Monitoring Performance of New Bus Routes

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Route-level demand models and service criteria are used by many transit systems to plan new service. Systematic criteria have also been developed for evaluating performance after service is initiated. A major source of uncertainty in new route introductions is the time needed for ridership to build to levels that are comparable with the productivities of well-established or mature routes. Decisions about route retention and elimination can be improved by analyzing the time required for route ridership to stabilize. Empirical results from the suburban Chicago region are used to illustrate a method for analyzing the time required for new routes to achieve stable levels of ridership and for summarizing the range of variation that can be expected when new routes are implemented. A simple method for estimating ultimate ridership based on early trends is also presented. These examples serve as illustrations of the range of variation observed in ridership on new routes and of an easy-to-use method for analyzing the time required for new routes to achieve stable ridership levels. Limitations and suggestions for further research are also noted.

The task of planning and implementing new bus routes in suburban growth centers presents interesting technical and political problems. Service planners are asked to develop estimates of potential ridership for use in prioritizing routes for implementation and calculating cost-revenue impacts. These estimates often become the subject of debate, and planners may be called on to defend projections before groups of citizens, elected officials, and transit system administrators. Once a route is implemented, performance is often closely monitored by oversight boards, and management may be asked to either eliminate or retain the route on the basis of ridership figures from the first few months of operation.

A number of tools have been developed to provide ridership forecasts for new routes and to structure the process of evaluating new routes after implementation. These tools include density and population criteria for providing transit service, models that forecast ridership on the basis of the performance of similar routes, and protocols for dropping or retaining low-productivity routes.

A major source of uncertainty in new route introductions is the time needed for ridership to build to levels that are comparable to the productivities of well-established or mature routes. Some routes are "instant successes." Others take several years to reach acceptable ridership levels, even with aggressive marketing efforts. The premise of this paper is that decisions about route retention and elimination can be improved by analyzing the time required for route ridership to stabilize. Empirical results from the suburban Chicago region showing the range of variation that can be expected when new routes are implemented are presented. A simple method for estimating ultimate ridership based on early trends is also presented, and a sample application to reduce uncertainty about ultimate usage levels is given. These examples serve as illustrations of the range of variation observed in ridership on new routes and of an easy-to-use method for analyzing the time required for new routes to achieve stable ridership levels. Limitations and suggestions for further research are also noted.

PROBLEM CONTEXT

The results and techniques presented are based on work done by the University of Illinois at Chicago for Pace. Pace operates as a division of the Chicago Regional Transportation Authority under Illinois law and is responsible for providing regular bus and paratransit service for the six-county area surrounding Chicago. New service planning at Pace involves local community leaders, Pace's Board of Directors, public hearings, and staff work by operations planners and research and marketing analysts. Figure 1 illustrates the process used to consider new service requests (*1*).

Like many transit systems, Pace has established warrants that are used in screening potential routes and setting levels of service. These are based on population and employment density. The basic warrant requires a threshold density of 4,000 persons per square mile in the service area (employees plus residents) as a condition for hourly service on fixed routes. A threshold density of 2,500 is required for feeder service. In addition to the basic warrant, Pace requires that the service area include either (a) eight contiguous quarter-sections having a density of 4,000 or more or (b) a 6 sq mi area in which 75 percent of the quarter-sections have densities of 4,000 or more.

In addition to these warrants, Pace uses a ranking system to prioritize new service introductions. Proposals for new routes are ranked on the basis of revenue and ridership expectations, demographics, and operational considerations. Table 1 summarizes the factors that are considered in this ranking process.

Route-level demand models based on the performance of existing routes and the demographics of service areas are used to estimate ridership for proposed routes (2). These models are based on a multiple-regression approach similar to that used in other transit systems (*3*).

Once service is initiated on a new route, Pace monitors performance and conducts evaluations after 6 months and again after 1 year of operation. A negative review at the 6-month point triggers intensive informational and marketing activities. A negative review at the 1-year point is followed by discussion

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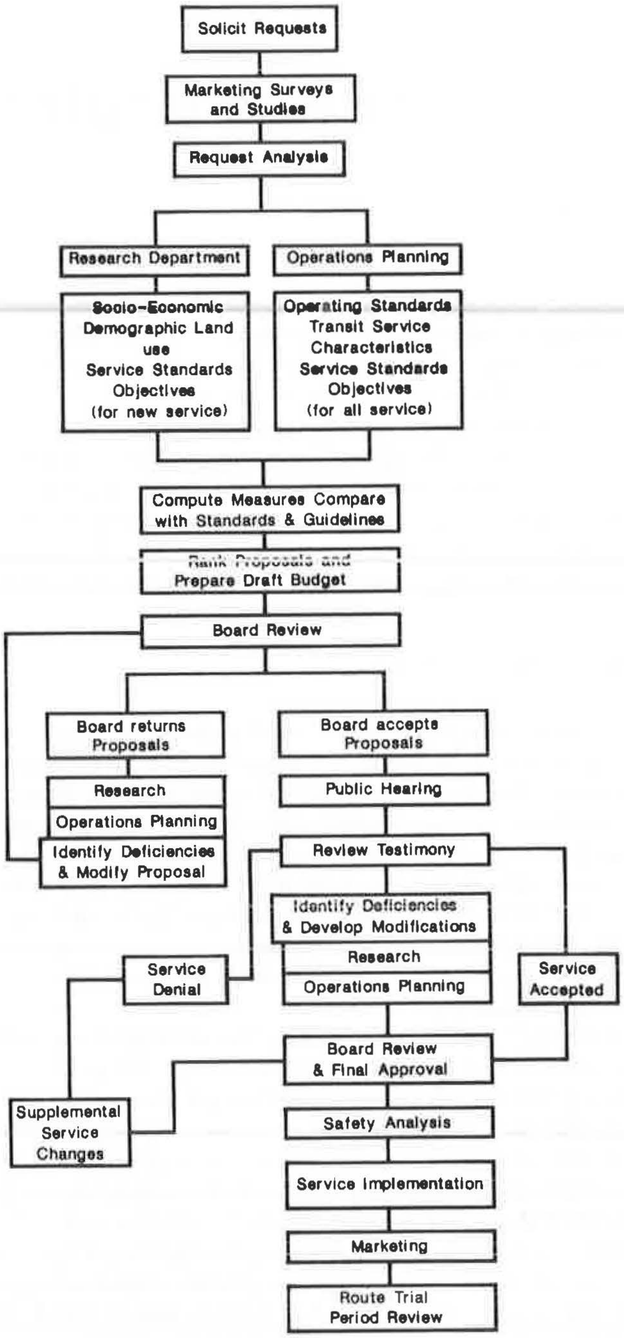

FIGURE 1 Review process for new service requests (*1*, Appendix I).

TABLE 1 CRITERIA FOR RANKING NEW ROUTE PROPOSALS (*1*, p. 6)

Criterion	Weighting Factor
Project revenue	1/3
Projected ridership	
Population and employment density	
Demographic characteristics	1/3
Area served	1/3
Cost of service	
Potential for improving operations	
Vehicle availability	

with elected officials of the area served by the route, possible service changes, and possible elimination in Month 15.

The criteria used to evaluate newly introduced routes are based on vehicle productivity and farebox recovery ratio indicators. After 6 months of operation, routes are expected to achieve productivities that are 20 to 25 percent of other routes operating in comparable areas. After 1 year of operation, routes are expected to have productivities that are 40 to 50 percent of other routes and to have farebox recovery ratios that meet similar standards. Figure 2 illustrates the process used in new route evaluations.

The procedures just described do not state absolute conditions or timetables for termination of low-productivity routes. They mandate performance reviews and consultation, but do not require elimination of low-productivity routes. This can result in rather lengthy and expensive attempts to preserve service in response to vocal citizens groups or elected officials who argue that each community should receive its "fair share" of transit service based on contributions generated by local sales tax revenues.

PURPOSE OF ANALYSIS

The analysis reported in this paper was performed to develop a tool for estimating the length of time required for new bus routes to achieve a stable level of ridership and for predicting the likely value of this ridership level. The results that are presented are intended to illustrate an approach that can be implemented quickly, using manual methods of analysis. Monthly route-level ridership data for 21 Pace bus routes were used in this study. These routes were identified by Pace's staff as new routes that had been introduced since 1980. Although it may be that results obtained from these data cannot be generalized to other urban areas, the approach that is demonstrated can.

PROCEDURES

Plots of route-level ridership over time were examined at the beginning of the study. After inspection of these plots, it was concluded that the patterns of the plots were sufficiently similar to permit the development of generalizations about the length of time required to achieve stable ridership and about the level of ridership that is achieved.

1. The first step was to identify the "ultimate" ridership levels of the routes in question. This was done by inspection of plots of route-level ridership data versus time. Although subjective judgments were involved in this step, inspection of the plots made it possible to disregard data points that were unusually high or low and compensate for seasonal variations. Figure 3 illustrates the process of identifying the ultimate ridership level of one route. All of the routes achieved a stable level of ridership during the time period studied. The impact of fare increases on ridership trends was minimal because the ridership on all routes had stabilized prior to a major fare increase that was implemented in 1986.
2. The second step involved
   - Computation of a daily average ridership level for each 3-mo period after introduction of each route,

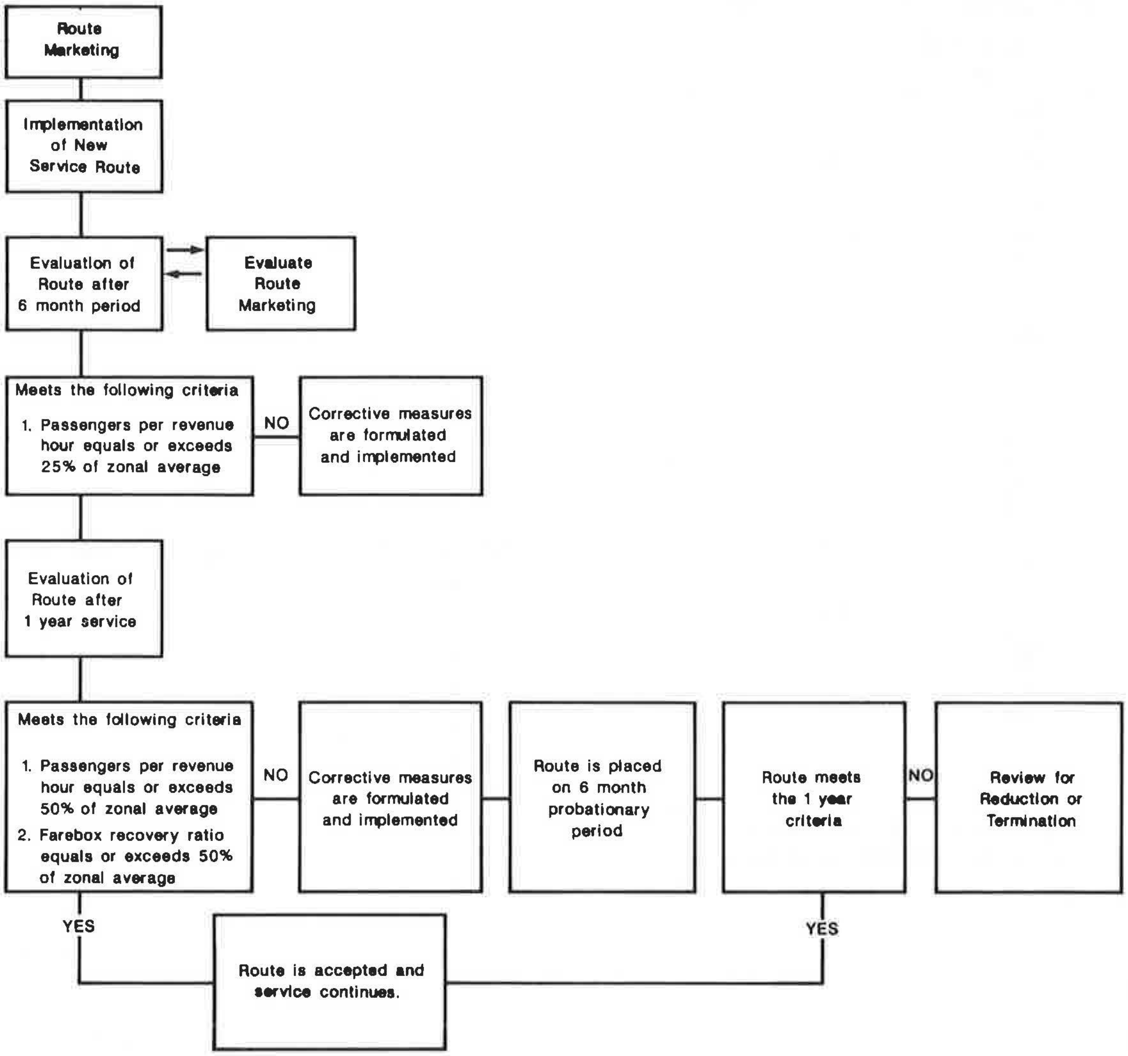

FIGURE 2 Evaluation of new route performance (*1*, Appendix III).

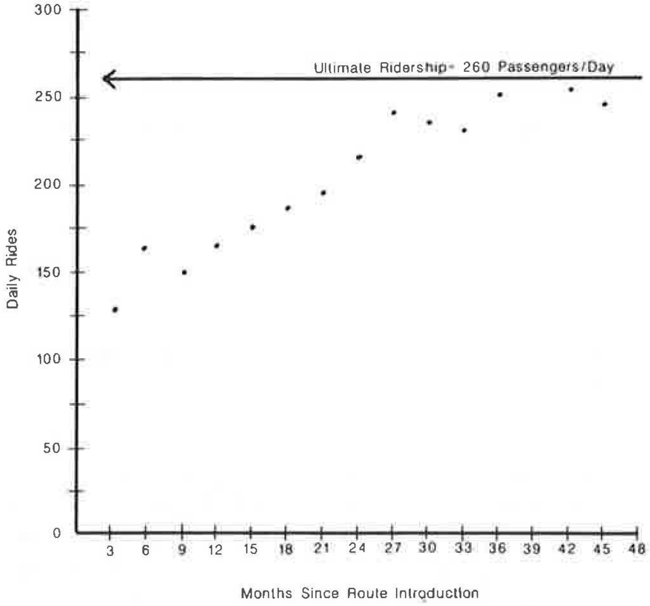

FIGURE 3 Determination of ultimate ridership level.

– Calculation of ratios to compare these averages with ultimate ridership levels, and

– Preparation of plots of these ratios against time.

The ratios computed in this step defined an index of ultimate ridership:

$$UI(i) = \frac{\text{estimated ultimate daily ridership level}}{\text{average daily ridership level for quarter } i}$$

Table 2 provides an abbreviated example of the calculation of this index, and Figure 4 shows a plot of the index versus time.

3. In response to questions about how long it takes to achieve stable ridership, additional plots were developed to display the percentage of ultimate ridership carried in each quarter. These plots are closely related to the plots of *UI* versus time. In fact, the percentage is simply the reciprocal of the index:

$$\text{Percentage of ultimate ridership carried in quarter } i = \frac{100\%}{UI(i)}$$

Figure 5 gives a sample plot for one route.

TABLE 2 CALCULATION OF ULTIMATE RIDERSHIP INDEX

Month	Average Daily Ridership	Quarterly Average	*UI*(*i*)[a]
1	116	–	–
2	139	–	–
3	131	129	2.01
4	159	–	–
5	157	–	–
6	160	159	1.63
7	150	–	–
8	146	–	–
9	156	151	1.72
10	164	–	–
11	165	–	–
12	168	165	1.57
13	173	–	–
14	188	–	–
15	164	175	1.48
16	172	–	–
17	187	–	–
18	193	184	1.41
19	190	–	–
20	196	–	–
21	196	194	1.34
22	221	–	–
22	228	–	–
23	228	–	–
24	243	230	1.13
.	.	.	.
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NOTE: Only 24 mo are shown for the sake of brevity.

[a] *UI*(*i*) is based on an ultimate ridership level of 260 passengers per day.

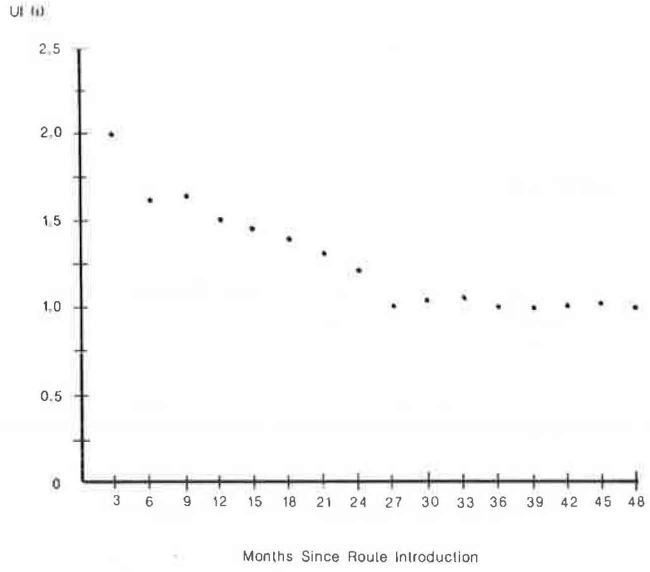

FIGURE 4 Plot of ultimate ridership index versus time.

RESULTS

Ridership statistics for each new bus route were analyzed using the procedures just presented. A summary of these analyses was prepared by graphing the median, interquartile range, and extreme values of the indices and percentages. Figure 6 summarizes the percentage of ultimate ridership carried for each quarter. Figure 7 summarizes calculated values for the ultimate ridership index (*UI*).

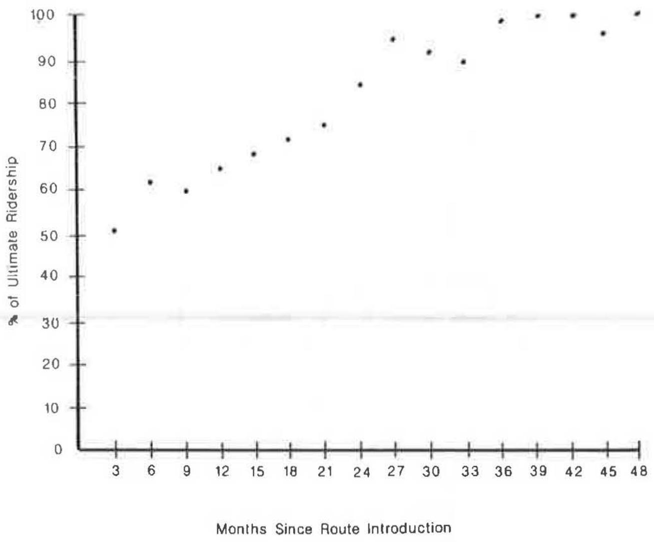

FIGURE 5 Plot of percentage of ultimate ridership carried per quarter.

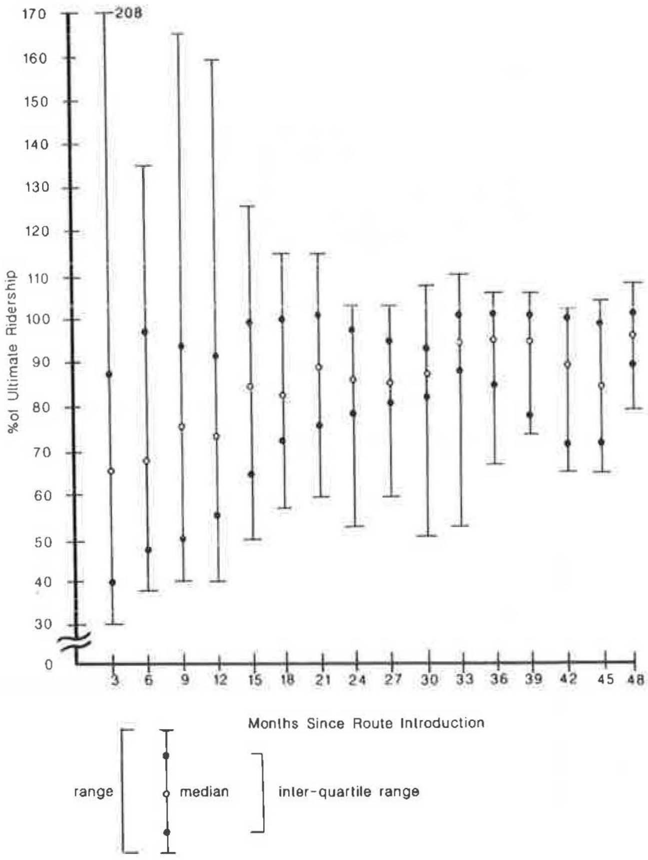

FIGURE 6 Percentage of ultimate ridership attained by quarter.

The results shown in the figures clearly indicate that there is a wide variation in the rate at which ridership builds to its ultimate level. In some cases, this is due to subsequent introduction of other, interconnected routes. But in others it may be due to slow dissemination of information or persistence in travel habits. In any case, the variation apparent in these results

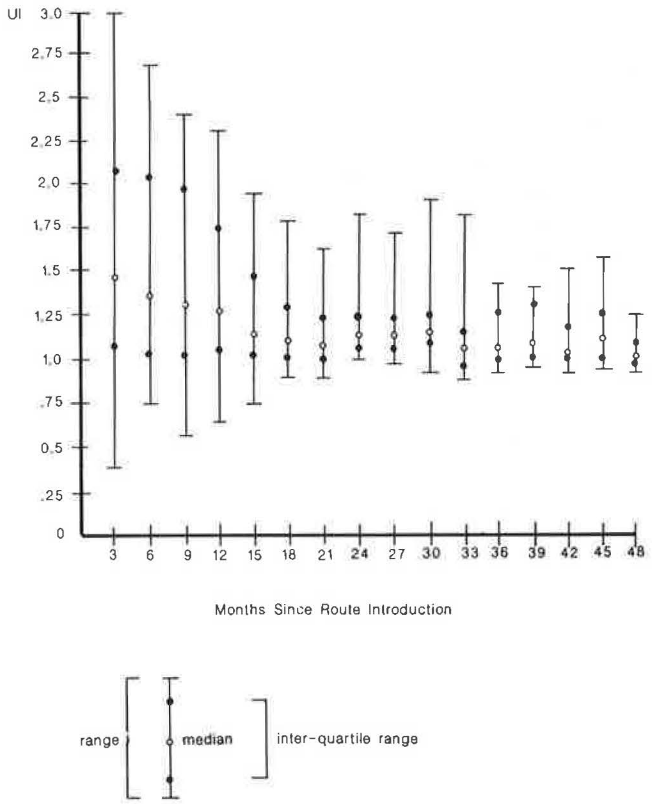

FIGURE 7 Indices for predicting ultimate ridership level.

indicates that discretionary provisions in route evaluation criteria are advisable and that additional analyses should be conducted to control for these factors based on local experience. Nevertheless, the convergence of the interquartile ranges suggests that, at least for Pace, a 2-year trial period should be adequate to evaluate new routes. It is a simple matter to recompute the indices for alternative time horizons. Two-year indices were in fact developed for the Pace data (*4*), but other time horizons may be appropriate depending on local conditions.

SAMPLE APPLICATIONS

To provide an example of the use of the ultimate ridership forecasting index *UI*, assume that a route has an average daily ridership of 200 for its fourth quarter of operation. Referring to Figure 7, we see that the median *UI* index for the fourth quarter of operation is 1.25. The extremes are 0.6 and 2.3. The interquartile range is 1.05 to 1.7.

Using the interquartile range, it can be forecast that the route in question will most likely have a daily ridership between 210 and 340 after the end of 5 years. Sample calculation:

1.05 × 200 = 210

1.7 × 200 = 340

In the extreme worst-case scenario, the ridership might decline to 120. Sample calculation:

0.6 × 200 = 120

The most optimistic forecast is that the ultimate ridership might be 460. Sample calculation:

2.3 × 200 = 460

A point estimate is that the ridership would be 250. Sample calculation:

1.25 × 200 = 250.

DISCUSSION

The results presented in this paper are intended to document the variability in new route performance and demonstrate a simple manual procedure for projecting probable future performance levels. The results shown in this paper cannot necessarily be generalized to other urban areas or time frames because they are conditional on ceteris paribus assumptions about fare levels, hours of service, route configurations, gasoline prices, highway congestion, and parking supply.

It is possible to explicitly incorporate these factors in statistical time-series models of ridership at the route level. These models could then be used to assess the relative impact of variables other than time on the observed ridership trends and to estimate ridership trends under various changes in exogenous factors. A limited number of tests of these ceteris paribus assumptions were conducted using autoregressive models that incorporated fare levels, hours of service, and private transportation price indices. These tests suggested that fares, headways, and automobile costs may account for as much as 30 percent of the observed variation over time, meaning that the maturation or trend effect accounts for 70 percent of the change noted. However, multicollinearity involving time and cost indices made it difficult to interpret these results unambiguously. Inspection of time-series plots for individual routes indicated that level of service effects and fare changes may have been responsible for some of the trends noted, but there were counter-examples of routes that had absolutely no variation in fare or headway showing expected trends. Additional research to clarify these patterns is clearly warranted, and data from other properties could be examined for comparative purposes.

CONCLUSIONS

Like those of many other transit systems, Pace's approach to analyzing the demand for fixed-route bus service involves estimation of ridership levels on the basis of demographics and economic activity levels. This methodology and the practice of ranking proposals for new service according to established service criteria provide for effective assessments of the viability of potential routes prior to service introductions.

The results reported in this paper were developed using a straightforward method for estimating ridership on the basis of early experience with new routes. The approach that is illustrated can be used to summarize the experience of any transit agency with new route introductions. The method presented herein can be implemented easily during service experiments using local data to reduce the range of uncertainty about the future performance of new routes. Although it is not possible to predict ultimate ridership levels without error, it is hoped that the proposed method will enhance the quality of decisions about route retention.

Two opportunities for further research were identified in this paper. The first involves the application of time-series modeling techniques to control for the effects of parking supply, congestion, transit fares, and automobile costs, and to estimate a pure trend effect. This type of model could be used to develop projections similar to those illustrated here, with the added benefits that statistical confidence intervals for forecasts and sensitivity to policy and environmental factors could be derived. The second opportunity would involve assembly of similar data from other properties to test the generality of the results reported. This would also require that controls for exogenous influences be applied.

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