*Abridgment*

# Modeling Dilemma of Intercity Bus Transportation

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**The operating strategies employed by intercity bus carriers to serve rural communities have remained an enigma to those attempting to model the bus industry. Intercity bus transportation has been a blending of local transit and trunkline corridor services. Economic and demand-based models generally lack sufficient detail for investigating service along specific routes. City-pair and rural transit models have each addressed only a part of intercity bus transportation. Models that bridge the gulf that separates local from trunkline services will probably employ some understanding of supplier strategies to describe bus service levels at intermediate rural locations.**

The intercity bus transportation network in the United States is unique among public transportation modes. It serves not only the major urban centers but also many thousands of rural towns and hamlets in every part of the country. Service levels at cities and travel needs of intermediate rural communities have been integrated by carrier management strategies. The result has been a regulated subsystem that exhibits a balance of resources and demands.

## LEGACY OF REGULATION

A significant product of the regulatory environment has been the institutionalization of internal cross subsidies by using profitable services and routes to offset losses incurred on those routes that bear little passenger traffic. In this way many rural routes have been preserved where local travel demand alone has not supported service.

Infusion of direct governmental subsidies into the rural transit systems over the past two decades has generally not gone to aid intercity bus transportation. Recently some states have begun to offer direct assistance to private intercity carriers--operating subsidies, bus acquisitions, and station improvements. To the extent that direct subsidies have relieved private carriers of supporting unprofitable routes, the delicate regulated balance maintained through cross subsidies has possibly been disturbed. States need to engage in detailed planning efforts that will guide prudent use of any direct subsidies to the intercity bus system. Whereas the regulatory perspective has sought balance on a systemwide basis, policies of direct subsidization will likely be on a specific route-by-route basis.

## NEED FOR BETTER MODELING

The lack of effective modeling of intercity bus transportation to date is remarkable when we consider that more than 300 million trips are taken annually by intercity bus riders in the United States (1). Federal corridor studies have focused on long-distance movements between large metropolitan areas, usually in a multimodal context, and small, intermediate service points are overlooked. State and local planners have, on the other hand, generally studied city transit problems and small isolated rural systems. The interregional traffic movements have remained separated from local transportation analyses, possibly as a reflection of the effects of strong jurisdictional boundaries and specific funding restrictions.

The intercity bus transportation network relies on rural passengers and package express from small communities. Although the route network ties together the major cities and capitals of the country, more than 30 percent of the system users are believed to be rural residents (1). Knowledge of rural service levels offered by intercity bus carriers is especially important when evaluating the potential for additional bus service or the likely impacts of discontinued service.

Service to small communities can require substantial route deviation from the most direct path between metropolitan hubs. Any increases in distance, in turn, impose additional operating costs and create delays for long-distance travelers. Since 1973, the prices of fuel and labor have increased at rates that outpace increases in revenues (2). If this trend continues, more rural places will either lose service or be served less frequently as carriers try to trim costs.

Determinations of appropriate intercity bus service levels are made in adversary proceedings before a regulatory body. They are based, in large part, on (a) the financial health of the carrier over the entire system and (b) the intensity of local opinion. Quantitative measures of carrier operating strategies would be helpful in defining the relation of service frequency to local conditions. In contrast, regulatory commission hearings are often accompanied by emotional rancor and legal manipulations. Objective analysis of a carrier's rural service patterns would be useful in evaluating levels of service.

Unfortunately, the rural service strategies of individual intercity bus carriers are not well known nor are they easily quantified. Many service decisions are apparently derived from the gut feelings of company officers. This intuitive approach is one that can be understood only after many years of operating experience. Although the method may suffice the needs of individual companies on an ad hoc basis, it offers little in assisting transportation planners and regulatory professionals to understand carrier rural service strategies.

Designers of public transportation systems in rural areas should strive to work in harmony with existing regulated intercity transportation services. Doing this could avoid duplicative new public investments by seeking maximum social benefit through use of transportation services already in place. Overall, a better understanding of the workings of private providers of intercity public transportation could contribute toward effective allocation of limited public resources and would likely produce higher levels of service at lower cost. The programmatic impact could be reflected at the local, state, and federal levels of government.

### Shortcomings of Previous Studies

Conventional modeling approaches have not been very successful in describing or predicting intercity bus services. Perhaps this failure has been due to the complex superposition of local and long-distance travel, as well as the local service aberrations that result from the regulatory process. Previous investigations of intercity transportation have generally used a demand-based projection of travel needs or employed a distributive technique (e.g., modal split analysis) to prorate estimated corridor traffic among competing modes.

However, demand for intercity public transporta-

tion in rural communities is often too low to support regular and frequent service. An extensive network of high-quality roadways and near-universal ownership of private automobiles have taken a toll on rural public transportation systems. Demand levels for bus travel have dropped so low in many rural markets that they are no longer economical to serve. The cost of operating an intercity coach may require an average load of 12-18 passengers just to break even.

Rural loads are typically far below this level. It is not surprising that Greyhound Lines claims it operates at a loss on at least 67 percent of its route miles (8,9). However, the rural routes must be viewed in the context of the total system and are beneficial to the carrier if they contribute to overall system profitability. Thus, factors other than rural route loads must be examined to adequately explain the observed service levels at intermediate service points.

### Problems of Economic Approaches

It is possible to analyze the intercity bus industry by employing economic concepts (3). However, this type of analysis is not specific or direct enough to be applied at the individual route level of analysis needed at intermediate rural locations. Revenues and costs, for example, have been generally aggregated and used as a systemwide measure of performance (4).

Aggregated statistics do not permit identification of specific profitable and unprofitable routes. They also tend to obscure the location and presence of cross subsidies. A recent staff study by the Interstate Commerce Commission (2) concluded, but only through indirect means, that "cross subsidization exists within the industry". The picture is complicated because revenues and costs associated with charter, regular route, package express, and special services have been difficult to segregate from each other. These other bus services have become other possible sources of cross subsidization.

Clues to finding profitable and unprofitable routes might lie in the review of actual route load factors. Such information is usually considered proprietary, and carriers are often reluctant to divulge it except when in their self-interest to do so, as before administrative law proceedings of regulatory bodies. It would generally be inconclusive to make any determination of profitability at the route or service point level of analysis in cases of feeder traffic, heavy package express use, empty long-haul seats, or cross subsidization. Furthermore, costs, fares, and quantities of service are likely not to be determined by local market conditions but rather to be a reflection of overall system performance as weighed in the regulatory arena. For all of these reasons, it has become apparent that techniques associated with economics of the firm have only limited application at the route and service point level of analysis of an intercity bus system.

### Elevator Principle of Demand

Local demand for service is a poor indicator of the frequency of intercity bus service. Many rural places produce few passengers yet receive daily service. For meeting occasional demands en route, buses generally have sufficient unused seating to accommodate those who may desire service.

Because of the fixed size of the bus, unused capacity through intermediate points may be unavoidable and caused by what some in the industry call the elevator principle (6). The analogy simply relates a declining load factor, often observed when a bus leaves an urbanized area and heads cross-country, to what happens with an elevator in a tall building when it loads at the ground floor and discharges persons floor-by-floor as it ascends. Lower load factors create room for those persons that board at intermediate points. Of course, the reverse effect is noted as buses approach urbanized areas (or the elevator descends to the ground floor).

At rural service points, demand is likely to be unknown prior to bus arrival. However, through experience, carriers have learned the times, days, seasons, and directions of heavy loadings and can dispatch extra bus sections accordingly. For example, the number of trunkline bus-miles operated in California by Greyhound Lines during 1979 exceeded the scheduled bus-miles (as shown in timetables) by 60 percent (5,7), which reflects heavy use of extra-section buses.

## CITY-PAIR AND RURAL TRANSIT MODELS

The literature is replete with examples of city-pair demand modeling, ranging from direct applications of gravity principles to the sophisticated incorporation of specific travel attributes. For rural areas, by contrast, transit demand has often been estimated in the form of aggregate system use and based on demographic data to produce average trip rates per capita. Recent work by Burkhardt and Lago (10) introduced a level-of-service factor to the demand analysis for specific rural routes.

Unfortunately, neither the city-pair models nor the rural transit models have been adequate to furnish good estimates of intercity bus service at rural intermediate service points. City-pair models have focused only on larger cities and metropolitan centers. Rarely have they included towns under 2500 population. In California, for example, the median population of all towns served by intercity bus is 1100 persons. Intermodal comparisons that have included commercial air carriers have tended to exclude places under 10 000 population. Although omission of small places has permitted satisfactory demand projections to be made for air travel (11), intercity bus trips have been poorly represented. Perhaps this weak performance of city-pair models can be partly explained in the overlooking of short local trips and the amount of traffic contributed by rural intermediate service points.

Rural transit models have suffered at the other extreme and have not been able to incorporate long-distance trunkline bus traffic. They have been too localized with emphasis on small service networks, with little or no reference to the intercity bus system.

In summary, the need exists for new approaches in modeling those rural transportation services now provided by the intercity bus industry. Supply factors, as well as demand factors, are important to an understanding of an industry that can serve rural America and larger cities at the same time (12). The need for highest use of every available transportation resource is evident now as never before. Concerns about energy costs and availability and reductions in federal operating assistance give new emphasis to understanding and using the private sector and the intercity bus industry for meeting the future needs of rural mobility.

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# Intercity Bus Riders in Texas

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**This paper includes summary information obtained from an on-board intercity bus survey performed in selected locations throughout Texas. The purpose of the survey was to gain insight into the socioeconomic and travel characteristics of intercity bus passengers in Texas. The survey instrument was also designed to collect data on general attitudes concerning service and fares and to identify the features of the existing service that are most important in generating ridership. The first section of this paper presents the major findings of the on-board survey. Then the results are presented of a comparison between the results of this on-board survey and the results of an on-board survey conducted in Michigan in 1977. The most significant findings of the user survey were that mean trip length was longer than generally reported, that users are generally satisfied with current service, and that Texas intercity bus riders do not appear to be significantly different from those in other parts of the United States. A large portion (28 percent) of intercity bus riders do not have an automobile available for the trip. Trips are made infrequently (the median is 3 times/year). The most significant trip purpose is to visit friends (38 percent). Any improvement in service should focus on safety, on-time performance, and comfort.**

The Texas State Department of Highways and Public Transportation, with funding from the Federal Highway Administration, contracted with the Texas Transportation Institute to conduct an extensive study of the intercity bus industry. The study was prompted by interest expressed by operators in the state. This paper reports the results of a portion of the study that concerned an on-board survey.

Although some information existed concerning intercity bus riders (1-4), there is reason to believe that intercity bus riders in Texas might have some unique characteristics. The reason for this belief is the generally healthier condition of the intercity bus industry in the Southwest (5). For this reason, it was decided to undertake an on-board study of bus passengers.

Since other on-board studies had been undertaken (1,4,6,7), it was also decided that a somewhat more extensive questionnaire would be used. The size of the questionnaire selected was both sides of one page. This length was thought to be brief enough to elicit a good response and also allow for the inclusion of some attitudinal questions not included in any previous survey. Both English and Spanish versions of the survey instrument were used because of the significant number of Spanish-speaking residents in the state.

A stratified sampling frame was selected because of regional differences within the state. [Previous studies (1,2,8) indicated that low-income persons are a significant part of intercity bus ridership.] The border area of the state is economically poorer than the rest of the state. Based on county economic characteristics, one region includes those counties along the border identified as having a lower economic base. The remaining counties were roughly divided in half.

Within each region survey points were further segmented by small [nonstandard metropolitan statistical areas (SMSAs)], medium (SMSAs less than 1 million) and large (SMSAs greater than 1 million) cities. Texas has approximately 1000 potential survey points, but only 25 points are in the medium or large category. The number of survey points in each strata are given in the table below.

| | Survey Points | | |
|---|---|---|---|
| Region | Small City | Medium City | Large City |
| North-east | 4 | 2 | 1 |
| North-west | 2 | 2 | 0 |
| South-west | 2 | 1 | 1 |

Figure 6. Mode of travel from bus station.

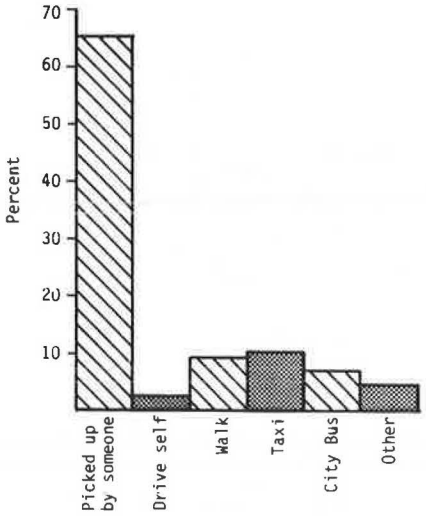



Figure 7. Trip purpose.

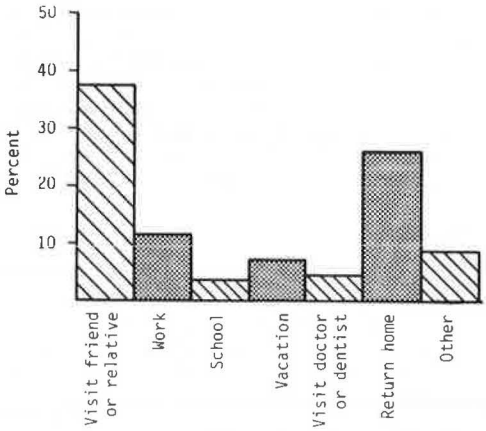



Figure 8. Alternative travel mode.

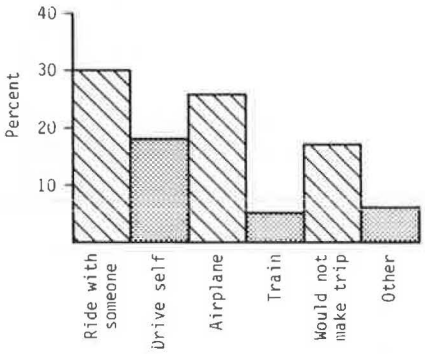
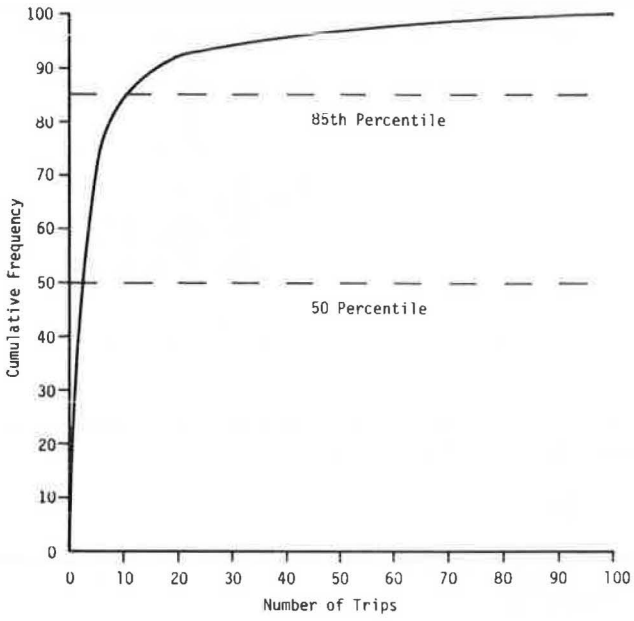



Figure 9. Number of intercity bus trips made by passengers in past year.




categories--those that have a choice of mode of travel and those that are captive and have no alternative mode of travel available. Passengers were asked how they would have made this trip if intercity bus service were not available. The responses are shown in Figure 8.

Forty-seven percent of the riders responded that they would have ridden with someone else or driven themselves. Twenty-five percent stated that they would have made the trip by airplane. This may have been the choice of those passengers making long trips, as 25 percent of the riders surveyed were traveling more than 600 miles. Seventeen percent of the riders stated they would not have made the trip if bus service had not been available.

Further analysis of data from those stating that they would not make the trip if intercity bus service was not available indicated that 45 percent owned a car that was available for the trip. Thus, the loss of bus service would appear to leave only a small number of persons without an alternative mode of travel.

## Number of Intercity Bus Trips in Past Year

Figure 9 illustrates the number of bus trips made by the respondents within the past year. For this survey a round trip was counted as two trips. As indicated, 50 percent of the users had ridden three times or less and 85 percent had ridden fewer than 10 times.

As previously mentioned, almost 50 percent of the riders stated that the purpose of their trip was to visit friends or relatives for vacation or for a medical appointment. These trips are generally not made frequently. Thus, this may be the reason for the low number of trips made by bus in the past year.

## Trip Length

Passengers were asked the origin and destination of their trips. From this information the length of each trip was calculated. Figure 10 shows the distribution of trip lengths for the passengers surveyed. Approximately 41 percent of the trips were less than 200 miles in length. However, 25 percent of the trips were more than 600 miles in length, and the average trip length was 498 miles.

The average trip length for intercity bus travel on a national level is reported to be 125 miles (9). However, there is reason to believe that the average trip length is actually longer than this due to the overcounting of passengers (10). Thus, the longer average trip found in Texas may not be as much of an anomoly as it appears.

Figure 10. Intercity bus trip length.

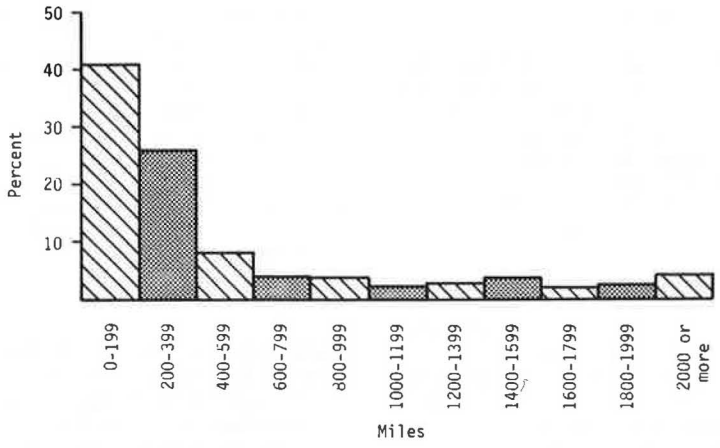



Figure 11. Passenger attitudes toward increased fares.

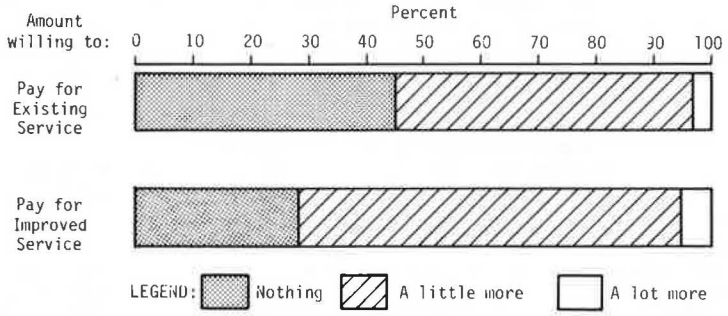



Table 1. Relative importance of various intercity bus features to users.

| Feature | Overall Rating[a] | Significance Level[b] |
|---|---|---|
| Safety at bus station and on bus | 4.44 | Most |
| Leaving and arriving on time | 4.38 | |
| Leg room and comfortable seats | 4.32 | |
| Availability and cost of gasoline | 4.13 | Intermediate |
| Having express bus service | 4.09 | |
| Frequency of intercity bus service | 4.05 | |
| Bus fare | 3.98 | |
| Speed of bus trip | 3.92 | |
| Cost of owning car | 3.90 | |
| Location of bus station | 3.87 | |
| Riding in new modern bus | 3.80 | |
| Local city bus transportation at destination | 3.67 | |
| Food service at bus station | 3.64 | |
| Availability of air or train service | 3.41 | Least |
| Automobile parking near bus station | 3.31 | |

[a] Each feature was rated on a scale of 1 (not important) to 5 (very important).
[b] To assess statistically significant differences in the responses, a Duncan's multiple range test for variable rank was performed to identify significantly different means. The responses fell into the three general significance levels shown in the table.

## General Attitudes

The survey asked certain questions designed to identify attitudes concerning intercity bus service and fares and to identify those features that were important to users in their decision to use intercity bus service.

### Service and Fares

Questions were asked concerning satisfaction with the existing bus service and attitudes toward the cost of the service. The response to the question "How would you rate your satisfaction with intercity bus service overall?" is summarized in the table below. As indicated, the overwhelming majority thought that the existing service is satisfactory. In fact, only 5 percent of the respondents were not pleased with the current service.

| Level of Satisfaction | Response (n = 1024) (%) |
|---|---|
| Very satisfactory | 41.8 |
| Satisfactory | 47.6 |
| Not satisfactory | 5.4 |
| No opinion | 5.2 |

Figure 11 shows the results of the questions concerning how much more users would be willing to pay for existing service and for improved service. Most riders surveyed indicated that they would be willing to pay a little more for both the existing service (51 percent), and for improved service (66 percent). Only a small number of persons would be willing to pay a lot more for either existing or improved service.

### Important and Unimportant Features of Intercity Bus Service

This study attempted to identify those features of existing intercity bus service that were most important to the users in their decision to use the service. In essence, an attempt was made to document those features of intercity bus travel that should be emphasized in the planning and operation of the service.

The survey included the following statement: "A number of different factors are important in deciding to use intercity bus service. Please circle the number that best explains how important the following features are to you in deciding to use the intercity bus." Following that, 15 intercity bus features were listed; the user rated each on a scale of 1 (not important) to 5 (very important). These results are summarized in Table 1. The three most

significant factors are within the control of operators.

To test for statistically significant differences in the responses, a Duncan's multiple range test for variable rank was performed to identify significantly different means. The Duncan method is a refinement of the protected least significant difference criterion for comparing ranked means on a pairwise basis. The Duncan method provides a reasonable tradeoff between type 1 and type 2 errors.

## COMPARISON WITH MICHIGAN SURVEY

In order to ascertain whether Texas intercity bus riders or trips have any unique characteristics, the results of the survey were compared with the results of a 1977 on-board survey conducted in Michigan (1). The survey results were compared by using the Kolmogorov-Smirnov test (11), which is a nonparametric test for differences between two cumulative distributions. The two-sample test analyses the hypothesis that the two independent samples come from identical continuous distributions. The test is sensitive to population differences with respect to location, dispersion, or skewness.

The Texas on-board survey was compared with eight questions from the Michigan survey. Questions concerning age, sex, occupation, vehicle ownership, mode of arrival at the bus station, mode of departure from the bus station, trip purpose, and the number of intercity bus trips made in the past year were compared. All comparisons were made at a level of significance of $\alpha = 0.05$. If the null hypothesis was rejected, evidence was sufficient to conclude that the samples are drawn from different populations. As given in the table below, the null hypothesis was only rejected for occupation.

| | Sample Population | |
|---|---|---|
| Question | Identical | Different |
| Age | X | |
| Sex | X | |
| Occupation | | X |
| Vehicle ownership | X | |
| Mode of arrival | X | |
| Mode of departure | X | |
| Trip purpose | X | |
| No. of trips | X | |

Note that the conclusion that occupations are different is dependent on the need to equate two different classification schemes. The differences between the two samples could be solely the result of the classification scheme. Therefore, the conclusion concerning differences in occupations is tenuous.

## SUMMARY AND CONCLUSIONS

The most notable finding concerning intercity bus riders is that the average trip length is nearly 500 miles. This is significantly longer than generally reported elsewhere. The difference appears to be due to the way ridership data are reported by individual companies.

The on-board survey indicated that 89 percent of the users were satisfied with the service. Improvement of service for existing riders would, therefore, not be likely to result in increased ridership. Features of intercity bus service most important to users included safety, being on time, and comfort. User attributes were not shown to be different for riders in Texas and Michigan. The most significant attribute of intercity bus riders is their lack of an available automobile with which to make the trip.

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