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Our troubled planet can no longer afford the luxury of pursuits confined to an ivory tower. Scholarship has to prove its worth, not on its own terms, but by service to the nation and the world.
—Oscar Handlin

Will Smart Bikes Succeed as Public Transportation in the United States?

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Abstract

Bicycle-sharing programs have received increasing attention in recent years with initiatives to increase bike usage, better meet the demand of a more mobile public, and lessen the environmental impacts of our transportation activities. In 1996, the smart bike, or automated bike rental system, was first implemented in the United Kingdom, leading to a growing number of programs throughout Europe and Asia. However, there are presently no such programs in the United States. This article examines the potential success of smart bike programs in the United States.

Introduction

The purpose of this article is to describe briefly the history and development of bicycle-sharing, review experiences of selected smart bike, or automated bike rental programs, and develop guidelines for a successful smart bike program in the United States. In researching the article, the authors surveyed selected programs around the world, interviewed key figures in those programs, and reviewed the literature.

The first section provides a brief history of bike-sharing programs and models. A listing of past and present smart bike programs follows it. The article concludes with a discussion of the most important characteristics that will determine the likely success of a smart bike program in the United States.

Background

Bicycles have several advantages over other modes of public transportation for short-distance urban trips because they:

- reach underserved destinations,
- require less infrastructure,
- are relatively inexpensive to purchase and maintain,
- generally do not add to vehicular congestion,
- do not create pollution in their operation, and
- provide the user with the added benefit of exercise.

In addition, bikes may increase trips on other modes of public transportation, as they expand the reach of trains and buses.

However, in comparison to other modes of transportation, bikes have their drawbacks, including:

- They can be uncomfortable in inclement weather (i.e., temperature extremes, high winds, precipitation).
- They can be used in ways unsafe to riders and pedestrians.
- They may be inaccessible to people with certain disabilities.
- They may be difficult to use in some topography.
- They require the user to have riding skills.
- They are most appropriate for shorter distances.

Two models of bike-sharing exist—one designed for community use and the other for residential use (Matsuura 2003). In the community bike-sharing model, an individual checks out a bike from one of many locations and returns it to another location. The residential bike-sharing model requires bikes to be returned at the same location from where they were checked out (usually apartment buildings). The residential model, which is used in Japan, is designed for denser cities where living and bike parking spaces are at a premium. Products such as the

Honda Cycle Partner and Fujitec 2-Ring Park are representative of the residential bike-sharing model (Fujitec 2003; Honda 2003). However, the focus of this article is on *community* bike-sharing.

There have been three generations of bike-sharing systems over the past 35 years (DeMaio 2003). The first generation of bike-sharing programs began in 1968 in Amsterdam, The Netherlands. Ordinary bikes, painted white, were provided for public use. However, the bikes were stolen and the program collapsed within days (Associated Press 1998). In 1995, in Copenhagen, Denmark, a second generation of bike-sharing programs was launched with improvements. These bikes were specially manufactured and could be picked up and returned at specific locations throughout the central city with a coin deposit. However, theft of bikes in second-generation programs continued to be a problem, which gave rise to the smart bike or third generation bike-sharing programs.

Smartening earlier bike-sharing systems with electronically locking racks or bike locks, telecommunication systems, and smartcards or magnetic stripe cards, has allowed better tracking, as the customer's identity is known. Customers not returning a bike within the allotted time for its use, are required to pay for the replacement cost of the bike. These technological features offer great improvements over earlier systems, which had no high-tech features for checkout or return, and relied solely on customer honesty.

There are two prevalently used locking technologies in smart bike systems. In the first, bikes are checked out from an automated bike rack with the use of a smartcard or magnetic stripe card. This technology is in use by companies such as Clear Channel Adshel, JC Decaux, and Gewista. The second technology provides an automated lock on the bike itself and relies on the user to communicate via mobile or pay phone for the entry code. Deutsche Bahn uses this technology.

Smart bike fleets range in size from 50 bikes in Porsgrunn, Norway, to 1,700 bikes in Berlin, Germany. The longest running program, Vélo à la Carte, is in Rennes, France, which started in 1998.

Figure 1. Oslo Bysykkel (SmartBike)

Source: Morten Kerr.

Very little research exists on bike-sharing. Literature on the similar shared-use concept for motor vehicles, called car-sharing, is extensive (see, e.g., Shaheen et al. 1998; Bonsall 2002; Cervero 2002; Litman 2003), but offers little guidance for bike-sharing, as the technologies and issues are quite different.

The Smart Bike Programs

Eleven smart bike programs currently exist worldwide, all in Europe (see Table 1). Six are provided by private companies—Clear Channel Adshel, JC Decaux, and Gewista—to local jurisdictions as part of a contract for outdoor furniture, such as bus shelters and kiosks. Three are provided by Deutsche Bahn, the German railroad company, as an extension of its passenger services. One program is offered by a quasi-governmental organization, OV-fiets, and another, Sandnes Bysykkel, is offered by the nonprofit City Bike Foundation of Sandnes.

Smart Bike Suitability for the United States

Factors critical for the success of a smart bike program in the United States include:

- customer demand,
- bike facilities and safety,
- profitability,
- theft and vandalism, and
- multimodal connectivity.

Customer Demand

The primary measurement of success of a smart bike program should be defined by demand, or ridership. Smart bikes can provide additional mobility choices for transit users and pedestrians, and thereby help retain transit riders and attract new customers. Smart bikes can assist pedestrians reach destinations that are too far or will take too long to reach by foot.

Existing smart bike programs are located in countries with relatively high percentages of individuals traveling by bike. For example, in The Netherlands, 28 percent of all trips were made by bike, and in Germany, 12 percent were made by bike in 1995 (Transportation Research Board 2001). While overall bike ridership is lower in the United States than in many European countries, more Americans are biking in recent years, and the demand for bike facilities is growing. Nationwide, bicycle modal share increased from 0.6 percent to 0.9 percent between 1977 and 1995 (Pucher et al. 1999). In the *National Survey on Transportation and the Environment 2000*, the Bureau of Transportation Statistics states that there are now more than 80 million U.S. residents who bicycle (U.S. Department of Transportation 2002).

Table 1. Summary of Smart Bike Programs

Country	City	Name of Program	Operator	Year Started	No.# of Bikes	No.# of Stations	Status	Note
Austria	Vienna	Citybike[1]	Gewista	2003	120	13	functional	47 more stations and 880 more bikes planned for '04.
France	Rennes	Vélo à la Carte[2]	Clear Channel Adshel	1998	200	25	functional	
Germany	Berlin	Call a Bike[3]	Deutsche Bahn	2002	1,700	43	functional	
	Frankfurt	Call a Bike[3]	Deutsche Bahn	2003	720	66	functional	
	Munich	Call a Bike[3]	Deutsche Bahn	2001	1,350	55	functional	
Netherlands	Amsterdam	Depo[4]	Depo BV	1999			folded	Program ended due to theft and lack of funding.
	Countrywide	OV-Fiets[5]	ProRail	2001	650	52	functional	500 more bikes planned for '04.
	Rotterdam	City Bike Rotterdam[6]		1997	25		folded	Program folded in '98 due to poorly functioning racks.
Norway	Bergen	Bergen Bysykkel[7]	Clear Channel Adshel	2002	100	10	functional	Evaluating program for possible continuation.
	Drammen	Drammen Bysykkel[8]	Clear Channel Adshel	2001	250	28	functional	
	Oslo	Oslo Bysykkel[9]	Clear Channel Adshel	2002	300	30	functional	
	Porsgrunn	Porsgrunn Bysykkel[10]	JC Decaux	2003	50	8	functional	
	Sandnes	Sandnes Bysykkel[11]	The Sandnes City Bike Foundation	2000	75	16	functional	
Singapore	Bukit Batok	SmartBike[12]	Clear Channel Adshel	2000	100	10	folded	Program ended due to lack of funding.
	Bukit Gombak	SmartBike[12]	Clear Channel Adshel	2000			folded	Program ended due to lack of funding.
	Tanjong Pagar	SmartBike[12]	Clear Channel Adshel	2001			folded	Program ended due to lack of funding.
United Kingdom	Portsmouth	Bikeabout[13]	Portsmouth University	1996			folded	Program ended due to lack of funding.

1. Vienna Citybike Website, *www.citybikewien.at*.
2. Vélo à la Carte Website, *veloalacarte.free.fr/rennes.html*.
3. Call a Bike, *www.callabike.de*.
4. Depo, *www.depo.nl/en/index.html*.
5. OV-fiets, *www.ov-fiets.nl/index.htm*.
6. Utopia, *www.utopia-eu.com/aspUtoProj.asp?num=152*.
7. Bergen Bysykkel, *www.adshel.no/English_WEB2003/bergen.html*.
8. Drammen Bysykkel, *www.adshel.no/English_WEB2003/drammen.htm+A6l*.
9. Oslo Bysykkel, *www.adshel.no/English_WEB2003/oslo.html*.
10. TA.no, *www.ta.no/nyheter/article679878.ece*.
11. Sandes Reiselivssenter, *www.cities-for-cyclists.org/sandness.htm*.
12. Free-bike scheme ends abruptly. *Straits Times.* May 3, 2003.
13. European Research Commission Joint Research Center, *www.jrc.es/projects/snm/confsev/No9.html*.

Surveys conducted by Vélo à la Carte in Rennes (France), the Danish Environmental Protection Agency, and Sandnes Bysykkel in Sandnes (Norway) suggest that potential smart bike customers are likely to be younger individuals in their twenties and thirties. In Rennes, the average age of a customer in 2003 was 31 years (Vélo à la Carte 2004). Rennes' average age is likely lowered by its being a university town. In Copenhagen, a majority of customers are between 20 and 39 years old (Danish Environmental Protection Agency 2001). In Sandnes, 45 percent of customers are between 21 and 45 years (Zanussi 2003). This is comparable with bicyclists in the United States, where 66 percent are 45 years or younger (U.S. Department of Transportation 2002). Smart bike programs in the United States would likely do well with generally younger people in their twenties and thirties.

Gender data are mixed. A majority of customers in Sandnes are male (66%) (Zanussi 2003), while a slight majority of customers (51%) using OV-fiets in The Netherlands are female (ProRail 2003). In the United States, 61 percent of bicyclists are male and 39 percent female (U.S. Department of Transportation 2002). Due to this, the preponderance of smart bike customers in the United States will likely be male.

While reduced traffic congestion is a noble goal, bike-sharing is likely to contribute minimally to this goal. Commuting to work represents only 9 percent of bike use in the United States (Pucher and Dijkstra 2000). Due to the low percentage of bike commuters in the United States, DiDonato et al. point out that bike-sharing will likely have little impact on traffic congestion (2002). They state that residents living downtown who want to bike will likely have their own and prefer its use. However, commuters will either drive or take transit downtown. Those arriving by car will likely not use a smart bike as a segment of their trip due to the directness car travel provides. On the other hand, commuters who take transit and must transfer or walk as part of their trip may choose to use a smart bike to save time instead of transferring or walking. Thus, of those trips made for commuting purposes, smart bikes will likely be most useful for the last leg of a trip to work or the first leg of the return home.

According to Pucher and Dijkstra, in the United States, bikes are used 82 percent of the time for social or personal business (2000). A survey conducted by OV-fiets revealed that approximately 50 percent of respondents use bike-sharing for social or personal business purposes. About 40 percent of respondents also use bike-sharing for recreational purposes (ProRail 2003). These data suggest smart bikes would be well suited to use for social and personal purposes in the United States.

Bike Facilities and Safety

Overcoming the lack of good bike facilities will be the greatest test in the application of smart bikes in the United States. Of all the countries with smart bike programs, many have a high modal split for bicycles in urban areas, including The Netherlands at 27 percent and Denmark at 20 percent. However, France has the smallest percentage at 4 percent. This is not far from the United States, which has a 1 percent modal split for bikes (Pucher and Lefevre 1996). It has yet to be determined if the U.S. bike modal split is strong enough to sustain a smart bike program.

While the United States does not have the quality and quantity of bike facilities that exist in Europe, great strides have been made over the past decade to make American cities and towns more bike friendly. As more bike facilities are created, there will be an increase in the number of bicyclists (Noland and Kunreuther 1995). As the number of bicyclists increases, so should the number of potential smart bike customers.

The notion of biking being unsafe will prevent many people from using smart bikes. There are studies dealing with the real and perceived danger of biking in the United States (Komanoff 1997; Pucher and Dijkstra 2000). John Pucher of Rutgers University states, "The overwhelming evidence is that cycling is much safer and more popular precisely in those countries where bikeways, bike lanes, special intersection modifications, and priority traffic signals are the key to their bicycling policies" (2001).

Smart bike programs must remove as much risk as possible. Customers can be provided a liability agreement, encouraged to wear a helmet, offered bike training classes, and provided a brightly colored smart bike. Also, the bikes should be maintained on a regular schedule (see the Theft and Vandalism section below).

Liability waivers for participants are common in bike-sharing programs and help to financially protect the administering organization. These agreements state the administering organization's duties regarding the maintenance of the bikes, and the customer's duties regarding safe use of the bike. Some programs, such as Germany's Call a Bike, offer the liability agreement on their website (Deutsche Bahn 2003). Others, such as the Arcata, California first-generation Library Bike, have stickers on each bike which read *Ride at Your Own Risk. All Bike Laws Apply* (Arcata Community Bike Program 2003). Being a litigious society, any American smart bike program would benefit from including a liability waiver.

Requiring mandatory helmet use would likely lessen smart bike ridership as it would make usage less convenient. Customers would need to carry their own helmet during their trip to the smart bike. Also, impromptu trips via smart bike would be prevented should a customer not have a helmet with him or her. The lending of helmets by a smart bike organization or local bike shop to smart bike customers raises sanitary issues as well as liability issues due to unreported defective helmets.

To improve visibility of the customer, smart bikes in countries abroad are usually colored a bright fluorescent shade or white. Many first-generation American bike-sharing programs have picked up on this safety measure. In addition, front and rear lights and reflectors also should be installed on the smart bikes. And finally, smart bikes must be maintained to ensure that each bike is in working condition.

Profitability

No smart bike program has made a profit to date. Clear Channel Adshel's smart bike systems do not charge a use fee. In addition, without advertising revenues, its smart bike programs could not operate economically (Grasso 2003). Deutsche Bahn did not disclose the profitability of Call a Bike, however, Joachim Schindler of Deutsche Bahn states, "We said in 2001 that it would take us two or three years to see a profit. We're well on our way" (Ollivier 2003).

Usage fees of the smart bike programs vary. Many have an annual membership charge of under $20 and no usage charges as long as the bikes are returned within a specified time. The Clear Channel Adshel system follows this model. The other model has a one-time membership charge and an additional usage fee. The Call a Bike program follows this model. The usage charge for Call a Bike is 4 or 6 cents per minute depending on whether the customer has a BahnCard or ActivTarif card, which cost 60 EUR ($68) and 20 EUR ($23), respectively.

The authors believe that not-for-profit smart bike programs are likely to be more successful in the United States than for-profit programs. A usage fee for smart bikes in the United States would likely provide enough disincentive to limit usage. Funding revenues for the not-for-profit smart bike programs come from advertisements on the bikes or in some cases street furniture installed by the supplier. Also, local governments where the program is based may provide subsidy.

Theft and Vandalism

Theft and vandalism present serious challenges to bike-sharing programs. However, the problem of theft has been lessened due to the technological improvement of bike tracking which was added with the third generation of bike-sharing systems. Customers must provide credit card information, so if they do not return a bike, they will be charged its replacement cost.

To prevent, or at least limit, vandalism, smart bikes are designed to be utilitarian and vandal-proof. Therefore, they are usually built with puncture-proof tires, a strong frame, and an adjustable seat post. The components are designed to require the use of special tools for disassembly, thereby discouraging unauthorized removal. In addition, most of the components are of uncommon dimensions that would not be usable on other bikes. The bikes also have a unique design so as to stand out from other bikes.

Many programs have a dispatch vehicle which is used as a mobile repair station for damaged bikes. Bikes that can be fixed on the spot are, while those needing major repair can be taken to the repair center (Adshel undated).

Multimodal Connectivity

Bike-sharing programs tend to be located in downtown areas. This is primarily due to the compactness of urban development where biking is ideal. Being concentrated in an urban environment provides a greater number of potential connections than in dispersed suburban locations. Considering the average bike trip length is about two miles and 24 minutes long, short trips in urban settings are ideal for smart bikes (U.S. Department of Transportation 2001).

Bike-sharing programs also tend to colocate a portion of their bike stations at downtown transit stations in order to improve access and mobility for transit customers. As the Danish Environmental Protection Agency states, bike-sharing is well suited "to make it easier for commuters to use a bicycle on the last leg of their public transport journey" (2001). Bike stations are also located downtown at places not well served by transit. This is done to extend the reach of the transit system, thereby assisting the transit user in reaching additional locations that would previously have required a longer walk or transfer.

By providing on-demand transportation for transit customers, the modal transfer becomes a seamless exit from the transit station to the smart bike with no wait time. As the Institute of Transportation Engineers states, "Many studies have indicated that the trip time associated with waiting for or transferring to a transit vehicle is perceived to be two to three times as onerous as the actual travel time. Therefore, anything that can be done to enhance this experience will have a positive effect on attracting riders" (1997). With an on-demand bike-sharing component in conjunction with a transit system, the wait time between transfers will decrease, therefore customers will likely be retained and new customers attracted.

Smart bikes being truly on-demand depends on a good distribution of the bikes. When smart bike customers do not provide a satisfactory distribution of the bikes through their use, program staff can move bikes from full to empty bike stations. The dispatch vehicle is used for this task.

Conclusions

Recent strides in smart card and wireless technologies have allowed bike-sharing to evolve into the third generation of the bike-sharing concept, or smart bikes. The high-tech smart bike system, first developed in the mid-1990s, has expanded to 11 cities over the past decade, however, none so far in the United States.

Implementation of smart bike programs in the United States would provide individuals with a greater number of mobility options. Smart bikes would complement transit and walking trips to offer greater mobility to its users. Improved access to transit stations will also assist transit agencies in retaining and attracting new customers.

Biking, and smart bikes in particular, are not suitable for all people or every American city. Suitable locations include urban areas with more compact downtowns, university campuses, and dense neighborhoods with a concentration of younger people. Organizations wanting to implement smart bike programs in the United States must examine the characteristics of their city and its people to determine smart bike's appropriateness. The authors believe there are many American cities where smart bikes would likely succeed.

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An Evaluation of the Role of Marketing in Public Transit Organizations

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Abstract

This study was designed to examine the role of marketing in public transit organizations from a management perspective. Using a survey methodology, a national survey was conducted with a sample of 820 managers and individuals from a variety of specialized transit organizations across the United States. Twenty-three percent of the survey sample responded. Of this total, 43 percent were managers in public transit organizations, with the remainder being from a variety of specialized transit organizations. A majority of the nonmanager group was comprised of government transit entities.

The findings suggest that some marketing departments are not a standard part of a transit firm's organizational structure, and the department may be relatively small. There may be budgetary constraints also. In addition, even though the employees with marketing responsibilities are generally well educated and have several years of transportation industry experience, they may still have misperceptions about the role of marketing in the company.

Introduction

The utilization of public transit has declined steadily in the United States and government officials and public transit managers across the country are in search of ways to increase the use of existing systems support for new services to reduce urban traffic congestion and air quality deterioration. Public transit organizations have belatedly recognized the importance of marketing after enhancing the operational efficiency of their systems. The strategic importance of the marketing function has received the increasing attention of public transit managers and the industry is increasingly becoming market oriented.

Little documented evidence exists relative to the marketing activities employed by public transit organizations. Information concerning the educational background of those responsible for the marketing activities of transit organizations is nearly nonexistent. A review of the perceptions of public transit managers relative to the effectiveness of specific marketing tactics and strategies is also needed. In addition, the desire of public transit managers for more marketing information and training is lacking. The goal of this study is to investigate the marketing resource needs of this important and largely beleaguered industry.

The three primary objectives of this research are to:

1 Assess the current utilization of marketing methods,

2 Determine specific marketing educational needs of transit managers, and

3 Identify how educational centers can assist in satisfying these needs.

Background

As we move into the 21st century, we find that the role of public transit in the United States is in a steady decline. The fact that the perception of public transit as a viable commuting option has experienced such a serious erosion is even more significant given the traffic congestion and air quality problems inherent in many urban areas. Public transit's overall share of the commuting market has declined from 3.6 percent in 1969, to 2.6 percent in 1983, to 2.0 percent in 1990 (Khattak, Noeimi, and Al-Deek 1996; Pisarski 1992). This loss of market share is even more dramatic for work commutes where public transit's share has declined from 12.6 percent in 1960 to 5.3 percent in 1990 (Khattak, Noeimi, and Al-Deek 1996; Ball 1994). The most dramatic evidence of the difficulty public transit has in attracting and retaining riders can be found in metropolitan areas where its market share declined by 24.9 percent from 1980 to 1990, while the total number of commute trips made by Metropolitan Statistical Area (MSA) residents increased by 20.5 percent (Kemp, et. al 1997).

In spite of the need for innovative marketing-based solutions, comparatively little attention has been directed by public transit agencies at developing new approaches to these problems. Part of the explanation may reside in either the inadequate marketing training and experience of public transit managers, or a simple lack of an appreciation of marketing approaches to the solution of these problems. Or, the explanation might incorporate both issues.

The intent of the research described and summarized below is to examine the marketing efforts of the public transit industry. The overriding purpose of this research is to provide a benchmark to guide the design of possible solutions to the problems faced by this important industry.

Research Design

To enhance the managerial relevance of the instrument used in the current study, public transit managers were involved in each step of the development process. The initial set of questions was developed through a review of the academic and popular press literatures and the input of public transit managers. Transit managers reviewed the survey instrument to ensure its relevance and completeness. Modifications were made based on that review.

The sample frame was drawn from the membership of the American Public Transit Association and the Association for Commuter Transportation. A random sample of 1,000 was generated from the two membership lists. The data was then collected over a six-week period.

Response Rate

Of the 820 deliverable surveys (180 were returned as undeliverable due to an incorrect address or the addressee having changed jobs), the 186 completed surveys represent a response rate of 23 percent. Given the length of the instrument, and the fact that the respondents were not prequalified (i.e., their participation was not sought before the survey was delivered), this is acceptable and quite typical for this type of research. Thus, it appears that there are no significant problems with either the sampling process or the actual sample.

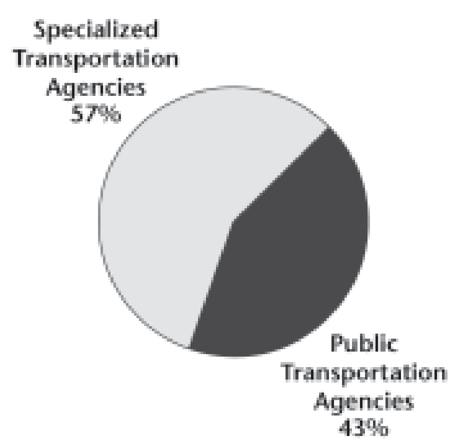
Respondent Characteristics

Organizational Type

Forty-three percent of the respondents (n=81) are from public transit agencies; the remaining 57 percent (n=105) are classified as specialized transportation agencies. The vast majority of the public transit agencies (59 of the 81) classify themselves as bus-only organizations. Those so classified are dispersed across what might be termed small, medium, and large-size fleets in near equal numbers. Of the remaining firms that classified themselves as public transit agencies (n=22), 1 describes itself as a heavy rail organization, 2 are commuter rail organizations, and 19 are multimodal.

Of the 105 specialized transportation agencies, the greatest number (n=39) classify themselves as transportation/van pooling/rideshare organizations. Twenty-three of the respondents indicate that they are employed by a local, state, or federal department of transportation, while 22 work for a transportation management association. The remaining 11 agencies are widely varied in their classification.

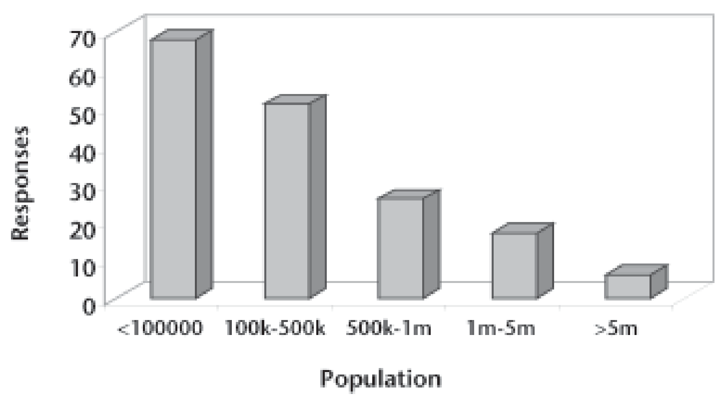
Figure 1. Description of Respondents



Population Size of Area Served

Forty percent of the respondents (n=74) are from organizations that serve populations of 100,000 or less. Another 30 percent (n=56) are from organizations serving areas in excess of 100,000 but less than 500,000; 15 percent (n=28) represent organizations whose market area has between 500,000 and 1 million individuals; 10 percent (n=21) are from areas of between 1 and 5 million; and 4 percent (n=7) have more than 5 million people in their market area. Thus, the sample represents a cross-section of the areas served by transit systems in the United States.

Figure 2. Distribution of Respondents Based on Population



Physical Size of Area Served

The greatest number of respondents (31 percent, n=58) came from areas of 100 square miles or less. An additional 23 percent (n=43) represent organizations that serve areas of more than 100 square miles, but no more than 500. The remaining respondents were scattered across larger areas. The data thus indicate that areas of all sizes are represented in the sample.

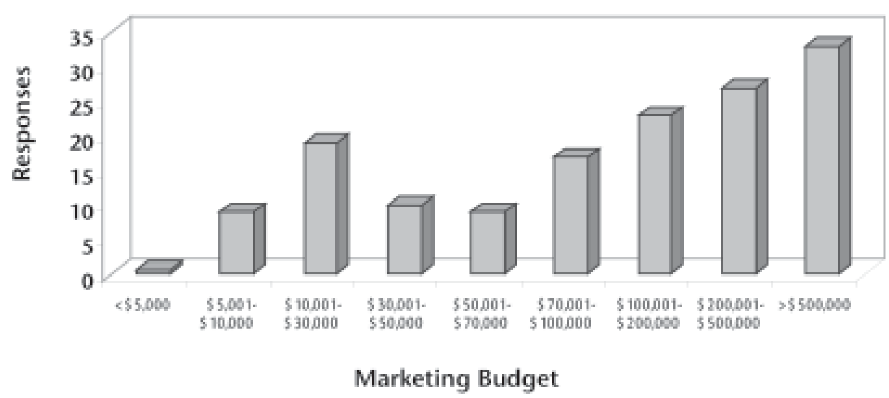
Organizational Structure

Slightly more than half of the respondents (51 percent, n=95) indicate that their organization has a marketing department. Of those with a marketing department, over half (51 percent, n=48) report having 1 to 3 full-time employees and 81 percent (n=77) report having a full-time staff of 10 or less. Nearly half (48 percent, n=46) of the respondents who report that their organization has a marketing department, indicate that they do not have part-time employees in the department. Of those organizations that report having part-time employees (49 percent, n=47), 46 percent (n=44) report having 1 to 3 employees. Thus, the evidence suggests that marketing departments are (1) not a standard part of the organizational structure of transit organizations and (2) small. This is supported by the fact that the majority of the respondents (63.5 percent, n=118) hold the opinion that their organization does not have enough personnel focused on marketing activities.

Marketing Budget

Interestingly, responses to the survey indicate that a true dichotomy exists relative to the funding of the marketing efforts of transit organizations. More than half of the respondents (51 percent, n=95) indicate that their organization's budget for marketing is in excess of $100,000, while 20 percent (n=37) report a budget in excess of $500,000. However, almost 29 percent (n=54) suggest that their budget is $30,000 or less. While this does not represent a true feast-or-famine situation (a marketing budget of $100,000 can hardly be considered a feast), it does suggest that public transit organizations can be accurately classified as either active or reluctant marketers.

Figure 3. Annual Marketing Budget



The Marketing Position

Eighty percent (n=148) of the organizations represented in the sample do not have a position that can be accurately described as a Director of Marketing. Of the organizations reporting that they do not have a top-level managerial position devoted to marketing, nearly half (47 percent, n=69) note that one individual is assigned responsibility for the firm's marketing efforts as a secondary task. Almost as many of the firms (44 percent, n=65) report that marketing responsibilities are spread across various individuals.

Figure 4. Is There a Marketing Director?

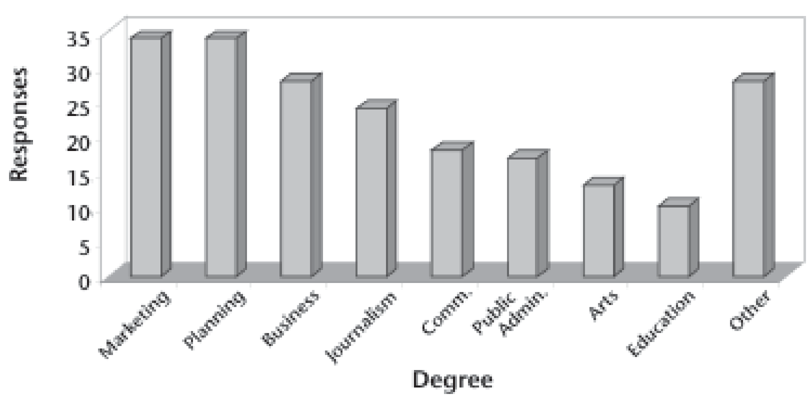
The fact that the majority of the organizations report that their organization does not have a top managerial position devoted to marketing is indicative of the lack of recognition afforded marketing within the transit industry. The relative high number of organizations that report the responsibility is dispersed across numerous individuals gives further evidence of the failure of transit organizations to fully embrace marketing as a necessary part of their managerial activities. It also provides evidence of their need for additional marketing education.

Educational Background

Survey responses indicate that 92 percent of the individuals deemed to be "most responsible for marketing..." have at least a four-year college degree. Of those having a degree, 41 percent received their degree in marketing or a related field (business or management). This suggests that those individuals responsible for the marketing activities of transit organizations are well educated. However, when combined with the findings relative to the lack of recognition afforded the position within the organizational structure, the results indicate that public transit marketing managers need help in educating other transit managers as to the relevance of marketing within the transportation industry. The data also does not specify whether the formal marketing education of the director was adequate for the position.

The survey responses also show that the vast majority of the individuals responsible for public transit marketing efforts have participated in (1) professional development seminars (83 percent) and (2) university-level marketing courses (65 percent). A significant number (36 percent) have also participated in post-graduate marketing courses. These results add support for the aforementioned conclusions and point to the receptivity of public transit marketers to continuing education efforts.

Figure 5. Education of Persons Responsible for Marketing Activities



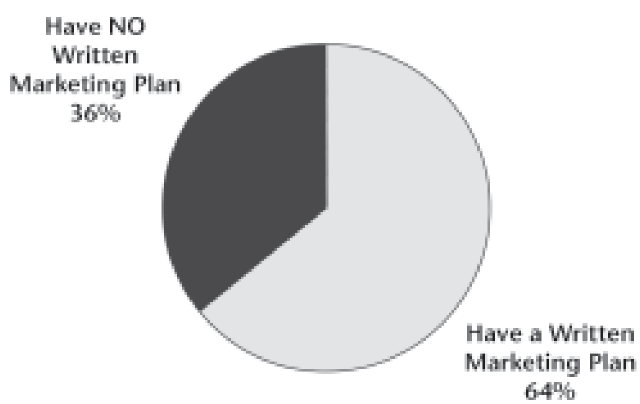
Experience

Survey results reveal that 39 percent of the individuals performing marketing activities in public transit organizations have more than 10 years experience in marketing. Another 24.5 percent have between 7 and 10 years of marketing experience. However, the results also indicate that 40 percent of those responsible for marketing activities have been involved in marketing with their current organization for 3 years or less and another 32 percent report 4 to 6 years of marketing experience with their current organization. When combined, these results seem to indicate that public transit marketers have significant marketing experience, but only a portion of it is with their current transit organization. This may indicate that marketers are being recruited from outside the industry. If this is the case, the need for further industry-specific or in-house marketing education becomes more obvious.

The Marketing Plan

Almost two-thirds (64.5 percent, n=120) of the respondents indicate that their organization has a written marketing plan. Of those whose organization has a marketing plan, 85 percent (n=102) state the time horizon of the plan is one year or less. A number of the organizations (33 percent, n=40) review their plan annually, although the number reviewing the marketing plan on a quarterly basis is similar (27 percent, n=32). Interestingly, a significant number of the respondents (19 percent, n=23) suggest that their organization does not have a fixed schedule for the review of their marketing plans.

Figure 6. Is There a Written Marketing Plan?



Basis for Segmentation

Respondents are asked to indicate which of a list of multiple segmentation options are used by their organization in their marketing efforts. Usage (heavy users, light user, nonusers) is identified as the most common (76 percent) basis for segmentation. Demographics (age, gender, education, etc.) (59 percent) and geographic measures (trip destinations and origins) (56 percent) are also identified as commonly used segmentation variables. Benefits (e.g., price, convenience, etc.) (48 percent) and psychographics (lifestyle variables) (36 percent) are also mentioned by a significant number of respondents. The frequency of the use of these segmentation variables is evidence of the growing interest in, and sophistication of, the marketing efforts of transit organizations.

Advertising

Respondents indicate that word of mouth is the most commonly used form of advertising (83 percent), followed by direct mail (71 percent), newspaper advertising (66 percent), and public service announcements (62 percent). Interestingly, the results suggest that the respondents feel that all seven of the advertising media identified (television, radio, newspaper, billboards, direct mail, word of mouth, and public service announcements) should be utilized to a greater extent. Differences between current use and should use is particularly dramatic for word of mouth, direct mail, television, and public service announcements. It seems obvious that the respondents feel that public transit organizations should (1) alter their distribution of advertising funds across the various media and (2) increase the overall use of advertising as a marketing tool.

Information Brochures

The survey results suggest that 98 percent of transit organizations currently use information brochures as marketing tools. Interestingly, respondents also indicate that the reliance on information brochures should be increased. The results make a strong case that public transit organizations are doing an adequate job with their marketing efforts, but appear to suffer from a resource allocation shortage.

Public Support and Sponsorship Programs

Forty-three percent of the respondents indicate that their organization currently uses these programs. Again, however, they suggest that such programs should be used more frequently. This is consistent with the aforementioned resource shortage. Greater utilization of sponsorship programs, and other public support could ease the need for resources.

Promotions (General)

On-site information booths are the one of most commonly used forms of promotion. Free rides, specific programs (e.g., monthly passes), and special events are all identified by respondents as being used by more than 50 percent of the transit organizations they represent. However, the results also indicate that the respondents again feel that transit organizations should not rely so heavily on these marketing efforts.

Employer-Based Marketing Efforts (General)

Employer sales calls, employer seminars, and special events are currently used as marketing tools by more than 50 percent of the responding organizations. Once again, however, the data indicate that the respondents feel that these efforts should be used more frequently.

Effectiveness of Current Marketing Activities

Advertising Campaigns

Radio is perceived to be the most effective of the media for advertising campaigns (1.21 on a five-point scale where 1 = effective and 5 = ineffective), with public service announcements the least effective (2.88). In general, advertising campaigns are considered to be moderately effective (2.19). These results indicate a need for public transit marketers to develop a greater knowledge of transit advertising campaigns in general, and radio specifically.

Programs (Overall)

Specific programs (e.g., monthly passes) (1.89 on a five-point scale where 1 = effective and 5 = ineffective) and multiple-use discounts (1.98) are judged to be the most effective of these programs. Overall, these programs are judged to be moderately effective (2.35). Five of the six programs rated as the most effective involve some sort of (discount) price appeal. This suggests a perception among the respondents that price is the major determinant of transit use. It also suggests that transit managers have a limited understanding of the role of marketing (beyond price appeals) and is indicative of a need for further educational efforts.

Employer-Based Marketing Efforts

Overall, employer based marketing efforts are also considered to be moderately successful (2.31). However, none of the specific programs are judged to be particularly effective (a range of 2.27 to 2.34). Creativity in designing more effective programs is needed and this is an area on which continuing educational efforts should focus.

Importance of Promotional Objectives

Informing commuters about the services offered was considered by respondents to be the most important objective of promotional programs (1.67 on a five-point scale where 1 = important and 5 = unimportant) followed closely by persuading commuters to use their service. Service comparison (comparison advertising) is considered by respondents to be largely unimportant (4.61). Again, these responses are not indicative of a thorough understanding and appreciation of marketing. This suggests a further area of need for potential educational efforts.

Sale of Advertising Space

Forty-two percent of the respondents (n=78) note that their organization sells space on transit vehicles to advertisers. Ten percent report that space on printed materials is sold for similar purposes. This, again, suggests an area where additional training might benefit transit marketers in their efforts to increase revenues.

Customer Comments

Only 39 percent of the respondents (n=73) indicate that their organization has a customer comment box. This suggests that adequate communication links may not have been established between transit organizations and their customers. Again, this is a topic that can be addressed in professional development seminars.

Customer Information Gathering Techniques

In the short term (weekly and monthly), in-person meetings are the most commonly utilized data-gathering technique. More formal research techniques (telephone surveys, on-board questionnaires, and focus groups) are used less frequently (annually or rarely) according to respondents. These results indicate a need for transit managers to develop a better understanding and appreciation of the value of the various customer information-gathering techniques.

Community Committees

Sixty percent of the respondents (n=112) indicate that their organization has formed community committees as a means of gathering customer information. The data suggest that the membership of such groups is relatively diverse. Regular users, local business representatives, and local government officials are the groups most frequently included on such committees. The data indicate that less emphasis is placed by the transit organization on ensuring that all racial, ethnic, and age groups are represented. Again, the data indicate that this is an area where additional training and educational efforts might be needed.

Perception of Marketing

A series of six questions that represent common misperceptions about marketing are used to assess the accuracy of the respondents' perceptions of marketing management issues. Respondents are asked to indicate their level of agreement with each statement using a scale where 1 = strongly agree and 5 = strongly disagree. The ideal response is a 5. Each statement is reviewed separately.

- The main objective of marketing is to increase revenue

The mean response of 3.26 indicates that, overall, respondents neither agreed nor disagreed with the statement. In reality, the objective of marketing is to identify the needs and wants of consumers and to determine how best to satisfy those needs and wants. Increases in revenues should be an outcome of this process, but not the primary objective. The responses indicate that there is a significant amount of confusion relative to the role of marketing in transit organizations.

- Transportation organizations should design a good, efficient service then convince people to use it.

The mean response of 2.24 indicates a fairly high level of agreement with the statement. Marketing's responsibility is to identify the strategies necessary to provide consumers with what they need and want. The above statement is an example of what commonly is known as a product-oriented approach to marketing; that is, build the best product and consumers will buy it. It is an approach that has been found lacking and indicates a significant misperception relative to the role of marketing.

- Marketing is properly part of the public relations responsibilities of transportation organizations.

The mean response of 2.23 again is indicative of a high level of agreement with this statement. Marketing is simply not public relations, and is not properly part of the public relations responsibilities of transportation organizations. Rather, the opposite is true; that is, public relations are part of the marketing function. Again, this result is evidence of a misperception that transportation organizations should endeavor to correct.

- Market segmentation is not a very useful strategy for transportation organizations.

The mean response of 4.04 indicates a high level of disagreement with this statement, as is desired. The value of segmentation is well documented; therefore, the respondents' responses to this statement are indicative of an appreciation for this important marketing tool.

- Scheduling of service should be a responsibility of marketers.

The mean response of 3.28 indicates that respondents neither agreed nor disagreed with the statement. Scheduling should be based on the needs and wants of transit customers. Therefore, it should be a responsibility of marketers. Again, this result is evidence of a misperception that transportation organizations should endeavor to correct.

- We've got marketing down, but we just don't know how to package our services.

The mean response of 3.88 indicates that respondents tend to disagree with this statement. However, part of marketing is the packaging of services. Complete disagreement is desired so the result can be considered to exhibit some evidence that the respondents do not have an adequate understanding of the role and responsibilities of marketing.

Professional Development Activities

Utilization of Service Firms/Agencies

Marketing consultant/researchers and design firms are identified as the most frequently utilized of the specialty firms, with business/financial advisors the least utilized. In general, the results indicate that transportation organizations frequently make use of outside experts.

Usefulness of Service Firms/Agencies

All of the firms are considered to be more useful than not useful. Design firms, production companies, and marketing consultant/researchers are rated as the most useful.

Willingness to Participate in Professional Development Seminars

The mean response of 1.96 indicates that respondents feel that public transit managers are willing to participate in professional development seminars.

Willingness to Participate if Continuing Education Units Are Offered

The mean response of 3.27 suggests that respondents feel that offering continuing education units for professional development seminars will neither increase nor decrease the willingness of transportation managers to participate.

Preferred Location

The west coast is the most frequently preferred location, but this question is greatly affected by the distribution of the responses. That is, more surveys were sent to the west coast than any other location. Therefore, this preference is not unexpected. The preferred cities are Los Angeles, Seattle, Chicago, New York, Washington D.C., Denver, Phoenix, Atlanta, and Charlotte.

Preferred Time of Year

The responses do not indicate that transportation managers have a preferred time for such seminars.

Perceived Usefulness of Seminar Topics

Marketing planning/strategy is the topic rated as the most useful. Interestingly, all of the topics listed are considered more useful than not useful. Other topics deemed especially useful are employer-based marketing, consumer behavior modification, marketing presentation skills development, and marketing as applied to a specific organization's services. Specifically, such activities as selecting target markets, developing marketing research skills, performing attitudinal and economic impact studies, and performing service evaluations were identified.

Appropriate Daily Fee

The mean response is $117 per day, but the largest number of respondents (43 percent) indicates that they perceived a fee of between $51 and $100 appropriate.

Summary and Conclusions

In a time when increasing the utilization of public transit options is perhaps more important than ever before, we find that there is a huge gap between the marketing knowledge available and its use by public transit organizations. Public transit organizations, as well as more specialized transit agencies, have belatedly recognized the importance of marketing the services they offer. Unfortunately, their marketing efforts are understaffed, underfunded, and underemphasized within their own organizations. Public transit marketers appear competent and highly educated, and they recognize the need for a greater marketing orientation within their agencies. They also note the need for additional marketing training and education, as well as staffing and financial resources.

Specifically, the findings presented here suggest first that most public transit marketing departments are small. Typically the department has one to three full-time employees and a like number of part-time assistants. Nearly two-thirds of the respondents consider their staffing for marketing activities to be inadequate.

Second, the marketing budget is small. Although 20 percent of the respondents state that their budget was in excess of $500,000, almost a third have less than $30,000 to spend on marketing. Obviously, the vast majority of public transit organizations have underinvested in marketing.

Third, 80 percent of the respondents report that their organization does not have a person who carries the title of Director of Marketing. Of the 80 percent, 44 percent report that the responsibility is split between several individuals and most of the remaining respondents (47 percent) indicate that one person manages their marketing efforts, but as a secondary responsibility. Marketing clearly does not receive a substantial level of organizational commitment within many public transit organizations.

Fourth, one of the more positive findings of the study relates to the background of the individual most responsible for marketing in public transit organizations. The overwhelming majority (92 percent) has a college degree with 48 percent having a graduate degree or at least some graduate work. Thirty-eight percent have a degree in marketing or some other business-related discipline. Also encouraging is the fact that 83 percent of the marketing managers have participated in professional development seminars and 65 percent have attended a university-level marketing class.

Clearly, most of the managers directly responsible for public transit marketing have an appropriate background. They also tend to have had substantial experience. Thirty-nine percent have been involved in marketing activities for more than 10 years and 60 percent have been involved in marketing in their current organizations for 4 or more years. Thus, the good news for transit organizations is that they have experienced and well-trained individuals directing their marketing efforts.

Fifth, it also appears that a substantial amount of strategic planning occurs in transit organizations. Sixty-five percent of the respondents report that their organization has a marketing plan, typically with a one-year or less planning horizon. Forty-two percent of the respondents suggest that their organization review the marketing plan quarterly or more often. While every transit organization should have a strategic plan, the fact that almost two-thirds currently embrace the concept should be encouraging for public transit marketers.

Sixth, in terms of specific marketing activities, most of the respondents report using segmentation strategies (89 percent), with usage being the most common (85 percent) basis employed to segment the transit market. Geographic, demographic, benefit, and psychographic segmentation is also used by a substantial number of public transit organizations. Again, this is evidence that there is some degree of sophistication in the marketing efforts of public transit organizations.

In rating their current marketing efforts, radio is clearly viewed as the most effective marketing tool. Price discounts (multiple-use discounts and monthly passes) are the only other program or activity rated below a 2.0 on a five-point scale where 1.0 = very effective. The two most important objectives of marketing activities are clearly identified as (1) informing commuters about the service offered and (2) persuading commuters to use their services. These are important marketing objectives; however, the responses suggest that transit organizations still do not fully comprehend the breath of marketing responsibilities.

Forty-two percent of the respondents indicate that their organization sells advertising space on their service vehicles, but only 10 percent reported selling such space on their printed materials (schedules, etc.). Thirty-nine percent of the respondents indicate that their organization has a customer comment box. In addition, more than half of the respondents suggest that their organization uses a telephone survey (50 percent) or on-board questionnaires (59 percent) annually or more often. Sixty-percent of the respondents also state that their company has formed some type of community committees to integrate the public into their planning processes. Again, the opportunity for additional marketing applications is clear.

While all of the above indicate an awareness of marketing activities, the responses to the summary also identify a major weakness in the marketing orientation of transit marketers. Specifically, the respondents, who are public transit marketers themselves, are asked to answer a series of six questions where five should elicit strong disagreement and one strong agreement. The questions are designed to assess the respondents marketing IQ—that is, their understanding of marketing.

The mean responses to these questions range from 2.23 to 4.04. Based on these six items, the seventh conclusion is that the respondents do not have a well-grounded understanding of marketing.

The eighth area examined is related to the use of consultants and service agencies by transit organizations. Utilization of service firms and agencies is high especially for advertising, marketing research, and the design and production of promotional materials. The respondents indicate that such firms and agencies have proven useful in their marketing efforts.

The ninth and final conclusion reached is that transit marketers are willing to participate in professional development seminars, whether continuing education units are offered or not. The preferred location for such seminars is a nearby large city—Los Angeles, Seattle, Chicago, New York, Washington, D.C., Denver, Phoenix, Atlanta, and Charlotte are the most frequently mentioned in each of the nine specified regions. No seasonal preference is exhibited.

In terms of topics considered useful, all 17 identified are considered useful to some extent. Those rated the most useful were (1) marketing planning/strategy, (2) employer-based marketing, (3) consumer behavior modification (4/5) promotion and marketing as applied to the organization's services (a tie), (6) targeting, (7/8) marketing research skills and performing target market studies (a tie), (9) performing attitudinal and impact studies, and (10) performing service evaluations. The mean daily fee considered appropriate for such a seminar is $117.

In conclusion, the survey results suggest that public transit marketers are well-educated individuals with substantial experience who need additional resources to improve their marketing efforts. Specifically, they need larger staffs, larger budgets, and more training. If local traffic congestion and air quality problems are to be solved, the above-mentioned resources are needed. An apparent trend within the industry is that market-oriented transit firms appear to have a growing appreciation of market-based strategies, if not a complete understanding of the practice of marketing. Nevertheless, in all too many instances, the resources needed for successful implementation have not been provided to the transit firm.

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Transit Price Elasticities and Cross-Elasticities

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Abstract

This article summarizes price elasticities and cross-elasticities for use in public transit planning. It describes elasticities and how they are used, and examines previous research on transit elasticities. Commonly used transit elasticity values are largely based on studies of short- and medium-run impacts performed decades ago when real incomes where lower and a larger portion of the population was transit dependent. As a result, they tend to be lower than appropriate to model long-run impacts. Analysis based on these elasticity values tends to understate the potential of transit fare reductions and service improvements to reduce problems, such as traffic congestion and vehicle pollution, and understates the long-term negative impacts that fare increases and service cuts will have on transit ridership, transit revenue, traffic congestion, and pollution emissions.

Introduction

Prices affect consumers' purchase decisions. A particular product may seem too expensive at its regular price, but a good value when it is discounted. Similarly, a price increase may motivate consumers to use a product less or shift to another brand.

Such decisions are said to be marginal. The decision is at the margin between different alternatives, and can therefore be affected by even a small price change.

Although individually such decisions may be quite variable and difficult to predict (a consumer might succumb to a sale one day but ignore the same offer the next), in aggregate they tend to follow a predictable pattern: When prices decline consumption increases, and when prices increase consumption declines, all else being equal. This is called the law of demand.

This article summarizes research on how price changes affect transit ridership. *Price* refers to users' perceived marginal cost—the factors that directly affect consumers' purchase decision. This can include both monetary costs and nonmarket costs such as travel time and discomfort.

Price sensitivity is measured using *elasticities*, defined as the percentage change in consumption resulting from a 1 percent change in price, all else held constant. A high elasticity value indicates that a good is price-sensitive; that is, a relatively small change in price causes a relatively large change in consumption. A low elasticity value means that prices have relatively little effect on consumption. The degree of price sensitivity refers to the absolute elasticity value—regardless of whether it is positive or negative.

For example, if the elasticity of transit ridership with respect to (abbreviated WRT) transit fares is –0.5, this means that each 1.0 percent increase in transit fares causes a 0.5 percent reduction in ridership, so a 10 percent fare increase will cause ridership to decline by about 5 percent. Similarly, if the elasticity of transit ridership with respect to transit service hours is 1.5, a 10 percent increase in service hours would cause a 15 percent increase in ridership.

Economists use several terms to classify the relative magnitude of elasticity values. *Unit elasticity* refers to an elasticity with an absolute value of 1.0, meaning that price changes cause a proportional change in consumption. Elasticity values less than 1.0 in absolute value are called *inelastic*, meaning that prices cause less than proportional changes in consumption. Elasticity values greater than 1.0 in absolute value are called *elastic*, meaning that prices cause more than proportional changes in consumption. For example, both 0.5 and –0.5 values are considered *inelastic* because their absolute values are less than 1.0, while both 1.5 and –1.5 values are considered *elastic* because their absolute values are greater than 1.0.

Cross-elasticities refer to the percentage change in the consumption of a good resulting from a price change in another related good. For example, automobile travel is complementary to vehicle parking and a substitute for transit travel, so an increase in the price of driving tends to reduce demand for parking and increase demand for transit.

To help analyze cross-elasticities it is useful to estimate *mode substitution* factors, such as the change in automobile trips resulting from a change in transit trips. These factors vary depending on circumstances. For example, when bus ridership increases due to reduced fares, typically 10 percent to 50 percent of the added trips will substitute for an automobile trip. Other trips will shift from nonmotorized modes, ridesharing (which consists of vehicle trips that will be made anyway), or be induced travel (including chauffeured automobile travel, in which a driver makes a special trip to carry a passenger). Conversely, when a disincentive, such as parking fees or road tolls, causes automobile trips to decline, there is generally a 20 to 60 percent shift to transit, depending on conditions. Pratt (1999) provides information on mode shifts that result from various incentives, such as transit service improvements and parking pricing.

Special care is required when calculating the impacts of large price changes, or when predicting the effects of multiple changes, such as an increase in fares and a reduction in service, because each subsequent change impacts a different base. For example, if prices increase 10 percent on a good with a –0.5 elasticity, the first 1 percent of price change reduces consumption by 0.5 percent, to 99.5 percent of its original amount. The second 1 percent price change reduces this 99.5 percent by another 99.5 percent, to 99.0 percent. The third 1 percent of price change reduces this 99.0 percent by another 99.5 percent to 98.5 percent, and so on for each 1 percent change. In total, a 10 percent price increase reduces consumption 4.9 percent, not a full 5 percent that would be calculated by simply multiplying –0.5 x 10. This becomes significant when evaluating the impacts of price changes greater than 50 percent.

Price elasticities have many applications in transportation planning. They can be used to predict the ridership and revenue effects of changes in transit fares; they are used in modeling to predict how changes in transit service will affect vehicle traffic volumes and pollution emissions; and they can help evaluate the impacts and benefits of mobility management strategies such as new transit services, road tolls, and parking fees.

Factors Affecting Transit Elasticities

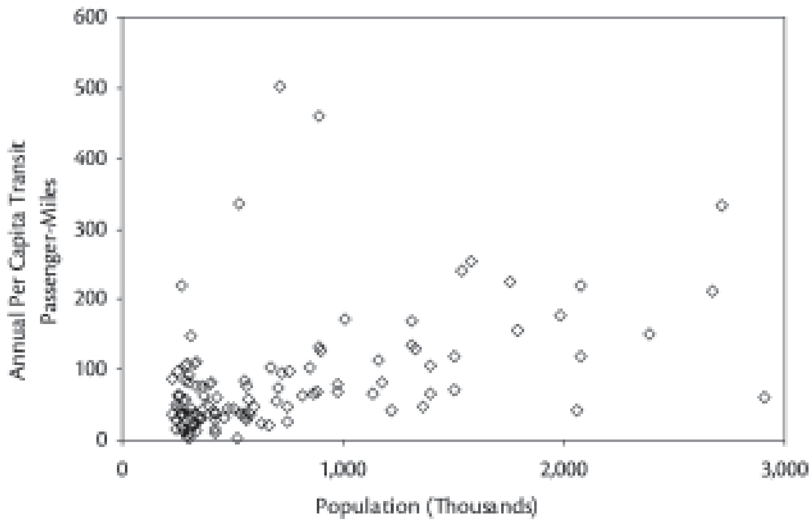
Many factors can affect how prices affect consumption decisions. They can vary depending on how elasticities are defined, type of good or service affected, category of customer, quality of substitutes, and other market factors. It is important to consider these factors in elasticity analysis.

Some factors that affect transit elasticities, as reflected in currently available research, are summarized below.

- *User Type.* Transit dependent riders are generally less price sensitive than *choice* or *discretionary* riders (people who have the option of using an automobile for that trip). Certain demographic groups, including people with low incomes, nondrivers, people with disabilities, high school and college students, and elderly people tend to be more transit dependent. In most communities transit-dependent people are a relatively small portion of the total population but a large portion of transit users, while discretionary riders are a potentially large but more price elastic transit market segment.
- *Trip Type*. Noncommute trips tend to be more price sensitive than commute trips. Elasticities for off-peak transit travel are typically 1.5 to 2 times higher than peak-period elasticities, because peak-period travel largely consists of commute trips.
- *Geography*. Large cities tend to have lower price elasticities than suburbs and smaller cities, because they have a greater portion of transit-dependent users. Per capita annual transit ridership tends to increase with city size, as illustrated in Figure 1, due to increased traffic congestion and parking costs, and improved transit service due to economies of scale.
- *Type of Price Change.* Transit fares, service quality (service speed, frequency, coverage, and comfort), and parking pricing tend to have the greatest impact on transit ridership. Elasticities appear to increase somewhat as fare levels increase (i.e., when the starting point of a fare increase is relatively high).
- *Direction of Price Change.* Transportation demand models often apply the same elasticity value to both price increases and reductions, but there is evidence that some changes are nonsymmetric. Fare increases tend to cause a greater reduction in ridership than the same size fare reduction will increase ridership. A price increase or transit strike that induces households

to purchase automobiles may be somewhat irreversible, since once people become accustomed to driving they often continue.

Figure 1. Transit Ridership Versus City Size



Source: Federal Transit Administration, 2001.

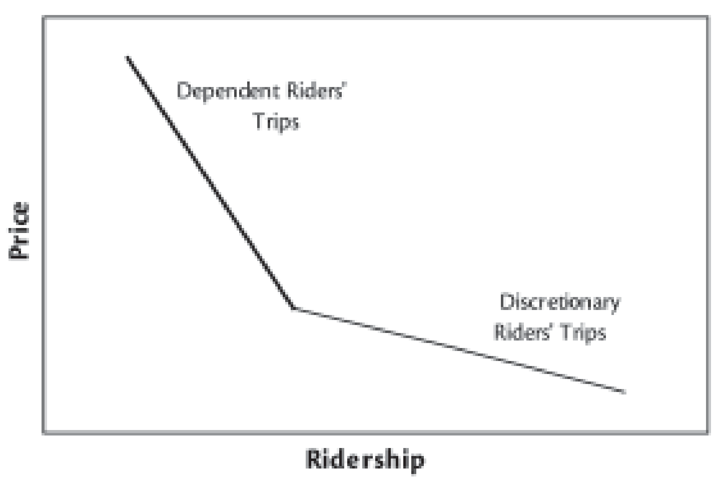
Figure 2. Dynamic Elasticity

Source: Dargay and Hanly, 1999.

- *Time Period.* Price impacts are often categorized as short-run (less than two years), medium-run (within five years) and long-run (more than five years). Elasticities increase over time, as consumers take price changes into account in longer-term decisions, such as where to live or work, as illustrated in Figure 2. Long-run transit elasticities tend to be two or three times as large as short-run elasticities.
- *Transit Type.* Bus and rail often have different elasticities because they serve different markets, although how they differ depends on specific conditions.

Because there is significant difference in transit demand between dependent and discretionary riders we can say that there is a kink in the demand curve (Clements 1997), as illustrated in Figure 3. As a result, elasticity values depend on what portion of the demand curve is being measured. Price changes may have relatively little impact on ridership for a basic transit system that primarily serves transit-dependent users. If the transit system wants to attract significantly more riders and reduce automobile travel, however, fares will need to decline and service improve to attract more price-sensitive discretionary riders.

Figure 3. Kink in the Demand Curve



Summary of Transit Elasticity Studies

Many studies have been performed on the price elasticity of public transit, and several previous publications have summarized the results of such studies, including Pham and Linsalata (1991); Oum, Waters, and Yong (1992); Goodwin (1992); Luk and Hepburn (1993); Pratt (1999); Dargay and Hanly (1999), TRACE (1999); and Booz Allen Hamilton (2003). Significant results from this research are summarized below.

General Transit Fare Elasticity Values

A frequently used rule-of-thumb, known as the *Simpson–Curtin* rule, is that each 3 percent fare increase reduces ridership by 1 percent. Like most rules-of-thumb, this can be useful for rough analysis, but it is too simplistic and outdated for detailed planning and modeling.

Table 1 shows transit fare elasticity values published by the American Public Transportation Association, and widely used for transit planning and modeling in North America. The values were based on a study of the short-run (less than two years) effects of fare changes in 52 U.S. transit systems during the late 1980s. Because they reflect short-run impacts and are based on studies performed when a larger portion of the population was transit-dependent, these values probably understate the long-run impacts of current price changes.

Table 1. Bus Fare Elasticities

	Large Cities (More than 1 Million Population)	**Smaller Cities (Less than 1 Million Population)**
Average for all hours	-0.36	-0.43
Peak hour	-0.18	-0.27
Off-peak	-0.39	-0.46
Off-peak average	-0.42	
Peak hour average	-0.23	

Source: Pham and Linsalata, 1991.

After a detailed review of international studies, Goodwin (1992) produced the average elasticity values summarized in Table 2. He noted that price impacts tend to increase over time as consumers have more options (related to increases in real incomes, automobile ownership, and now telecommunications that can substitute for physical travel). Nijkamp and Pepping (1998) found elasticities in the –0.4 to –0.6 range in a meta-analysis of European transit elasticity studies.

Table 2. Transportation Elasticities

	Short-Run	***Long-Run***	***Not Defined***
Bus demand WRT fare cost	-0.28	-0.55	
Railway demand WRT fare cost	-0.65	-1.08	
Public transit WRT petrol price			0.34
Car ownership WRT general public transport costs			0.1 to 0.3
Petrol consumption WRT petrol price	-0.27	-0.71	-0.53
Traffic levels WRT petrol price	-0.16	-0.33	

Source: Goodwin, 1992.
Note: WRT = With Respect To

Dargay and Hanly (1999) studied the effects of UK transit bus fare changes over several years to derive the elasticity values summarized in Table 3. They used a dynamic econometric model (separate short- and long-run effects) of per capita bus patronage, per capita income, bus fares, and service levels. They found that demand is slightly more sensitive to rising fares (-0.4 in the short run and –0.7 in the long run) than to falling fares (-0.3 in the short run and –0.6 in the long run), and that demand tends to be more price sensitive at higher fare levels. Dargay and Hanly found that the cross-elasticity of bus patronage to automobile operating costs is negligible in the short run but increases to 0.3 to 0.4 over the long run, and the long-run elasticity of *car ownership* with respect to transit fares is 0.4, while the elasticity of *car use* with respect to transit fares is 0.3.

Table 3. Bus Fare Elasticities

Elasticity Type	Short-Run	Long-Run
Non-urban	-0.2 to –0.3	-0.8 to –1.0
Urban	-0.2 to –0.3	-0.4 to –0.6

Source: Dargay and Hanly, 1999, p. viii.

Another study compared transit elasticities in the UK and France between 1975 and 1995 (Dargay et al. 2002). It indicates that transit ridership declines with income (although not in Paris, where wealthy people are more likely to ride transit than in most other regions) and with higher fares, and increases with increased transit service kilometers. These researchers found that transit elasticities have increased during this period. Table 4 summarizes their findings.

Table 4. Transit Elasticities

	England		***France***	
	Log-Log	Semi-Log	Log-Log	Semi-Log
Income				
Short run	-0.67	-0.69	-0.05	-0.04
Long run	-0.90	-0.95	-0.09	-0.07
Fare				
Short run	-0.51	-0.54	-0.32	-0.30
Long run	-0.69	-0.75	-0.61	-0.59
Transit VKM				
Short run	0.57	0.54	0.29	0.29
Long run	0.77	0.74	0.57	0.57
Annual fare elasticity growth rate		1.59%		0.66%

Source: Dargay et al., 2002, Table 4.

With a log-log function, elasticity values are the same at all fare levels; whereas with a semi-log function, the elasticity value increases with higher fares. Log-log functions are most common and generally easiest to use. Semi-log elasticity values are based on an exponential function, and can be used for predicting impacts of fares that approach zero, that is, if transit services become free, but are unsuited for very high fare levels, in which case semi-log may result in exaggerated elasticity values.

For typical fare changes between 10 percent and 30 percent, log-log and semi-log functions provide similar results, so either can be used.

Table 5 summarizes estimates of transit fare elasticities for different user groups and trips types, illustrating how various factors affect transit price sensitivities. For example, it indicates that car owners have a greater elasticity (-0.41) than people who are transit dependent (-0.10), and work trips are less elastic than shopping trips.

Table 5. Transit Fare Elasticities

Factor	Elasticity
Overall transit fares	-0.33 to −0.22
Riders under 16 years old	-0.32
Riders aged 17–64	-0.22
Riders over 64 years old	-0.14
People earning <$5,000	-0.19
People earning >$15,000	-0.28
Car owners	-0.41
People without a car	-0.10
Work trips	-0.10 to −0.19
Shopping trips	-0.32 to −0.49
Off-peak trips	-0.11 to −0.84
Peak trips	-0.04 to −0.32
Trips < 1 mile	-0.55
Trips > 3 miles	-0.29

Source: Gillen, 1994, pp. 136–137.

Rail and bus elasticities often differ. In major cities, rail transit fare elasticities tend to be relatively low, typically in the −0.18 range, probably because higher-income residents depend on such systems (Pratt, 1999). For example, the Chicago Transportation Authority found that peak bus riders have an elasticity of -0.30, and off-peak riders -0.46, while rail riders have peak and off-peak elasticities of -0.10 and -0.46, respectively. However, fare elasticities may be relatively high on routes where travelers have viable alternatives, such as for suburban rail systems where most riders are discretionary.

Commuter transit pass programs, in which employers subsidize transit passes, are effective at increasing ridership (Commuter Check, Commuter Choice). Deep discount transit passes can encourage occasional riders to use transit more frequently, and if implemented when fares are increasing, can avoid ridership losses (Oram and Stark 1996). Many campus UPass programs, which provide free or discounted transit fares to students and staff, have been quite successful, often doubling or tripling the portion of trips made by transit, because college students tend to be relatively price sensitive (Brown, Hess, and Shoup 2001).

Table 6 summarizes travel demand elasticities developed for use in Australia, based on a review of various national and international studies. These standardized values, adopted by the Australian Road Research Board, are used for various transport planning applications throughout the country, modified as appropriate to reflect specific conditions.

Table 6. Australian Travel Demand Elasticities

Elasticity Type	Short-Run	Long-Run
Bus demand and fare	-0.29	
Rail demand and fare	-0.35	
Mode shift to transit and petrol price	+0.07	
Mode shift to car and rail fare increase	+0.09	
Road freight demand and road/rail cost ratio	-0.39	-0.80
Petrol consumption and petrol price	-0.12	-0.58
Travel level and petrol price	-0.10	

Source: Luk and Hepburn, 1993.

Service Elasticities

Service elasticities indicate how transit ridership is affected by transit service quality factors (e.g., availability, convenience, speed, and comfort), based on transit vehicle mileage, hours, frequency, and priority (Kittleson & Associates 1999; Phillips, Karachepone, and Landis 2001).

Pratt (1999) finds that completely new bus service in a community that previously had no public transit service typically achieves 3 to 5 annual rides per capita, with 0.8 to 1.2 passengers per bus-mile (0.5 to 0.7 passengers per bus-kilometer). The elasticity of transit use to service expansion (e.g., routes into new parts of a community) is typically in the range of 0.6 to 1.0, meaning that each 1 percent of additional transit vehicle-miles or vehicle-hours increases ridership by 0.6 percent to 1.0 percent , although much lower and higher response rates are also found (from less than 0.3 to more than 1.0). The elasticity of transit use with respect to transit service frequency (called a *headway elasticity*) averages 0.5, with greater effects where service is infrequent. There is a wide variation in these factors, depending on type of service, demographic, and geographic factors. Higher service elasticities often occur with new express transit service, in university towns, and in suburbs with rail transit stations to feed. On the other hand, some service increases result in little additional ridership. It usually takes one to three years for new routes to reach their full potential ridership.

Improved marketing, schedule information, easy-to-remember departure times (e.g., every hour or half-hour), and more convenient transfers can also increase transit use, particularly in areas where service is less frequent (Turnbull and Pratt 2003).

Voith (1991) found that, as with monetary price elasticities, service elasticities tend to increase over time. He concludes, "The findings suggest that reductions in public transportation subsidies that result in higher fares and lower service quality may produce higher subsidy costs per rider than would be the case with higher total subsidy. Thus, the results from this analysis support the common public perception that raising public transit fares and reducing service simply reduce ridership, requiring further fare increases and service cuts."

Multimodal Models

Some researchers have assembled elasticity and cross-elasticity data to create models that predict how various combinations of changes in transit fares, transit service, and vehicle operating costs would affect transit ridership and automobile travel. These models can help answer questions concerning the potential role that transit can play in addressing strategic transportation objectives such as congestion and emission reductions. They can help predict the impacts of integrated mobility management programs that include complementary strategies to encourage more efficient transportation patterns, such as combinations of service improvements, fare reductions, and parking or road pricing.

The METS (MEtropolitan Transport Simulator, Institute for Fiscal Studies 2001) is an urban transport demand simulation model available on the Internet (*http://vla.ifs.org.uk/models/mets22.html*). METS was developed in the early 1980s for use by the UK Department of Transport, and updated in 2000. It allows users to predict the changes in transit and automobile travel that would result from changes in transit service quality, frequency, fares, and car costs.

Hensher (1997) developed a model of cross-elasticities between various forms of transit and car use, illustrated in Table 7. This type of analysis can be used to predict the effects of transit fare changes on vehicle traffic, and the effect that road tolls or parking fees will have on transit ridership. Such models tend to be sensitive to specific demographic and geographic conditions and so must be calibrated for each area. For example, Table 7, which is based on a survey of residents of Newcastle, a small Australian city, indicates a 10 percent increase in single-fare train tickets will cause a 2.18 reduction in the sale of those fares, and a 0.57 percent increase in single-fare bus tickets.

Table 7. Direct and Cross-Share Elasticities

	Train	***Train***	***Train***	***Bus***	***Bus***	***Bus***	***Car***
	Single Fare	Ten Fare	Pass	Single Fare	Ten Fare	Pass	
Train, single fare	-0.218	0.001	0.001	0.057	0.005	0.005	0.196
Train, ten fare	0.001	-0.093	0.001	0.001	0.001	0.006	0.092
Train, pass	0.001	0.001	-0.196	0.001	0.012	0.001	0.335
Bus, single fare	0.067	0.001	0.001	-0.357	0.001	0.001	0.116
Bus, ten fare	0.020	0.004	0.002	0.001	-0.160	0.001	0.121
Bus, pass	0.007	0.036	0.001	0.001	0.001	-0.098	0.020
Car	0.053	0.042	0.003	0.066	0.016	0.003	-0.197

Source: Hensher, 1997, Table 8.

TRACE (1999) provides detailed elasticity and cross-elasticity estimates for various types of travel (e.g., car-trips, car-kilometers, transit travel, walking/cycling, commuting, business) and conditions, based on numerous European studies. Comprehensive sets of elasticity values such as these can be used to model the travel impacts of various combinations of price changes, such as a reduction in transit fares combined with an increase in fuel taxes or parking fees. It estimates that a 10 percent rise in fuel prices increases transit ridership 1.6 percent in the short run and 1.2 percent over the long run, depending on regional vehicle ownership. This declining elasticity value is unique to fuel, because fuel price increases cause motor-

Table 8. Elasticities with Respect to Fuel Price

Term/Purpose	*Car Driver*	*Car Passenger*	*Public Transport*	*Slow Modes*
Trips				
Commuting	-0.11	+0.19	+0.20	+0.18
Business	-0.04	+0.21	+0.24	+0.19
Education	-0.18	+0.00	+0.01	+0.01
Other	-0.25	+0.15	+0.15	+0.14
Total	-0.19	+0.16	+0.13	+0.13
Kilometers				
Commuting	-0.20	+0.20	+0.22	+0.19
Business	-0.22	+0.05	+0.05	+0.04
Education	-0.32	+0.00	+0.00	+0.01
Other	-0.44	+0.15	+0.18	+0.16
Total	-0.29	+0.15	+0.14	+0.13

Source: TRACE, 1999, Tables 8 and 9.
Note: Slow Modes = Walking and Cycling

ists to purchase more fuel-efficient vehicles. Table 8 summarizes elasticities of trips and kilometers with respect to fuel prices in areas with high vehicle ownership (more than 450 vehicles per 1,000 population).

Parking prices (and probably road tolls) tend to have a greater impact on transit ridership than other vehicle costs, such as fuel, typically by a factor of 1.5 to 2.0, because they are paid directly on a per-trip basis. Table 9 shows how parking prices affect travel in a relatively automobile-oriented urban region.

Hensher and King (1998) calculate elasticities and cross-elasticities for various forms of transit fares and automobile travel in the Sydney, Australia, city center. Table 10 summarizes their findings. The table shows, for example, a 10 percent increase in prices at preferred CBD parking locations will cause a 5.41 percent reduction in demand there, a 3.63 percent increase in park-and-ride trips, a 2.91 increase in public transit trips, and a 4.69 reduction in total CBD trips.

Table 9. Parking Price Elasticities

Term/Purpose	*Car Driver*	*Car Passenger*	*Public Transport*	*Slow Modes*
Trips				
Commuting	-0.08	+0.02	+0.02	+0.02
Business	-0.02	+0.01	+0.01	+0.01
Education	-0.10	+0.00	+0.00	+0.00
Other	-0.30	+0.04	+0.04	+0.05
Total	-0.16	+0.03	+0.02	+0.03
Kilometers				
Commuting	-0.04	+0.01	+0.01	+0.02
Business	-0.03	+0.01	+0.00	+0.01
Education	-0.02	+0.00	+0.00	+0.00
Other	-0.15	+0.03	+0.02	+0.05
Total	-0.07	+0.02	+0.01	+0.03

Source: TRACE, 1999, Tables 32 and 33.
Note: Slow Modes = Walking and Cycling

Table 10. Parking Elasticities

	Preferred CBD	*Less Preferred CBD*	*CBD Fringe*
Car trip, preferred CBD	-0.541	0.205	0.035
Car trip, less preferred CBD	0.837	-0.015	0.043
Car trip, CBD fringe	0.965	0.286	-0.476
Park-and-ride	0.363	0.136	0.029
Ride public transit	0.291	0.104	0.023
Forego CBD trip	0.469	0.150	0.029

Source: Hensher and King, 2001, Table 6.

Conclusions and Recommendations

An important conclusion of this research is that no single transit elasticity value applies in all situations: Various factors affect price sensitivities including type of user and trip, geographic conditions, and time period.

Available evidence suggests that the elasticity of transit ridership with respect to fares is usually in the –0.2 to –0.5 range in the short run (first year), and increases to –0.6 to –0.9 over the long run (five to ten years). These are affected by the following factors:

- Transit price elasticities are lower for transit-dependent riders than for discretionary (choice) riders.
- Elasticities are about twice as high for off-peak and leisure travel as for peak and commute travel.
- Cross-elasticities between transit and automobile travel are relatively low in the short run (0.05), but increase over the long run (probably to 0.3 and perhaps as high as 0.4).
- A relatively large fare reduction is generally needed to attract motorists to transit, since they are discretionary riders. Such travelers may be more responsive to service quality (speed, frequency, and comfort), and higher automobile operating costs through road or parking pricing.
- Due to variability and uncertainty, it is preferable to use ranges rather than point values for elasticity analysis.

Commonly used transit elasticity values primarily reflect short- and medium-run impacts and are based on studies performed 10 to 40 years ago, when real incomes where lower and a greater portion of the population was transit dependent. The resulting elasticity values may be appropriate for predicting how a change in transit fares or service will affect next year's ridership and revenue, but long-run elasticity values are more appropriate for strategic planning. Conventional traffic models that use standard elasticity values based on short-run price effects tend to understate the potential of transit fare reductions and service improvements to reduce problems such as traffic congestion and vehicle pollution. Conversely, these models will understate the long-term negative impacts that fare increases and service cuts can have on transit ridership, transit revenue, traffic congestion, and pollution emissions.

In most communities (particularly outside of large cities) transit-dependent people are a relatively small portion of the total population, while discretionary riders (people who have the option of driving) are a potentially large but more price-sensitive market segment. As a result, increasing transit ridership requires pricing and incentives that attract travelers out of their cars. Combinations of fare reductions and discounted passes, higher vehicle user fees (e.g., priced parking or road tolls), improved transit service, and better transit marketing can be particularly effective at increasing transit ridership and reducing automobile use (Victoria Transport Policy Institute 2002).

Transit planners generally assume that transit is price inelastic (elasticity values are less than 1.0), so fare increases and service reductions increase net revenue. This tends to be true in the short run (less than two years), but long-run elasticities approach 1.0, so financial gains decline over time.

Not all increased transit ridership that results from fare reductions and service improvements represents a reduction in automobile travel. Much of this additional ridership may substitute for walking, cycling, or rideshare trips, or consist of absolute increases in total personal mobility. In typical situations, a quarter to half of increased transit ridership represents a reduction in automobile travel, but this varies considerably depending on specific conditions.

Table 11 summarizes recommended generic values based on this research. These values reflect the results of numerous studies, presented in a format to facilitate their application in typical transport planning situations. High and low values are presented to allow sensitivity analysis, or a midpoint value can be used. Actual elasticities vary depending on circumstances, so additional review and research is recommended to improve and validate these values, and modify them to specific situations.

Table 11. Recommended Transit Elasticity Values

	Market Segment	***Short Term***	***Long Term***
Transit ridership WRT transit fares	Overall	−0.2 to −0.5	−0.6 to −0.9
Transit ridership WRT transit fares	Peak	−0.15 to −0.3	−0.4 to −0.6
Transit ridership WRT transit fares	Off-peak	−0.3 to −0.6	−0.8 to −1.0
Transit ridership WRT transit fares	Suburban commuters	−0.3 to −0.6	−0.8 to −1.0
Transit ridership WRT transit service	Overall	0.50 to 0.7	0.7 to 1.1
Transit ridership WRT auto operating costs	Overall	0.05 to 0.15	0.2 to 0.4
Automobile travel WRT transit costs	Overall	0.03 to 0.1	0.15 to 0.3

Note: WRT = With Respect To

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Modeling Generalized Cost of Travel for Rural Bus Users: A Case Study

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Abstract

In order to formulate rational improvement proposal for rural bus services, it is necessary to understand how people value different attributes of travel. In this article, the disutilities of travel have been modeled based on stated choice data collected from trip-makers traveling along a rural bus route in Midnapur district, West Bengal, India. Multinomial Logit Model (MNL) is used to develop utility equations and the total disutility of travel is estimated in the form of generalized cost. The perceived values associated with in-vehicle travel time, service headway, and comfort level for the study route are estimated and found to be significant.

Introduction

Passenger transportation demand in rural India is largely served by the bus transportation system. In India, more than 70 percent of the population is located in rural and suburban areas. The rural population predominantly consists of low-income households with very low car ownership. Therefore, the rural population is almost completely dependent on the available bus transportation system, creating a vital role for rural bus service in the economic growth and development of the country.

Despite ample opportunities for improvement of rural bus transportation in India over several decades, this mode has not drawn adequate attention from transportation professionals and policy-makers. Improvement may be in the form of increase in frequency, comfort level, travel speed etc. However, every possible improvement in existing service is likely to be attributed to an increase in fare level. Therefore, for judicious improvement planning, it is necessary to understand users' perception about various attributes of travel. The objective of this article is to understand rural bus users' perceptions for different attributes of service and model the generalized cost of travel. A typical rural route served by the bus transportation system in India has been considered in the case study.

Many researchers have attempted to model people's perceptions about various attributes using Revealed Preference (RP) and/or Stated Preference (SP) data (Adamowicz et al. 1994; Bates 1982; Kroes and Sheldon 1988; Louviere 1988; Hensher 1994; Jose Holguin-Veras 2002). RP requires a large sample size and cannot accommodate hypothetical alternatives. SP surveys gained importance over RP due to their smaller sample size requirement and their ability to accommodate hypothetical alternatives yet produce results comparable to/on par with RP results (Hunt 2001). Multinomial Logit (MNL) modeling has been widely accepted by researchers and practitioners for analyzing the RP or SP data (Louviere and Woodworth 1983; Jose Holguin-Veras 2002; Hunt 2001). Attributes considered in utility equations, developed by MNL model, have different measuring units. Conversion of these attributes into a common unit enables comparison or estimation of relative importance of each attribute over the other. Summation of these converted attributes is called the generalized cost.

In this article, modeling of generalized cost of travel has been demonstrated with reference to a rural bus route in India, which is connecting a district head quarter (Midnapur) and a tourist place (Digha) in West Bengal, India. The two areas are connected by a direct bus route of 142km. Travel demand along this route is largely served by ordinary bus service. The bus service takes about 5 hours to cover the distance of 142km and serves about 35 intermediate stops.

For the development of utility model, it is necessary to create a database with the help of SP and/or RP observations. Normally, pure SP-based data should be avoided for the development of discrete choice models, as the reliability of parameter estimates could be low. However, for the study bus route all users are essentially captive riders and do not have a choice other than accepting the existing bus service. Therefore, for the development of utility model for rural bus users, the database is created based on only SP observations.

Further, there is currently limited information in the literature on stated choice experiments in the context of rural passenger transportation in India or other developing countries. Therefore, before creating a large database for the development of a refined model, a limited number of observations were obtained and analyzed. The utility model developed based on these observations is reported in this article.

Methodology

Approach

The SP method, which evolved out of conjoint analysis where attributes are considered jointly, is employed in the present work. Conjoint analysis is an established approach for understanding and predicting consumer trade-offs and choices in marketing research. SP techniques have largely been used in a wide range of disciplines such as transportation (Hensher 1994; Lai and Wong 2000), environmental (Opaluch et al. 1993; Adamowicz et al. 1998), and product marketing (food, home appliances etc.). Most of the SP studies were carried out using traditional rating-based preference techniques (Hunt 2001; Lai and Wong 2000; Praveen and Rao 2002). In rating-based SP studies, numbers (e.g., 1= highly preferred, 5= highly not preferred) are used to represent the preferences of individuals. These numbers may not represent the actual or true choice behavior of individuals due to the lack of strong theoretical foundation consistent with economics (Adamowicz et al. 1998). As Stated Choice Methods (SCM) have strong theoretical foundation based on economic theory, they are used to model the behavior of individuals. The SCM facilitates estimation of the importance of each attribute from people's responses as they trade off among the alternatives, represented by various attributes and their levels, in the form of choice sets. These methods also facilitate the analysis of how decisions vary with variations in the magnitude of the attributes to model consumer surplus. In this study, different profiles are generated using various attributes with different levels and presented to the respondent in the form of a choice set. Responses in the form of "choices" among the presented choice alternatives are used to estimate the importance of the attributes.

Theoretical Background

Random Utility Theory (Thurstone 1927; McFadden 1974), the basis for several models and theories of decision making in psychology and economics, states that the utility of each element consists of an observed (deterministic) component denoted by *V* and a random (disturbance) component denoted by ε,

$$U = V + \varepsilon$$

The deterministic part *V* is again a function of the observed attributes (*z*) of the choice as faced by the individual, the observed socioeconomic attributes of the individual (*S*), and a vector of parameters (β), then

$$V = V(z, S, \beta)$$

A probabilistic statement can be made (due to presence of the random component) as, when an individual "n" is facing a choice set, C_n, consisting of J_n choices, the choice probability of alternative i is equal to the probability that the utility of alternative "i," U_{in}, is greater than or equal to the utilities of all other alternatives in the choice set. That is:

$$P_n(i) = \Pr(U_{in} \geq U_{jn}, \text{ for all } j \in C_n)$$

$$P_n(i) = \Pr(V_{in} + \varepsilon_{in} \geq V_{jn} + \varepsilon_{jn}, \text{ for all } j \in C_n, j \neq i)$$

Assuming IID (Gumbel distribution) for ε, the probability that an individual chooses i can be given by the MNL Model (McFadden 1974; Ben-Akiva and Lerman 1985)

$$P_{in} = \frac{e^{V_{in}}}{\sum_{j \in jn} e^{V_{jn}}} \quad (1)$$

The deterministic component of the utility function can be expressed as

$$V_{in} = \beta_1 X_{in1} + \beta_2 X_{in2} + \ldots + \beta_k X_{ink} \quad (2)$$

Where:

V_{in} is the deterministic component of utility function

$\beta_1, \beta_2, \ldots, \beta_n$. are the parameters associated with attributes

$X_{in1}, X_{in2}, \ldots, X_{ink}$ are the attributes describing the alternative

Now, let us consider a generalized form of utility equation as follows:

$$U = \alpha(\text{In-vehicle Travel Time}) + \beta(\text{Travel cost}) + \gamma(\text{Discomfort Level}) + \varepsilon \quad (3)$$

Where:

In-vehicle travel time, travel cost, and discomfort level are the attributes of travel
α, β, and γ are the coefficients associated with these attributes

A unit change in the utility value contributed only through change in the in-vehicle travel time would be caused by changing the in-vehicle travel time by $1/\alpha$.

The ratio of in-vehicle travel time to the travel cost indicates the value of in-vehicle travel time in monetary terms as perceived by the commuters. Therefore, value of in-vehicle travel time (a_1)= α/β. Similarly, value of discomfort (a_2)= γ/β.

The Generalized Cost of Travel, summation of the attributes, which are converted into common unit, from origin i to destination j can be expressed in the following form:

$$C_{ij} = a_1\, tt_{ij} + a_2\, (dl_{ij}-1)*(tt)_{ij} + F_{ij} + \delta \quad (4)$$

Where:

- tt_{ij} is the in-vehicle travel time between origin i and destination j
- dl_{ij} represents the discomfort level experienced
- F_{ij} is the direct cost of travel from i to j
- δ is the modal penalty representing all attributes not included in generalized cost (e.g., safety, convenience, reliability etc.)
- a_1 (i.e., α/β) and a_2 (i.e., γ/β) are weights attached to each disutility. They have dimensions appropriate for conversion of all attributes to common unit (normally in monitory terms).

Survey Forms

Survey forms were designed for collecting data related to trip characteristics, respondents' socioeconomic characteristics, and stated preference "choice" from the choice set. During the preliminary investigation it was observed that the journey speeds for buses are considerably low (about 30kmph), comfort is less (all the buses are overcrowded for most of the journey period), and the average headway is about 30 minutes. Therefore, attributes such as discomfort, headway, in-vehicle travel time, and fare are considered for the preparation of choice sets. Each attribute is further described by three levels. Levels are decided following discussions with experts and trip-makers. Discomfort, a qualitative attribute, is defined and coded on an integer scale (see Table 1).

Table 1. Attribute Discomfort Representation

Condition of Travel	DL Value
Seating	1
Standing comfortably	2
Standing in crowd	3

The attributes and corresponding levels as used in the study are shown in Table 2.

Table 2. Attributes and Levels

Attributes	Level 1	Level 2	Level 3
In-vehicle travel time	-15%	-10%	-5%
Travel cost	+5%	+10%	+15%
Discomfort	Seating	Standing comfortably	Standing in crowd
Service headway	30 min.	45 min.	60 min.

Fractional factorial orthogonal main effects design is used to produce nine choice alternatives. To reduce the confusion and/or fatigue of respondents, these nine choice alternatives are grouped into three blocks and each respondent is randomly assigned one of the three blocks and asked to choose an alternative.

Database

The database consists of information related to route, trip, respondent's socioeconomic characteristics, and finally respondent's preference in the form of "choice." Route characteristics include length of the route, number of bus stops, fare structure, and schedule. Trip characteristics are origin, destination, purpose, duration of the trip, and fare paid. Socioeconomic characteristics of the respondent include age, gender, education, profession, and income. Preference data is collected in the form of choices where respondents choose an alternative from the three alternatives given in the choice set.

Route characteristics and mode characteristics data are collected from secondary sources such as the Regional Transport Authority (RTA) and transport agencies. Bus stop based interviews are conducted to acquire data related to trip characteristics, socioeconomic characteristics of the respondent, and respondent's stated choice.

Model Development

During the survey, 180 samples were collected from twelve different locations on the study route. However, only 76 refined samples were used for the development of the utility equation. The SP choice data was coded and fed to LIMDEP 8.0 (2002) for the estimation using MNL (Maximum Likelihood Estimate) models. The discrete choice MNL model was used to analyze the data. Several alternative models were attempted using various combinations and definitions of attribute variables. Finally, the following utility model was selected, based on signs of the coefficients, statistical significance of the coefficients, and predictability of the model. MNL model estimation results are shown in Table 3.

$$U = -22.03389\,(TC) - 7.28656\,(TT) - 1.57575\,(DL) - 0.89663\,(SH) \tag{5}$$

Where:

TC	equals Travel Cost in rupees per km
TT	is in-vehicle travel time in minutes per km
DL	represents the Discomfort Level
SH	equals Service Headway in minutes per km length of travel

Direct Travel Cost

Based on established fare structure, the direct travel cost model is developed as follows:

D $\geq$4 km Direct travel cost = 300 paise

D > 4 km Direct travel cost = 300 + 31 (D-4) paise

Where:

D is the distance of travel in km

Generalized Cost

Based on the utility model developed here (Equation 5), the values of different attributes are estimated as follows:

Value of In-vehicle travel time	= 7.28656/22.03389
	= 0.33 rupees per minute
	= 33 paise per minute
Value of in Service Headway	= 0.89663 /22.03389
	= 0.0406 rupees per minute
	= 4.06 paise per minute
Value of discomfort	= 1.57575/22.03389
	= 0.0715 rupees per unit DL per km
	= 7.15 paise per unit DL per km.

Generalized Cost (in paise) = 33 (In-vehicle travel time in minutes)
+ 4.06 (headway in minutes)
+7.15 (Existing DL -1)*(Travel distance in kilometers)
+ Direct Travel Cost (6)

Results and Discussions

From Table 3, it can be seen signs of the parameter estimates are as expected and in agreement with the actual condition of the study route. It is evident from the t-ratios that the parameter estimates are statistically significantly different from zero as absolute t-ratios of all the parameters are greater than 1.96 (Louviere et al. 2000) except for cost attribute. The overall goodness of fit is considered using Pseudo R^2 (R-squared). Value of the pseudo R^2 between 0.2 and 0.4 indicates acceptable model fit (Louviere et al. 2000).

Table 3. MNL Model Estimation Results

Attribute	Coefficient	Abs. t-ratio
Cost	-22.03389	1.226
In-vehicle Travel Time	-7.28656	3.133
Discomfort	-1.57575	4.278
Service Headway	-0.89663	2.386
Number of samples = 76		
Log likelihood function = -59.45		
Log-L[L(0)] = -79.03		
R-squared = 0.2478		

The ratio of the parameter estimate for in-vehicle travel time over parameter estimate for travel cost, 33 paise per minute, is the estimated value of in-vehicle travel time. Similarly, the ratio of parameter estimate for discomfort over parameter estimate for travel cost, 7.15 paise per unit DL per km, is the estimated value of a unit change in discomfort level per kilometer of travel. The values of in-vehicle travel time and discomfort level, as obtained from the present study reflect the extremely poor operating conditions of the existing bus service along the study route. The ratio of parameter estimate for in-vehicle travel time over parameter estimate for discomfort is 4.6. This indicates that in-vehicle travel time is four and half times as important as travel comfort. Similarly, the ratio of parameter estimate for service headway over parameter estimate for discomfort is 0.56, which indicates that the service headway is 56 percent as important as comfort. These two observations suggest that the existing comfort level in the services is poorer than what people expect it to be. The ratio of parameter estimate for service headway over parameter estimate for in-vehicle travel time is 0.12. This indicates that the service headway is only 12 percent as important as in-vehicle travel time.

The modeled value associated with in-vehicle travel time is much higher as compared to the values associated with other attributes of travel. The higher value associated with in-vehicle travel time is primarily due to overcrowding inside the buses laced with longer journey time offered by the existing bus service. However, the modeled values associated with different attributes of travel are perceived values obtained from SP experiments and they are, therefore, influenced by the existing service attributes. A comparison of the values of in-vehicle travel time and service headway indicates that user preference is more on reduction of in-vehicle travel time rather than improving the service headway. Further, as rural bus users normally plan their trips based on existing schedule, the waiting time is much less than the service headway. Accordingly, the perceived value of waiting time will be higher than the value of service headway.

The values associated with different attributes of travel, as obtained from the present work, are also compared with the findings reported in literature. The value of in-vehicle travel time and discomfort level as reported for Mumbai were 21 paise per minute (13.2 rupees per hour) and 4.5 paise per minute (7.5 rupees per hour) per unit change in discomfort level, respectively (Mumbai Metro Planning Group 1997). Although these values are for urban public transport users corresponding to the year 1997, they are generally in agreement with the values obtained from the present work. The value of journey time was reported as 42NOK (. Indian rupees 250) per hour for public transport users in Akershus, Norway (Nossum 2003). In Australia, a study of high speed rail indicated that the value of door-to-door travel time savings ranged from $36 (. Indian rupees 1170) per hour for discount economy travel to $59 (. Indian rupees 1920) per hour for full economy travel for air business market and a line haul time value as $10.86 (. Indian rupees 350) per hour for the car nonbusiness market (Hensher 1997). A study of the Cleveland-Columbus-Cincinnati High Speed Rail service showed the value of travel time as $12 (. Indian rupees 530) per hour and $4 (. Indian rupees 170) per hour as the value of frequency for bus nonbusiness trip-makers (Transportation Economics & Management Systems 2001).

In general, there is wide variation of the values associated with travel time. The value of travel time is controlled by socioeconomic characteristics of users: in rural India, it is predominantly low-income people with negligible car ownerships; in urban areas, it is a mix of low- to high-income people with higher levels of car ownership. Again, the socioeconomic characteristics of public transport users in developed and developing countries are different. Therefore, the values associated with different attributes of travel in devloped and developing countries are also found to be different. The perceived values associated with different attributes of travel for rural bus users in India is much lower than the values reported in developed countries predominantly due to the difference in socioeconomic characteristics.

Conclusions

To formulate rational improvement strategy for bus transportation in rural India, it is essential to understand how users value different attributes of travel. There is currently limited information available in literature about the values associated with different attributes of travel for rural bus users in developing countries such as India. In the present research, a choice-based conjoint analysis method has been applied for modeling the values associated with different attributes of travel with reference to a typical rural bus route in India. This research found that the stated preference data are effective for developing a utility model comprising different attributes of travel, even in a nonurban scenario. Responses obtained from nonurban trip-makers in the form of choice are consistent and encouraging. Based on the utility equation, values of in-vehicle travel time, service headway, and comfort level are estimated. Finally, the generalized cost model was developed with reference to the study route. The estimated values associated with in-vehicle travel time, comfort, and headway of service are found to be significant and in agreement with the actual condition of the study route. Therefore, all these attributes should be considered while formulating improvement proposals for rural public transportation systems.

The values associated with different attributes of travel depend on socioeconomic characteristics of users. The modeled values obtained in the present work are generally in agreement with the limited findings available in India. However, the modeled values are much lower than the findings reported in literature for developed countries. This is because rural bus users in India are predominantly low-income people. The number of observations used in the present work is limited and the model presented is also an initial attempt. Further works are necessary to refine the model based on additional data and apply the knowledge for improving the bus transportation in rural India.

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Pedestrian Safety and Transit Corridors

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Abstract

This research examines the relationship between pedestrian accident locations on state-owned facilities (highways and urban arterials) and the presence of riders loading and alighting from bus transit. Many state facilities are important metropolitan transit corridors with large numbers of bus stops users, resulting in increased exposure of pedestrians to traffic and in increased numbers of collisions. The research also examines the association between pedestrian collisions and other travel generators (concentrations of retail activity and housing) as well as environmental conditions (wide roadways, high traffic volumes, and high speed limits).

Based on a retrospective sampling approach and logistic regression models, the study shows that bus stop usage is associated with pedestrian collisions along state facilities. Less strong, but significant associations exist between retail location and size, traffic volume, and number of traffic lanes, and locations with high levels of pedestrian-vehicle collisions. The findings suggest that facilities with high numbers of bus riders need to accommodate people walking safely along and across the roadway. They support the development of state DOT programs for multimodal facilities, which integrate travel modes in major regional facilities within local suburban communities and pay specific attention to the role of transit in shaping the demand for nonmotorized travel on the facilities.

Problem Statement

Collisions between motor vehicles and pedestrians along state highways with transit routes are associated with high rates of injury and death of pedestrians and constitute a significant societal problem. In Washington State more than 30 percent of vehicle-pedestrian collisions are not on city streets where travel on foot may be expected, but on large state roads that are typically considered regional or transregional facilities designed for moving traffic (Washington State Department of Transportation 1997). Between January 1995 and December 2000 state facilities accounted for over 1,795 collisions involving more than 1,995 pedestrians (Table 1). Of these, 175 pedestrians were killed and 376 disabled. Using federal and state cost formulas, average yearly societal costs were more than $100,000,000.

Collisions are especially concentrated in metropolitan areas. King County, Washington's most urbanized county with 20 percent of the state's population, has a disproportionate number of pedestrian-vehicle collisions. With 56 pedestrian fatalities and 144 disabling injuries, the county accounts for 36 percent of state societal costs associated with pedestrian collisions over this same six-year period. Within King County, collisions are concentrated on State Route 99 (SR 99), which accounts for 43 percent of pedestrian vehicle collisions in the county and 16 percent for the state as a whole. Originally part of US 99, first commissioned in 1926 and stretching from Canada to Mexico, SR 99 became the urbanized region's second most important north-south thruway after the construction of Interstate 5 in the 1960s. Much of the corridor presents difficult and dangerous conditions for pedestrians. Development along the highway is strip commercial, the facility is wide with four to six travel lanes, traffic volumes are high, ranging from 20,000 to 40,0000 ADT, and large segments have no curbs and no sidewalks. It is also an important transit corridor.

Table 1. Reported Pedestrian Collisions on State Routes, 1995–2000

	Washington State		King County		SR99 in King Co.	
	1995-2000	Avg. Yearly	1995-2000	Avg. Yearly	1995-2000	Avg. Yearly
Collisions	1795	299	670	112	289	48
Pedestrians	1895	316	714	119	303	51
Fatal Injuries	175	29	56	9	23	4
Disabling Injuries	376	63	144	24	65	11
Societal Cost	$610,208,000	$101,701,333	$222,015,000	$37,002,500	$97,414,000	$16,235,667

State highways like SR 99 are common in many metropolitan areas. Designed for transregional traffic, these facilities have been lined with and surrounded by suburban development. As an alternative arterial street network was never developed (Untermann 1984; Southworth and Owens 1993), such regional facilities now also carry substantial local traffic. They even act as main streets, containing most of a community's retail, commercial, and institutional uses. The mismatch of facility design and current patterns of use may be an important reason why there are high collision rates in these places. The financial and political costs of converting highways back to their former, narrower purposes would be enormous, and it is thus important to understand the relationship between new use patterns and collisions.

Figure 1: Development along SR 99 north of Seattle. Regional highways have become urbanized roads with a variety of activities and uses.

National, state, and local road design programs are being developed and implemented to address the growing demand for multimodal transportation on facilities of regional significance within metropolitan areas (U.S. Department of Transportation and Federal Highway Administration 2003; Florida Department of Transportation 2001; Huang, Stewart et al. 2001). Transit plays a significant role in generating pedestrian traffic on these highways, making it essential that facility design insure the safe integration of transit users with the driving public. This research supports the development of these programs and policies, and specifically the need for safety investments in regional traffic facilities that act as *de facto* transit and pedestrian zones.

Research Objective

The main purpose of this research is to examine the relationship between pedestrian accident locations on state facilities and the presence of riders loading and alighting from bus transit, controlling for other factors. Transit riders are pedestrians exposed to potential vehicle collisions. Transit commuters, for example, depart and return on opposite sides of roadways, necessitating at least one daily crossing. Large numbers of bus stops users are therefore likely to be associated with increased collisions. The research also examines other pedestrian travel generators, such as concentrations of retail activity and housing, as well as physical environmental conditions that affect pedestrian safety, such as wide roadways, high traffic volumes, high speed limits, traffic signalization, and crosswalk markings (Zegeer, Stewart et al. 2002; Koepsell et al. 2001).

The approach taken in this article differs from most previous safety research, which focuses on the increased risk of collision associated with facility characteristics while controlling for exposure. In other words, researchers have so far been interested in identifying unsafe conditions independent of the location and magnitude of pedestrian activity (Zegeer, Seiderman et al. 2002). This focus makes sense in areas where pedestrian volumes are high or evenly distributed along facilities, but it is less appropriate along state highways in suburbanized areas, where the presence of pedestrians tends to be sporadic. In these latter cases, the risk of collision is likely related not only to an interaction of pedestrian behavior and environmental factors, but also to actual pedestrian activity at certain locations. Unfortunately, data on the location and volume of pedestrian activity along suburban highways are incomplete or missing. In response, this study uses data on locations with high numbers of pedestrian-vehicle collisions and examines whether these locations are associated with potential pedestrian generators. The argument is that limited resources for improving pedestrian safety make it essential to target public spending at the most dangerous locations. To do so requires an understanding of the links between pedestrian generators, most specifically bus stops, and pedestrian-vehicle collisions.

Variables and Data Sources

The study area for the project is the urbanized area of King County. Highway segments with large numbers of pedestrian-vehicle collisions are treated as the dependent variable. Indicators of pedestrian activity including bus stop usage and land uses that likely generate pedestrian traffic are treated as one category of independent variables. Roadway and facility conditions are treated as a second category of independent variables.

Pedestrian-Vehicle Collision Locations

Primary data are based on Pedestrian Accident Locations (PALs) identified by the Washington State Department of Transportation (WSDOT). WSDOT defines a PAL as four or more collisions over a six-year period along a 0.10-mile section of roadway (528 feet). The concept of PAL was developed in transportation planning to identify highway segments that have large numbers pedestrian collisions. This research is first in using PAL to analyze underlying factors. PALs are used as the dependent variable because data on the precise locations of individual pedestrian collisions have not been available. Data on individual collisions would yield more analytical power, facilitating the use of nondichotomous variables and allowing for testing the effect of different spatial aggregations of collisions (beyond the 0.10 mile segments used).

For the 1995–2000 data period, 47 percent of the State's 120 PALs were located in King County (Table 2, Figure 2). King County PALs contained 55 percent of the total pedestrian collisions, 60 percent of fatalities, and 56 percent of disabling injuries located within all the PALs in Washington State. Because of large concentrations of PALs and continuously urbanized environmental conditions on SR 99, a separate analysis was done for this facility. SR99 contains 57 percent of PALS in King County and 27 percent of PALS in the State as a whole. Calculated societal costs for SR99 PALs average more than $10,000,000 a year.

Table 2. PALs, Constituent Injuries, and Costs in Washington State, King County, and SR99 in King County

	Washington State		King County		SR99 in King Co.	
	1995-2000	Avg. Yearly	1995-2000	Avg. Yearly	1995-2000	Avg. Yearly
# of Pals	120	NA	57	NA	33	NA
Collisions	554	92	305	51	186	31
Fatal Injuries	30	5	18	3	13	2
Disabling Injuries	123	21	69	12	45	8
Societal Cost	$173,919,000	$28,986,500	$98,327,000	$16,387,833	$64,795,000	$10,799,167

Indicators of Pedestrian Activity

Indicators of pedestrian activity include bus stop usage, location of retail uses, concentrations of residences, and the locations of supermarkets, fast food restaurants, and school sites. It is hypothesized that these suburban pedestrian activity generators are positively associated with PAL sites. Data for bus stop usage are from METRO (the county transit agency) Automatic Passenger Counts (APC). Total daily boardings and alightings for each stop were averaged for two counting periods, fall 2000 and fall 2001. Land use data are from King County Assessor's data for each tax parcel attached to a geospatial database of approximately 500,000 parcels.

Indicators of Roadways Conditions

Data for roadways include traffic volumes, roadway width and number of lanes, traffic speed, and speed limits. As volumes, speeds, and roadway size increase, it is hypothesized that pedestrian risk, especially for street crossing, also increases. WSDOT geospatial (GIS) data on state highways were used for geocoding and mapping PALs. Data on traffic volumes as well as roadway attributes, such as travel lanes and posted speed limits, were obtained from the Puget Sound Regional Council (PSRC). All data were spatially overlaid and combined using GIS.

The number of intersections per one-half mile of linear roadway, or intersection density, was calculated from King County Network data using GIS and also used as an independent variable. Because the relationship between intersection density and environmental conditions is not well understood, the direction of the rela-

Figure 2. Pedestrian Accident Locations (PALs) on State Routes in King County

tionship to PALs was not hypothesized. High intersection density may increase pedestrian risk because of frequent vehicle turning movements. Yet very low intersection density may also increase risk: because signalized intersections are typically placed one-half mile apart or more in suburban environments, pedestrians may engage in risky mid-block highway crossings rather than choose to make the long walk to a protected crossing and back.

Research Design

This research uses a retrospective sampling approach (Ramsey et al. 1994) to test variables for their power to distinguish between a set of predefined locations, in this case all PALs, and a set of other, randomly selected locations, in this case non-PAL sample points (hereafter referred to as "sample points"). Problems of spatial correlation precluded treating highways as a continuous series of points, and a limited number of sample points were drawn representing 0.10-mile segments. Sample points were not drawn along controlled or limited access facilities including large portions of SR 99 in the City of Seattle and Interstate 90. Approximately 50 sample points were drawn along SR 99 and 75 on other state facilities within the urbanized area (see Table 3).

Data for pedestrian activity generators and roadway characteristics were attached to each PAL and sample point. Bus boardings and alightings were aggregated for each 500-foot highway segment, approximately overlapping the length of 528-foot PAL segments. Land-use generators, such as the total floor area of commercial uses, were measured based on walking sheds of one-quarter mile from the center of PALs and sample points. Housing unit densities were measured using a one-half mile figure as a proxy for the potential for generalized pedestrian activity. Table 4 describes the variables and the data sources used. The principal modeling technique was binary logistic regression. Analysis was performed on three sets of data: (1) all facilities, (2) SR 99, and (3) facilities other than SR 99. Separating SR 99 was justified because it is more substantially developed and used than other facilities, and contains a disproportionate number of PALs.

Table 3. PAL and Sample Points on SR99 and Other State Routes in King County

	SR99	Other State Routes	Total
PALs	33	23	56
Sample Points	49	76	125
Total	82	99	181

Table 4. Principal Variables

Variable Name	Description	Source data	Notes	Data Type
PAL	Designation of whether a point is a PAL or a sample point	WSDOT PAL data	Dependent Variable	Binomial
SR99	Designation of whether PAL or sample point is located on SR99	WSDOT PAL data		Dummy
BUS250	Mean daily people getting on and off bus within 250 feet of center of PAL (262 foot radius) or sample point. ** Expressed in 10's of users.	Metro Automatic Passenger Counts (APC)	APC data is for bus stops. Data for stops within 250 ft. of PAL or sample aggregated using GIS	Continuous
RETQRTMI	Square feet of retail space within one-quarter mile of center of PAL or sample point. Expressed in 100,000's of sq. ft.	King County Parcel Data (Assessor's files)	Square footage aggregated and attached to PAL or sample point	Continuous
DUHLFMI	Number of dwelling units within one-half mile of PAL or sample point	King County Parcel Data (Assessor's files)	Units aggregated and attached to PAL or sample point	Continuous
HWYGRCRY	Grocery store on state route within one-quarter mile of center of PAL or sample point	King County Parcel Data		Dummy
HWYFSTFD	Fast food restaurant on state route within one-quarter mile of center of PAL or sample point	King County Parcel Data		Dummy
SCHOOL	School located within one-quarter mile of center of PAL or sample	King County School Theme		Dummy
24HR_VOL	Average daily traffic volume. Expressed in 1000's of vehicles	PSRC Emme2 model data	Volume for closest link to center of PAL or sample point	Continuous
LAN_OP	Number of lanes	PSRC GPS roadway data	Lanes for closest link to center of PAL or sample point	Ordinal (varies from 2 to 8)
CSPD_OP	Congestion traffic speed for off peak period	PSRC Emme2 model data	Speed for closest link to center of PAL or sample point	Continuous
INTSECT	Number of intersections within one-quarter mile of PAL or sample on roadway that PAL or sample is located	King Cty intersection theme derived form street theme	Aggregated and attached to PAL or sample point	Continuous

** Note difference between diameter of PAL (528 ft) and aggregation of bus stop data (500 ft.) due to rounding in raster data model

Analyses and Findings

Variables were examined in terms of their means and standard deviations. Correlation analysis was used to explore basic relationships between variables and test for multicolinearity.

Descriptive Statistics

Basic descriptive statistics PALs and sample points on all state facilities in King County and for SR99 are presented in Tables 5 and 6. Mean bus stop use within all PAL and sample points is 54 persons day. On SR 99 only, this about doubles to a mean of 101 persons. The areas around PALs and sample points are clearly urbanized, although substantial variation is found in the mean of 100,000 square feet of retail space within one-quarter mile. Compared to the entire data set, points along SR 99 have more housing units, with a mean of almost 2,000 within the buffer zones. Also, a higher percentage of SR 99 points are located near groceries, fast food restaurants, and schools. State facilities are heavily trafficked, with a mean of 40,000 daily vehicles for all PALs and sample points, and a mean of 57,000 on SR 99. SR 99 also has more travel lanes. Finally, both sets show mean off-peak speeds modeled at just over 30 miles an hour. They have similar numbers of intersections per one-quarter mile of highway, with a mean of about 4.6, or about one every 300 feet, but there is a fair degree of variation in this figure.

Table 5. Descriptive Statistics for PAL and Sample Points on All State Facilities in King County

	N	Minimum	Maximum	Mean	Std. Deviation
BUS250	181	0	93	5.4	12.88
RETQRTMI	181	0	8.95	0.96	1.29
DUHLFMI	181	0	5578	1536	1031
HWYGRCRY	181	0	1	0.13	0.33
HWYFSTFD	181	0	1	0.38	0.49
SCHOOL	181	0	1	0.29	0.46
24HR_VOL	176	0.4	109.6	40.3	26.1
LAN_OP	176	2	8	3.9	1.2
CSPD_OP	176	12.1	44.7	31.5	5.9
INTSECT	181	1	13	4.57	3

Table 6. Descriptive Statistics for PAL and Sample Points on SR99 in King County

	N	Minimum	Maximum	Mean	Std. Deviation
BUS250	82	0	93	10.1	17.6
RETQRTMI	82	0	8.95	1.17	1.47
DUHLFMI	82	18.64	5578.104	1984.49511	1181.436518
HWYGRCRY	82	0	1	0.16	0.37
HWYFSTFD	82	0	1	0.46	0.5
SCHOOL	82	0	1	0.38	0.49
24HR_VOL	82	12.9	109.6	57	24.6
LAN_OP	82	2	8	4.5	1
CSPD_OP	82	24	43.8	33.4	5.1
INTSECT	82	1	13	4.9	3.3

Correlations

Pearson correlation coefficients show that variables have only weak to moderate relationships with each other. Only two variables have Pearson coefficients above 0.5: 24-hour traffic volumes (24HR_VOL) with the number of dwelling units located within one-half mile of points (DUHLFMI) where the correlation is 0.51; and (24HR_VOL) with the number of travel lanes (LAN_OP) where the correlation is 0.69. These and all other correlations make basic sense and do not present statistical problems.

Logistic Regression

Logistic regression was used due to the dichotomous nature of the dependent variable (whether a point is a PAL or not). The technique assesses other variables in terms of their power to predict the value of the dependent variable. In this case, the probability that a site is a PAL divided by the probability it is a non-PAL sample site (an odd ratio) is linearly regressed against the vector of the predictor variables. The exponential function of variable coefficients, Ex(B), can be interpreted as a multiplicative effect on the odd ratio of a one-unit change in the variable. The intercept cannot be interpreted. All variables were entered into the regressions.

Model 1: Results for ALL PAL and Sample Points in King County

Model 1 is statistically significant at the 0.01 level (Table 7). The Cox and Snell R Square suggests that about a third of the variance in the dependent variable (whether a point is a PAL or not) is explained by the independent variables. Overall, 80 percent of total points are correctly predicted, with about 91 percent of non-PALs correctly predicted and only 57 percent of PAL correctly predicted.

Two variables are statistically significant: BUS250, the number of people boarding and alighting from bus within 250 feet of the center of a PAL or sample point expressed in tens of bus users; and RETQRTMI, the amount of building area in retail uses within one-quarter mile of the center of a PAL or sample point, expressed in 100,000s of square feet. The value of Exp(B) for BUS250 suggests increasing bus stop usage by 10 people increases the odds that a point will be a PAL by 1.17 times. This supports the principal hypothesis of the study that increased bus stop usage is positively related to Pedestrian Accident Locations. Likewise, with RETQRTMI the value of Exp(B) suggests that adding 100,000 square feet of retail uses (about the size of two grocery stores) increases the odds that a point will be a PAL by about 1.5. In addition to increased pedestrian activity, increased levels of retail activity may also be associated with environmental factors that increase risk such as large numbers of active driveways along highways. The research cannot separate these possible effects.

Model 2: Results for SR99 PAL and Sample Points in King County

Similar to the first model, Model 2 is statistically significant at the 0.01 level with about a third of the variation in the dependent variable explained (Table 8). Slightly better than the first model, Model 2 classifies about 75 percent of all points correctly, with 86 percent of non-PAL sample points and about 61 percent of PAL points correctly classified.

Bus stop usage is statistically significant, but unlike Model 1, retail activity (RETQRTMI) is not. The value of Exp(B) value suggests that an increase of 10 bus stop users increases the odds a site is a PAL by 1.16, similar to Model 1. The descriptive statistics for PAL and sample points helps explain these results (Table 9). On average, PALs have six times the bus stop usage of sample points, and about 50 percent more retail footage, but for all other variables, differences between PALs and sample points are slight. In other words, most points along SR 99 have similar conditions in terms of nearby land uses, traffic volumes and speeds, number of lanes, and intersection densities. The lack of variation in these variables urges cau-

Table 7. Variables in Model 1 for All PAL and Non-PAL Sample Points in King County

	B	S.E.	Wald	Sig.	Exp(B)
BUS250	0.158	0.033	23.029	**0**	1.171
RETQRTMI	0.398	0.195	4.165	**0.041**	1.489
DU1000	0.128	0.264	0.234	0.628	1.137
HWYGRCRY	-0.889	0.706	1.584	0.208	0.411
HWYFSTFD	0.382	0.451	0.72	0.396	1.465
SCHOOL	0.011	0.485	0.001	0.981	1.011
24hr_VOL	-0.118	0.118	1.007	0.316	0.888
LAN_OP	0.561	0.297	3.565	0.059	1.752
CSPD_OP	-0.03	0.041	0.541	0.462	0.97
INTSECT	0.04	0.083	0.231	0.63	1.041
Constant	-3.22	1.486	4.698	0.03	0.04
Summary Stats.	**Chi-Sq.**	**DF**	**Sig.**	**-2 log likelihood**	**Cox and Sneel R Sq.**
	71.5	10	0	146.7	0.33

Table 8. Variables in Model 2 for SR99 PAL and Non-PAL Sample Points in King County

	B	S.E.	Wald	Sig.	Exp(B)
BUS250	0.151	0.039	15.409	**0**	1.163
RETQRTMI	0.332	0.246	1.828	0.176	1.394
DU1000	0.05	0.364	0.019	0.891	1.051
HWYGRCRY	-0.231	0.896	0.067	0.796	0.794
HWYFSTFD	-0.685	0.682	1.008	0.315	0.504
SCHOOL	0.065	0.633	0.011	0.918	1.067
24hr_VOL	-0.266	0.18	2.17	0.141	0.767
LAN_OP	0.111	0.416	0.072	0.789	1.118
CSPD_OP	0.018	0.071	0.063	0.801	1.018
INTSECT	0.18	0.134	1.807	0.179	1.198
Constant	-2.243	2.306	0.946	0.331	0.106
Summary Stats.	**Chi-Sq.**	**DF**	**Sig.**	**-2 log likelihood**	**Cox and Sneel R Sq.**
	33.6	10	0	76.9	0.34

tion in concluding that environmental conditions along the route do not contribute to pedestrian collision risk. Indeed the high concentrations of PALs suggest hazardous conditions along much of the highway's length to which the types of environments these variables proxy may contribute.

Table 9. Comparative Descriptive Statistics for PAL and Sample Points on SR99 in King County

		N	Minimum	Maximum	Mean	Std. Deviation
Sample Points	**BUS250**	49	0	29	3.3	6.7
	RETQRTMI	49	0	5.51	0.93	1.22
	DUHLFMI	49	19	5578	1952	1356.7
	HWYGRCRY	49	0	1	0.16	0.37
	HWYFSTFD	49	0	1	0.45	0.503
	SCHOOL	49	0	1	0.43	0.5
	24HR_VOL	49	17.1	109.6	57.6	26.8
	LAN_OP	49	2	6	4.5	0.94
	CSPD_OP	49	24	43.8	33.4	5
	INTSECT	49	1	13	4.8	3.3
PALS	**BUS250**	33	0	93	20.2	23.3
	RETQRTMI	33	0.05	8.95	1.52	1.74
	DUHLFMI	33	665	4008	2032	876.5
	HWYGRCRY	33	0	1	0.15	0.36
	HWYFSTFD	33	0	1	0.48	0.51
	SCHOOL	33	0	1	0.3	0.47
	24HR_VOL	33	12.9	103.6	56.1	21.3
	LAN_OP	33	4	8	4.5	1.1
	CSPD_OP	33	24	43.1	33.5	5.3
	INTSECT	33	1	13	5	3.4

Model 3: Results for Non-SR99 PAL and Sample Points in King County

Model 3 is statistically significant at the 0.01 level with almost half of the variation in the dependent variable explained. This is substantially higher than for the first two models. The model predicts about 90 percent of points correctly, with 94 percent of sample points and 74 percent of PALs correctly predicted. This is substantially higher than the SR 99 model. Table 10 shows four variables to be statistically significant at the 0.05 level. First, bus stop usage is significant, with an Exp(B) suggesting that an increase in usage by 10 people increases the odds that a site is a PAL by 1.5. Also significant is the dummy variable HWYGRCRY, indicating the presence of a grocery store but the coefficient is negative, opposite to the hypothesized direction of effect. However, the value of Exp (B) is extremely small at 0.003 with a 95 percent confidence interval ranging from 0.000 to 0.670. It is not possible to interpret these results without further research.

Table 10. Variables in Model 3 for Non-SR99 PAL and Non-PAL Sample Points in King County

	B	S.E.	Wald	Sig.	Exp(B)
BUS250	0.415	0.185	5.031	**0.025**	1.515
RETQRTMI	0.986	0.528	3.488	0.062	2.681
DU1000	0.287	0.659	0.19	0.663	1.333
HWYGRCRY	-5.658	2.682	4.45	**0.035**	0.003
HWYFSTFD	0.043	1.074	0.002	0.968	1.044
SCHOOL	3.27	1.895	2.977	0.084	26.311
24hr_VOL	0.621	0.292	4.529	**0.033**	1.861
LAN_OP	2.726	1.306	4.361	**0.037**	15.276
CSPD_OP	0.019	0.065	0.083	0.774	1.019
INTSECT	0.258	0.272	0.902	0.342	1.295
Constant	-17.569	7.149	6.039	0.014	0
Summary Stats.	**Chi-Sq.**	**DF**	**Sig.**	**-2 log likelihood**	**Cox and Sneel R Sq.**
	63.6	10	0.00	41.03	0.49

The final two significant variables are both related to traffic and roadway conditions. The value of Exp(B) for 24-hour traffic volume (24hr_VOL) indicates the addition of 10,000 vehicles a day increases the odds a site is a PAL by 1.8. The value of Exp(B) for travel lanes (LAN_OP) suggests that each new travel lane increases the odds a roadway segment is classified as a PAL by more than 15 times. The direction of effect for both these variables is as hypothesized.

Discussion

All models show a positive relationship between bus stop usage and PAL sites and therefore support the principal hypothesis of the study. The SR99 model shows bus stop usage as the only statistically significant predictor of PALs. This maybe explained by the lack of variation in the other variables capturing pedestrian activity and road characteristics along the route. In addition to fairly high bus stop usage, SR99 has substantial retail activity, large numbers of housing units located along it, four to six travel lanes, and high traffic volumes—all factors that likely contribute to the large number of collisions and Pedestrian Accident Locations found along this roadway.

With more variations in the level of urbanization and in road characteristics, the non-SR 99 model suggests that traffic volumes and the number of traffic lanes are also statistically significant predictors of PALs. This is consistent with previous studies (Zegeer 1991). Because roadway widening is a common approach to dealing with the added traffic that comes with increased development, the potentially large effect of adding a traffic lane on the likelihood of creating a PAL deserves further research.

Future Research

PALs are practical and useful as a planning tool to direct safety dollars to specific locations along roadways. They also work as a measure of high-collision location associated with high bus usage. Yet at more than 500 feet in length, they are too large a spatial unit of data and analysis to research specific site conditions. PALs are not an effective dependent variable to model fine-grained differences in environments and the specific driver and pedestrian behaviors that may be associated with collisions—as, for example, modeling pedestrians crossing streets or turning vehicle movements. The length of a PAL also tends to smooth out variations in housing densities, retail area characteristics and other environmental attributes around collision sites, thus likely reducing the statistical power of modeling efforts. Further research must test different spatial aggregations of pedestrian collisions along routes and include such site-specific data on environmental conditions as sidewalks, crosswalks, and signalization.

The power of current GIS technology and analysis makes it possible to use small spatial units of analysis across large study areas (Steiner et al. 2002). To achieve this, new disaggregate data from both transportation and planning sectors are needed to increase analytical power. Although not available for this study, the eminent release of WSDOT data on individual collisions on all state and non-state roadways will make such analyses possible in the near future. The very high societal costs of collisions involving pedestrians bring urgency to the development of tools that define precisely where and how to invest safety dollars.

Conclusions

This study finds that the level of bus usage along state highways is significantly associated with high rates of pedestrian-vehicle collisions. In terms of policy, this result suggests that bus stops serving large numbers of riders should either be removed from state highways, or targeted for immediate safety improvements. Given the degree of urbanization and lack of other travel corridors in many metropolitan areas today, the former strategy is simply not realistic. Instead, facilities with high numbers of bus boardings or alightings must be designed to allow people to safely walk along and across the roadway.

It makes eminent sense to find that roads with high volumes of bus riders have more vehicle-pedestrian collisions than those with low ridership or no transit. Indeed, it may seem too obvious to researchers whose focus has been to identify factors affecting the relative risk of collision independently from the total number of pedestrians using given locations. Yet, this finding requires a rethinking of existing policies and institutional responsibilities to insure the safety of pedestrians on high-volume suburban corridors. It questions the appropriateness of current transit and highway safety programs that, to date, give low priority to the provision of safe facilities for transit riders walking to and from bus stops. It suggests that, in increasing their support of bus transit for roadway design and investment, safety programs within highway agencies place emphasis not only on the use of facilities by transit vehicle, but also on riders walking to and from those same vehicles. The finding also indicates that the responsibility of transit agencies to insure the safety of riders lies not only inside transit vehicles and at transit stops, but also extends to nearby locations along or across the road.

In metropolitan regions, high-volume state highways commonly lined with zones of strip-retail uses and active bus stops must be recognized as multimodal facilities. For these facilities, specific attention must be paid to the role of transit in shaping the demand for nonmotorized travel. Because many of these roadways have few or no pedestrian facilities, the relevant factor in improving their safety with limited resources is to target the locations where pedestrians are likely to be found. Safety investments should be directed to these locations. State DOTs, local jurisdictions, and transit staff must work together to identify facilities and locations where bus riders are at risk and take appropriate steps to insure pedestrian safety at and beyond bus stops.

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