips are taken with passes than without them reflects the fact that the marginal charge to the pass holder is zero and the user will ride transit until satiated. In most cases, however, the marginal cost of providing transit service is not zero.

The actual benefit or utility of frequent transit travel depends on the quality of service provided. In very small systems and on commuter services where the opportunities for off-peak and weekend transit travel are small, the monthly average trip rate will be in the low 40s and monthly passes can then be priced at 42-52 times the base fare. In larger systems where more off-peak travel opportunities exist, monthly passes should be priced between 52 and 60 times the base fare. For very large transit properties where the number of monthly unlinked trips can be greater than 100 (as in Chicago), monthly passes should be priced at more than 60 base-fare trips.

PRICE DISCRIMINATION THROUGH TWO-PART PERMIT PLANS

The monthly-pass example illustrates the fact that pass programs are seldom self-financing. This occurs because the quantity or marginal charge is zero, which in turn encourages pass users to ride until satiated. The extra travel increases the off-peak costs of the transit system.

Analysts of the economic welfare aspects of two-part tariffs, such as Gabor (16,17), argue that optimal two-part tariffs require the quantity or marginal charge--in an economic welfare sense--to be set equal to the marginal costs that each user imposes on the system. In terms of transit planning this argues for a two-part tariff where the marginal charge is set equal to the marginal off-peak transit costs, whereas the fixed charge is set at the maximum willingness to pay or consumer surplus. Since the concept of a nonzero quantity or marginal charge cannot be accommodated with a pass program (whose marginal charge is zero), it is necessary to look elsewhere for the design of fare prepayment plans that meet the economic welfare criteria (also called the Pareto optimum criteria) of economics.

Fortunately, the often-ignored permit plans provide an ideal implementation procedure for the economic welfare underpinnings of optimal two-part tariffs. In the first place, permit plans provide a relatively easy method of discriminating among user groups with different transit-fare elasticities, such as commuters, students, the elderly, the handicapped, and the poor. Moreover, the permit plan could be redesigned into a two-part permit plan charging a fixed charge for a permit to travel at a quantity charge equal to the marginal off-peak cost. The quantity or marginal charge could be paid with tickets in order to preserve the economic advantages of fare prepayment plans.

In terms of the demand functions presented in Figure 1, the implementation of the proposed permit plan would mean charging a marginal or quantity charge of 0Z equal to the off-peak marginal cost for each rider purchasing the permit at the maximum-willingness-to-pay level represented by the area $P_1a_1Z'Z$. To capture the cash-avoidance benefits of fare prepayment, the marginal charge could be paid through tickets. The infrequent rider would still be left to pay in cash fares or be served through another short-term ticket plan. The impact of the two-part permit plans would be to reduce the number of generated rides below that of pass programs while still capturing a significant consumer surplus. In this fashion, fare prepayment revenues are increased with a modest increase in off-peak travel. An on-going UMTA demonstration of permit plans in Bridgeport, Connecticut, may throw more light on the promise of this concept.

Two-part permit plans offer another advantage over pass programs in that they provide an excellent adjunct or supplement to distance-based fare systems, enabling distance-based fares to reflect the demand elasticities unique to each user group. More experimentation with their use is in order.

CONCLUSIONS

This analysis of the costs and returns of transit fare prepayment reveals that when properly priced, fare prepayment plans can improve a transit system's performance and operating ratio. If care and attention are taken to convert dwell-time savings into operating-cost savings through proper schedule changes and to capture all cash-flow benefits, transit fare prepayment plans can be cost-effective alternatives to cash fares.

Today, however, most fare prepayment plans are improperly priced. As a general rule--depending on the mix of frequent and infrequent riders--two types of prepayment plans should be made available to the general public: (a) a short-term ticket plan (punch cards should be avoided) to serve infrequent riders and (b) a long-term plan, such as a monthly pass, for more frequent transit users. The short-term, trip-limited plan should be priced identically to the cash fare (i.e., no discounts). The price of monthly passes should depend on the trip frequency distribution of transit riders and the opportunities for extra travel during the off-peak period at low marginal costs. There may also be opportunities for implementing fare prepayment plans for specific user groups.

Although each transit agency is unique in terms of its ridership distribution and off-peak travel possibilities, some guidelines on the proper pricing of monthly passes can be advanced. In large transit systems where off-peak service levels are relatively high, monthly passes should be priced between 52 and 60 rides. In some cases, passes can be priced at levels more than 60 times the base fare. In smaller systems where the potential for greater off-peak travel is limited, monthly passes could be priced at lower levels of 42-52 rides. Nevertheless, transit operators must be sure that there is enough off-peak capacity to serve the extra off-peak ridership generated by the program. If monthly passes are priced at or below 40 rides, revenue losses will occur, thereby exacerbating the difficult financial position of transit agencies. Monthly and weekly passes are valuable products in which transit riders have shown immense interest. There is no cost-effective reason for transit operators to have to offer permanent discounts over the equivalent cash fares in order to sell transit passes. It should be evident that the full opportunities for adopting fare prepayment plans in a cost-effective fashion have barely been explored in American transit systems.

ACKNOWLEDGMENT

This research was funded by UMTA. The study was prepared for the Pricing Division of the Office of Service and Methods Demonstrations within UMTA's Office of Transportation Management and Demonstrations. Opinions expressed in the article are ours.

REFERENCES

1. Transit Fare Prepayment. UMTA, Aug. 1976.
2. Bureau of Management Consulting. The Ottawa Bus-Pass System: An Examination of Effects. Urban Transportation Research Branch, Transport Canada, Montreal, Sept. 1977.
3. The Costs of Transit Fare Prepayment Programs: A Parametric Cost Analysis. Ecosometrics, Inc., Bethesda, MD, Res. Rept. 125-7, Feb. 1982.
4. Wilbur Smith and Associates. Bus Use of Highways: Planning and Design Guidelines. NCHRP, Rept. 155, 1975.
5. Charles River Associates. An Evaluation of Free Transit Service. U.S. Department of Transportation, Aug. 1968.
6. Booz-Allen and Hamilton, Inc. Impact of Fare Collection on Bus Design. UMTA, April 30, 1979.
7. D. Jhaveri. Analysis of Revenue-Ridership Relationship of Selected RTA Carriers. TRB, Transportation Research Record 799, 1981, pp. 26-28.
8. A. Fujita, T. Hamayasu, P. Ho, and J. Magapdi. Fare Changes and Prepaid Pass Programs: Honolulu's Experience. TRB, Transportation Research Record 799, 1981, pp. 32-38.
9. Charles River Associates, Inc. Jacksonville Fare and TFP Study. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, April 1978.
10. E. Page. Factors That Influence Choice Among Transit Payment Methods: A Study of Pass Use in Sacramento. TRB, Transportation Research Record 799, 1981, pp. 20-26.
11. L.D. Taylor. The Demand for Electricity: A Survey. Bell Journal of Economics. Vol. 6, No. 1, Spring 1975.
12. R.D. Willig. Consumer Surplus Without Apology. American Economic Review, Sept. 1976.
13. W.C. Gilman and Co. A Survey to Evaluate the Criteria Which Influence the Purchase and Use of a Monthly Pass. Bi-State System of St. Louis, MO-IL, Dec. 1964.
14. A.M. Lago, P.D. Mayworm, and J.M. McEnroe. Transit Ridership Responsiveness to Fare Changes. Traffic Quarterly, Jan. 1981, p. 134.
15. A. Grey. Urban Fares Policy. D.C. Heath and Co., Lexington, MA, 1975.
16. A. Gabor. A Note on Block Tariffs. Review of Economic Studies, Vol. 23, 1955-1956.
17. A. Gabor. Peak Loads and Efficient Pricing: Further Comment. Quarterly Journal of Economics, Aug. 1960.

Publication of this paper sponsored by Committee on Transit Service Characteristics.