boxes can be eliminated. Such current use results in a considerable inefficiency in revenue collection.

### Transit Commitment

RT feels that monthly-pass users, particularly persons purchasing their passes at work, are more committed to transit than cash users. Several demonstration findings support this belief, although the evidence is not yet fully conclusive. First, cash payers who bought passes during the 25 percent discount increased their transit use by 10 percent. Second, among regular transit users surveyed over a 16-month period, pass users were slightly less likely to stop using transit than cash users. Finally, pass users, and particularly pass users buying their passes at work, were quickest to return to transit following the May 1979 strike.

Since almost 30 percent of Sacramento's regular transit riders stop using transit each year, any strategy that lowers this dropout rate even slightly is highly desirable. In recognition of this, RT increased the relative discount of monthly passes compared with daily cash payment in September 1979, when all fares were raised.

### Administrative Costs

The costs of administering the monthly-pass program were perceived by both the transit operator and the individual employers to be small. RT's administrative costs totaled only about $0.03/bus trip taken with a pass (exclusive of special demonstration costs). Through the results of the second demonstration, RT hopes to further reduce this figure. While the unit costs incurred by employers were higher ($0.50/pass, or about $0.01/bus trip), only a handful of the more than 60 firms that participated in the program felt that their costs were significant.

### Recruitment of Employers

The initial recruitment of employers to sell passes proved to be extremely disappointing, with few employers viewing the program as beneficial. The Sacramento experience demonstrated that a strong incentive is necessary to induce employer involvement. Generating employee interest, rather than appealing only to management, is also very helpful. Little success can be expected if a transit operator only appeals to an employer's social conscience, even if the employer heavily subsidizes employee parking, as was the case for most Sacramento employers.

### Payroll Deduction

The initial demonstration plan called for employers to sell passes by payroll deduction, but this requirement was subsequently relaxed, and the vast majority of firms sold passes over-the-counter. Payroll deduction was viewed as a burdensome technique, and few employers offered it. Among those who did offer payroll deduction, pass sales per employee were 15-20 percent of those occurring at firms selling passes over-the-counter. The implied long-term commitment of signing up for payroll deduction discouraged pass use, and this sales technique is not very promising for transit fare prepayment.

### Pass Sales and Ridership Impacts

Although monthly-pass sales and transit ridership increased substantially over the course of the first demonstration, much of the increase can be attributed to two exogenous events that occurred during this time: a fare restructuring that decreased the relative cost of passes and an increase in gasoline prices that encouraged transit ridership. Nevertheless, the employer pass program, including the three-month 25 percent discount, caused a long-term increase in total monthly-pass sales of 6 percent. Transit ridership among participating employees rose by 4.5 percent, resulting in an 0.7 percent increase in systemwide ridership. While these gains are not spectacular, the additional revenue that they brought in far exceeded the lost revenue due to the three-month pass promotion discount.

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# Factors That Influence Choice Among Transit Payment Methods: A Study of Pass Use in Sacramento

ELIZABETH PAGE

During the 1960s, as exact change requirements were instituted on most transit systems, many operators developed transit fare prepayment (TFP) programs as a convenience to their passengers. In recent years, operators have broadened their views of these programs and attention has focused on identification of the market for TFP, determination of the magnitude of any benefits realized by purchaser or operator, and development of ways to promote its use. In this paper, a choice model is developed and estimated to explain the factors that influence a transit rider's decision to purchase a monthly pass or to pay cash fare on a daily basis. The population under study is a sample of employees at worksites participating in an Urban Mass Transportation Administration service and methods demonstration project of employer-sponsored pass sales. The estimation results indicate that the initial cash outlay required to purchase a

**monthly pass may be a deterrent to its use by some persons with limited incomes. The most important determinant of all transit rider's choices between paying cash fare and buying a pass is the relative cost of the two payment methods. Low-income persons are more sensitive than high-income persons to the savings that can be realized when a pass is used.**

During the 1960s, as exact change requirements were instituted on most U.S. transit systems, many operators developed transit fare prepayment programs as a convenience to their passengers. Transit fare prepayment (TFP) encompasses all methods of paying for transit trips before they are actually taken and includes passes, tickets, punch cards, and tokens. As of 1976, 93 percent of U.S. transit systems use some form of TFP instrument and many systems offer a wide variety of prepaid plans.

Generally, prepaid instruments fall into two categories--those that allow an unlimited number of transit boardings within a specified time interval and those that allow a specified number of boardings over an unlimited period of time. The first type--passes--varies in duration from one day to one year and may carry time-of-day restrictions. Tickets, punch cards, and tokens--the second type--are commonly sold in various denominations (e.g., single-ride, 20-ride).

When tickets, punch cards, and tokens are not discounted in price relative to cash fare, the attractiveness of the payment method to the purchaser is due to the convenience of not having to carry exact change and to the ability to budget for transit trips over a desired time interval. Passes, on the other hand, offer a potential discount to the purchaser. The savings (relative to cash fare) that are realized by a purchaser will depend on the frequency of use within the time period--the more the pass is used, the lower will be the cost per trip. The transit rider, then, in deciding whether or not to purchase a pass, must weigh his or her expected discount (based on anticipated transit use) against the probability that actual transit use will be less than the break-even level. Therefore, the pass purchaser bears a set of risks. Actual transit use may be less than expected due to illness, weather conditions, family matters, and so forth. On the other hand, external factors may also cause actual transit use to be greater than expected, resulting in the realization of unanticipated savings. In addition to the potential discount that they provide, passes also eliminate the need for exact change and serve as a budgetary mechanism for transit trips.

In recent years, operators have broadened their view of prepayment programs. Instead of being considered solely as a convenience item for riders, transit fare prepayment is also being viewed as a marketing mechanism for transit. TFP users may exhibit a stronger commitment to transit than do cash payers and may be more likely to continue using it regularly. Since the marginal cost of an additional bus trip is zero when a pass is held, pass purchasers may use transit more frequently than do cash payers. In addition to these ridership benefits, TFP has been associated with improved cash flow and lower cash management costs for the operator, shortened boarding times, and heightened public awareness of transit. Consequently, attention has focused on identification of the market for TFP, determination of the magnitude of any benefits realized by purchaser or operator, and development of ways to promote its use.

The Office of Service and Methods Demonstrations of the Urban Mass Transportation Administration (UMTA) has sponsored a number of demonstrations in recent years that were designed to address these questions. In Austin, Texas, and Phoenix, Arizona, the impacts of short-term price reductions on longer-term purchasing behavior, transit riding, and the transit operator were examined. In Tucson, Arizona, marketing efforts are being directed at university students--a group felt to be particularly receptive to transit and to prepayment. Finally, demonstration projects in Jacksonville, Florida, and Sacramento, California, tested the viability and effectiveness of enlisting the support of employers in selling and distributing monthly passes at the work place. Data from the Sacramento project were used in this study of the factors that influence a transit rider's decision to purchase a monthly pass.

## SITE AND DEMONSTRATION PROJECT DESCRIPTION

Sacramento is a rapidly growing, low-density city of 262 000 persons. A key feature of the area is a heavy reliance on public employment. Two U.S. Air Force bases are located in Sacramento; consequently, it has twice as many government workers as the national average and relatively little manufacturing employment. Personal income in Sacramento is higher than the national average, as is automobile ownership. Public transit use is low compared with cities of comparable size, although transit ridership roughly doubled during the mid-1970s. An extensive freeway system provides fast automobile travel.

Sacramento's Regional Transit (RT) uses 223 buses to transport approximately 45 000 passengers/weekday. During the demonstration period the base fare was $0.35, and riders from several outlying cities were charged $0.50 inbound and $0.35 outbound. Monthly passes and individual ride tokens were sold at 35 outlets throughout the Sacramento area (e.g., banks, schools, stores), and daily passes could be purchased on board the buses. Table 1 gives the fare structure prior to September 1979.

RT's monthly pass is transferable--purchasers are permitted to lend their passes to family members or friends when they are not using it. The break-even trip frequency for both base and zonal monthly passes was 34. Any additional trips taken with the pass resulted in an average cost per trip that was below the standard fare. A pass purchaser who commuted to and from work every day by bus and took no additional trips realized a 14 percent savings over cash fare. Approximately 20 percent of all boarding passengers show a monthly pass.

Although there are no free or reduced-cost transfer fares, a passenger making a round trip by transit can purchase a daily pass (with exact change) when boarding the bus and thereby obtain free transferring privileges. Persons using daily passes can be assumed to be those using the pass for convenience only, those having to transfer, and those boarding the bus more than twice that day. Since the time interval over which the trips must be taken is so short and the cash outlay is so low, daily-pass purchasers bear little risk of not making the anticipated number of trips and breaking even.

The Sacramento demonstration involved the solicitation of 52 employers to participate in the distribution of monthly passes at the work place. A three-month discount of $3.00/pass was offered at the beginning of the program to generate employer participation and to stimulate employee interest. Few employers chose to subsidize the pass or to permit payment through payroll deduction. Evaluation issues concerned the effectiveness of employer-sponsored pass distribution in attracting new transit users, inducing cash payers to switch to passes, and increasing transit ridership. Sacramento was also considered an excellent site in which to study the factors that determine a transit

**Table 1. RT fare structure.**

| Type of Fare | Cost ($) |
|---|---|
| Cash fare | |
| Base | 0.35 |
| Youth, elderly, and handicapped | 0.15 |
| Outlying cities (inbound only) | 0.50 |
| Tokens | 0.35 |
| Daily pass | |
| Base | 0.70 |
| Youth, elderly, and handicapped | 0.30 |
| Outlying cities (inbound only) | 0.85 |
| Monthly pass | |
| Base | 12.00 |
| Elderly and handicapped | 3.00 |
| Outlying cities | 15.00 |

rider's choice between purchasing a monthly pass or paying cash fare.

## DATA

The data used in this study were obtained in a self-completion mail survey of employees at participating employers conducted in late August 1979. Survey forms were distributed at 28 firms that had been selling passes for approximately 1 year. Of the 22 130 surveys distributed, 4556 were returned--resulting in a response rate of 20.6 percent.

Since the decision of whether or not to purchase a pass or to pay cash fare is relevant only for those who have already made the decision to travel by transit, the sample was first reduced to study of the 1104 respondents who reported that they ride the bus at least once per month. Second, transit riders who normally purchase tokens or daily passes were culled from the data set. Finally, when all individuals who had missing data for any of the relevant variables were excluded, a sample of 732 respondents remained.

## MODEL

Econometric methods were chosen instead of cross-classification techniques for analysis of the payment method decision because they permit apportionment of the variance in purchasing among a host of relevant variables. By explicitly controlling for multiple influences, the multivariate approach is better than cross-classification for testing hypotheses regarding causality. The coefficients of the model indicate the marginal contribution of the independent variables to the variance in the dependent variable. When formulated on a sound theoretical basis, an econometric model can be used to explain and, ultimately, to predict phenomena such as pass-purchasing behavior. The objective of this study was to develop sound explanatory econometric models of pass-purchasing behavior.

The model specified for this study was of the binary logit structural form with alternatives corresponding to "normally purchases a monthly pass" and "normally pays cash fare." The model was estimated on a sample of transit riders whose employers sell monthly passes at the work place and who normally buy a monthly pass or pay cash for their transit trips. The model form estimated for the study was $\text{Prob(Pass)} = 1/[1+\exp(U_c-U_p)]$ where $U_c$ refers to utility associated with paying cash and $U_p$ refers to utility associated with using a pass.

The logit model is particularly well-suited to this analysis. The basic axiom of behavioral disaggregate choice theory is that the individual, the decision-making unit, chooses from a set of discrete alternatives the one with the greatest attractiveness, or utility. This choice process is appropriate in analyzing a transit rider's decision regarding fare payment method. The individual evaluates the convenience and the relative cost of each method and chooses the one that is most attractive. An individual's observed choice, then, may be explained by the attributes of the alternatives and selected characteristics of the individual. Of the available disaggregate choice models, logit is theoretically appealing and relatively easy to estimate. It permits evaluation of the impacts of various policies--for example, pass price, on the share of transit riders who use passes and pay cash. Elasticities of the probability of purchasing a pass with respect to included variables are also obtained.

## UTILITY FUNCTION

It was postulated that an individual's decision regarding purchase of a monthly pass would be strongly influenced by the anticipated savings relative to cash fare. Those who would save money by using a pass are more likely to buy one than are those who would not save money. Ideally, construction of such a variable would include information regarding an individual's expected use of transit over the coming month. This information was not available from the employee survey. Respondents were asked to report their transit trip frequency for work and nonwork purposes during a normal week, and this frequency was multiplied by 4.3 and used as a proxy variable for anticipated frequency. The variables SAVPOS and SAVNEG were constructed by multiplying each respondent's number of monthly transit boarding times the base fare and subtracting the price of the pass. For those individuals who would realize positive savings with the pass, the value of the savings was included in SAVPOS and a value of 0 was assigned to SAVNEG. For those individuals who did not travel enough to make purchase of the monthly pass economical, the loss (a negative value) became the variable SAVNEG. A zero was assigned to SAVPOS.

It is important to note the shortcomings of employing reported trip frequency as a proxy for anticipated frequency. If holding a pass induces increased trip making, the trips are overvalued when they are multiplied by the base fare and included in the savings variables as determinants of payment method. This overvaluation may have been partially offset by excluding trips made by other persons with the purchaser's pass. It was felt that an individual's primary consideration in deciding whether or not to purchase a pass is the savings realized through his or her own trip making, not that of other persons. To the extent that trips made by one's family, friends, or coworkers are valued at some level greater than zero, the saving realized with a pass is understated.

Separate variables were entered into the utility function for negative and for positive savings because it was hypothesized that the magnitude of their effects on the probability of purchasing a pass would differ. It was expected that a unit increase in SAVNEG would have a greater impact on pass purchasing than would a unit increase in SAVPOS. Therefore, a positive coefficient for SAVPOS and a positive coefficient of greater magnitude for SAVNEG were expected.

As noted earlier, a prospective pass purchaser weights his or her expected discount against the probability that actual transit use will be greater or less than anticipated. Presumably the decision maker considers an anticipated trip frequency and recognizes that there is some variance associated with it. In formulating the model, an attempt was made to construct variables that would represent the

effect of the variance of anticipated frequency on purchase choice. The percentage of total boardings for work trips was included for this reason.

An individual who uses the bus exclusively for work trips presumably has a smaller variance associated with anticipated trip frequency. The number of work trips required in a month can be easily predicted by the decision maker. The actual number of work trips taken can, of course, be less than anticipated due to illness or travel but will rarely exceed the anticipated number. Therefore, the decision maker can calculate the savings associated with pass use and bears only a small risk of actual transit use falling below the level. Similarly, there is little chance that actual use will be greater than anticipated.

On the other hand, an individual who uses the bus for both work and nonwork purposes has a greater variance associated with anticipated transit use. Although the individual bears a greater risk of actual transit use falling below the anticipated level, he or she also has the potential for reaping unanticipated windfall with a pass. The probability of making unplanned nonwork trips may serve as an inducement to buying a pass.

The ratio of work trips to total trips, WKRATIO, was therefore included in the model with its expected sign uncertain. If the first effect predominates, persons with higher work ratios purchase passes, and WKRATIO would exhibit a positive sign. If the second effect is dominant, however, persons who take a large percentage of nonwork trips purchase passes and the coefficient would have a negative sign.

Another variable that was formulated to represent the risk associated with purchase of a pass was the number of automobiles per household worker. It was hypothesized that the fewer alternatives available to a transit rider, the more likely he or she would be to make the anticipated number of trips by bus. Therefore, a negative coefficient was expected for CARSPW.

It has been suggested that the relatively large cash outlay required to purchase monthly passes may be a barrier to their use by low-income persons. In the Austin demonstration, 10 percent of the nonusers who were interviewed reported that the primary reason they did not use passes was "I can only afford to pay for one bus trip at a time." If the cash-outlay barrier is significant, the flow of benefits from monthly passes is regressive, accruing to those persons with higher incomes. To test the hypothesis that low-income persons are less likely to buy passes than high-income persons, a household income dummy variable was included in the model. Since the respondents to the survey were all employed, very-low-income persons were not represented in the sample. The binary variable INCD was assigned a 1 for individuals who reported a total household income of $15 000 or less, zero otherwise. A negative coefficient would support the notion that the cash-outlay requirement is a significant deterrent to pass use by lower-income persons. A positive coefficient would not support this hypothesis and would indicate instead that low-income persons are more sensitive to the savings that could be realized by using a pass and, hence, more likely to purchase one.

Finally, a male-female dummy variable was included in the model. There were no expectations as to the sign of this variable, but it was intended to represent household decisions regarding access to family automobiles. If primary workers (predominantly male) have primary access to the family automobile, presumably their transit trip frequency would exhibit greater variance than would the secondary worker's. On the other hand, if the secondary worker has primary access to the family automobile so that household-related trips may be made enroute to work, the secondary worker's transit trip frequency would exhibit greater variance. A significant coefficient on the dummy variable, MALE, could also indicate that males and females value the attributes to passes and cash fare differently.

## ESTIMATION RESULTS

The model was estimated by the maximum likelihood method and the results are presented in Table 2.

As was expected, the savings variables are of primary importance in explaining transit riders' choices between fare payment methods. The elasticity for those persons who do not ride transit often enough to break even with a pass is greater than for those persons who would realize savings by purchasing a monthly pass. Therefore, a unit decrease in the price of a pass (hence, a unit increase in savings) will have a greater impact on the choices of those who have negative savings.

In Figure 1, the choice probabilities predicted by the model for a range of values of the savings variables are illustrated. In estimation of the function, all other variables were evaluated at their means, and a weighted average of choice probabilities for lowand high-income persons was taken. The figure illustrates, for example, that an individual exhibiting mean values of the other variables who rides the bus infrequently enough so that he or she would lose $6.00/month by buying a pass has a 12 percent probability of buying one. If savings were increased (by either a reduction in the price of the pass or an increase in trip frequency) so that the monthly pass cost only $3.00 more than cash fare, the probability of choosing it would rise to 28 percent. If the same individual rides transit often enough so that a $3.00 savings over cash fare would be realized by buying a pass, the probability that it is chosen is 60 percent. If savings were increased to $6.00/month, the probability of choosing the pass would increase to 68 percent. Also, if he or she reported making the break-even number of trips each month, the probability of selecting the pass over cash fare would be 51 percent.

The estimation results indicate that low-income persons are somewhat less likely to buy passes than high-income persons. This could be due to the relatively high initial cost being a deterrent to its use by some employees with limited incomes. However, the low significance of this variable (80 percent level of confidence for a two-tailed test) leaves this interpretation open to debate. In addition, the model reveals that males are much less likely to buy passes than females. Since the automobile-availability coefficient is not significantly different from zero, this reflects a fundamental difference in the way men and women value cost savings and convenience rather than the male's access to household automobiles. The ratio of work trips to total trips has a coefficient close to zero. As noted earlier, two competing effects, neither dominant, are likely to have produced the small coefficient. Those who have high work-trip ratios buy passes because they can closely predict the savings that will be realized. On the other hand, those who have lower work-trip ratios buy passes because their potential for increased savings is greater. The presence of both these effects in the estimation sample probably resulted in the small coefficient.

Despite the model's overall goodness of fit and the fact that most of the coefficients exhibited the expected signs, it was hypothesized that the utility

**Table 2. A fare payment method choice model (binomial logit fitted by the maximum likelihood method) estimated on data collected in Sacramento.**

| Independent Variable | Estimated Coefficient | t-Statistic | Elasticity at the Mean |
|---|---|---|---|
| SAVPOS [monthly transit boardings times cash fare minus pass price (in cents)—positive values] | 0.117 | 4.65 | 0.25 |
| SAVNEG [monthly transit boardings times cash fare minus pass price (in cents)—negative values] | 0.336 | 6.92 | -0.35 |
| WKRATIO (monthly work trip boardings divided by total monthly boardings) | 0.054 | 0.113 | -0.02 |
| CARSPW (number of household cars divided by number of household workers) | -0.062 | -0.454 | -0.03 |
| YDINC (1 if annual household income is ≤$15 000; 0 otherwise) | -0.264 | -1.35 | -0.14 |
| MALE (1 if respondent is male; 0 if female) | -0.50 | -2.81 | -0.15 |
| CONSTANT | 0.412 | 0.762 | |

Notes: Likelihood ratio, 328.86.
Likelihood ratio index, 0.298.
Log likelihood for the model with the constant only, -551.58.
Log likelihood for the full model, -387.148.
Percentage correctly predicted, 76.
Number of people in sample who chose monthly pass, 363; cash fare, 369; total sample size, 732.

**Figure 1. Predicted probabilities of pass purchase.**

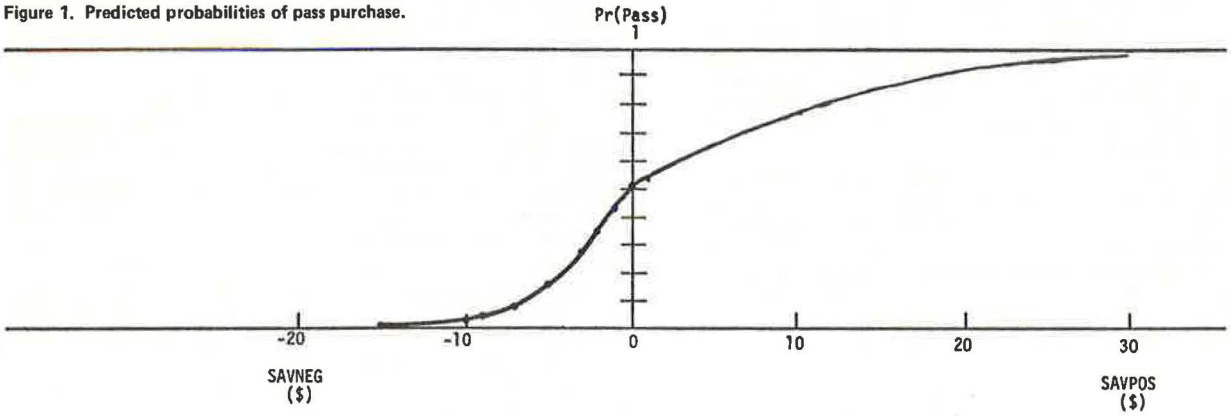


**Table 3. Unrestricted fare payment choice model (binomial logit fitted by the maximum likelihood method) estimated on two income groups in Sacramento.**

| | Household Income per Year | | | |
|---|---|---|---|---|
| | ≤$15 000 | | ≥$15 000 | |
| Independent Variable | Coefficient | t-Statistic | Coefficient | t-Statistic |
| SAVPOS [monthly transit boardings times cash fare minus pass price (in cents)—positive values] | 0.154 | 3.48 | 0.098 | 3.13 |
| SAVNEG [monthly transit boardings times cash fare minus pass price (in cents)—negative values] | 0.214 | 2.75 | 0.395 | 6.28 |
| WKRATIO (monthly work trip boardings divided by total monthly boardings) | -0.122 | -0.151 | -0.012 | -0.020 |
| CARSPW (number of household cars divided by number of household workers) | 0.131 | 0.475 | -0.126 | -0.796 |
| MALE (1 if respondent is male, 0 if female) | -0.722 | -2.14 | -0.411 | -1.93 |
| CONSTANT | 0.058 | 0.065 | 0.574 | 0.846 |

Notes: Log likelihood for the unrestricted model, -384.28.
Log likelihood for the restricted model, -387.15.
Likelihood ratio, 5.74, which is significant at the 95 percent confidence level.

**Table 4. Elasticities at the mean for the unrestricted model.**

| | Household Income per Year | |
|---|---|---|
| Variable | ≤$15 000 | ≥$15 000 |
| SAVPOS | 0.38 | 0.18 |
| SAVNEG | -0.18 | -0.29 |
| WKRATIO | -0.05 | -0.01 |
| CARSPW | 0.04 | -0.05 |
| MALE | -0.19 | -0.12 |

functions of low-income persons might differ in form from those with higher incomes, necessitating the estimation of separate models for the two groups. In particular, it was felt that low-income persons who could realize positive savings by purchasing a pass would be more responsive to small increases in savings than would other persons. Similarly, low-income persons for whom purchase of a pass is not economically practical were expected to be less responsive to small increases in savings than other persons.

To test this hypothesis, a model was estimated that relaxed the restriction that the value of the coefficients is the same for the two income groups. The model included a set of variables for low-income persons, which took on a value of 0 for high-income persons, and a set of variables for high-income persons, which took on a value of 0 for low-income persons. The results of this estimation are presented in Table 3. The elasticities of included variables, calculated at the means, are included in Table 4. The ratio of the log likelihoods for the former restricted model and this unrestricted model is significant at the 95 percent level of confidence, indicating that segmentation of the sample and estimation of separate coefficients for the two income groups contribute to the explanation of fare payment method choice.

As expected, the unrestricted model indicates that, at positive values of the savings variable,

the low-income group is more than twice as responsive to changes in savings than the high-income group. At negative values of savings, the low-income group is less responsive. Coupled with the results obtained in the initial estimation, the models indicate that low-income persons are less likely to buy passes than those with higher incomes because of the high initial cost, yet they are more responsive to improvements in the cash savings that can be realized through its use. No other significant differences between the groups were revealed in the unrestricted model. The automobile-availability elasticities have opposite signs but, since the coefficients are not significantly different from zero, the elasticities should not be considered reliable.

## CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The models estimated in this study provide some evidence that the initial cash outlay required to purchase a monthly pass may be a deterrent to its use by persons with limited incomes. The most important determinant of all transit rider's choices between paying cash fare and buying a pass is the relative cost of the two payment methods. Those who normally make more than the break-even number of trips in a month are more likely to buy passes than those who do not. Low-income persons in this group, even though they have a lower probability of purchasing a pass, are more responsive to improvements in the relative price of passes than are higher-income persons. Of those transit riders who do not use the bus often enough to make purchase of a monthly pass economical, the higher-income group is more responsive to improvements in the relative price of passes. Females are more likely to choose passes than males, reflecting a fundamental difference in the way the sexes value economy and convenience. It was hypothesized that transit riders who have ready access to other modes are less likely to buy passes because they perceive a greater risk of not making the anticipated number of trips and breaking even with a pass, but the models indicate that automobile ownership is not a significant factor in the payment method decision. Finally, a coefficient near zero was estimated for a variable that reflected work trips as a percentage of total trips, and it is suggested that two competing influences resulted in that outcome. Individuals who make almost exclusively work trips by bus buy passes because they can closely predict their actual transit use and savings to be realized with a pass. On the other hand, those who also use the bus for nonwork purposes buy passes because they have the potential for realizing unanticipated savings.

The insights into the fare payment method decision that were gained from the model are augmented by examining the reasons given by cash payers for their decision not to use passes. Of the study sample, 14 percent of the respondents gave reasons such as "I don't know much about them," "They are inconvenient to buy," and "I don't like to pay for transit rides that far in advance." A resounding 86 percent of the respondents stated that they do not buy passes because "I don't use the bus enough."

Closer examination of the 288 respondents who gave that reason reveals that 42 percent of them reported an average transit trip frequency higher than the break-even level. The savings over cash fare that could be realized by these 121 individuals range from $0.04 to $18.10; the mean is $2.74. Evidently a substantial number of transit riders fail to recognize that the monthly pass is the lower-cost alternative for them. To do so requires knowledge of the price of the pass, calculation of the break-even trip frequency, and comparison of the break-even level with expectations regarding future transit use.

Pass use then, could probably be increased significantly by developing marketing techniques that bridge the gaps in the transit rider's decision calculus. Instead of merely stating the price of the pass, advertising could stress that above the break-even point all rides are free. It is important to recognize, however, that raising the sophistication of riders concerning the break-even trip frequency and the savings function may have an adverse impact on system revenues.

From the standpoint of maximizing revenue, the best market in which to expand pass use is among riders who make less than the break-even number of trips and among those who will increase the frequency with which they use transit, especially during the off-peak period, in order to break even with a pass. However, increased sophistication among riders concerning the economies that can be realized with a pass should result in those who normally make more than the break-even number of trips choosing it. A loss in revenue equal to the fare times the number of trips taken above the break-even level results from each of these individuals who buys the pass. Therefore, it may not be in an operator's best interest to educate riders to make rational, well-informed decisions regarding fare payment method.

It would be of considerable interest to examine the factors that influence the demand for daily passes in Sacramento. The daily pass can be used purely as a substitute for cash, or may involve break-even considerations (with less risk involved) similar to the monthly pass. With the daily pass included in the choice set, it would be possible to properly evaluate the impact of transferring among vehicles on the fare payment method decision of a transit rider. However, in order to evaluate the relative cost of using daily passes, monthly passes, or cash it is essential to determine the number of days in a month that the bus is used. If a transit rider makes many trips in a month, but on a relatively small number of days, the daily pass may be the most economical payment medium. If the bus is used on most days in the month, the monthly pass is likely to be the low-cost alternative. A combination of methods may also be used. Thirty-two respondents in the study sample who regularly make transfers to complete their trips report that they usually pay a cash fare. Presumably, daily passes are used on days when transfers are made and cash fare is paid at other times. Proper evaluation of the choice among the three payment methods, then, requires the collection of data on transit use and payment method by a sample of respondents during every day of a month. A travel diary is suggested for this purpose.

It would be desirable to obtain information regarding pass purchasers' expected use of the pass over the coming month rather than rely on actual use. Comparison of anticipated use with actual use would permit estimation of induced trip making and would provide insight into the variance around expected frequency that is such an important determinant of choice among transit fare payment methods.

More research is needed to fully examine the impact of household income on the choice of payment method. The estimation results presented in this paper provide some weak evidence that, other factors held constant, low-income persons are less likely to purchase passes than higher-income persons. An important limitation of this data set in exploring this relationship, however, is the relatively high income of its members. Additional insight could be

gained through a random sample of transit riders instead of a sample of employees who use transit.

Finally, as stated at the outset, the objective of this study was to develop sound explanatory econometric models of pass-purchasing behavior. The estimation results presented here provide significant insight into the transit payment method decision. Given an adequate data set, the models developed here could be readily adapted as tools for predicting demand for alternative payment options.

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*Abridgment*

# Analysis of Revenue-Ridership Relationship of Selected RTA Carriers

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**Revenue and ridership are the two most important indicators of transit system performance. Many management decisions are based on them. How reliable and accurate are these data? How does one affect the other? How do they compare among carriers? Using percentage changes in the time-series of revenue and ridership and ordinary least squares, it is shown that the approach provides a valuable tool to examine the consistency of data and compare structural relationship of revenue and ridership of carriers without regard to size, location, or other attributes. It is noted that, with one exception, all Regional Transportation Authority carriers showed marginal revenue productivity of riders constant but less than one for the study period. Six of the 12 carriers, most small ones, showed poor to very poor revenue-ridership relationship.**

Revenue and ridership are the two important indicators of transit operation. The two indexes, however, may not move in the same direction or at the same rate. Strikes, accidents, change in fares or composition of riders, and faulty and inconsistent reporting of revenue or ridership may account for discrepancies.

This study addresses the question of reliability of joint ridership-revenue data of 12 carriers of the Regional Transportation Authority (RTA) in Chicago. The carriers include the Chicago Transit Authority's bus and rail operations, five commuter railroads, and five suburban bus systems. The management objectives include understanding of (a) the expected change in revenue given the change in ridership and vice versa and (b) the evaluation of current and past ridership-revenue data.

It is noted that many carriers, including those in the RTA system, report significant increase in ridership without comparable growth in revenue. Could this be because of the increasing number of discount riders, such as elderly, handicapped, and monthly-pass users, that allow for unlimited rides at a far lower rate than the single fares? Or, are our data suspect?

## STUDY APPROACH AND METHODOLOGY

This paper attempts to determine the association between revenue and ridership through a study of linear relationships between sequential changes in the time-series of revenue and ridership. The suggested statistical approach provides confidence intervals for accepting or rejecting the data based on past relationships. The study also helps to compare the structural relationship of revenue and ridership of RTA carriers irrespective of size, location, fare levels, or other agency-specific characteristics. The method allows the measurement of changes in relationships over time.

Simple revenue and ridership time-series are good descriptives of the transit systems but do not reveal their dynamic relationship. Further, seasonality and other fluctuations make them not very useful. They usually fail the statistical requirement of independence of observations. Further, because of size differences, comparison of carriers is not feasible. This is an important practical drawback that does not permit the establishment of norms against which performance of carriers may be measured.

The time-series method of percentage change in revenue and ridership overcomes these objections and provides readily interpretable criteria for inter-carrier comparisons and assessment of revenue-ridership data. Even when significant changes such as fare increase take place, the series are not affected except for the observation following the change. The study approach aids in the detection of shifts in the ridership-revenue relationship.

Regression analysis of percentage-change data has an appealing analytical and practical meaning. For instance, in the absence of subsidized and special fares, every percentage change in ridership results in an identical percentage change in revenue. Each carrier can be measured against this unit state in terms of percentage change in revenue associated with a percentage change in riders.

As illustrated in Figure 1, in unit state, the regression intercept is zero and the slope of the regression line is 1, that is, each percentage change in ridership is expected to result, on the average, in a percentage change in revenue. A consistent revenue-ridership reporting system will always suggest an intercept zero, or nearly so, while the slope may vary from zero to 1, but non-zero for all practical purposes because a zero value would indicate no relationship between revenue and ridership. The value of the slope is determined by the average fare level of new riders, if the system is growing, or riders leaving the system, in case of ridership decline, relative to the base riders and revenue. If new riders' average fare is greater than that of the base riders, the slope value ex-