Use of Travelers' Attitudes in Rail Service Design

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In this paper, an analysis framework in which attitudinal data are used to support service design decisions for a public transportation system is described. An analysis of the riders' ratings identified the rail service performance weaknesses that limit ridership. The identification of strong monotonic relationships linking objective measures of rail performance to rider perceptions made it possible to forecast the impact of service improvements on travelers' service ratings and on mode choice to predict ridership changes. The analysis framework provides transit agencies with a tool both to diagnose deficiencies in the service provided to travelers and to evaluate the ridership impact of service improvements and marketing changes aimed at increasing ridership levels. The framework was applied to Chicago area commuter rail service to demonstrate its feasibility.

In this paper, an analysis approach is developed to assist transit agencies in improving service design in an effort to increase rider patronage and farebox-generated revenue. The approach framework is based on the analysis of travelers' perceptions of the service attributes of rail transit and other modes and on the influence of these factors on travelers' choice behavior. This method extends previous approaches by developing a link between objective measures of service levels and travelers' perceptions of corresponding service attributes. These relationships are used to forecast the effects of service changes on riders' perceptions and ridership.

The traditional public transit agency approach has been to provide service at the lowest possible fares to attract or retain ridership. During the past decade, however, transit agencies have faced severe financial difficulties due to increasing operating costs, declining or stable ridership patterns, and decreasing federal and state funds for operating subsidies and capital investments. These factors have created increasing financial pressure and have forced transit agencies to seek ways to cover a greater share of their costs with passenger revenue (*1*).

The most common reaction of transit agencies has been to maintain low fares and reduce operating costs through cutbacks in the level of service offered. This practice, however, produces a negative pattern of ridership decreases in response to the reduced level of service. An alternative response to the transit finance problem is to combine improvements in the quality of service with reasonable fare increases. This approach will attract riders who are relatively insensitive to fare increases and are willing to pay higher fares in return for better levels of service (*2*).

The approach developed in this paper provides transportation agencies with a tool to determine whether low ridership is due to poor service or negative misperceptions among travelers, to evaluate and compare a set of alternative service and marketing strategies, and to select service designs that can be expected to produce larger increases in ridership.

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DEVELOPMENT OF THE ATTITUDINAL APPROACH TO TRAVEL ANALYSIS

The models employed in transportation analysis to predict mode ridership evolved from models based on geographical aggregation to models that relate individual consumer behavior to characteristics of the alternatives available to the traveler. Early aggregate mode split models used the geographical zone as the unit of analysis and averaged across the observed behavior and the characteristics of individual travelers. The use of aggregate data and the lack of a behavioral basis for these models produced poor estimation results. These techniques also led to the development of relationships that were not correctly sensitive to policy variables and could not be used to support the decision making process (*3*).

In response to the limitations of aggregate mode split models, disaggregate econometric models were developed on the basis of theories of individual behavior. The use of the individual traveler or the household as the unit of analysis allowed the disaggregate models to reflect the underlying decision-making process of the traveler (*4*).

The specification of a traveler's utility function allows the researcher to

- Relate observed travel patterns to characteristics of alternative modes,
- Account for the effect of travelers' socioeconomic characteristics on their travel choices, and
- Consider the effect of situational constraints on mode choice decisions.

In comparison with the aggregate mode split approach, disaggregate econometric models enhance understanding of the determinants of travel choice behavior. It must be noted, however, that the disaggregate model structure also assumes that each traveler has full information about the available modal alternatives and objectively evaluates a limited range of modal attributes, leading to a choice based on maximization of the utility of using a particular mode (*5*).

It has long been recognized that the appeal of objects and personal values influence individual behavior but not necessarily in a rational way (*6*). Many transportation studies have identified nonobjective attributes as important determinants

of travel choice (*7–11*). Choice models that are based on attitudes instead of objective measures overcome the limitations of the econometric approach by recognizing the role of travelers' perceptions, their imperfect information about modal alternatives, and the importance of a wide range of service characteristics, including some for which there are no objective measures. The use of travelers' perceptions thus offers better insight into consumers' decision process and allows the transportation agency to evaluate a broader range of potential strategies to influence consumers' choices and travel behavior, as explained by Koppelman and Pas (*12*).

Louviere et al. (*13, 14*) argued that travelers' choices are driven by their subjective evaluations of alternative modes. These choices are in turn affected by the objective characteristics of the system, which may be differently perceived by each individual. In the information-processing stage, various system characteristics are related to a smaller number of perceptual dimensions, whose relative importance determines travelers' preferences. During this process, travelers' perceptions are strongly influenced by their individual characteristics, their biases and normative beliefs, and the information that they have about alternatives.

The analysis framework described in this paper is based on the Consumer Oriented Transportation Service Planning framework (Figure 1), which was developed by Tybout et al. (*15*) for studying consumer responses to changes in transportation services. The model structure assumes that travelers' behavior expresses their preference, subject to the influence of situational constraints. Travelers' perceptions of their alternatives are directly related to their preferences and are influenced by performance characteristics of the system and individual psychological and social characteristics. These factors suggest that, from a transit agency perspective, travelers' behavior can be affected by changing their perceptions of the alternatives. In this context, the range of policy variables is not limited to service and fare changes but also includes marketing and promotional strategies that inform travelers of the attractive features of the transit service offered and modify their perceptions about those features.

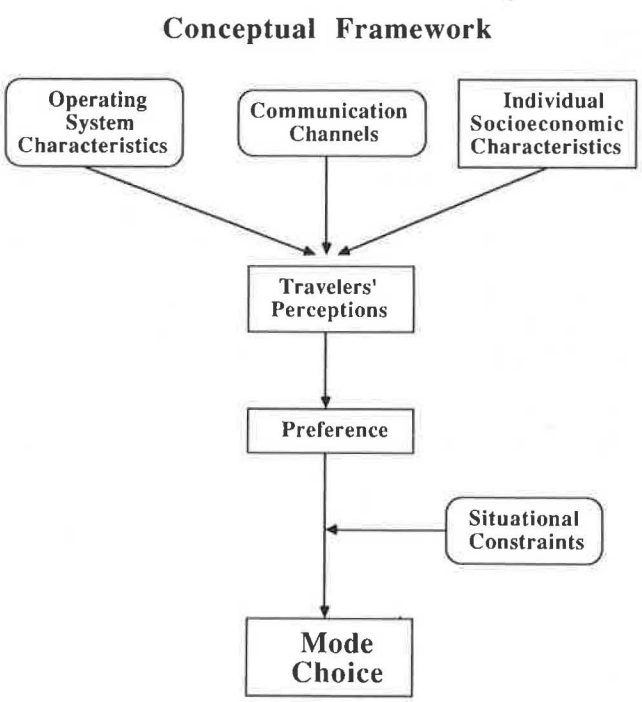

FIGURE 1 Conceptual framework for the consumer-oriented transportation service model (*15*).

APPLICATION OF ATTITUDINAL APPROACH TO SERVICE DESIGN

Limitations of Existing Attitudinal Models

The application of the attitudinal approach in a mode choice context enhances understanding of consumer behavior by including nonquantifiable aspects of the level of service as important determinants of mode choice (*16–22*). However, the drawback in attitudinal modeling is the lack of an essential link between objective measures of performance and subjective travelers' beliefs (*23, 24*). Because the actual performance characteristics are likely to have a strong influence on the formation of travelers' perceptions and are controllable by transit service management, it is essential to estimate how changes in level of service influence travelers' perceptions and consequently affect their observed behavior. This evaluation can be accomplished by developing relationships that relate objective measures of service performance to travelers' ratings of service attributes. These relationships can be used to forecast the impact of marketing actions and service improvements on travelers' ratings of service attributes and, consequently, on ridership levels.

Development of a Service Design Approach

In this paper, a service design–oriented framework is developed for use by transportation agencies as both a diagnostic and a forecasting tool. The method can be used to identify the aspects of service that most influence travelers' mode choice decisions and to evaluate alternative service design options.

The framework is developed by formulating relationships to quantify the influence of objective (engineering) measures of performance on travelers' perceptions of related service attributes. The relationships are based on measures of transit service performance that can be clearly related to riders' ratings of corresponding service attributes. These relationships are incorporated into a choice model that expresses mode choice as a function of travelers' perceptions. The choice model is used to forecast the impact of transit service improvements and thus provide managerially useful information on expected ridership responses to service and marketing changes.

SERVICE DESIGN BASED ON ATTITUDINAL ANALYSIS

Introduction

The service design–oriented framework uses travelers' perceptions of levels of service to

- Diagnose the perceived strengths and weaknesses of transit service, allowing identification of potential areas for service improvements, marketing strategies, or both;

TABLE 1 TRAVELERS' RATINGS OF CAR AND RAIL SERVICE ATTRIBUTES

Variable Name	Service Attribute	Rail Mean Rating	Car Mean Rating
QUICKLY	Getting to destination quickly	7.43	6.50
COST	Low cost	6.01	5.52
RELAX	Relaxing environment	7.33	4.84
SCHEDULE	Setting your own schedule to come and go as you wish	5.38	8.55
TEMPERATURE	Comfortable temperature	7.31	8.26
CRIME	Safety from crime	7.95	7.79
READ	Reading or doing paperwork	6.89	1.60
TALK	Talking with other people	6.01	3.39
CARRY	Ease of carrying briefcase, packages or papers	6.78	8.61
PRIVACY	Travelers' feeling of privacy	5.14	8.75
ACCIDENT	Little risk of accidents	8.20	5.13
ONTIME	Getting to destination on time	8.24	7.02
MINWALK	Keeping walking to a minimum	6.24	8.00
KNOWHOW	Transportation that I know how to use	8.13	9.06

NOTE: The 14 attributes of service are rated on a scale of 0 to 10, where 0 is poor and 10 is excellent.

- Develop a relationship between perceptions and service characteristics so that perceived weaknesses can be verified and the impact of service improvements on travelers' perceptions assessed;
- Identify the service attributes that have the most influence on travelers' mode choice so that direct service improvements or marketing strategies can be directed; and
- Evaluate alternative strategies by predicting the impact of transit service improvements on ridership.

To accomplish these objectives, data were collected on travelers' attitudes toward the level of service offered by automobile and transit alternatives. Such data can be gathered by using telephone surveys or printed questionnaires. Travelers' perceptions were reflected by their ratings on each of 14 service attributes (Table 1). Travelers were asked to rate each service attribute on a 0 to 10 or other scale in which higher ratings reflected more positive attitudes. Service ratings that reflected travelers' relative assessments were obtained for each alternative mode. Additional data were collected on travelers' socioeconomic characteristics, mode preference and choice, residence and work locations, and frequency of transit use.

In Figure 2, which is the flow chart for the analysis approach, each step of the analysis is related to the expected outcome and the corresponding actions to be considered by a transit agency. The following sections briefly describe how each of the outlined analysis objectives was accomplished by using the proposed analysis methodology. Then the results of an application of the methodology to the Chicago area commuter rail system (METRA) are presented.

Strengths and Weaknesses of a Transit Service

An evaluation of strengths and weaknesses of transit service as perceived by riders is obtained by comparing travelers' ratings of selected service attributes. These comparisons can be made at two levels: first, by identifying differences in travelers' perceptions of automobile and transit service, and second, by identifying differences among riders who use different portions of the transit system.

The comparison of mode service ratings is first used to identify service attributes that are perceived as good or bad over the entire transit system. Then, comparisons of riders' ratings for different portions of a transit system can be used to identify weaknesses and strengths on specific rail lines or bus routes. Analysis of variance can be used to test whether the observed differences in perceptions are statistically significant.

Objective Performance Measures Versus Riders' Perceptions

Relationships between objective measures of transit performance and riders' perceptions are obtained by associating riders' ratings of transit service attributes with measures of performance for different parts of the transit system. For example, the operating speed of a transit line can be compared with riders' perception of "going to destination quickly." These relationships allow the transit researcher to gain an enhanced understanding of the ways in which consumers' perceptions and behavior are affected by differences in the level of transit service. By using these relationships, transit agencies can also verify whether lower ratings reflect a lower level of transit service or are the result of riders' misperceptions about the level of transit service. Agencies can also select those measures of performance that most clearly reflect consumers' perceptions and can then design service improvements accordingly.

Identifying the Most Important Service Characteristics

A transit agency needs to focus its marketing and service improvement efforts on those aspects of transit service that are most likely to influence travelers' decisions to use the

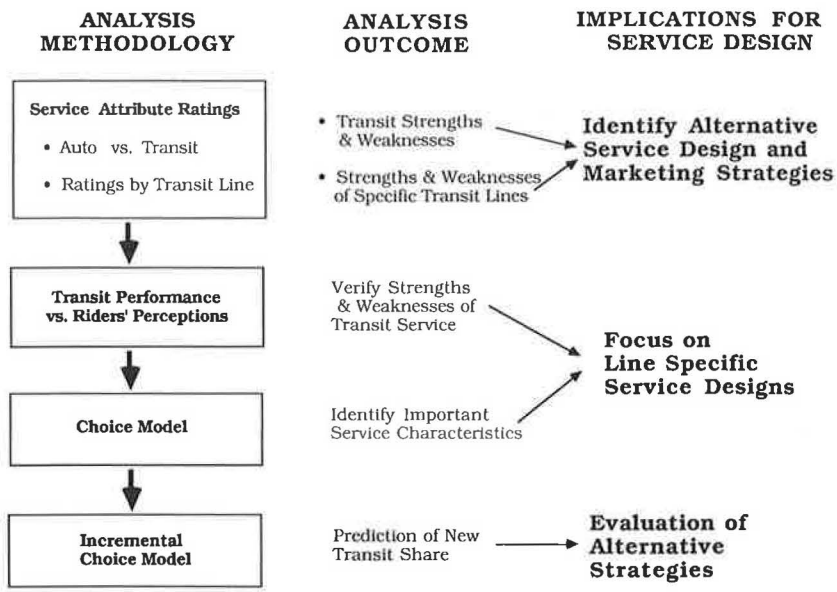

FIGURE 2 Overview of the analysis approach.

transit service instead of their own cars. The most important service characteristics can be identified either by the reasons that the travelers give as most important for choice of mode or by statistical analysis that links their mode choice to service attributes of the alternatives. The choice model that was developed for the current analysis relates travelers' mode choices to their perceptions of transit and automobile service attributes. The magnitude of the choice model parameters reflects the relative importance of aspects of service on travelers' choice.

Evaluation of the Impact of Service Improvements

The objective of a transit agency is to select, from the alternative strategies identified through the analysis of riders' perceptions, the strategy that is likely to be most effective in increasing rider patronage and farebox-generated revenues. The proposed forecasting framework relates service improvements to changes in travelers' perceptions and also relates changes in perceptions to an expected change in transit ridership levels. This approach can be used to forecast the impact on transit ridership of changes in the level of service offered or changes in marketing. A complete evaluation of the alternative options requires that both the feasibility of each set of service improvements and the costs associated with service improvements or marketing strategies be taken into account.

The incremental logit model used for these forecasts determines the impact of improvements in transit service, under the assumption that the level of service and travelers' perceptions of other alternatives are unchanged (*25*). The inputs to the model are the current market share of transit and the changes in travelers' perceptions of transit service. The output is the estimated new share of transit ridership that arises from the implemented service improvements. An implicit assumption of this formulation is that changes in the level of transit service are effectively communicated to all travelers through appropriate advertising and promotional strategies.

The predicted market share of transit, $S^{new}_{transit}$ is a function of the current market share, $S_{transit}$, and the change in travelers' perception of transit service, $DU_{transit}$, that is the result of service improvements:

$$S^{new}_{transit} = \frac{S_{transit} * \exp(DU_{transit})}{S_{transit} * \exp(DU_{transit}) + (1 - S_{transit})}$$

APPLICATION OF APPROACH TO RAIL SERVICE DESIGN

Analysis Context and Data Sources

The public transportation system studied in this analysis is the commuter rail system (METRA) in the Chicago metropolitan area. METRA is a high-quality radial commuter rail system that runs between the suburbs and the Chicago central business district (CBD). The system includes 11 rail lines that offer different levels of service. The peak hour daily ridership ranges from fewer than 1,000 passengers to 20,000 passengers.

The analysis is based on travelers' perceptions in two survey-generated data sets: an on-board survey of commuter rail riders consisting of ~4,000 observations across 10 METRA rail lines and a randomly selected telephone survey sample of ~1,500 suburb-to-CBD commuters. Both surveys were similarly structured and included information on the travelers' socioeconomic characteristics, their perceptions of the level of service offered by rail and other modes, and their chosen and alternative modes.

The large sample size of the on-board survey was used to make line-by-line comparisons and to develop relationships between objective performance measures and riders' perceptions. The telephone survey data were used to develop the mode choice model, which includes commuters' choices of automobile, rail, or other forms of public transit.

Strengths and Weaknesses of METRA Rail Lines

The average METRA rail and automobile ratings for the 14 attributes of service are presented in Table 1. Rail was rated

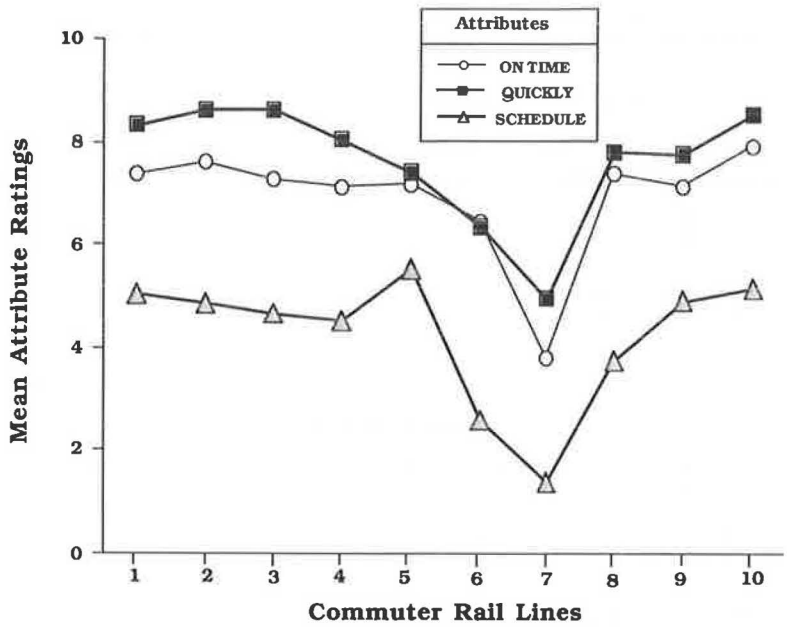

FIGURE 3 Riders' ratings by rail line.

superior to automobile in getting to destination quickly and on-time; cost of service; travelers' ability to read, do paperwork, or relax en route; travelers' ability to talk to others; and allowing travelers to feel safe from crime and accidents. On the other hand, automobile was rated higher in convenience and flexibility; ease of carrying a briefcase or packages; keeping walking to a minimum; providing a transportation system that travelers know how to use; providing comfortable temperature and feeling of privacy; and ease of setting one's own schedule.

This comparison suggests that the ability to read, do paperwork, or relax en route, along with the superior rail performance characteristics (speed, on-time performance, low cost) might be exploited in marketing METRA rail service and that a more frequent scheduling of trains and other changes meant to make riding METRA more convenient might be targets for service improvements.

It is also useful to compare the ratings of rail service given by METRA users with those given by drivers. Service attributes for which METRA riders' ratings are much higher than nonusers' ratings can be the focus of marketing or promotional strategies to "correct" the ratings of nonriders. Both strategies are aimed at improving nonusers' attitudes toward METRA with the expectation that some will shift to riding the rail system.

Among the same 14 attributes, riders on different rail lines gave similar ratings on the attributes of comfort, safety, ability to read and relax en route, and the social aspects of their everyday trip. Ratings differed across lines, however, for aspects of service that are closely related to rail operating characteristics, that is, flexibility in setting their own schedules (SCHEDULE), speed of rail (QUICKLY), and on-time reliability (ONTIME). A qualitative assessment of differences in riders' perceptions of level of service is provided by plotting the mean attribute ratings for aspects of service by rail line (Figure 3). These plots highlight important differences across lines. Lines 7 and 6, for example, are rated lower than all other lines for all three attributes. These two lines also receive the lowest ratings on overall satisfaction, indicating that it may be useful to direct service or marketing improvements at these lines.

A statistical analysis of riders' ratings of service across METRA lines supports the argument that differences in riders' perceptions can be primarily attributed to differences in performance characteristics across METRA lines. It can be concluded that ratings of attributes that correspond to service characteristics that can be controlled by METRA vary widely across rail lines. The association of these differences with objective measures of rail service by line is examined next.

Objective Measures of Rail Performance and Riders' Perceptions

Objective measures of rail performance were available for rail speed, on-time reliability, and frequency of service. Graphical and statistical approaches were used to investigate the relationships linking these measures of rail performance to riders' perceptions. The specific relationships examined were between

- The number of peak hour trains scheduled and riders' average ratings of the "ease in setting own schedule to come and go as desired,"
- The average delay per delayed train and riders' ratings of "getting to destination on time," and
- The average rail operating speed and riders' subjective evaluation of "getting to destination quickly."

For all three aspects of service, it was expected that riders' ratings would increase with increasing quality of service. In addition, ratings were expected to increase at a decreasing rate above a satisfactory level of service.

- *Schedule Flexibility* Given that the majority of METRA

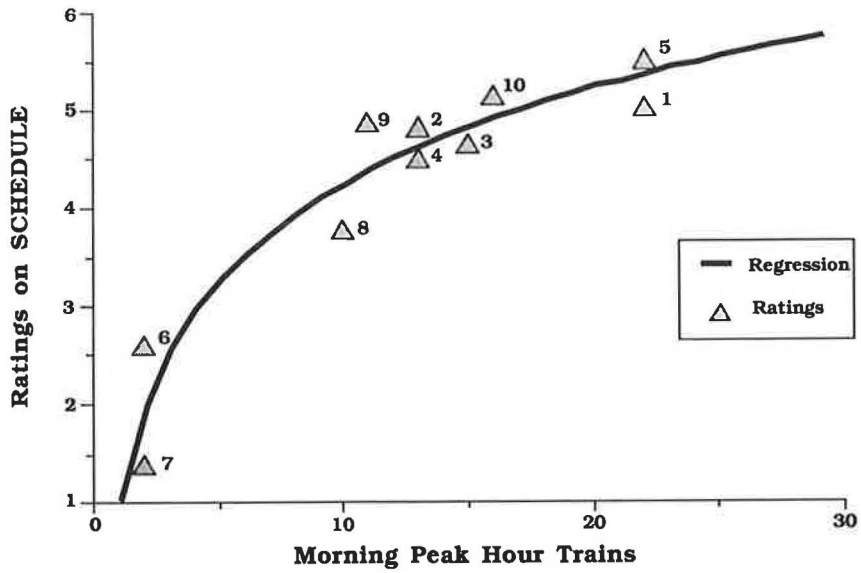

FIGURE 4 Perceptions of train frequency.

TABLE 2 MEASURES OF DELAY DURATION AND RIDERS' ONTIME PERCEPTIONS

METRA Rail Line No.	Riders' ONTIME Ratings	Trains On Time (%)	Delay per Late Train
1	8.32	98.34	13.0
2	8.59	98.58	10.8
3	8.60	98.67	11.6
4	8.04	97.02	11.1
5	7.40	95.63	15.5
6	6.33	94.61	16.5
7	4.97	96.47	16.9
8	7.80	96.19	11.8
9	7.76	96.60	11.7
10	8.52	99.69	4.5

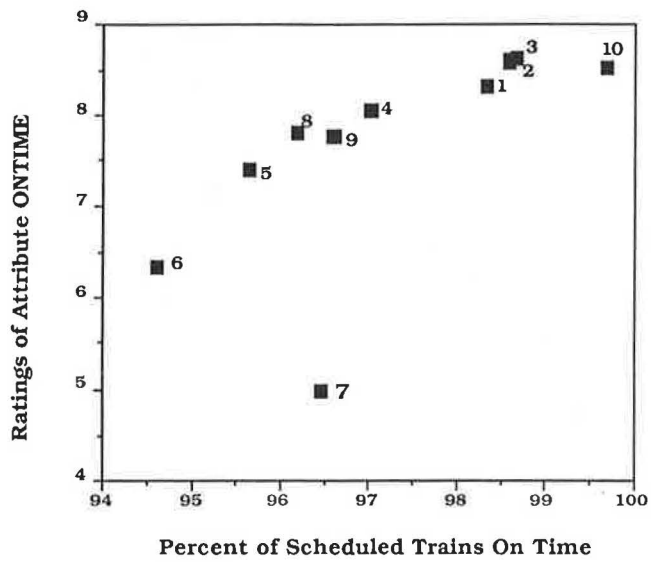

FIGURE 5 Delay frequency and riders' perceptions.

riders' trips were daily work commutes, a comparison was made of riders' perceptions of ease in coming and going as they wished with the number of morning peak hour trains scheduled (Figure 4). The number of morning peak trains varied from 2 to 22. As shown in Figure 4, ratings on SCHEDULE have a strong monotonic relationship with the number of peak hour trains, and the relationship has a diminishing marginal form. The graph confirms that the reported differences in riders' perceptions were related to the level of service offered. Lines 7 and 6, which had only two morning trains, received a much lower rating than did other METRA lines.

- *On-Time Reliability* The commuter rail system in Chicago has a good on-time performance record, ranging from a low of 94 percent to a high of 99.7 percent of peak hour trains arriving at their destination less than 6 minutes late (Table 2). The ratings of ONTIME are weakly related to the percentage of trains more than 6 minutes late (Figure 5). A stronger relationship exists between ratings of ONTIME and the severity of delays expressed by the average delay per delayed train (Figure 6). Thus it was concluded that severity of delays is a more appropriate determinant of riders' perception of rail reliability than percentage of late trains.
- *Getting to Destination Quickly* The relationship between average operating speed and riders' ratings of getting to destination quickly is not clear (Figure 7), but it does illustrate a strong basis for the poor ratings by riders of line 7. The absence of a strong monotonic relationship may be due to the influence of delays on riders' perception of getting to destination quickly. In addition, riders' ratings are quite similar for all lines with average speeds greater than 30 miles per hour. The high rating by riders for line 10, despite its low average speed, is probably due to its excellent on-time performance. These observations suggest that the current approach can be enhanced by developing associations between each service rating and several objective measures of service.

These relationships, which link riders' subjective evaluations to objective measures of rail service, provide a basis from which the transit operator can identify whether riders' unfavorable perceptions of aspects of rail service are due to

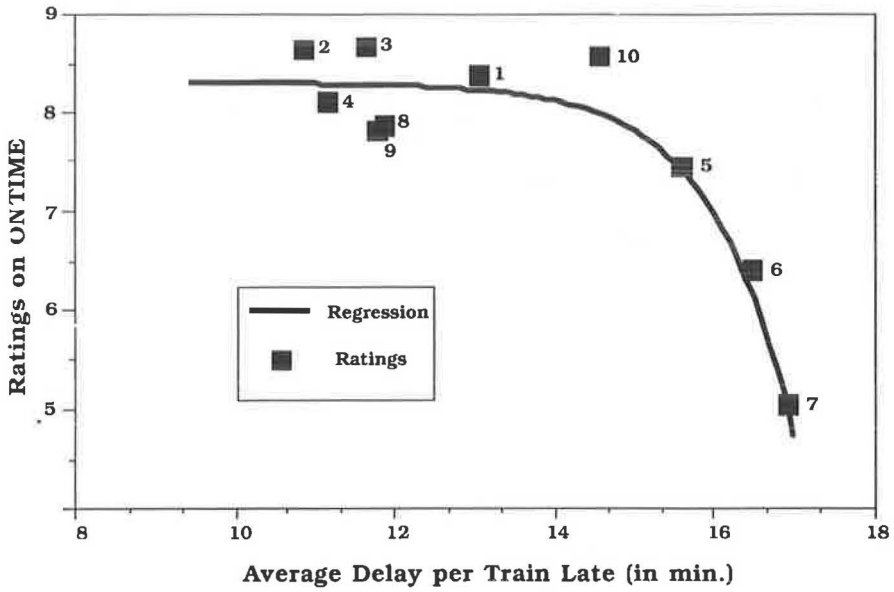

FIGURE 6 Delay severity and riders' perceptions.

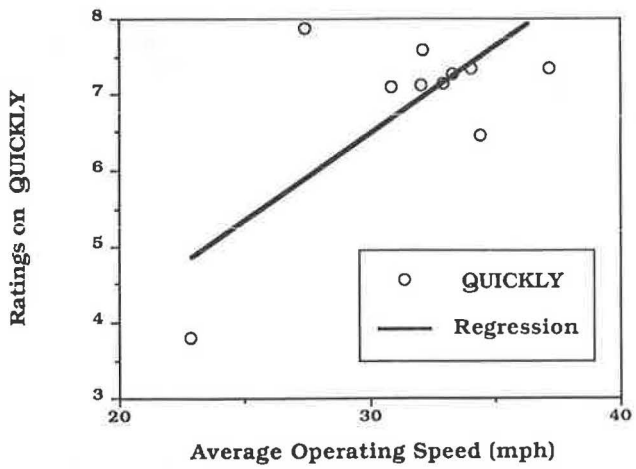

FIGURE 7 Assessment of rail speed.

a low level of service or to riders' misperceptions. These results could guide the choice between a marketing and promotional strategy to enhance the perceptions of positive attributes of transit service or service improvements to enhance the service provided. In addition, these relationships could be used to evaluate the impact of different levels of service improvement on riders' perceptions and, consequently, on ridership.

Importance of Service Characteristics

The relative importance of different service attributes can be used to direct transit management's attention toward those attributes that should be given high priority for service improvement. A random sample of suburb-to-CBD commuters, both METRA riders and others, were asked to rate the importance of each of the 14 attributes listed in Table 1. Rail riders and other public transit users selected performance characteristics (speed and on-time reliability) and feeling safe as their most important determinants of choice. Drivers placed high importance on schedule flexibility.

An alternative approach to determining attribute importance is to construct a model of mode choice behavior that relates the observed mode choice to travelers' ratings of aspects of service offered by commuter rail, private car, and other forms of public transit. The importance of service attributes in commuters' mode choice is reflected in the relative magnitudes of the model coefficients. The preferred model specification presented in Table 3 is consistent with travelers' stated importance but is more specific.

The resulting model specification is similar to traditional mode choice models in that it includes travel time (travelers' perception of QUICKLY), out-of-vehicle travel time spent walking to the station or the parking lot (minimum walk time: MINWALK), and out-of-pocket cost (COST of service). In addition, travelers' choices are also influenced by the ONTIME reliability of their alternatives, the ability to RELAX en route, and their familiarity with the transit system (KNOWHOW to use). Other attributes, including schedule flexibility, did not appear to be important in determining observed choice behavior.

Impact of Service Improvements on Ridership

The relationships developed in this section can be used to evaluate the ridership impact of selected service improvements. This approach is demonstrated by consideration of the effect of rail on-time reliability on rail ridership. Reliability has been recognized as an important determinant of mode choice, and relationships linking riders' ratings to actual rail operating characteristics were developed. The proposed approach is demonstrated by examining the effect on ridership of a reduction of average delay per delayed train to 14 minutes on lines 5, 6, and 7. The reported delay on these lines was greater than 15 minutes.

The forecast approach is based on the association of a change in expected service with riders' ratings of that service attribute and subsequent use of the choice model to predict mode shares on the basis of the revised service ratings. The choice model application is made at the aggregate level for each line by

TABLE 3 SPECIFICATION OF THE MODE CHOICE MODEL

Service Attribute Variables	Parameter Coefficient	*t* Statistic
Automobile dummy variable	1.23	8.4
Public transit dummy variable	1.55	5.8
Getting to destination QUICKLY	0.15	3.8
Ability to RELAX en route	0.14	4.4
KNOWHOW to use the system	0.14	3.2
Getting to destination ONTIME	0.11	2.7
Keeping walking to a minimum: MINWALK	0.09	2.5
Low COST of service	0.08	2.8

NOTE: All parameters are statistically significant at $a = 0.05$. Summary statistics: log likelihood, −318.4; likelihood ratio index, 0.421; likelihood ratio statistic, 462.6; percent correctly predicted, 82.9; degrees of freedom, 785.

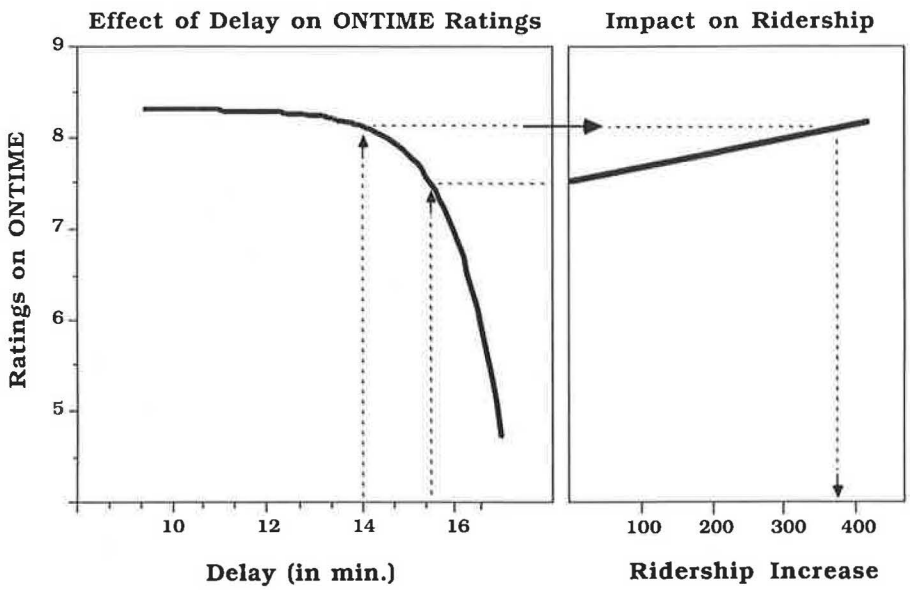

FIGURE 8 Impact of ONTIME improvements on ridership.

TABLE 4 RIDERSHIP IMPACT OF IMPROVEMENTS IN ON-TIME RELIABILITY

METRA Rail Line No.	Future ONTIME Rating	Future Market Share	Current Peak Hour Ridership	Future Peak Hour Ridership	Ridership Changes: Percent Increase	Ridership Changes: Rider Increase
5	8.20	0.71	13,131	13,508	2.87	377
6	8.20	0.45	640	726	13.48	86
7	8.20	0.49	1,641	2,026	23.48	385

using the incremental form of the logit model to reduce aggregation errors, as described by Koppelman (*25*).

The application of the prediction methodology is demonstrated in Figure 8 for an improvement in the on-time performance of line 5 from a 15.5-minute to a 14-minute average delay per delayed train. The relationship between objective measures of delay and riders' perceptions, as described previously, is used to predict riders' ratings for improvements in on-time performance level. Then the incremental mode choice model is used to predict the new market share of rail and the expected increase in ridership.

The expected ridership impacts (new ridership and change in ridership) for lines 5, 6, and 7 are presented in Table 4. The inputs to this analysis are the existing mode share and ridership and the existing and predicted user service ratings. The future ratings of service are estimated by using the target service level and the relationships that link riders' perceptions to service attributes. The future mode share is estimated by applying the incremental logit model, as illustrated in Figure 8.

The impact of a reduction of the average delay per late train to 14 minutes is shown in Table 4. The greatest percentage increases in ridership are forecasted for lines with the worst on-time reliability record (lines 7 and 6), whereas the greatest increase in actual ridership is expected for line 5, which serves a corridor with high travel volume.

Evaluation of Options

The demonstration of the methodology focused on forecasting ridership gains that are the result of service improvements. An integrated approach to service design requires that the

cost of alternative options be considered along with technical considerations about the feasibility of the proposed improvements. Thus the complete analysis is able to focus on net revenue gains and can examine whether service improvements are justified by comparing the annual equivalent cost of the required capital investment with the increase in revenue.

Alternatively, the low price elasticity of commuter rail riders can lead to a policy of service improvements combined with fare increases, aimed at recovering part of or all the capital investment needed. The willingness of travelers to pay for the new service can be assessed by applying the prediction methodology to a range of fare and level of service combinations.

CONCLUSIONS

The use of attitudinal analysis approaches to guide transit agencies' service design decisions has been demonstrated in this paper. The preferred method is to use travelers' perceptions along with engineering measures of performance because the combination provides better insight into consumer behavior and therefore allows a better diagnosis of the problems facing urban transit. A transportation agency can use the enhanced understanding of travelers' behavior to identify a wide range of service improvements and marketing actions that can be used to attract ridership.

The policy value of the relationships that link objective measures of transit performance to riders' perceptions is their potential use as both a diagnostic instrument and a monitoring tool. Riders' perceptions can be used to diagnose weaknesses of specific transportation services, and changes in the level of service offered can be made accordingly. Similarly, for a high level of service, these relationships allow identification of riders' misperceptions. Responses could include appropriate marketing and promotional strategies.

As a monitoring tool, riders' attitudes can be used to ensure that level of service standards and riders' perceptions are maintained and to determine whether service improvements have produced the anticipated favorable changes in travelers' perceptions. The analytic framework applied in the case of urban rail transit also allows estimation of the impact of service improvements on ridership by comparing the estimated effects on ridership that result from the different options.

Priorities for service and marketing improvements are determined by identifying the importance of service attributes to travelers. Areas for concentrated efforts through marketing actions or service improvements are thus determined by identifying the service attributes to which travelers are most sensitive.

The feasibility of applying the analytic framework to public transit has been demonstrated in this paper. Monitoring the impacts of actual service changes provides a basis for validation and refinement of the methodology, allowing enhancement of the reliability of the conceptual structure.

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