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Qualitative Research to Assess Interest in Public Transportation for Work Commute

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Abstract

Given the need for reducing single occupancy vehicle commutes, this article presents a case study of employer-based research. Using conjoint analysis as a qualitative research method, factors that potentially influence people's choices to drive alone to work were studied at a major company in Columbus, Ohio. Such factors included reasons for driving alone, satisfaction with commute, perceptions toward transportation modes, importance of transportation attributes, and likelihood to switch if certain Transportation Demand Management measures were implemented. Target groups were formed by using simple regression and cluster analysis of a stated-ranking question regarding transportation attributes.

Introduction

Increased mobility produced by low-density development, rising affluence, and the relative affordability of owning and operating automobiles is clearly valued by people, especially in the United States. Beyond mobility, however, increased automobile use arguably produces a number of negative outcomes, among them are more time spent in traffic congestion; air, water and noise pollution; energy consumption; urban sprawl; and traffic accidents.

Academic researchers, policy-makers, and practitioners are keenly interested in identifying means of effecting modal shifts among commuters, if not reducing total distance travelled. Among the methods that have been attempted are restrictive policies, such as increasing parking fees and implementing road tolls, or incentive policies, such as offering reduced bus passes. Most of these have proven to be only marginally effective and still do not produce the desired outcomes (Meyer 1999; Baldassare et al. 1998). Therefore, some empirical studies conclude that people are resistant to changing their travel mode (Curtis and Headicar 1997; Moeller and Thoegersen 2003; Bamberg et al. 2003). However, many of these existing approaches to exploring commuting behavior, including the extent to which it occurs and the spatial relationships between home and work locations, are not comprehensive enough measures. To further examine these questions, disaggregate data and qualitative research methods are helpful.

To identify some of the factors that influence people's travel decisions and prevent commuters from using alternative modes of transportation, the presented research applied an in-depth employee survey using conjoint analysis elements. As with qualitative research in general, the research usually does not provide representative data. For the purpose of demonstration, however, the results were used to define target groups for marketing public transportation and to determine the type of actions that would increase an employee's likelihood to switch.

This article presents a case study analyzing the travel behavior of employees of a major company in downtown Columbus, Ohio. Working with private employers allows the researcher to gain easy access to employee information, such as housing distribution and working hours, and to the company's internal and external environment, which provides further explanation of travel behavior. In addition, employers will be more likely to support such research if the study results include concrete recommendations for the site. Further, others have found that employers tend to have a significant impact on reducing commute automobile travel when being actively involved (Winter 2000; Schreffler 2000).

Literature Review

Qualitative Research

Social scientists have long been interested in understanding travel behavior, but to this end they have predominately employed quantitative research methods (Golledge and Stimson 1997; Clifton and Handy 2003). Although qualitative techniques do not yield statistically significant results, they are ideally suited for exploratory research such as identifying influential factors of travel behavior (Golledge and Stimson 1997). Qualitative survey techniques like attitudinal surveys, focus groups, personal interviews, and participant-observation methods provide more detailed answers to current questions and issues regarding transportation and travel behavior. While qualitative methods offer great potential for transportation research, it cannot be argued that they should not be seen as a replacement to quantitative methods, but should be viewed as an extension to assist in explaining psychological and socially influential factors in travel behavior (Clifton and Handy 2003; Goulias 1995; Poulenez-Donovan and Ulberg 2004).

It is well established in the literature that cognitive processes play an important role in determining travel behavior to work (Louviere and Hensher 2001; Axhausen and Sammer 2001). As such, revealed preference, stated preference, discrete choice analysis, and conjoint analysis methods have been used in the field of transportation research to develop predictive choice models. Stated preference experiments are commonly employed for identifying the most important product features or alternatives for travel by providing respondents with different hypothetical scenarios relating to a current behavior such as the work commute (Hunt and Millan 1997; O'Fallon and Hensher 2004). Stated-choice questions demand choosing one of several alternatives or scenarios; stated-preference questions request the evaluation of each alternative by scaling methods; and stated-ranking questions ask the respondents to rank several alternatives by preference.

Conjoint analysis involves the use of designed hypothetical choice scenarios to measure individuals' preferences and predict their choice in new situations. Alternatives are described by their main features, called attributes. Multiple hypothetical alternatives, called product profiles, are generated and presented to respondents who are requested to express their degree of preference for these profiles or choose between these profiles (Backhaus et al. 2000). Conjoint analysis is well suited for travel behavior research because it allows the researcher to estimate the importance a person attaches to different features of a product without direct questioning. Consequently, conjoint analyses can help determine the transportation mode attributes most relevant to the consumer and how variations of the attributes and its levels will influence consumer behavior.

In the present study, conjoint analysis was valuable for identifying the attributes of transportation services that are most important to car drivers and the trade-offs they would be willing to make if certain attribute changes occurred. The research was conducted in a qualitative manner. Its main intention was to be comprehensive by surveying a wide variety of possible influential factors, such as spatial, behavioral, psychological, and social ones.

Spatial, Behavioral, Psychological, and Social Theories

The physical structure of urban environments undeniably influences travel behavior. However, spatial and behavioral theories of travel behavior cannot be treated independently but must be studied together, and urban planning and travel demand management should be complementary processes (Golledge and Stimson 1997; Boarnet and Crane 2001; Holcombe and Staley 2001).

Personal and situational constraints significantly influence travel behavior, and so mode choice depends not only on origin, destination, and sociodemographic characteristics, but also on individual's motives, interests, and intentions. To better identify people's motivations and perceptions regarding transportation and land use, all of the possible influential factors for mode selection should be studied, including personal and external constraints, attitudes toward the different modes of transportation, importance of transportation attributes, and sociodemographics (Anable 2005). The notion that internal constraints on an individual level need to be addressed in addition to the analysis of exogenous forces is vital for developing effective policies (Golledge and Stimson 1997).

Understanding and explaining travel behavior can be further enhanced by relying on psychological theories about attitudes and behavior, and especially theories that offer possible means of predicting behavior (Bordens and Horowitz 2002; Moeller and Thoegersen 2003).

Based on cognitive social psychology theories, attitudes are usually learned through socialization but can be altered through learning processes (Bordens and Horowitz 2002). Others, however, including Moeller and Thoegersen (2003), suggest that travel mode choice is often influenced by habits, and is thus repeated behavior. Repeated behavior helps decrease the volume of cognitive effort necessary for decision making and allows individuals to make decisions with growing automatism. Unfortunately, changing habits is very difficult because it requires more effort to make new decisions, such as time and comfort costs. Also, new decisions are only feasible if sufficient information about alternatives is available.

Huey and Everett (1996) use the "concept of reinforcement delay" to explain resistance to modal change. They argue that the benefits of using alternative modes of transportation, in particular public transit, such as saving gas, decreasing pollution, and reducing traffic, are important assets. However, the public transit user does not immediately recognize those "rewards." Within their research, Huey and Everett (1996) demonstrate the lack of immediate reinforcement for public transportation systems and the need to create awareness for the "punishers" of private vehicles, such as air pollution, traffic congestion, and higher transportation costs.

Concluding from the above-mentioned theories and empirical findings, it is evident that spatial and behavioral analysis should be undertaken together to successfully influence travel behavior. Psychological studies have revealed that it is important to know about internal constraints and attitudes to understand the decision process for mode choice. In addition, information regarding people's attitudes and the importance they place on attributes of transportation services is needed to help in marketing alternatives successfully.

With these theories and methodologies in mind, an employer-based case study performed in Columbus, Ohio, using qualitative research is described below.

Case Study

Study Area: Columbus, Ohio

With more than 1.5 million residents in 2005, the Columbus metropolitan statistical area (MSA) is the 31st most populated MSA in the United States. Since 1990, Columbus' population has grown 12.4 percent, and the Mid-Ohio Regional Planning Commission (MORPC) projects population growth to continue at the same rate until 2010. By 2030 the population is forecasted to increase by 36 percent (MORPC 2004). Employment growth in Central Ohio increased 18 percent between 1990 and 2000, adding more than 120,000 jobs to the region. Vehicle Miles Traveled (VMT) in Columbus has far surpassed population growth, rising 31 percent between 1990 and 2000.

As with many midwestern cities, the vitality of Columbus' downtown has declined in recent decades; this change is marked by the loss of large shopping centers and private employers to the surrounding suburbs (MORPC 2004). However, major efforts are being made to preserve and improve the original Central Business District (CBD). Many companies have headquarters in Columbus' CBD where they could take advantage of a highly developed transportation infrastructure and agglomeration of similar firms and support services.

In addition to concerns about increased VMT and suburban sprawl, Franklin County, which encompasses the majority of the city of Columbus, and five surrounding counties have been recognized as an air quality nonattainment area. To avoid stringent policies regarding emission regulations, it is necessary to implement strategies that will decrease automobile usage in the future and enhance mobility options for employees despite growing traffic volumes. One possibility is to improve the local transit system by increasing both service coverage and frequency.

Study Object: Employees at a Major Downtown Company

A single major employer in downtown Columbus was selected for this case study. The company employs more than 2,800 workers at its headquarters, which is located in the Columbus CBD and easily accessible by four major interstates or state highways. Its location also offers reasonable access to public transportation; it is within seven blocks of the transit terminal for all bus lines servicing Franklin County and beyond.

However, an efficient highway network and abundant parking potentially deter many employees from choosing alternative modes. The company currently owns two parking garages with combined 2,010 spaces and rents another 532 spaces, offering a total of 2,542 parking sites to their employees for $40 or $60 per month. The ratio of 1.1 employees per parking space is high for a dense downtown area.

Although the transportation and urban infrastructure clearly impede the popular use of public transportation, transit still has its place in Columbus and can, when marketed and serviced correctly, obtain a large ridership. Some of the strategies needed to make transit use more attractive are discussed as part of the research results.

Methodology

The objective of this case study is to identify the presence and importance of latent factors in travel behavior decision making, such as attitudes and perceptions about alternative modes, the work commute and travel costs, and to define different target groups. Therefore, a survey called the "Work Commute Satisfaction Survey" (subsequently referred to as WCSS) was conducted in November 2004. The survey was designed only for current single occupancy vehicle (SOV) users. A total of 60 employees were selected based on their gender, working hours, and residential location. Fifty-two of these employees participated, representing a high response rate of 89 percent. To facilitate participation, the employer provided free lunch on the company's executive floor upon completion of the survey.

The survey contained 53 questions and took approximately 40 minutes to complete. Questions were structured into five different substantive components. Question structures included multiple-choice and conjoint analysis elements consisting of ranking, Likert scaling, and a stated-ranking question. The questions were all utilized to gain detailed knowledge about factors that lead SOV commuters to not choose alternative modes, and can be summarized into the following five subject areas:

- *Work and Home*, including multiple-choice questions such as housing location and choice, employer choice, working hours, or routes to work.
- *Commute Travel*, including multiple choice, scaling and ranking questions regarding commute to work, reasons for choosing the car, satisfaction with work commute, trip-chaining, possible improvements for route to work, ranking of attributes for transportation services, and personality traits.
- *Opinion*, including a series of attitudinal questions toward all modes of transportation regarding the employee's (dis)agreement with given statements, ranking of transportation modes by preference, as well as likelihood to switch to alternative modes if certain measures were implemented.
- *Suppose …*, including a scenario of transportation characteristics on plan cards for the respondent to rank by preference.
- *About You*, including multiple-choice questions regarding sociodemographic and socioeconomic aspects of each individual.

The stated-ranking question was conducted by providing the respondents with plan cards that offered 9 out of 27 possible randomly chosen scenarios of commute travel (see Table 1). Each scenario contained one out of three possible choices per attribute. By asking respondents to trade off between scenarios, conjoint analysis is useful for determining the optimal features for a transportation service, in the opinion of the respondent, by estimating the weight people place on various factors that underlie their decisions.

The results were analyzed using the statistical program SPSS as well as a geographical information system to visualize respondents' home locations and estimate transit potential by residency.

In addition to the qualitative survey, an Intranet survey was conducted in May 2005 with all 2,811 employees at the company's downtown headquarters. The objective was to determine the current modal split as well as to provide the employer with more representative data and information about the type of measures that would increase employees' likelihood to switch to alternative modes. For this study, however, focus shall be placed on the analysis of the qualitative survey as the following section describes.

Table 1. Description of Attribute Cards

A You can leave home or work whenever you want. You pay 30% more versus your current commute. Your travel time stays the same.	**B** There are only a limited number of departure times you can choose from. Your travel costs stay the same. Your travel time stays the same.	**C** There are many departure times you can choose from. You save 30% versus your current commute. Your travel time stays the same.
D There are only a limited number of departure times you can choose from. You pay 30% more versus your current commute. Your travel time takes 15 minutes less than now.	**E** You can leave home or work whenever you want. You save 30% versus your current commute. Your travel time takes 15 minutes less than now.	**F** There are many departure times you can choose from. Your travel costs stay the same. Your travel time takes 15 minutes less than now.
G There are many departure times you can choose from. You pay 30% more versus your current commute. Your travel time takes 15 minutes more than now.	**H** You can leave home or work whenever you want. Your travel costs stay the same. Your travel time takes 15 minutes more than now.	**I** There are only a limted number of departure times you can choose from. You save 30% versus your current commute. Your travel time takes 15 minutes more than now.

Results

Identifying Target Groups through Self-Selection of Attributes

Often, Transportation Demand Management (TDM) marketing strategies are directed toward specific target groups. Such target groups can either be defined by their travel behavior or their values for transportation attributes.

The WCSS survey produced no significant results for forming target groups by residential area or by sociodemographic variables. Instead, an analysis of the importance of transportation features, such as flexibility, time, and cost, implied that it would be more useful to divide commuters into each one of these groups.

Two WCSS questions were used to either request the participant's ranking of attributes by preference or to demand an orderly scaling of attributes from 5 = Very important to 1 = Very unimportant. The ranking order for both questions resulted as follows: flexibility, then time, then cost. Time seemed to be the second most important factor in choosing a mode. However, the stated-ranking question provided different results. This task asked participants to rank index cards that described feature characteristics of transportation choices by their preference (see Table 1). Only transportation attribute scenarios and attribute levels were provided to the participants, without referring each scenario to a particular mode. Thus, perceptions about other modes should not have influenced the preference ranking. Time received the lowest relevance when choosing between possible transportation scenarios. The average importance of the three attributes was as follows: flexibility (41 percent), cost (36 percent), and time (21 percent).

This discrepancy in results could be explained by the *amount* of savings (30 percent/15 minutes) described in the plan cards, suggesting that the ranking order of attributes will change depending on the amount of money or time that could be saved. The results also indicate that cost becomes more important when reaching a certain level. Thus, as cost rises, flexibility and time decrease in value. Further research is necessary to help define the threshold that will increase the value of cost savings.

To determine the importance or utility individuals placed on each attribute by their rank choice, a simple regression analysis was performed. In this case, the rankings of each respondent were dummy-effect coded and interpreted as metric-scaled dependent variables while the attributes and their parameter values served as the independent variables. Target groups were defined based on the value each member placed on the attribute.

To differentiate between target groups, a cluster analysis was applied by quantitatively comparing multiple characteristics. Thus, respondents were placed into more or less homogeneous groups. The cluster analysis for this research was performed by using the Ward Method and the squared Euclidian distance (Backhaus et al. 2000).

As described earlier, qualitative research will not enumerate statistical frequencies but rather can provide further information about behavioral and influential factors on mode choice. Thus, due to the small sample size, results will only present tendencies of the member's characteristics in each group.

Attribute Groups

Although all participants state that convenience is the most important transportation attribute for them, not all participants fell into the "flexibility" category when analyzing their plan card choices. Instead, nearly half of the participants seemed to be more concerned about costs, while another 10 percent valued time the most. As Table 2 illustrates, members of each attribute group differ based on selected characteristics.

For example, cluster 1 (flexibility) consists of more women. Half of all group members have a bus stop near their home, yet if no car was available, most would want to carpool. Clearly, cost savings is not very important. While many have to pick up their children before or after work, participants in this group demonstrate the highest overall satisfaction with their current commute. Consequently, members of cluster 1 indicate the least overall likelihood to switch to alternative modes. More than 38 percent of the participants state that they are "much more likely" to switch in response to only three scenarios: The implementation of a Guaranteed Ride Home (GRH) program, increased traffic congestion, and the implementation of a light rail system.

Participants in cluster 2 (cost) are primarily employees with a college degree who tend to have a higher interest in public transportation. This group further contains a significantly higher percentage of employees who occassionally use alternative modes. More than 41 percent of the interviewees indicate a higher likelihood to switch to alternative modes of transportation if a GRH program were implemented, gas prices increased, parking search and cost increased, congestion grew worse, or if a light rail were implemented.

In cluster 3 (time), men seem slightly overrepresented. Interviewees in this group are all employees with a college degree and a household income of $80,000 or more. While none had a bus stop near their home, this group demonstrates the highest likelihood to switch. The measures that would make over 40 percent of the participants "much more likely" to switch to other modes include the implementation of a GRH program, receiving money for not using a parking space, increased parking search and costs, growing congestion, assistance in arranging car- and vanpools, reserved parking, construction of HOV Lanes, increased bus services, and the implementation of a light rail system.

Table 2. Characteristics of WCSS Participants per Attribute Cluster

	Cluster 1: Flexibility (N=21)	*Cluster 2: Cost (N=22)*	*Cluster 3: Time (N=5)*
Gender Female Male	 38% 62%	 14% 86%	 20% 80%
Primary age group(s)	46-55 (40%)	36-45 + 46-55 (64%)	any
Married	76%	90%	80%
Highest level of education	Varies from high school to PhD degree	All have continuing education	All have at least a bachelor's degree
Household income	$20,001 to >$140,000	$40,001 to >$140,000	$80,001 to >$140,000
Availability of bus stop at home	50%	27%	0%
Occasionally use other modes to work	14%	31%	0%
Used alternative modes before	76%	77%	40%
If no car was available Carpooling COTA bus	 57% 29%	 32% 45%	 20% 20%
Overall satisfaction with commute (Scale 1 to 5, with 5 = Very satisfied)	4.02 [Range: 3.1–5.0]	3.7 [Range: 2.8–4.8]	3.2 [Range: 2.7–3.5]
Pick up children	19%: daily 14%: 1–2 times/week	13%: daily 4%: 1–2 times/week	0%
Rank attributes[a] Convenience Cost savings Time savings	 1.7 4.9 3.7	 2.2 3.7 4.4	 1.4 3.4 3.8
Participants who rank … as most important:[a] Convenience/flexibility Cost savings Time savings	 76% 0% 9%	 73% 0% 5%	 80% 20% 0%
Importance of attributes[b] Convenience Cost savings Time savings	 100% 85% 100%	 100% 86% 86%	 100% 60% 100%
Attitudes toward different modes of transportation[c]	Bus: 3.4 Car/vanpooling: 3.5	Bus: 3.5 Car/vanpooling: 3.8	Bus: 3.3 Car/vanpooling: 3.5
Overall likelihood to switch (1=Not at all likely to 3=Very likely)	1.58	2.02	2.13

a. Within the survey question, participants were asked to rank 12 attributes from 1 = highest rank to 12 = lowest rank (Calculated: SUM Rank numbers divided by SUM Participants).

b. "%" indicates the combined percentage of participants who claimed that a particular attribute is either "very important" or "somewhat important" (Scale 1 to 5).

c. A list of 60 different attitudinal statements regarding travel behavior and transportation modes was provided to each participant, asking them to rank each one on a scale from 1 to 5, with 1 = Strongly disagree to 5 = Strongly agree. The statements regarding bus usage and carpooling were then summarized and weighted to receive an overall score regarding the participant's attitude toward these modes. Therefore, 5 = positive versus a 1 = negative attitude.

Summary and Recommendations

The overall study results suggest that flexibility, cost, and time are the most important reasons for choosing a transportation mode. These results are not surprising. However, answers of the stated-ranking question indicate that commuters will trade off transportation attributes if provided with concrete scenarios. For this particular study, results demonstrated that flexibility and time decrease in value when cost reaches a certain level.

Travel demand management strategies can be enhanced by marketing efforts directed toward members of each attribute group, based on their observed transportation characteristics. According to the presented research, it can be assumed that people's sensitivity to transportation attributes significantly influence their likelihood to make certain travel decisions, and that the value they place on travel characteristics cannot be elucidated by only their sociodemographic characteristics.

When forming target groups by using these attributes, it is obvious that TDM concepts which value a particular attribute seem to work best for each group and therefore should be marketed accordingly. For example, cost-sensitive commuters, such as in cluster 2, will react quicker to obvious increases in travel costs, such as parking or gas, while time-sensitive employees, such as in cluster 3, should be provided with personal assistance on carpooling and transit. When implementing any of the TDM strategies, it is important to market the qualities of each measure in such a way that it is compelling to the members of the group it addresses. For example, marketing TDM measures related to cluster 3 should be directed to high-paid male professionals living in the suburbs.

Public transportation, in particular, tends to be the most efficient alternative transportation service for any commuter if applied and marketed correctly. An improved transit service can address each identified target group. Unfortunately, like many transit systems in the United States, the local bus authority is plagued by a lack of adequate funding. Decreased federal and state funding and low farebox revenue, the result of low ridership, promises continued financial troubles for the transit authority. For reasons related to the transit service constraints, two options should go hand in hand:

1. Focusing information and marketing on those transit routes that are most accessible to employees' homes as well as nearest to the company while

keeping each target group attributes in mind. It often is not enough to just provide the service but to also ensure that the employees know about it.

2. Encouraging public-private partnerships on transportation infrastructure projects, including subsidizing transit in order to increase service frequency and speed. In general, service expansion rather than decreased fares has proven to be a more effective means of increasing ridership (Schimek 1996).

Overall, many fundamental policies which can create a better balance between auto and transit are very important in influencing the analyzed decision process. Such policies include the increase in gas taxes to use toward public transportation, or allowing for more flexible working hours and types (e.g., telecommuting).

Future Research

Travel behavior is a complex process that promises to remain a rich area for transportation research. The use of qualitative methods and scenario-building tools, such as the conjoint analysis presented here, are examples of the potential for innovative methods in TDM to get a more in-depth understanding of travel choices. Several potential areas of future research related to this study include more investigation of the type of scenarios and the parameter values that are most appropriate as thresholds when commuters change the ranking of attribute values, and to test if the results of this study and the identified clusters are representative of a larger population. Since this research was conducted in a very auto-oriented environment, it would also be interesting to see if similar results are obtained when studying a commuter population in a city with much more transit-oriented land use and service coverage.

As indicated in this article, employers play a significant role in achieving commuter modal shift. As such, more research should be conducted to identify successful means of encouraging companies to actively participate in local transportation projects and as a result implement measures that are responsive to their employees' travel needs. Cooperating with surrounding companies could then lead to more effective measures aimed at improving public transportation, biking lanes, and sidewalks.

In addition to only addressing individual companies to get involved in TDM, future research could also include studying the type of impact that multiple employers can have on changing basic transportation policies toward more positive ones for transit when cooperating with the city and public transit agency.

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Managing Limited Access Highways for High Performance: Costs, Benefits, and Revenues

Patrick DeCorla-Souza, Federal Highway Administration

Abstract

Managed lanes are a set of lanes where highway operations strategies are actively applied in response to changing conditions. High-Occupancy/Toll (HOT) and Express Toll lanes are examples of managed lanes. The transportation operations concept discussed in this article involves conversion of existing freeways (all lanes) into premium-service free-flowing highways that provide fast, frequent, and inexpensive express bus service and charge all private vehicles a variable toll—except for authorized buses and certified ridesharing vehicles. The toll would vary by level of demand and would be set high enough to guarantee that excessive demand will not cause a breakdown of traffic flow. This article discusses the advantages of this concept. It introduces a new sketch-planning tool that provides estimates of costs, benefits, and revenues from applying the concept on a highway network in a prototypical large metropolitan area. The estimates suggest that implementing the concept can provide significant net social benefits. It may also generate sufficient new toll revenue to pay for all costs for implementation and operation, including new express bus and park-and-ride services that would complement the pricing scheme.

The views expressed in this article are those of the author and not necessarily those of the U.S. Department of Transportation or the Federal Highway Administration.

Introduction

Growing congestion on metropolitan highway networks poses a substantial threat to the U.S. economy and to the quality of life of millions of Americans. In the short term, congestion pricing—also known as value pricing—can relieve traffic congestion and reduce the waste associated with it. In the United States, several congestion pricing projects have been implemented involving separated lanes on freeways called High-Occupancy/Toll (HOT) lanes, in which demand is managed using variable tolls. Congestion pricing involves "open-road" tolling, or no toll booths. All tolls are collected electronically at highway speeds.

This article introduces a comprehensive pricing concept termed "Super HOT" transportation. It discusses the Super HOT concept, its advantages, the benefits and revenues from establishing a Super HOT transportation network in a prototypical major metropolitan area, and its costs and financial feasibility.

The Super HOT Transportation Concept

Role of Congestion Pricing

Once freeway traffic exceeds a certain threshold level (measured in terms of flow of vehicles per lane per hour, or in terms of density of vehicles per mile), both vehicle speed and vehicle throughput drop precipitously. Data show that maximum vehicle throughput occurs at speeds of about 45 mph to 55 mph (Chen and Varaiya 2002). When severe congestion sets in, the number of vehicles that get through per hour can drop by as much as 50 percent, while speeds drop to "crawl" speeds of 15 to 20 mph (Chen and Varaiya 2002). At high vehicle densities, traffic bogs down due to traffic demand exceeding the supply of road space. Traffic flow is kept in this condition of "collapse" for several hours after the rush of commuters has stopped. This causes further delay for motorists who arrive later in the day.

With peak-period highway pricing, a variable toll dissuades some motorists from using limited access highways (generally freeways) at critical locations where traffic demand is high, and where surges in demand may push the highway over the threshold at which traffic flow collapses. Pricing prevents a breakdown of traffic flow in the first instance, and thus maintains a high level of vehicle speed and throughput throughout the rush hours. Collapse of traffic flow from overcrowding is avoided. Not only are *more* motorists able get to their destinations during each hour—they also get there *faster*. Each priced lane in the median of State Route 91 in Orange County, California (on which traffic flow is managed using variable tolls) carries twice as many vehicles per lane as the adjacent toll-free lanes during the hour with heaviest traffic (U.S. Department of Transportation 2005). Management of traffic flow through pricing has allowed twice as many vehicles to be served per lane at three to four times the speed on the free lanes.

Currently, U.S. freeway systems use congestion delay as a way to ration scarce road space during rush hours. Delay imposes huge social costs on the traveling public and on the economy, and is an extremely wasteful way to allocate scarce road space. If freeway road space were instead rationed using variable tolls, the revenue generated would simply be a transfer of resources from motorists to the highway operator, and would not be a waste. The revenue could be used to generate further benefits for commuters or to reduce taxes. Unlike taxes, the toll revenue would be obtained from travelers willing to pay to get a direct benefit in return—the reduced waste of their time. By reliably preventing traffic flow breakdown and thereby ensuring a predictable trip travel time, freeway pricing would also reduce the "buffer" time that commuters must otherwise plan into their schedules. It would reduce fuel consumption and emissions, and reduce diversion of traffic to alternate routes where they may cause further congestion.

It might appear counterintuitive that imposing a new toll on a currently free road can actually reduce traffic on parallel facilities. Figure 1 and Table 1 attempt to demonstrate how this may happen. Figure 1 shows the magnitude of the waste of time and vehicle capacity that occurs when traffic flow breaks down on the four eastbound lanes of I-66 outside the Capital Beltway in Northern Virginia, inbound toward Washington, D.C. Traffic flows freely up to 7am. In the one-hour period between 6 and 7am, 8,000 vehicles are carried at an average speed of 55 mph. Traffic flow breaks down between 7 and 8am, with speeds dropping to 30 mph and vehicle throughput dropping to 7,000 vehicles. From 8 to 9am, throughput drops further to 6,000 vehicles, and average speed drops further to 25 mph. The reduced flow of 6,000 vehicles per hour continues between 9am and 10am, with speed increasing slightly to 30 mph. Table 1 provides estimates of time wasted, and the potential value of time savings on the freeway if free flow of traffic could be maintained. As much as $10 million annually could be saved on the 10-mile eastbound freeway segment with good traffic flow management in the morning peak period. Table 1 also shows that after accommodating the 19,000 existing users of the eastbound freeway who travel during the 7 to 10am period, there will be spare capacity of up to 5,000 vehicles available for use from 9 to 10am. This available capacity will draw drivers from alternative routes and from other times of the day (i.e., those who currently try to avoid congestion on the freeway). Thus, pricing the freeway to maximize throughput will reduce traffic levels on alternative routes and at other times of the day.

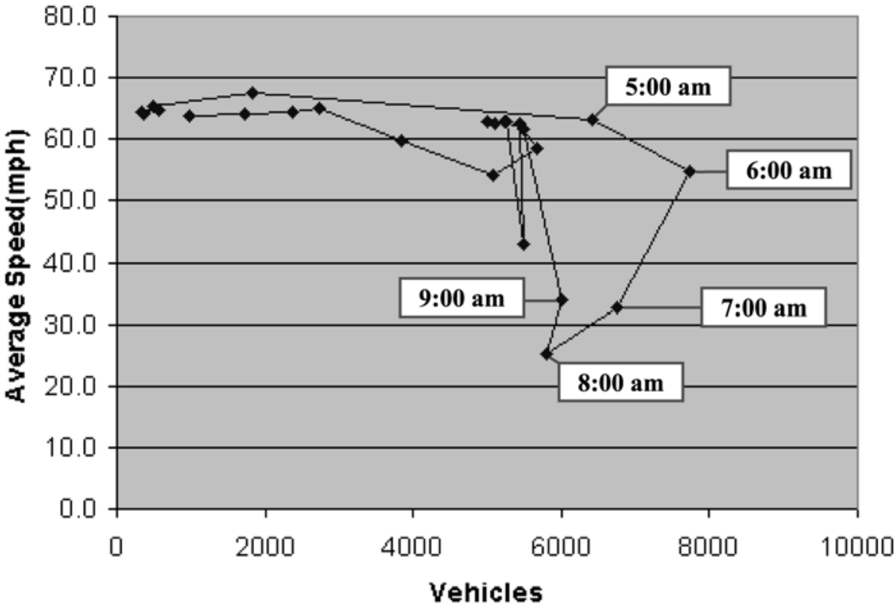

Figure 1. Traffic Volumes and Speeds on I-66 Eastbound in Northern Virginia (Four Lanes, Morning Peak Period)

It takes only a small reduction in traffic demand at critical times during the peak period to restore free flow. Motorists in Washington, D.C. experience free-flowing traffic during rush hours in August, with only a small fraction of workers away on vacation and less than a 10 percent drop in peak-period traffic volumes. Similar experiences are reported in metropolitan areas in California on state holidays, when only state employees are off work. So the key is to shift a few rush-hour travelers to other modes or to other times of travel. Estimates of transit price cross-elasticity with respect to driving demand range from 0.025 to 0.056 (Glaister and Lewis 1978). Long-term elasticities tend to be much higher (Lee 2000) due to the ability of travelers to respond through changes in job or residential location in the longer term. This suggests that a 5 percent reduction in driving could be achieved by a combination of reductions in transit fares and travel time. With free-flowing

Table 1. Potential Impacts of Congestion Pricing on I-66 Eastbound

	7–8am	*8–9am*	*9–10am*	*Total*
7–10am (no pricing)				
Traffic volume	7,000	6,000	6,000	19,000
Average speed (mph)	30	25	30	
Travel time per mile (min.)	14,000	14,400	12,000	
Travel time for 10-mile trips (min.)	140,000	144,000	120,000	404,000
7–10am (with pricing)				
Traffic volume	8,000	8,000	3,000	19,000
Average speed (mph)	55	55	55	
Travel time per mile (min.)	8,727	8,727	3,273	
Travel time for 10-mile trips (min.)	87,273	87,273	32,727	207,273
Benefits 7–10am (with pricing)				
Daily travel time savings (min.)				196,727
Annual travel time savings for 10-mile trips (hours)				819,697
Value of annual time savings (at $12 per hr.)				$9,836,364

freeways, the entire freeway network could serve as a transit "fixed guideway," providing travel time advantages for express bus services.

Additional reductions could be achieved through an increase in carpooling, vanpooling, flextime, and telecommuting. If freeways were free flowing, the entire freeway network could serve as a virtual HOV network that provides toll-free service to vanpools and carpools certified by employers or the metropolitan ridesharing agency. (Certification of ridesharing vehicles avoids the need for on-highway enforcement of occupancy requirements, which can be difficult to accomplish and may disrupt the flow of traffic). HOVs would have a time advantage, providing an inducement for mode shifts to HOVs. Based on before and after data from 10 HOV lane projects implemented in the United States, Richard H. Pratt, Consultant, Inc. et al. (2000) estimate that HOV lanes result in an increase of 14 percent in average vehicle occupancy for autos, carpools, and vanpools over *all* lanes of the freeway. This is equivalent to a 12.3 percent reduction in driving.

It is also important that area employees have flexibility to travel at less busy times or to telecommute. Employers could be encouraged to provide such flexibility for their employees, perhaps by setting target levels for the share of flextime and telecommuting employees for employer-certified carpools to get toll exemptions. Other motivations, such as tax incentives, may also be used.

Preserving Motorist Choice

A pricing strategy would need to address two key issues:

1. The public is opposed to having no choice but to pay for a service that they have been getting for free. So a pricing scheme may need to preserve the motorist's choice not to pay. A toll-free choice, with the same amount of motorist delay as before (or less), will be desirable, similar to the free lanes adjacent to HOT lanes.

2. The toll price will need to be high enough that the total user-borne cost to drive on a priced highway (i.e., time cost plus toll cost) will not be lower than the user-borne cost to drive prior to pricing (i.e., time cost only). If the perceived user-borne cost were lower after implementing pricing, the inducement to drive could increase, endangering the free flow of traffic. To counter this effect, increased inducements would then need to be provided for other modes to compete effectively with driving.

In the priced lane projects implemented in the United States to date, motorists have a choice not to pay tolls and suffer congestion delays in the adjacent toll-free lanes. The advantage of this approach is that no driver is made worse off. The limitation is the huge waste of time that continues on the free lanes when traffic flow breaks down.

Economics Nobel Prize winner William Vickrey suggested a way to preserve the motorist's choice *not* to pay on a priced highway by creating a toll-free bypass around toll gantries placed across all existing lanes of the roadway. Motorists who choose to do so can wait in a queue in the toll-bypass lane and pay a "time" price equivalent to their previous congestion delay time. This solution by itself will not work, because releasing queued vehicles after they have waited in line for the required time period would cause traffic flow to break down. It would simply delay the onset of congestion by a few minutes. But if the required reduction in driving demand during the critical period is achieved by mode shifts or shifts in time of travel, all remaining vehicles could be accommodated at free flow. Thus, to begin with the queue delay in the bypass lane might be zero. But this would not last long. As drivers notice the shortness of the queue delay, they would shift to the toll-bypass lane, until the time delay in the queue would be equivalent to the value of the (dynamically varying) toll in effect at the time. The two would be in equilibrium.

The length of the toll-bypass lane would depend on the toll rate and corresponding "time" price in effect, and the queue discharge rate. For example, if the toll were \$1 and the value of time of freeway travelers were 20 cents per minute (i.e., \$12 per hour), the "time" price in the toll-bypass lane would be 5 minutes. If the queue discharge rate were 15 vehicles per minute, the total number of vehicles to be accommodated in the toll-bypass lane would be 75 vehicles.

System Operation

Super HOT system operation would involve conversion of *all* lanes on existing freeways into premium-service free-flowing freeways that provide fast, frequent, and inexpensive express bus service. All vehicles, except authorized buses and certified ridesharing vehicles, would be charged a variable toll set high enough to guarantee that high demand will not cause a breakdown of traffic flow. Tolls would be charged during congested periods only.

A peak-period commuter would have several options:

- Pay a relatively low toll for the convenience of driving alone in free-flowing traffic on the Super HOT highway system.
- Join a carpool or vanpool and enjoy a fast trip on the Super HOT highway system for an even lower price by sharing the cost of the toll, or drive for free in an employer-certified or ridesharing agency-certified carpool or vanpool.
- Use newly expanded, faster and more convenient transit services provided by express buses that run on the Super HOT highway system.
- Drive alone for free, either on the arterial street system (which would be enhanced with advanced traffic signal optimization), or on the freeway by using toll-bypass lanes constructed in advance of toll gantries. The toll-bypass lanes would allow motorists to pay a "time" price in lieu of a toll, by waiting in the toll-free queue.

Licensed drivers in the area covered by the priced network, on request, could be issued an inexpensive electronic transponder (e.g., a "sticker" tag) free of charge, along with a transportation account. Nonresidents could purchase the tags at retail outlets such as 7-Elevens, or from ATM-like machines at welcome stations located at approaches to the metropolitan area. Those not having transponders could be "video-tolled," meaning that cameras would take pictures of their license plates, and the vehicle owner would be billed for the toll plus a small administrative charge to cover the extra costs. For example, on November 1, 2006, the

Florida Turnpike Enterprise, in conjunction with the Tampa Hillsborough County Expressway Authority, launched a "Pay-by-Plate" system, the first video-toll account system in the United States. Customers who are occasional users of the Lee Roy Selmon Crosstown Expressway (between Tampa and Brandon, Florida), and do not have a transponder, can call a toll-free number to open an account. They pay a toll of $1.25 (instead of $1.00 for those with transponders) to cover costs to process the license plate images.

Ramp meters could be used on freeway entrance ramps to ensure that merging of incoming traffic does not break down mainline traffic flow, and to discourage short trips on the freeway on sections where there may not be a toll gantry.

To ensure premium service for buses and carpools when lane blockages occur as a result of an incident, overhead lane controls would be installed. The lane controls would provide priority for buses and certified HOVs during incidents. A clear lane would be designated for use only by buses and certified HOVs. If there is spare capacity available in the lane, it could be opened up to other vehicles for a premium toll set high enough to ensure that the traffic in the lane continues to flow freely. Vehicles in other lanes that do not get service at the guaranteed speed, due to the incident, would get an automatic refund on tolls paid.

Addressing Traffic Diversion Concerns

When toll rates are raised on existing tollways, some drivers divert to toll-free arterials or surface streets to avoid paying the higher tolls. However, unlike conventional tollways, priced highways provide many more travel options. A Super HOT system would have several differences relative to tollways. These differences would reduce the potential for traffic diversion to parallel toll-free facilities.

First, variable tolls would provide options to motorists to reduce or eliminate their costs for new tolls by shifting their time of travel. In the case of tollways with flat tolls all day, drivers cannot escape tolls or avail themselves of a lower toll rate simply by traveling at a different time.

Second, introduction of variable tolls during congested periods would be accompanied by high-quality transit services and expanded availability of enhanced carpool and vanpool options on free-flowing "virtual" HOV networks, so that some solo drivers would shift to using transit, vanpools, or carpools, rather than diverting to parallel toll-free roadways.

Third, those who are not willing to pay the toll would have an option to wait in a toll-bypass lane and get a high-speed, predictable trip time for free. Wait times on the toll-bypass lanes can be expected to be lower than delays on alternative routes. Thus, there would be no incentive to divert from the freeway.

Fourth, when pricing is introduced on previously congested highways, some motorists who had been deterred by freeway congestion and had diverted to parallel arterials may shift back to the free-flowing priced highways, which would accommodate higher rush-hour traffic volumes in a shorter period of time, as explained previously with the I-66 example. Despite this shift from arterials, however, as long as parallel arterials remain toll free, new motorists (e.g., those who shift from other less convenient times of travel) can be expected to take the place of any traffic that shifts from the arterials to the priced highways. Thus, while total hourly vehicle and person trip throughput in the corridor may increase, severity of arterial congestion cannot be expected to improve significantly during key congested periods. However, the *duration* of congestion (i.e., the length of the congested period) can be expected to be shortened. For example, the availability of spare capacity on I-66 from 9am to 10am will draw traffic from parallel arterials, reducing congestion on the arterials during that hour.

Finally, if toll revenues are used to pay for optimizing traffic signal controls on parallel arterials (in cases where they may not currently be optimized), this could help to further improve traffic flow on them.

Advantages of a Super HOT Transportation System

An entire metropolitan Super HOT network can be put in place in a relatively short period of time. Time-consuming and lengthy environmental review processes generally associated with freeway widening projects will not delay implementation. Some new investment will be needed for the initial shoulder bus lanes, toll-bypass lanes, management and operation of the freeway and arterial networks, new express bus and vanpool services, and new park-and-ride facilities. However, these will not require the extent of environmental review normally necessary for road-widening projects.

The Super HOT concept has several advantages over the managed lane approach. Since all lanes would be priced, there would be no need for additional rights-of-way and pavement for barrier or buffer separation between priced lanes and toll-free general-purpose lanes. Neither would expensive connector ramps be needed for efficient movement of priced vehicles through busy freeway interchanges. All lanes would be available for use by all vehicles. This would maximize motorists' freedom to switch lanes and consequently maximize highway capacity. A slower moving vehicle in a separated single lane causes a gap to build up in front of it, reducing vehicle throughput. Additionally, vehicle throughput *per lane* is lower when fewer adjacent lanes are available for use by all traffic, since drivers of faster vehicles find it more difficult to switch lanes and overtake slower vehicles to occupy large gaps between vehicles.

Super HOT highways would allow direct access to premium service lanes from *all* existing freeway entrance ramps. They would avoid the need for traffic to merge into and out of priced lanes from adjacent general-purpose lanes. Such weaving movements are inconvenient for buses and for motorists, and reduce safety and highway capacity on the free lanes.

With Super HOT highways, much more premium service capacity would be available on multiple lanes. Therefore, relatively lower toll rates would be sufficient to ensure that traffic demand does not rise above available capacity. This would make use of the highway more affordable to a larger population of middle- and lower-income motorists. And those who cannot afford the toll nor shift their mode or time of travel would be no worse off than before, since they could choose a toll-bypass lane and pay a "time" price no higher than their previous delay time, to get free-flowing service on the freeway in return.

Finally, with a Super HOT system, *all* lanes are congestion free.

Benefits and Revenues

A sketch-planning tool, Tool for Rush-hour User Charge Evaluation (TRUCE), was developed by the author to assist in the estimation of the potential impacts of a Super HOT transportation facility or network, in particular the costs, benefits, and revenues.

Two scenarios were assessed, representing a range of congestion levels on freeway networks in major metropolitan areas in the United States. These scenarios were evaluated for a prototypical area (either an entire metropolitan area or a significant portion of a major metropolitan area) with approximately 1.0 million drivers and an existing 100-mile freeway network comprising a total of 600 lane miles (i.e., freeways with an average of 6 lanes; 3 lanes in each direction). The scenarios are as follow:

1. *A moderately congested freeway network*, with an average peak-period speed of 40 mph and a total of 4 hours of congestion per day (i.e., about 2 hours in the morning and about 2 hours in the afternoon). Note that the "average" speed of 40 mph represents a composite of quite high traffic speeds on some segments of the network and much lower speeds on other segments. For example, if half of all vehicles travel at a speed of 60 mph (i.e., 1 minute to travel 1 mile) and the other half travel at a speed of 30 mph (i.e., 2 minutes to travel 1 mile), the average speed of all vehicles would be 40 mph (i.e., 1.5 minutes to travel 1 mile). Assuming a free-flow freeway speed of 60 mph, this scenario represents a peak-period "travel time index" of 1.5 (i.e., ratio of average peak-period travel time to free-flow travel time; Texas Transportation Institute 2005).
2. *An extremely congested freeway network*, with average peak-period speeds of 30 mph and a total of 6 hours of congestion per day (i.e., about 2.5 hours in the morning and about 3.5 hours in the afternoon). For example, if half of all vehicles travel at a speed of 60 mph (i.e., 1 minute to travel 1 mile) and the other half travel at a speed of 20 mph (i.e., 3 minutes to travel 1 mile), the average speed of all vehicles would be 30 mph (i.e., 2 minutes to travel 1 mile). This scenario represents a peak-period "travel time index" of 2.0.

For comparison, in 2003, the average daily congested travel period in major U.S. metropolitan areas amounted to about 6.5 hours (Texas Transportation Institute 2005). By using relatively fewer hours of congestion in this analysis, we ensure a conservative estimate of toll revenue and benefits from travel time savings.

Estimates of Travel Impacts

The analysis assumes that flextime, telecommuting arrangements, transit, and ridesharing will in aggregate attract about 16 percent of motorists from driving alone on the priced highways during critical times during the congested periods. (The basis of this assumption is discussed later in this article). A drop of 16 percent in traffic volume will also result in a very significant reduction in delay. Under normal circumstances, the reduced "time" cost would induce additional drivers to use the facility, causing congestion to recur. With pricing, however, variable tolls would be set high enough to ensure free flow of traffic. The toll rates would therefore be equivalent to the value of time that is saved, so that total user-borne cost to use the facility stays roughly the same. Consequently, additional travel would not be induced. There may, of course, be a change in the demographic composition of users. Those with higher values of time would perceive a reduction in their costs, and would increase their use of the priced highway. This will be balanced by a reduction in use by those with a lower value of time, who will perceive an increase in their costs.

To simplify the analytical process, we make several assumptions. Table 2 presents an analysis of what these assumptions mean in terms of the various categories of freeway travelers. It uses as an example an existing "base" peak-period freeway throughput of 20,000 person trips. This existing travel is carried in a little less than 18,000 vehicles. Assumptions and their plausibility are demonstrated through the example in Table 2, and are explained below.

Table 2. An Example of Redistribution of Mode of Travel with Congestion Pricing

	Person Trips		*Vehicle Trips*	
	Percent	***Number***	***Percent***	***Number***
Before Pricing				
Solo-drivers	80%	16,000	90%	16,000
Carpoolers/vanpoolers	18%	3,600	10%	1,800
Transit riders	2%	400	0.1%	10
Total	**100%**	**20,000**	**100%**	**17,810**
Auto, carpool and vanpool trips		19,600		17,800
Average vehicle occupancy				1.10
After Pricing				
Solo-drivers paying tolls	50%	10,000	67%	10,000
Carpoolers/vanpoolers paying tolls	10%	2,000	7%	1,000
Certified carpoolers/vanpoolers	20%	4,000	13%	2,000
Previous transit riders	2%	400	0.1%	10
New transit riders	5%	1,000	0.2%	25
Solo-drivers choosing toll-bypass lanes	10%	2,000	13%	2,000
Solo-drivers choosing alternative times, etc.	3%	600	0%	0
Total	**100%**	**20,000**	**100%**	**15,035**
Auto, carpool and vanpool trips		18,600		15,000
Average vehicle occupancy				1.24
Change in average vehicle occupancy				**12.6%**
Change in number of vehicles				2,775
Percent change in number of vehicles				**15.6%**
Changes resulting from pricing				
Vehicle trip reduction from new transit ridership			5.6%	1,000
Total vehicle trip reduction			16%	2,775
Toll-paying vehicle trips (includes some carpools)			62%	11,000
Toll-exempt vehicle trips (certified ridesharing vehicles)			11%	2,035
Vehicle trips using toll-bypass lanes			11%	2,000

Due to reductions in transit travel time and fares, it is assumed that approximately a third of diverted travelers (i.e., 5% of total existing peak-period users) will shift to use of express buses. This is consistent with the cross-elasticity estimates discussed earlier.

It is assumed that ridesharing will increase from an existing level of 18 percent of person trips (or 10% of existing vehicle volume) to about 30 percent of person trips. This assumption amounts to a 12.5 percent increase in average vehicle occupancy (AVO) for autos, carpools, and vanpools, from 1.10 to 1.24, as indicated in the example provided in Table 2. This 12.5 percent increase in AVO is less than the average AVO increase of 14 percent observed for 10 HOV lane projects implemented in the United States (Richard H. Pratt, Consultant, Inc. et al. 2000).

It is assumed that an additional 3 percent of drivers will choose to telecommute or travel at other times. Given the potential of teleworking, and National Household Travel Survey data indicating that 10 to 23 percent of peak-period trips are made solely to shop (U.S. Department of Transportation 2004), this is a plausible assumption.

It is assumed that half of all travelers would continue to drive solo, paying the full toll. It is plausible that 50 percent of travelers would have a value of time that exceeds the average value of time, based on which the toll rate is estimated. They would value the time savings more than the toll. It is assumed that an additional 10 percent of travelers would pay half the going toll rate by sharing the toll with another person in a noncertified carpool.

Finally, it is assumed that the balance of 10 percent of travelers (11% of existing drivers) will choose to use the toll-bypass lanes.

Overall, these assumptions translate to about 16 percent of total peak-period vehicle traffic demand shifting to other modes, to other times of travel, or to telecommuting. While anecdotal evidence suggests that a 10 percent shift would be adequate, the higher percentage shift provides a factor of safety.

Estimates of Highway User Benefits

As shown in Table 3, TRUCE begins with estimation of average travel time that would be saved on a trip that uses a 10-mile segment of the freeway network. These savings are converted into monetary values, based on the inflation-adjusted average value of time per hour per person recommended by U.S. DOT (U.S. Department of Transportation 2002). Although generally not perceived by motorists, delay reductions also result in significant fuel consumption savings, due to fewer accelerations and braking events. To be conservative in estimating benefits, estimates of fuel consumption savings are based on estimates of fuel saved by a *small* car per minute of delay reduced, as documented in the American Association of State Highway and Transportation Official's (AASHTO's) *User Benefit Analysis for Highways Manual* (ECONorthwest et al. 2003).

Table 3. Benefits to Toll-Paying Motorists

	Initial Congestion Level	
	Moderate	***Extreme***
Average time saved per freeway trip		
Peak-period average travel speed (mph) before pricing	40.00	30.00
Average freeway trip length (miles)	10.00	10.00
Travel time for average freeway trip (minutes) before pricing	15.00	20.00
Average speed with pricing	60.00	60.00
Travel time for average freeway trip (minutes) with pricing	10.00	10.00
Travel time saved on average trip (minutes) with pricing	5.00	10.00
Average time using alternative toll-free bypass		
Ratio of toll-free travel time to prior freeway travel time	1.00	1.00
Travel time on toll-free route	15.00	20.00
Extra travel time relative to priced freeway travel time	5.00	10.00
User cost savings per freeway trip		
Average value of time per hour saved	$12.00	$12.00
Value of time saved	$1.00	$2.00
Fuel saved per minute of delay (gallons)	0.042	0.042
Fuel cost per gallon	$2.50	$2.50
Value of fuel saved per minute of delay reduced	$0.11	$0.11
Value of fuel saved over a 10-mile trip	$0.53	$1.05
Total value of time and fuel cost savings	$1.53	$3.05
Estimated average toll per trip	**$1.00**	**$2.00**
Net user cost savings per freeway trip	$0.53	$1.05
Assumed avg. vehicle occupancy for certified carpools	2.00	2.00
Net user cost savings per certified carpool vehicle trip	$2.53	$5.05

Table 3 presents user cost savings per freeway trip for those paying the toll. Net user cost savings per freeway trip are estimated by subtracting the toll cost from the monetary value of time and fuel cost savings. For certified carpools, travel time savings are multiplied by auto occupancy to get total time savings. For informal carpools that pay tolls, it is assumed that the total time savings of occupants will be equal to the value of the toll paid. Net user cost savings are thus equal to the value of fuel savings, as they are for solo drivers. While average values of time are useful in estimating aggregate benefits for all motorists, motorists' values of time are actually distributed over a range. Motorists with higher values of time will perceive proportionally higher benefits. Motorists with lower values of time would perceive disbenefits if they had to pay a toll, and would respond to new congestion tolls by choosing the toll-free bypass lane, or by diverting to other modes, routes, or times of the day. Their disbenefits (i.e., "consumer surplus" losses) are accounted for in aggregate highway benefit estimates provided in Table 4.

For the purpose of estimating the average peak-period toll rate, we assume that:

- In deciding whether to pay the toll, motorists would consider how much delay they would incur in the toll-bypass lane and compare the equivalent monetary cost of that delay to the going toll rate.
- A current freeway motorist who wants to avoid the toll by waiting in the toll-bypass lane would face a travel time equal to the "base" congested travel time on the freeway (i.e., prior to introduction of pricing). If this delay were lower than before, additional travel would be induced. If it were higher, diversion to alternative routes could occur.
- Of those motorists who decide to pay the toll (i.e., 50% of all travelers), the solo driver who values his or her time the least would have a value of time equal to the average value of time for all travelers (i.e., $12 per hour). This value, along with the queue delay time, determines the toll rate. The two would be in equilibrium.

Based on a value of time of $12 per hour, the average peak-period toll for a 10-mile freeway trip is estimated to range from about $1 to $2 for passenger cars. It is assumed that trucks would pay toll rates that reflect their relative passenger car equivalents. Since a heavy truck on average consumes two to three times the lane capacity of a passenger car in free-flowing traffic, toll rates for trucks would average about 2.5 times the toll rates for passenger cars.

Table 4 provides estimates of highway benefits and toll revenues for the two scenarios. Existing peak-period demand for freeway use is estimated to be equal to the total vehicle volume that currently uses the freeway during the congested peak period. Over all lanes in both directions of the freeway, existing hourly peak-period traffic volume is assumed to be 1,800 vehicles per lane. This accounts for both lost throughput in the heavy traffic direction, as well as vehicle volumes in the reverse direction.

Table 4. Highway User Benefits and Toll Revenues

Vehicle trips on 10-mile freeway		
Average prior peak-period traffic volume per hour per lane	1,800	1,800
Average number of lanes (both directions)	6	6
Average number of hours of congestion daily	4	6
Average prior peak period traffic volume daily	43,200	64,800
Percent traffic volume reduction with pricing (from Table 2)	16.00%	16.00%
Average traffic volume with pricing	36,288	54,432
Number of vehicles diverted	6,912	10,368
Percent of vehicles exempt from tolls (from Table 2)	11.00%	11.00%
Number of vehicles exempt from tolls	4,752	7,128
Percent of vehicles choosing to pay "time" price	11.00%	11.00%
Number of vehicles choosing to pay "time" price	4,752	7,128
Number of priced vehicles	26,784	40,176
Daily benefits on 10-mile freeway		
User cost savings to exempt vehicles (carpools)	$11,999	$35,996
User cost savings to motorists choosing "time" price	$0	$0
User cost savings to priced motorists	$14,062	$42,185
Estimated average value of time of diverted motorists	$9.00	$9.00
Consumer surplus change for diverted motorists	-$864	-$2,592
Toll revenues	$26,784	$80,352
Change in fuel tax receipts	-$2,649	-$7,947
Total benefits	$49,331	$147,994
Annual benefits and toll revenue for managed network		
Number of weekdays per year	250	250
Annual tolled vehicle trips for 10-mile highway	6,696,000	10,044,000
Annual benefits for 10-mile highway	$12,332,844	$36,998,532
Number of miles of priced highway network	100	100
Annual tolled vehicle trips for 100-mile network	66,960,000	100,440,000
Annual benefits for priced highway network	**$123,328,440**	**$369,985,320**
Annual toll revenues for 10-mile managed highway	$6,696,000	$20,088,000
Annual toll revenues for managed highway network	**$66,960,000**	**$200,880,000**

Social benefits of the network are estimated by accounting for:

1. *Net user cost savings* on the priced freeway. Benefits to those who continue to travel on the freeway are estimated based on the benefits per vehicle trip calculated in Table 3. *Losses of consumer surplus* by motorists who shift from driving alone on the freeway are estimated based on the rule of half. It is calculated as the number of deterred motorists times half the difference between (1) monetary value of motorists' travel time plus toll cost on priced freeways and (2) monetary value of motorists' travel time cost prior to pricing. Given typical observed distributions of values of time of motorists (Steimetz and Brownstone 2004), it is reasonable to assume that the 16 percent of all motorists who shift from driving alone in the peak periods on the freeway would have a value of time equal to about 75 percent of the average value of time (i.e., $9).
2. *Toll revenue* "transfers" from motorists to the system operator. (Tolls paid by motorists are subtracted in computing net user cost savings under item 1 above.)
3. *Reductions in government fuel tax receipts* due to reduced fuel consumption estimated at 40 cents per gallon for state and federal taxes combined. (Fuel taxes are included in fuel cost savings estimated to compute user cost savings under item 1 above.)

Several components of social benefits are not included in the above social benefit calculations:

1. *Benefits from an increase in trip time reliability*. With more predictable trip times, travelers will be able to reduce the "buffer" time that they build into their schedules. Surveys of travelers who use priced lanes in San Diego and in Orange County, California, suggest that travelers perceive that they save almost twice the amount of time that they actually save. This may simply reflect a reduction in the amount of "buffer" time that they allocate for their trips, due to the reliability of their trip times.
2. *Environmental and safety benefits*, such as reductions in air pollution, noise, and greenhouse gas emissions, and accident cost reductions. Environmental benefits are expected to be positive, since mode shifts will reduce vehicle traffic, and higher traffic speeds will reduce most emissions. Shortening of response times for emergency personnel may save lives. With reduced traffic, the number of accidents would also be reduced; however, severity

of accidents would increase due to higher speeds, raising the average cost per accident.

3. *Impacts of traffic diversion on congestion levels on parallel toll-free routes.* As discussed earlier, modal and time of travel choices and the availability of the toll-bypass lane are expected to limit traffic diversion, so any negative impacts are expected to be minor, and positive impacts may occur due to increased vehicle and person throughput in the freeway corridor.
4. *Benefits to businesses and the economy*, including productivity benefits from reduced freight delays and increased reliability of deliveries.
5. *Increase in energy security* due to reduced fuel consumption.
6. *Increased opportunities for civic participation*.
7. *Reduced distortions in the housing market*.

Based on the above analysis, annual benefits are estimated to range from $123 million to $370 million. Toll revenues are estimated to range from $67 million to $200 million annually.

Transit Benefits

Table 5 presents estimates of transit benefits. Travel time savings for existing bus passengers are assumed to be equivalent to those accruing to motorists. Operating cost savings for existing bus services are computed by combining driver time savings and bus fuel cost savings. Fuel cost savings are based on AASHTO estimates of fuel consumption per minute of delay for a single-unit truck (ECONorthwest 2003).

Existing bus service is estimated at 6 buses per hour, with 40 passengers per bus, resulting in an estimated 240 riders per rush hour in each freeway corridor. This amounts to 2 percent of travelers on a 6-lane freeway carrying 12,000 people per rush hour (i.e., 2,000 people per lane, based on 1,800 vehicles per lane per hour and an average vehicle occupancy of about 1.10).

As discussed earlier, our analysis assumes that 5 percent of freeway drivers (i.e., a third of the 16% diverted rush-hour solo drivers) will use transit. Benefits to new transit riders are estimated based on the rule of half (i.e., half of the change in travel time costs, times the estimated number of new riders).

Table 5 indicates that annual transit benefits would range from $6 million to $17.5 million. Total highway and transit benefits combined would range from $129 million to $388 million.

Table 5. Transit Benefits

	Initial Congestion Level	
	Moderate	**Extreme**
Average time saved per existing bus rider		
Base peak-period average travel speed (mph)	40.00	30.00
Average trip length on freeway (miles)	10.00	10.00
Travel time on freeway (minutes)	15.00	20.00
Average speed with congestion-based tolls	60.00	60.00
Average travel time on freeway (minutes)	10.00	10.00
Travel time saved on freeway (minutes)	5.00	10.00
User cost savings per existing bus rider		
Average value of time per hour saved	$12.00	$12.00
Value of time saved	$1.00	$2.00
Operating cost savings per existing bus vehicle trip		
Bus operating cost per hour	$100.00	$100.00
Bus operating costs saved	$8.33	$16.67
Fuel saved per minute of delay (gallons)	0.328	0.328
Fuel cost per gallon	$2.50	$2.50
Value of fuel saved per minute of delay reduced	$0.82	$0.82
Value of fuel saved over a 10-mile trip	$4.10	$8.20
Total bus operating cost savings	$12.43	$24.87
Transit benefits per day on managed highway segment		
Existing peak-period buses per hour (both directions)	6	6
Number of hours of express bus service	4	6
Number of bus runs per day	24	36
Average number of passengers per bus	40	40
Total passengers per hour (both directions)	960	1,440
User cost savings to existing bus passengers	$960	$2,880
Vehicle reduction from shifts to transit	5.0%	5.0%
Number of new bus passengers	2,160	3,240
Consumer surplus change for new riders	$1,080	$3,240
Bus operating cost savings	$298	$895
Total benefits	$2,338	$7,015
Annual transit benefits for managed network		
Number of weekdays per year	250	250
Annual benefits for 10-mile highway	$584,600	$1,753,800
Number of miles of managed network	100	100
Annual new bus passengers for network	5,400,000	8,100,000
Annual benefits for managed highway network	**$5,846,000**	**$17,538,000**

Costs

Highway Operating Costs

To estimate capital costs for toll collection, an open-road electronic toll collection system was assumed, with toll gantries installed at 5-mile intervals, and at the boundaries of the priced network. Unit capital cost estimates were provided by Mitretek (personal communication from Paul Gonzalez, September 2006). Total capital costs were annualized based on a 7 percent discount rate and 30-year life.

Average operating costs for toll collection are estimated at 8.5 cents per trip, based on an estimate of 5 to 10 cents per trip by ITS Decision, Service and Technologies (2005). Since toll collection costs will decrease with large-scale implementation, this is a conservative estimate.

In addition to toll collection costs, highway operations will involve costs for traffic management, such as operation of variable message signs, traffic monitoring equipment, and communications. Data from the I-15 FasTrak budget and expenditure data for FY 2005 indicate that annual costs for *both* traffic management and toll collection on the dynamically priced I-15 HOT facility in San Diego were about $0.7 million in fiscal year 2005. The facility carried about 5 million vehicles during that year, about 75 percent of them nontolled HOVs. The remaining 25 percent were tolled vehicles. Subtracting costs for tolling (at 10 cents per trip), traffic management costs for the year are estimated at $575,000, or 11.5 cents per vehicle served. Based on these cost estimates, a total cost of 20 cents per vehicle trip was estimated for tolling and traffic management combined.

As shown in Table 6, total annual operating costs for toll collection and traffic management would range from $13 to $20 million, with the higher costs associated with a longer congested period in areas with high existing congestion levels. Capital costs would be $68 million, or annualized costs of $5.5 million. Additional capital costs would be incurred for construction of toll-bypass lanes. It is estimated that a total of 20 lane-miles of new pavement (i.e., 40 half-mile sections) would need to be constructed, and that existing rights-of-way would be adequate. At an average cost of $3 million per lane mile, capital costs for toll-bypass lanes are estimated at $60 million, or annualized costs of $4.8 million.

Total annualized highway system costs would range from $23 to $30 million.

Table 6. Annualized Highway System Costs (Thousands of Dollars)

	Initial Congestion Level		
	Moderate		**Extreme**
Annualized capital cost for toll-bypass lanes	$4,835		$4,835
Annualized capital cost tolling	$5,471		$5,471
Annual cost for operations	$13,392		$20,088
Total annual costs	**$23,698**		**$30,394**
Open Road Tolling Capital Costs	***Unit Cost***	***Units***	***Total Cost***
Per lane			
Gantry structure	$25		
Toll tag reader	$15		
Camera and structure (violations)	$8		
Controller	$14		
Small building/structure	$15		
Subtotal	**$77**	**200**	**$15,400**
Telecommunications			
Conduit, design and fiber optic install (per mile)	**$120**	**100**	**$12,000**
Roadside Information			
Dynamic message sign, structure, and controller	**$250**	**100**	**$25,000**
Transportation Management Center			
Information dissemination	$150	1	$150
Arterial surveillance/cell phone probes	$160	1	$160
Back office toll and violation processing	$100	1	$100
Integration with 511 system and traveler info website	$75	1	$75
Subtotal	**$485**	**1**	**$485**
Transponders	**$0.010**	**1,500,000**	**$15,000**
Total			**$67,885**
Annualization factor			12.409
Annualized capital cost			**$5,471**
Toll-Bypass Lane Capital Costs			
Capital cost for toll-bypass lanes	$1,500	40	$60,000
Annualized capital cost			**$4,835**

Transit and Park-and-Ride Costs

The express bus system would need to carry all travelers who would shift from driving on the freeway to transit (i.e., 5% of peak-period freeway demand that is expected to shift to transit), as discussed earlier. As indicated in Table 7, depending on existing levels of congestion, new daily ridership is estimated to range from 22,000 to 32,000, or 5 million to 8 million annually.

Table 7. Transit and Park-and-Ride Costs

	Initial Congestion Level	
	Moderate	**Extreme**
Express bus service costs		
Average subsidy per passenger mile	$0.50	$0.50
Average bus trip length (miles)	12	12
Average subsidy per passenger trip	$6.00	$6.00
Number of new bus passenger trips per day per 10-mile segment	2,160	3,240
Number of new bus passengers per day for network	21,600	32,400
Number of weekdays per year	250	250
Annual new bus passenger trips	5,400,000	8,100,000
Annual subsidy	**$32,400,000**	**$48,600,000**
Park-and-ride costs		
Average cost per space per day	$2.00	$2.00
Number of new parking spaces needed daily	10,800	16,200
Daily parking cost	$21,600	$32,400
Number of weekdays per year	250	250
Annual parking cost	**$5,400,000**	**$8,100,000**
Total costs		
Total annual transit subsidy and parking costs	**$37,800,000**	**$56,700,000**

Transit subsidy needs were estimated at 50 cents per passenger mile, based on nationwide subsidies of $23.5 billion supporting 50 billion passenger miles annually (Taylor and VanDoren 2002). An average bus passenger trip was estimated at 12 miles, based on work trip length data (U.S. Department of Transportation 2004). Total annual transit subsidy costs are estimated to range from $32 million to $48 million.

Most of the new park-and-ride spaces will be needed in exurban or suburban locations. At these locations, it is more likely that a public agency will own land within existing rights-of-way near interchanges or along the freeway. It may therefore be possible to build new park-and-ride facilities on surface lots, adjacent to express bus stations. Also, it may be possible to use existing parking spaces at shopping centers near the freeway, reducing new construction costs. Parking costs are estimated at $2.00 per parking space per day, based on annualized costs for construction and maintenance of surface parking spaces in outer suburbs (U.S. Department of Transportation 1992), adjusted for inflation. Total annual costs for providing parking are estimated at $5 million to $8 million, with the high-end costs associated with higher transit use in more congested areas.

Total combined annual costs for transit subsidies and parking at park-and-ride lots are estimated to range from $38 million to $57 million.

Financial Feasibility

Table 8 summarizes estimates of toll revenues, benefits, and costs of the multimodal pricing package. Benefit/cost ratios would range from 2.1 to 4.4, depending on the severity of existing levels of congestion. Because of the conservative assumptions used to estimate benefits in the analysis, these estimates are conservative. The results suggest that the multimodal pricing package would be financially self-sufficient. Surplus revenue would be much higher in more severely congested areas, because of higher toll rates as well as longer congested periods during which tolls would be charged. Annual toll revenue surpluses would range from $5 million to $114 million.

Table 8. Benefits, Costs, and Financial Feasibility

	Initial Congestion Level	
	Moderate	*Extreme*
Annualized benefits (million $)		
Highway benefits	$123.33	$369.99
Transit benefits	$5.85	$17.54
Multimodal benefits	$129.17	$387.52
Annual costs (million $)		
Highway costs	$23.70	$30.39
Transit costs	$37.80	$56.70
Multimodal costs	$61.50	$87.09
Multimodal benefit/cost ratio	*2.1*	*4.4*
Annual toll revenues vs. costs (million $)		
Toll revenues	$66.96	$200.88
Multimodal costs	$61.50	$87.09
Surplus	**$5.46**	**$113.79**

Conclusions

A Super HOT transportation network in a large metropolitan area could provide social benefits that far exceed multimodal investment and operating costs. Revenues from tolls would be sufficient to pay for all costs, including new express bus services and park-and-ride services that would complement the pricing scheme. The multimodal pricing package would be financially self-sufficient, with annual toll revenue surpluses depending on the severity of congestion. A limited short-term "trial" demonstrating the concept in a congested corridor may help show if the concept will work, and lead to public acceptance of larger-scale implementation.

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Demand Responsive Route Design: GIS Application to Link Downtowns with Expansion Areas

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Abstract

The movement of residential locations to suburban areas to obtain cheaper land results in increasing mobility and infrastructure problems. One of the important infrastructures is transportation, which determines the level of accessibility of people and commodities from one place to another. Therefore, Transportation Demand Management (TDM) measures are important in providing an optimal transit route to increase accessibility of public transportations. In the past, several researchers have developed various TDM programs, including public transport improvement as a strategy to encourage a more transit-oriented society. This study attempts to create a methodology of identifying bus links between urban centers and newly developed urban expansion areas using Geographical Information Systems by considering reduction of route overlapping. A TAZ-based analysis is undertaken to identify the demand responsive bus routes, which maximize population coverage, minimize travel time, and reduce duplicating routes.

Introduction

The competition for land makes residential developments more difficult to undertake in urban centers. The limited ability of residents, particularly low- and middle-income people, to pay for housing forces housing developments to be carried out in suburban areas at a cheaper price. The movement of residential locations to suburban areas to obtain access to land results in problems of increasing mobility and infrastructure demand. One of the infrastructures is transportation, which determines the level of accessibility of the people and commodities from one place to another (Kuswara et al. 2006). Therefore, Transportation Demand Management (TDM) measures are important for providing optimal transit routes and for increasing the accessibility of public transportation.

In the past, several researchers have developed various TDM programs. Among these programs are improvements to public transport as a strategy to encourage a more transit-oriented society (online TDM encyclopedia, updated November 2006). In this regard, different approaches have been implemented to identify the optimal route, including the emerging technique of Geographical Information Systems (GIS) application. Verma and Dhingm (2003) discussed a model that identified demand-oriented urban rail transit corridors on a city road network using GIS. Likewise, Sekhar et al. (2003) implemented a route-based analysis for optimized bus route design using GIS. The analysis was based on maximizing population coverage along transit routes, transit coverage to trip-attraction centers, access for residents in low-income dwellings along the transit route, and the transit level of service (frequency). Unlike the route-based analysis, Ramirez and Seneviratne (1996) implemented zone-based GIS transit route design by estimating the potential ridership for each zone and assigning scores to the street links. The same types of route design analysis have been developed with different objective functions (Sulijoadikusumo and Nozick 1998; Abkowitz et al. 1990; Ramirez and Seneviratne 1996).

Despite the previous studies conducted, the objective of reducing route overlapping has gained little attention. This study attempts to create a methodology of identifying a bus link between urban centers and the newly developed urban expansion areas using GIS by considering minimization of route overlapping, maximize population coverage, and minimize travel time.

Public Transportation Demand

Case Study Area

The case study examines Addis Ababa, the capital city of the Federal Democratic Republic of Ethiopia, located in the center of the country. Established in 1886, the city has experienced several planning changes that have influenced its physical and social growth. In the city of Addis Ababa, the dominant public transportation modes are city buses (40%) and mini vans or small taxis (60%), both of which are entirely limited in delivering service to the inner and intermediate parts of the city (Ethiopian Road Authority [ERA] 2005). Buses, operated by a solitary public company, have 30 seats but a carrying capacity of 100 people in crowded situations, whereas taxis, run by a private association, have a carrying capacity of 4 (small taxis) to 12 (minivan taxis) people. No rail transit or bus rapid transit (BRT) operates within the city. Car ownership is low, though growing quickly, so residents largely depend on buses and taxis for their day-to-day mobility. Walking is used for short trips only. Unlike other cities in Ethiopia, bicycle use is insignificant because of topographic inconvenience. Analysis of the transit availability indices show that only the city center is served by the existing bus networks, leaving urban expansion areas with low transit availability (Mintesnot and Takano 2006).

The Demand

According to two surveys (one is a trip survey of 750 households in inner, intermediate, and periphery areas, conducted in September 2004 by the authors of this article; the other is a survey of 5,000 households conducted by the ERA in December 2004), an estimated 3,348,317 person trips per day are made, on average, in the city of Addis Ababa. The overall per capita trip rate (PCTR), including persons of all age groups, is 1.07 (including walking trip) and 0.43 (excluding walking trips). When people between the ages of 0 to 5 are excluded, the PCTR increases to 1.141 and 0.451 with and without walking trips, respectively. This indicates that limited transport accessibility occurs in the city despite the prevailing high demand. Except for the three subcities, which are considered intermediate zones, the share of buses in the city ranges from 11 percent to 15 percent. Walking is the dominant mode if all short trips are considered (60.5%). However, according to the general analysis results of our survey, 64 percent of the respondents use bus as their typical mode of transportation, 18 percent use taxi, and 12 percent walk. The remaining respondents stated using other modes of transportation such as a private car. The share of trips by minivans and small taxis varies widely among the subcities, with the inner city having a high share of 32 percent and the peripheral area experiencing a low share of 12.2 percent. When trip length is concerned, bus and minivan taxi travel time accounts for up to 90 minutes. The majority of the residents have an in-bus time of 50 to 60 minutes.

Generally, travel demand is as high as 11.05 million passenger-km on an average day. Of this, walking accounts for 27.3 percent. Buses and taxis account for 25 percent and 34 percent, respectively, indicating their role and importance in the city. Trip characteristics of all trips in the city indicate a wide dispersal pattern. However, movement to and from central areas is reasonably high. Walking trips are confined within the subcity or to and from adjacent subcities. Trips made by city bus or minivan have a wide-ranging pattern because they create interaction among the subcities (ERA 2005; Mintesnot and Takano 2006).

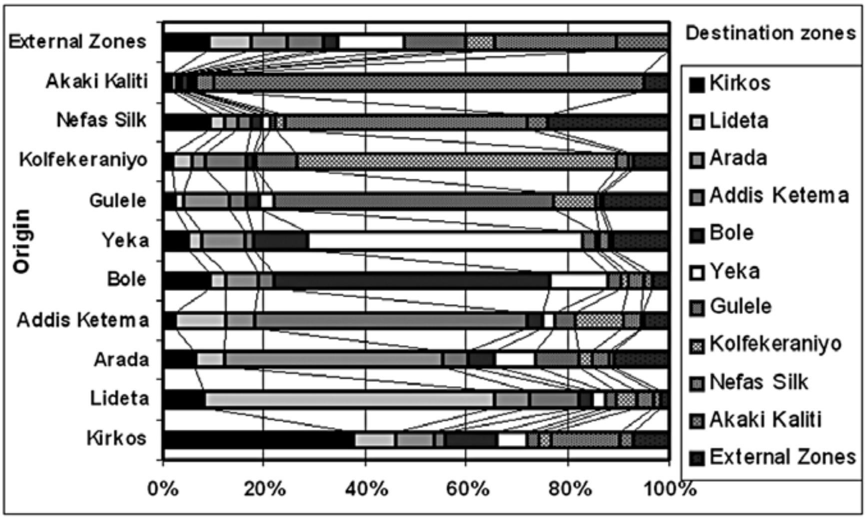


Figure 1. O-D Matrix of All Trips

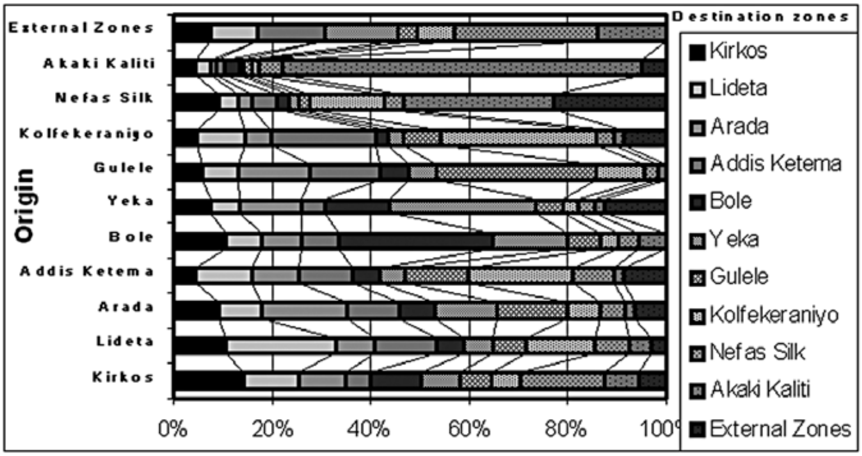


Figure 2. O-D Matrix of Bus and Taxi Trips

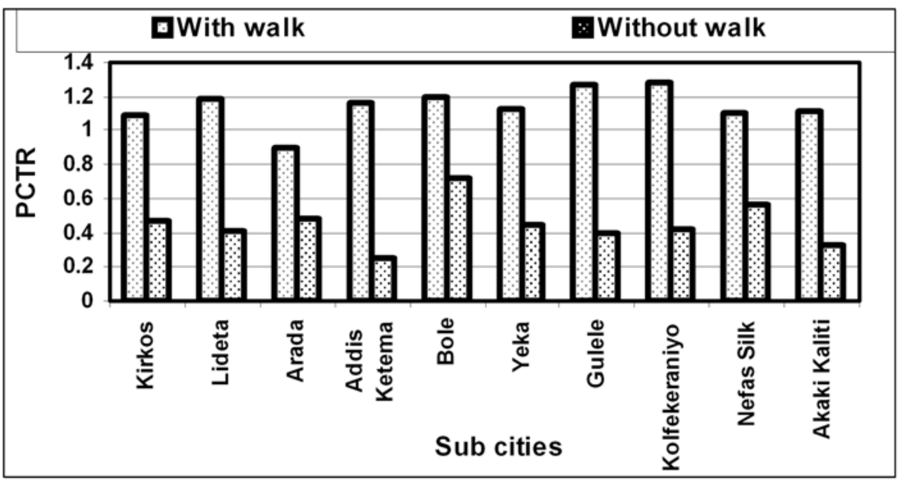


Figure 3. Per Capita Trip Rate, with or without Walking Trips

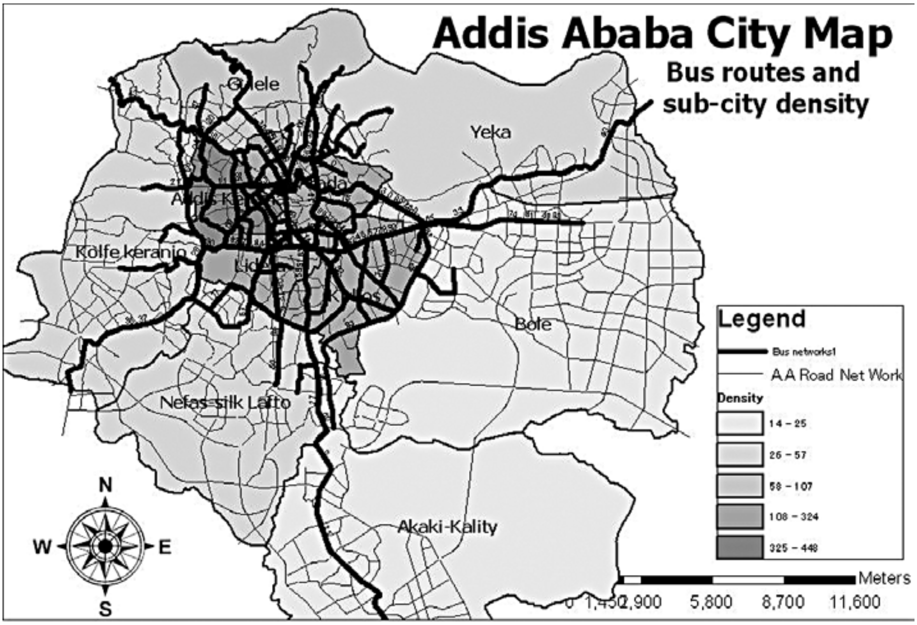


Figure 4. Addis Ababa City with Subcity Divisions

The uncontrolled urban growth also creates potential trips from the suburb to the inner cities. From 1984 to 1994, 14,794 illegal/informal houses were developed in the urban peripheries (accounting for 15.7% of the total housing stock). Since 1999, government-initiated housing projects through cooperatives and individual housing constructions schemes have been developed. In 2000, the regional government issued a legalization policy for informal settlements; municipal offices provided utilities such as electricity and water. These urban expansions created a potential trip generation to city centers where commercial and economic activities take place. Despite the growth in travel demand, no considerable expansion of public transportation occurred. Studies of public transportation strategies within the city, such as provision of BRT and light rail, have been undertaken (ERA 2005; Mintesnot and Takano 2006; ORAAMP 2002); however, implementation is constrained by financial problems of the regional and national governments. As an immediate action for tackling the existing travel demand by expanding the existing bus services, the government and the bus company must consider route expansion proportionate to the city's growth. With this problem in mind, this study's objective is to provide a methodology for linking urban centers (economic and employment centers) to the residential areas in the suburbs.

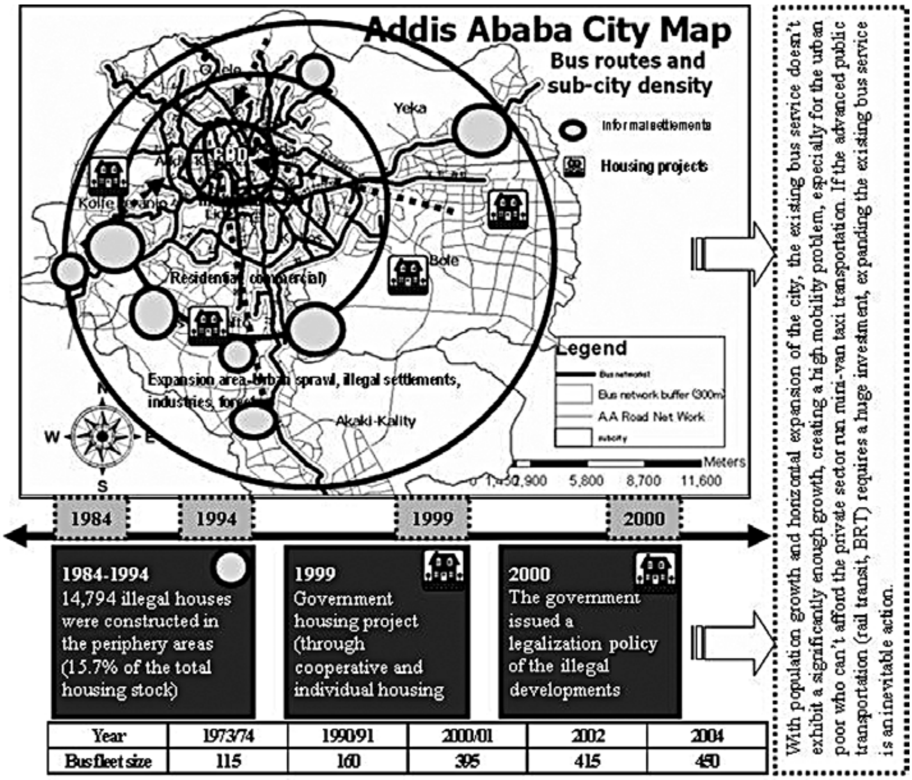


Figure 5. Synthesis of Urban Expansion vis-à-vis Public Transportation Demand

Demand Responsive Route Design: GIS Application

Methodology

The methodology of connecting the innercity with the new neighborhoods is undertaken by a route-searching mechanism of maximum population areas and areas with minimum route overlapping. The Traffic Analysis Zone (TAZ)-based approach assigns the existing route characteristics with respect to the TAZ and the TAZ's population to the street links and calculates route impedance factors.

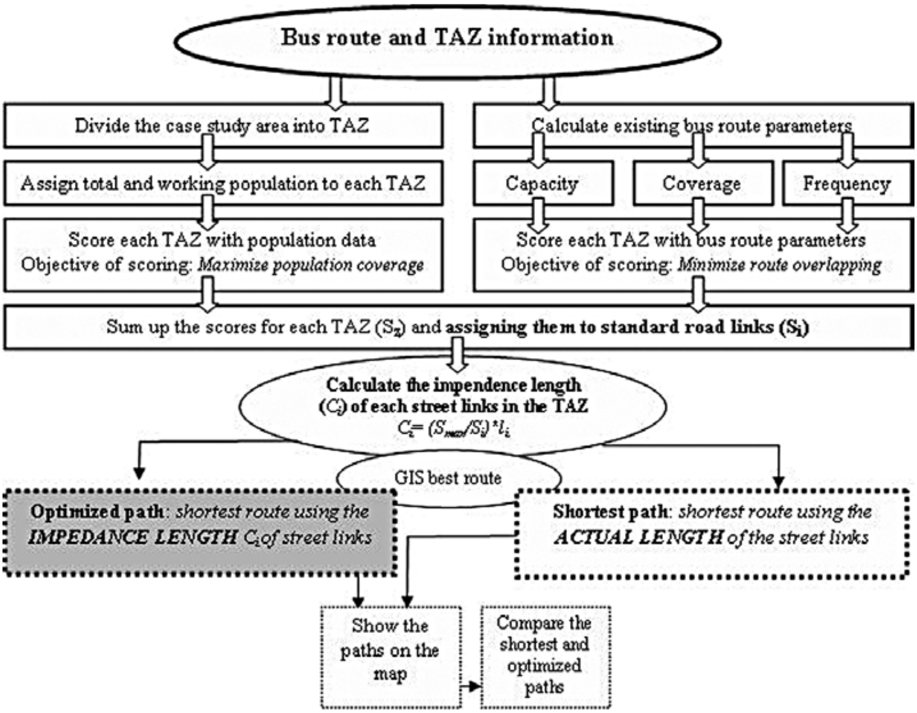


Figure 6. Framework of the Proposed Method

For this, Addis Ababa is divided into 308 TAZs, which cover an average area of 1.56 square kilometers. The bus and road network and bus stops were digitized using GIS. Bus capacity data was provided by Anbessa City Bus Enterprise, and the population of each zone was collected from the city's administration office. The area of each TAZ was calculated using GIS, and baseline data were prepared for the three bus service components: capacity, coverage, and frequency. The Network Analyst extension of ArcView was applied for optimum route searching.

Objective Functions and Route Design Parameters

The first step of implementing this proposed approach is to define the objective functions and route design considerations. The objective functions are the most important, but sometimes conflicting functions of the route design occur. The transit operator chooses the shortest path to minimize operating costs; however, the shortest path is not always the maximized route. Travelers always choose the shortest walk from their trip origin (e.g., home) to the bus stops and the shortest in-vehicle time from their origin to destination. Additionally, the optimum route should keep the required route spacing and reduce route overlapping. Therefore, this study's three objective functions are:

- *min{TT}*: minimize travel time by providing the shortest possible path.
- *max{pop, density, employee}*: maximize overage of trip generation areas.
- *min{RO}*: minimize route overlapping/duplication.

Route design is based on certain parameters, such as the overall and working populations, existing bus route coverage, frequency, and capacity.

Minimize Travel Time: min {TT}. The basic objective of any optimization approach is to minimize the travel time, which includes waiting, in-vehicle, and walking times. Passengers choose the route to their destination based on the shortest travel time. Several shortest path algorithms have been developed in various forms to find the shortest possible path in the given network. One of the classical and widely used algorithms is Dijkstra's algorithm (see Osegueda et al. 1999): let $c_{ij} > 0$ be the length of arc (i, j). It is desired to find the shortest route from a source node "o" to a terminal node "d" through the arcs of the network. Define a label for node j as the estimate (temporary or permanent) of the length of the shortest path from the source to node j. If the node label is temporary, it will be represented by δj; if it is permanent, by [δj]. Permanent labels represent lengths of the actual shortest paths.

- *Step 0:* $[\delta o] = 0; \delta i = c_{oi}$
- *Step 1:* $[\delta j] = \{\delta i\} \min$

  $i \in \mathbf{T}$

  j: last node to get a permanent label

  T: *set of nodes with temporary label*
- *Step 2: If [δd] is found, stop; otherwise, go to step 3*
- *Step 3:* New $\delta i = \min \{\text{old } \delta i; [\delta i] + cji\}$ *for* $i \in \mathbf{L}$

  L: set of unlabeled nodes reached from last permanently labeled node
- *Step 4: Go to step 1*

This shortest path algorithm is embedded in the GIS shortest path finder, if the optimization objective functions are properly designed. The important question here is whether the shortest possible path is the best route. As stated previously, route designs often have conflicting and multiple criteria. Therefore, the following sections focus on formulating the shortest possible path, with the maximum route attraction coverage and minimum route overlapping.

Maximize Trip Generation Coverage: max {pop, density, and employee}. Population density is the best representation of the potential point of origin, in terms of daily trips. Employment density represents the number of jobs per square km. Typically, work trips account for well over half of a transit system's ridership (Transport Research Board 1995). Sekhar et al. (2003), in their work, "An Approach to Transit Path Design using GIS," considered trip generators based on dwelling units as the main sources of trip productions. Other studies, however, considered the population along the route or in the TAZ. In this study, the total and the working populations in a given TAZ are considered, so that the TAZ will be scored according to the population (i.e., the larger the population the higher score given to the TAZ), which lead us to the maximization process as seen later, in which the score will be assigned to the street links in each TAZ.

Minimize route overlapping: min {RO}—(Serve the underserved area). This criterion refers to a situation where two or more distinct routes, serving the same passenger market(s), appear within close or overlapping proximity. Streamlining/ reduction is designed to control the duplication of bus routes thereby ensuring transit services are adequately distributed geographically within a service area. By ensuring this, services can be more widely dispersed throughout neighborhoods (Transport Research Board 1995). This current research considers the minimization of route overlapping with the principle of serve the underserved area. Some urban locations have several bus routes passing through, while other localities suffer from the unavailability of transit routes. Therefore, in an effort to connect the innercity with the newly developed neighborhoods, route overlapping issues must be addressed. To achieve this, the three service features of existing bus routes (bus coverage, frequency, and capacity) are chosen, after which the TAZs are scored with coefficients of the chosen bus service features in such a way that a minimum coefficient creates a higher score for the TAZ; the score will be assigned later to the street links in the TAZ.

Bus Route Coverage, Frequency, and Capacity

The Local Government Commission of the United States, as an experimental measure, first introduced the Local Index of Transit Availability or LITA (Rood 1998). In this study, bus availability and bus service intensity are combined to create a City Index of Bus Availability or CIBA. The focus here is on buses, because they are the only transit option for Addis Ababa, as no rail service operates within the city.

CIBA combines three aspects of transit service intensity—*capacity, frequency,* and *route coverage*—to rate each TAZ. The capacity component uses seat-km divided by population; the frequency component is calculated as the number of buses per day; the route coverage component uses transit stops per square kilometer. After normalizing the index, the amount of transit service available is related to that area's population and land area.

Bus capacity. Capacity can be defined in different terms such as vehicle capacity, person capacity, maximum capacity, and design capacity (see Transport Research Board 2003 for definitions). Person capacity is used in this study. This capacity component is the calculation of seat-km per capita. The total amount of daily bus seats is calculated as a product of the total number of buses arriving at a specific stop in the TAZ, and the number of seats on the bus.

$$C_{TAZi} = \frac{BS \ x \ l_{TAZi}}{Pop_{TAZi}} \quad (1)$$

where:

C_{TAZi} is capacity score in the ith TAZ

BS equals total daily bus seats

l_{TAZi} represents route length

Pop_{TAZi} equals population in TAZ_i

Bus route frequency. This parameter refers to the headway between two consecutive buses (the waiting time for the travelers). Frequency measure is based on the total daily number of buses on all the lines that have at least one stop or station in the TAZ.

$$F_{TAZi} = TB, \text{ if } l_{TAZi} \text{ has at least one stop in TAZi; 0, otherwise} \quad (2)$$

where:

F_{TAZi} is frequency score in the ith TAZ

TB equals total number of buses

Bus coverage. The bus coverage component of the transit availability analysis focuses on the spatial distributions of the existing bus service in the city, and is calculated based on the density of transit stops or stations.

$$CO_{TAZi} = \frac{S_{TAZi}}{A_{TAZi}} \quad (3)$$

where:

CO_{TAZi} is coverage score in the ith TAZ

S_{TAZi} represents number of bus stops

A_{TAZi} is area of the TAZ_i

The three scores are then added up for each TAZ, while the mean and standard deviation are calculated, thereby standardizing the score.

Standardized score = ([capacity, frequency or coverage score] - [mean of distribution])/[standard deviation].

The overall CIBA score of each analysis zone can be calculated and the result can be joined with the map to represent which areas are well served or underserved by the existing bus supply.

Overall CIBA score = ([capacity score] + [frequency score] + [bus coverage score]).

At this point, rescaling the CIBA score is essential for greater ease of interpretation. To make all values positive, 5 was added to the overall score (see Figure 10).

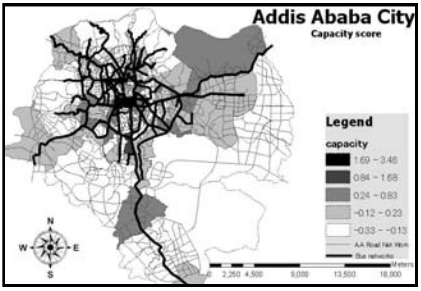


Figure 7. Capacity Scores

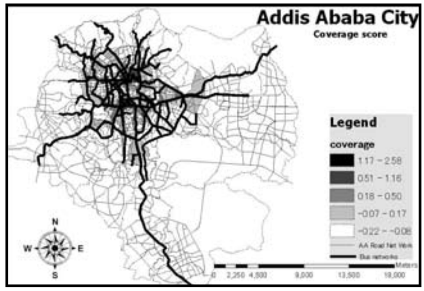


Figure 8. Coverage Scores

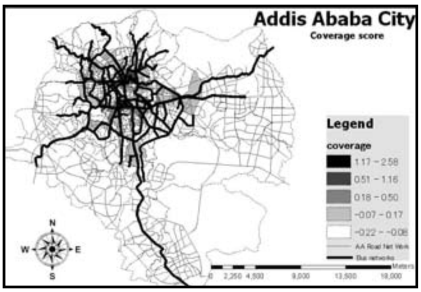


Figure 9. Frequency Scores

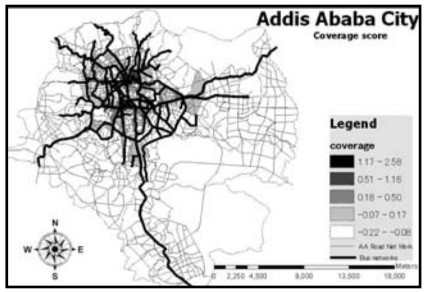


Figure 10. Overall CIBA Scores

Indexing the Route Design Parameters

Recalling the objective functions of maximizing route coverage and minimizing route overlapping, the indexing process is performed in such a way that, the larger the population, the higher the score, and the larger the coefficient of bus route parameters, the smaller the score assigned to the TAZ (see Table 1).

Table 1. Indexing TAZ with Objective Functions

Maximizing Trip Coverage			Minimizing Bus Route Overlapping			
TAZ score	*Population*	*Workers*	*TAZ score*	*Bus Capacity*	*Bus Coverage*	*Bus Frequency*
1	<10000	<1000	5	<4.5	<4.5	<4.5
2	10000-25000	1000-3000	4	4.5-5.5	4.5-5.5	4.5-5.5
3	25000-40000	3000-5000	3	5.5-6.5	5.5-6.5	5.5-6.5
4	40000-55000	5000-7000	2	6.5-7.0	6.5-7.0	6.5-7.0
5	55000+	7000+	1	7+	7+	7+

Maximization
Total population=IF(Tazi>55000,”**5**”,IF(Tazi >40000,”**4**”, IF(Tazi >25000,”**3**”,IF(Tazi >10000,”**2**”,”**1**”))))
Working population=IF(Tazi >7000,”**5**”,IF(Tazi >5000,”**4**”, IF(Tazi >3000,”**3**”,IF(Tazi >1000,”**2**”,”**1**”))))

Minimization
Capacity, coverage, and frequency=IF(Tazi >7,”**1**”,IF(Tazi >6.5,”**2**”, IF(Tazi >5.5,”**3**”,IF(Tazi >4.5,”**4**”,”**5**”))))

Impedance Coefficient

Once the scores for the population and bus route parameters are assigned to each TAZ, adding up the scores provides the coefficient of that TAZ, $\mathbf{S_z}$. Now each TAZ with a higher population and lower transit availability receives a high score, and vice versa. The next step is assigning the scores to the standard street links for bus transportation in each TAZ, $\mathbf{S_i}$. If the entire link belongs to the zone, the full value is assigned, but if the link is shared by two TAZs, the average of the value is assigned. Based on the assigned scores, the impeded length can be calculated as follows:

$$C_i = (S_{max}/S_i)*l_i$$

where:

S_{max}	is the maximum value of S_i for all segments
S_i	is the optimization score of segment i
l_i	is length of the segment i in kilometers
(S_{max}/S_i)	represents the impedance coefficient

Table 2. TAZ Scores and Impendence Coefficient

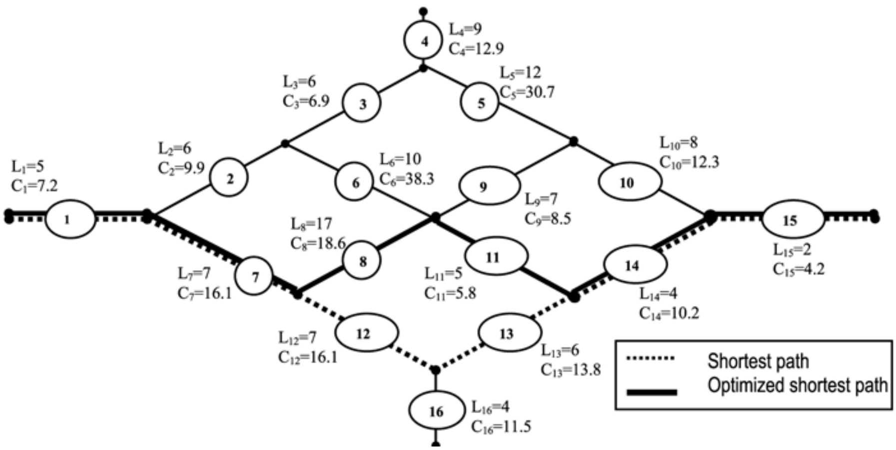
TAZ No.	TAZ Name	Pop.	Index	Work. Pop.	Index	Capa-city	Index	Cove-rage	Index	Freq-uency	Index	Total index	Impedance Coefficient
1	W01K01	9371	1	2901	2	4.535	4	4.789	4	4.485	5	16	**1.50**
2	W01K03	7363	1	2280	2	4.891	4	4.967	4	5.708	3	14	**1.71**
3	W01K04	11379	2	3523	3	5.225	4	6.072	3	6.080	3	15	**1.60**
4	W01K05	6024	1	1865	2	5.453	4	5.778	3	5.278	4	14	**1.71**
5	W01K06	8032	1	2487	2	4.749	4	4.605	4	4.245	5	16	**1.50**
…	…	…	…	…	…	…	…	…	…	…	…	…	**…**
302	W21K04	8400	1	3333	3	7.691	1	6.282	3	7.701	1	9	**2.67**
303	W21K19	4721	1	1873	2	5.652	3	4.979	4	6.184	3	13	**1.85**
304	W21K20	4721	1	1873	2	4.700	4	4.846	4	4.882	4	15	**1.60**
305	W23K08	9005	1	1574	2	4.928	4	4.381	5	5.097	4	16	**1.50**
306	W23K09	7771	1	1359	2	4.601	4	4.854	4	4.721	4	15	**1.60**
307	W23K10	3735	1	653	1	6.603	2	4.540	4	5.097	4	12	**2.00**
308	W23K14	23200	2	4056	3	4.333	5	4.261	5	4.101	5	20	**1.20**

Optimized Route

The final step is to carry out the GIS best-route finding analysis with the origin (urban center) and destination (expansion zone) that satisfies the following equation:

$$\min \left\{ \sum_{l=O_l}^{D_l} C_i \right. \qquad (4)$$

The origin and destination are selected based on the O-D data collected by the ERA in 2004. The methodology proposed in this study can be applied to any given origin and destination by transit operators or government planning officials. According to the ERA O-D data, high bus trips originate from one of the urban centers and are destined to one of the expansion suburbs where urban development is being undertaken. The Network Analyst extension of the ArcGIS software is implemented for route-searching routines, giving the calculated impeded length as the weight of the street link. According to the output, the proposed route satisfies the optimum fulfillment of the objective functions when compared to the shortest path. An illustrative example is presented in Figure 11.



Route	*Hypothetical Length (L_i)*	*Hypothetical Optimization Score (S_i)*	*Impedance Coefficient (S_{max}/S_i)*	*Impedance Length (C_i)*
1	5	16	1.4	7.2
2	6	14	1.6	9.9
3	6	20	1.2	6.9
4	9	16	1.4	12.9
5	12	9	2.6	30.7
6	10	6	3.8	38.3
7	7	10	2.3	16.1
8	17	21	1.1	18.6
9	7	19	1.2	8.5
10	8	15	1.5	12.3
11	5	20	1.2	5.8
12	7	10	2.3	16.1
13	6	10	2.3	13.8
14	4	9	2.6	10.2
15	2	11	2.1	4.2
16	4	8	2.9	11.5

L_i= Actual length

C_i= Impedance length= (S_{max}/S_i)*Li

S_{max} = Maximum value of S_i for all segments

S_i = Optimization score of link "i" comprising maximum population, minimum bus route coverage, bus frequency, and capacity (Pop. index +working pop. index+Coverage index+frequency index+ capacity index; see Table 1 for how the indexing is done)

Optimized path is the shortest route using IMPEDANCE LENGTH (C_i) of street links as a weight for the link (bus routes in the place where there is high demand)

Shortest path is the shortest route using ACTUAL LENGTH of the street links as a weight for the link

Figure 11. Example of Shortest and Optimized Routes

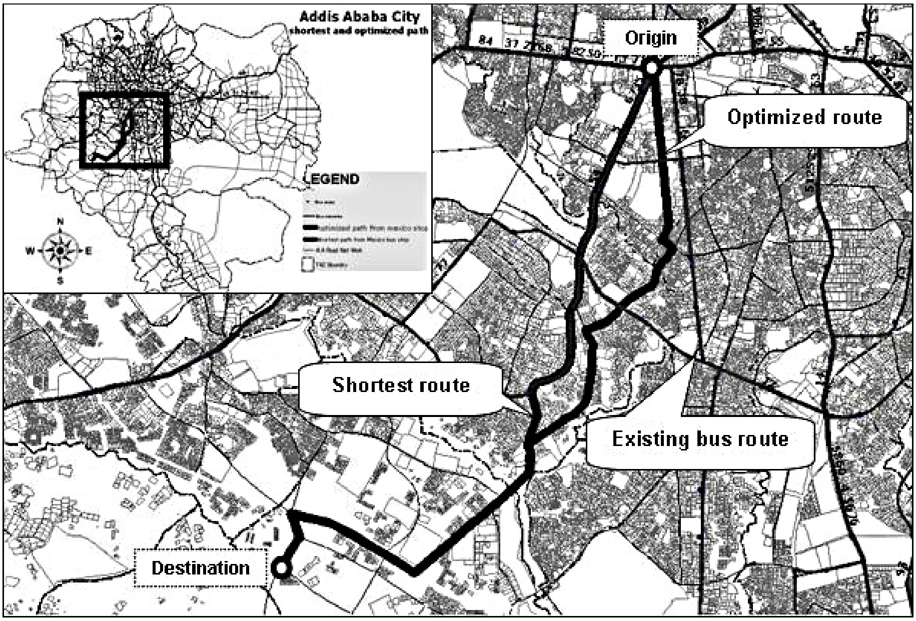


Figure 12. Actual GIS Output of Shortest and Optimized Path

Route Evaluation

Both transit operators and passengers prefer shorter and faster routes to reduce operating costs and in-vehicle time. Often, to reduce access impedence, tortuous routes are constructed, although they are likely to increase both in-vehicle time and operating cost (Chien et al. 2001). However, according to the GIS output of this research, the length of the optimized path is 7.8km, which has no significant difference to the shortest path (7.1km); the new optimum route meets the criteria of increasing coverage and reducing route duplication, whereas the shortest path overlapped existing routes (see Figure 12). The change in each TAZ's level of bus service is analyzed to evaluate the effect of the added route. All service intensity parameters have shown a change in response to the new route. With the addition of more routes, the level of TAZ would increase, especially for TAZs in periphery areas, which exhibited below average scores. Those TAZs show an increase with regard to better capacity, coverage, and frequency scores (Figure 13).

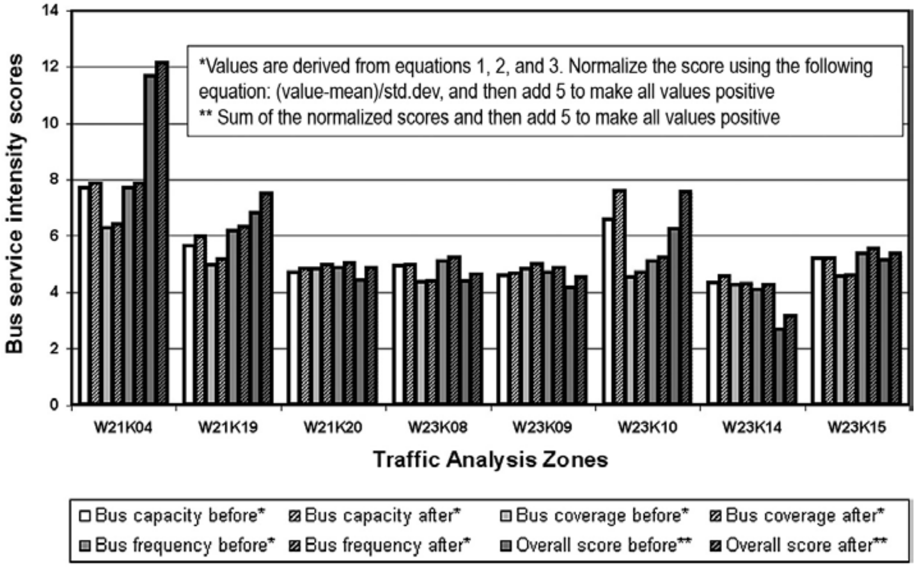


Figure 13. Comparison of Bus Service Intensity Before and After Route Addition

Conclusion

Although public transit provides a relatively small portion of the total travel, it provides a much larger portion of particular types of travel (e.g., suburb commuters to the city center) and is an effective solution to certain transportation problems. It is most suitable for medium-distance trips in urban areas or on any corridor with adequate demand and as an alternative mode for travelers who, for any reason, cannot use a private automobile. For suburb commuters traveling to the city center for different purposes, the integrated public transportation route is essential. The route design procedure requires consideration of multicriteria parameters to produce an optimum route. The shortest route is not always the optimum route from the transit operator's or traveler's points of view. This research focuses on the application of GIS for bus route design with defined route design objectives. It follows simple procedures using the GIS powerful analysis capability. The unique feature of this study is the minimization of route overlapping so as to provide routes to underserved areas. For situations like Addis Ababa, where horizontal urban expansion is prevailing and several constraints for transit service development exist, the optimized route to link the urban centers with expansion areas is important. The methodology and results of this study would be useful for bus companies, municipal governments, and transit developers that seek to take part in the transit development of the city.

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Does Government Structure Matter? A Comparative Analysis of Urban Bus Transit Efficiency

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University of North Carolina at Charlotte

Abstract

As public transit becomes more and more important to our economy, it is imperative that we understand which governing system achieves optimal efficiency. Following up on the work of Perry and Babitsky (1986), we quantitatively test whether certain forms of public governance are more efficient administrators of bus service. We utilize 2004 data from the National Transit Association database and control for federal funding, whether services are contracted out, region, population density, whether the system has a fixed guideway, the presence of local dedicated funding, and the ratio of local to federal funding. We find that special-purpose governments are more likely than general-purpose governments (cities and counties) to operate more efficiently. We also discovered that governments that contract out for some or all of their bus services are also more likely to be efficient than those public agencies that directly operate all of their services.

Introduction

This research is designed to add some theoretical and empirical insight into how forms of government impact the operating efficiency of bus service. Bus service is found in every major city throughout the United States. It is a popular transit option because of its operating flexibility and ability to be constructed quickly, incrementally, and economically. The systems vary in usage, design, and operations. Currently, bus service is almost exclusively operated at the local level publicly, either through city or county government or via a special- purpose government developed for transit.[1]

Of interest to policy-makers is the question: Does form of government matter? In other words, are some types of governments more efficient than others in delivering bus service? Specifically, are special-purpose governments that perform a single function, public transit, more efficient than general-purpose governments (cities and counties) that perform multiple functions? In this article, we empirically test whether certain forms of government operate more or less efficiently while controlling for whether some or all of the functions are contracted out, the ratio of local to federal funding, whether the system contains a fixed guideway, region, existence of a dedicated form of funding, and service area density.

Forms of Transit Governance

Little research has addressed whether form of government impacts service delivery in general and transportation efficiency specifically. More than 20 years ago, Perry and Babitsky (1986) examined the organization of mass transit systems by testing the viability of particular privatization strategies for the operations of bus service. They utilized data from 1980 and 1981 reported under Section 15 of the Urban Mass Transportation Act and compared five existing organizational forms on a variety of efficiency, effectiveness, and utilization indicators. They found that publicly managed special-purpose governments (especially public authorities) stood out from other types of governments. They debunked past research findings, which they believed had overstated the relative efficiency of general-purpose governments. They argued that these systems were more efficient than other publicly owned systems in revenue generation in 1981. The purpose of our study is to follow up on Babitsky and Perry's (1986) findings to determine if, 20 years later, bus service systems are more efficient when housed in a special-purpose government than in a general-purpose government using the latest transit data (2004).

Other research on transit governance has tested the relationship between form of government and federal funding. Smirnova, Leland, and Johnson (2005) argue that institutional arrangements for transit districts make a difference in securing funds from the federal government—especially when they embark on large capital projects such as building or expanding a subway, commuter rail, or light rail system.

Their research quantitatively tests whether certain forms of government are more conducive to receiving federal funding while controlling for mode, region, population, and key electoral swing states. Utilizing the 2002 data at the transit agency level, from across the entire universe of transit agencies in the United States, they find a relationship between federal funding and form of government. The federal government indirectly favors special-purpose governments over general-purpose governments in their allocation of transit funding. This could be in part because they are more aggressive in their requests for funds.

The search for appropriate forms of government for delivering public service has been a recurring theme within the literature of public administration and public policy. According to Perry and Babitsky (1986), early municipal reforms were motivated by the concern for eliminating corruption associated with basic urban services such as police and public sanitation. Reforms initiated in the 1960s to stem corruption emphasized decentralization of these services to improve responsiveness and accessibility (Perry and Babitsky 1986). More recent reforms have focused on privatization, especially contracting out, which is the opposite of what has occurred with public transportation. Until 1964, when federal capital subsidies were made available to local governments, increasing numbers of bus systems were acquired by public agencies (Perry and Babitsky 1986). Today, as will be discussed below, the majority of bus systems are publicly owned.

Public bus systems are typically housed either in general-purpose governments (cities or counties) or special-purpose governments. Within these two types, some systems are contracted out and operated by a private management service company. Under this classification of transit governance, a resident team of professionals provides technical support from the firm's central office and controls the day-to-day operations of the system. The contract's financial conditions are usually on a fixed-fee or percentage of gross farebox revenue basis with provisions for inflation (Perry and Babitsky 1986).

A key feature of special-purpose governments is that their jurisdictions are not confined to one city or county, and are regional in nature. They are part of what Olberding (2002) calls "targeted" regional strategies for communities facing problems that require cooperation. Such strategies have become popular in the past three decades and are not as radical or politically problematic as metropolitan governments, consolidation, or annexation (Smirnova, Leland, and Johnson 2005). The attractiveness of special-purpose governments is evidenced by their popularity. Special-purpose governments have grown from approximately 8,000 in the 1940s to more than 35,000 today (Olberding 2002).

While special-purpose governments do have territorial boundaries, they also have a level of geographic flexibility (Hooghe and Marks 2003) that general-purpose governments do not. Special-purpose governments often overlap other governments (Burns 1994). When a special "need" arises that falls outside traditional city and county boundaries, creating a special-purpose government is one method that citizens can utilize to address it.

The definition of special-purpose governments for this research includes public authorities, government corporations, and special districts. This distinction is used by Eger (2002) to differentiate their forms. Each category is represented by the entity's ability to control the amount of information reported to the state government, its financial characteristics, and its ability to issue debt (Eger 2002). While the authority of each of these types of special-purpose governments to tax and spend varies based on state law and type of organization, they all are motivated by a single factor and driven toward a single outcome (Foster 1997). We have included several control measures to differentiate between various types.

Whereas special-purpose governments provide for greater regional cooperation, they have been criticized for devoting proportionally more resources to relatively expensive capital projects compared to a typical general-purpose government. The costs for special-purpose governments (particularly public authorities) are higher for a variety of reasons. The most common are higher service quality and limited political visibility (associated with greater freedom to implement unpopular development projects; Smirnova, Leland, and Johnson 2005). Nevertheless, they are the most popular form of local government in the United States as well as the fastest growing (Burns 1994). Conversely, general-purpose governments for the purpose of this study are defined as cities and counties that provide public transportation. Transit agencies in these systems must compete with other goods and services for revenue (Smirnova, Leland, and Johnson 2005).

The boundaries that citizens draw when they create special-purpose governments or city or county governments matter in American politics because they define the limits of particular arrangements of political power, types and levels of service delivery, characteristics of political participation and accountability, and certain arrangements for funding the work of the local government (Burns 1994). For this study, we assert that institutional arrangements for transit agencies matter, and believe that there is still support for Perry and Babitsky's findings that they are more efficient in delivering bus service. This research explores whether special-purpose governments are more efficient because they are better suited to address regionwide transit problems that lead to increased ridership. While a regional approach seems logical, and special districts appear to be politically feasible options, special-purpose governments face additional barriers. Unlike general-purpose governments, special-purpose governments must secure funds regionally outside traditional city and county borders. This requires horizontal intergovernmental cooperation and bargaining or contracting, which may be a disincentive for expanding into new territory if the special-purpose government requires a dedicated funding source (Smirnova, Leland, and Johnson 2005).

Dataset Description and Selection Procedures

The National Transit Database (NTD) provides an invaluable source of quantitative data on federal transit funding, efficiency measures, effectiveness measures, and forms of government for our research. The response rate to the NTD is about 100 percent. "Simply put, the universe is known" (BTS 2002). We use the latest released dataset for the 2004 fiscal year, which includes the institutional forms of transit agencies represented in Table 1. In this article, we focus only on the U.S. states and exclude territorial transit agencies such as in Puerto Rico. Also, we are interested only in the difference between special- and general-purpose governments so we exclude state-run services and privatized services from our study.

We define special-purpose governments as a single-purpose agency with either an elected or appointed board of directors. This includes public authorities and special districts. We define general-purpose governments as a unit of a city or county government. This limits our universe to 533 agencies, with a proportional sample of each type as demonstrated in Table 2. There are also two additional criteria for our sample: type of service and mode of transportation. The type of service (TOS) focuses on the agencies that directly operate (DO) or contract out (PT) for part or all of their services; thus, we eliminate unique or special service providers, such as agencies that are engaged only in planning activities.

Table 1. Transit Agencies by Institutional Agency Type

Agency Type	*Total N*	*Mean Service Area (square miles)*	*Mean Service Population*
1. Public agency or authority that directly operates all transit service (not a state DOT)	210	283	325,538
2. Public agency or authority that contracts for some or all transit service (not a state DOT)	341	332	714,650
3. State Department of Transportation	5	1,021	1,854,448
4. Private transportation provider reporting on behalf of a public agency or authority (not a broker)	35	408	1,297,412
5. Private transportation broker reporting on behalf of a public agency or authority	2	586	1,430,034
6. Other	28	1,989	3,850,842

Source: Authors' calculations based on 2004 NTD database.
Notes: The total universe constitutes 637 transit agencies, but 16 are from Puerto Rico. Thus, total population of interest is 621 for this table.

Table 2. Transit Agencies by Institutional and Organization Type

Institutional Type	*Directly Operates Services (DO, total N= 134)*	*Purchased Transportation (PT, total N=173)*
General-purpose government (total N=153)	N=74 Mean area size=178 Median area size=39 Mean population served= 115,771 Median population served=78,585	N=79 Mean area size=178 Median area size=59 Mean population served= 361,849 Median population served=170,669
Special-purpose government (total N=154)	N=60 Mean area size=389 Median area size=103 Mean population served= 275,154 Median population served=154,601	N=94 Mean area size=478 Median area size=296 Mean population served= 1,091,351 Median population served=524,725

Source: Authors' calculations based on 2004 NTD database. N=307.
Notes: The table excludes 63 agencies with less than 9 vehicles as well as 133 agencies that do not operate buses for mass transit (only vanpool or direct response services).

With the second selection criteria, mode of transportation, our sample focuses on agencies that operate bus (MB) or bus and any additional mode of transportation. Thus, we exclude transit agencies that operate only vanpool or direct response services as well as agencies that provide only rail services such as the Alaskan Railroad. Vanpool services are usually very small agencies, while light rail services are operated by large agencies. We also look at fixed guideway systems (FG) for bus operations because we hypothesize that providing such services requires considerably higher operating and capital expenses. Table 3 represents a typology of transportation modes by rail/nonrail and FG/non-FG. Our additional mode of transportation variable includes all rail modes and FG rubber tire modes such as trolleybuses or aerial tramway.

Table 3. Transportation Modes

	Rail	***Nonrail***
Fixed Guideway (FG): A separate right-of-way (ROW) or rail for exclusive use of mass transportation or "using fixed catenary system usable by the other forms of transportation"	Automated Guideway (AG), Cable Car (CC), Commuter Rail (CR), Heavy Rail (HR), Inclined Plane (IP), Light Rail (LR), Monorail (MO), Alaska Railroad (AR)	Aerial Tramway (TR), Bus (MB), Ferry boat (FB), Trolleybus (TB), Bus Rapid Transit (BRT)
Nonfixed Guideway (NFG) "mixed traffic ROW"	Not applicable	Bus (MB), Demand Response (DR), Jitney (JT), Publico (PB), Vanpool (VP)

Source: Authors' typology based on NTD 2004.

Another important consideration for our study is region because we hypothesize that nonunionized labor (prevalent in the South) reduces labor costs. Table 4 represents the regional distribution of population by organizational form and institutional type and represents the final select sample of 307 agencies. As Tables 2 and 4 demonstrate, utilizing Census Bureau classifications, there is almost an even split between special-purpose governments and general-purpose governments in our sample.

Table 4. Organizational and Institutional Forms by Regions

	Organizational Form					
	Directly Operated Services (public management)		*Contracting Out for Some or All of the Services*		*Total*	
Region	Special-purpose (1)	General-purpose (2)	Special-purpose (3)	General-purpose (4)	N	%
Northeast	11	8	19	5	43	14%
Midwest	20	12	22	30	84	27%
South	24	38	24	25	111	36%
West	5	16	29	19	69	22%
Total	60	74	94	79	307	
%	20%	24%	31%	26%		

Source: Authors' calculations from 2004 NTD database.

The resulting population of agencies is not a selected sample, but the universe of interest on which we would like to focus in the following sections of our article. As Table 4 demonstrates, special-purpose governments and general-purpose governments are more or less uniformly distributed across four U.S. Census regions.

Research Design

The conceptual model represented in Figure 1 is designed to help answer the research question: "All other things being equal, are special-purpose governments more efficient than general-purpose governments in delivering bus services?" We derive this model from the literature review section of this article.

Our model includes several independent variables that measure the level of efficiency of transit operations. The vector of our dependent variables is listed in Table 5. We test several effectiveness indicators to corroborate the results of the efficiency tests. Foster (1997) questions whether special-purpose governments can still be more effective than general- purpose governments even if they may not be as efficient.

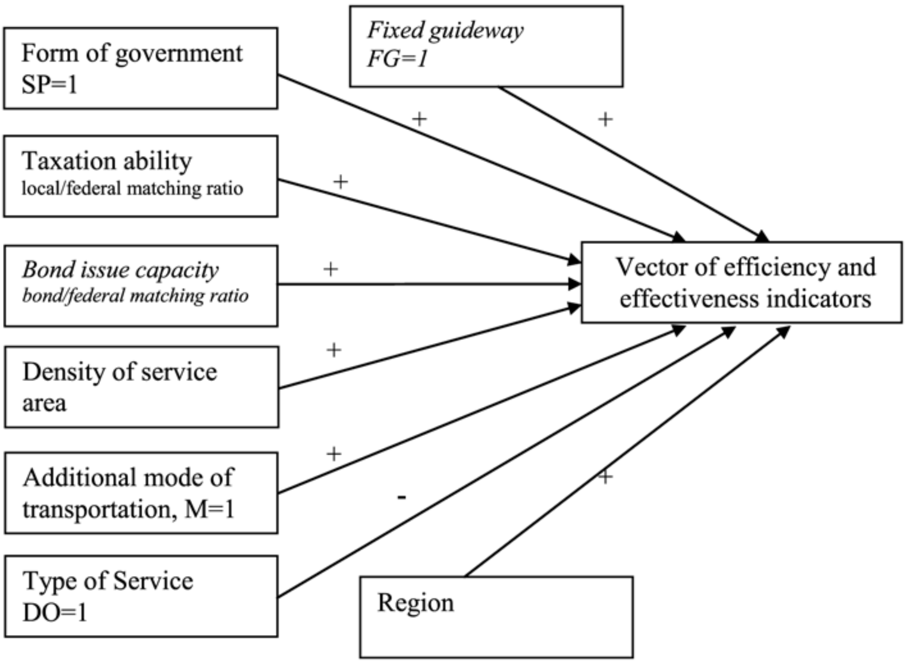

Figure 1. Conceptual Model

The variables indicated in italics are tested, but excluded from the final analysis because of multicollinearity.

Table 5. Performance Indicators

Latent Concept	*Performance Indicators*	*Limits to Internal Validity of the Measurement*
Efficiency Measures		
I. Labor productivity	1. Revenue vehicle mile per total employee hours 2. Revenue vehicle hour per total employee hours	Hours of daily service Labor work rules Size of administrative personnel Service area network characteristics
II. Service efficiency	3. Operating expenses per revenue vehicle mile 4. Operating expenses per revenue vehicle hours	Service area population characteristics Service area network characteristics
III. Cost efficiency	5. Farebox recovery ratio 6. Fare revenues per passenger trip	Fare structure Hours of daily service Service area network structure
Effectiveness Measures		
IV. Vehicle utilization	7. Revenue vehicle miles per vehicle operating in maximum service 8. Revenue vehicle hours per vehicle operating in maximum service	Peak/off peak ratio Labor work rules Daily service vehicle/total fleet ratio Service area network characteristics
V. Service effectiveness	9. Passenger trip per revenue vehicle hour 10. Passenger trip per revenue vehicle mile	Service area population characteristics Service area network characteristics
VI. Cost effectiveness	11. Operating expense per passenger mile 12. Operating expense per unlinked passenger trip	Service area population characteristics Service area network structure

Even though we test the same environmental factors against our performance indicators, the presumption is that the explanatory power of each of these indicators will differ from our measures of efficiency and effectiveness. The rationale for using several different performance measures is that these ratios approach efficiency differently. For example, the National Transit Database 2004 Annual

Report lists two separate indicators for efficiency: operating expense per revenue vehicle mile and operating expense per revenue vehicle hours. Both of these measures attempt to assess inputs (operating expenses) per unit of provided service measured as either revenue vehicle miles (RVM) or revenue vehicle hours (RVH). Both measures have different strengths and weaknesses. While RVM are affected by route structure and road capacity, RVH are impacted by work hours and labor regulations (Fielding, Glauthier, and Lave 1978; Giuliano 1980). Thus, using both measures gives us a more accurate picture of the underlining latent dimensions of service efficiency. Both measures also allow us to test whether special-purpose governments are more efficient because of their geographic flexibility (Hooghe and Marks 2003). We also expect that general-purpose governments will have higher efficiency levels when measured by RVH. Often, RVH-based measures are considered better measures for efficiency indicators (Fielding, Glauthier, and Lave 1978), but our assumption is that RVM are able to capture the geographical dimension of special-purpose governments, which is theoretically important to our study.

As demonstrated in Table 5, there are several important efficiency and effectiveness dimensions that we estimate for bus transit. Service and cost-efficiency measures are supplemented by effectiveness measures because along these dimensions, special-purpose governments may appear to be less efficient, but more effective. It is our notion that the same number of institutional and environmental factors (discussed later in this article) will impact such measures. However, the coefficients and impacts of independent variables could vary from measure to measure.

In this article, we test the following hypothesis: special-purpose governments are more efficient in delivering bus services than general-purpose governments. Therefore, one of our main explanatory variables is the form of government: special-purpose versus general purpose governments. We coded "1" if a transit agency is operated by a transit authority or special district and "0" if it is operated by the unit of city or county government. We also control for regional differences and include a dummy variable that equals "1" if a transit agency is situated in the South, and "0" for all other regions. As noted before, Southern agencies may have lower labor costs because of state right-to-work laws and the absence of unions.

The next control variable that we test is population density of the service area. We use the population served over the area served for each transit agency as a measure of whether the service area is more sparsely populated or more compact.

We assert that the denser the population, the more efficient service areas become due to heavier usage and shorter trips.

We employ a dummy variable to control whether a system contains a fixed guideway. A fixed guideway is "a mass transportation facility using and occupying a separate right-of-way or rail for the exclusive use of mass transportation and other high occupancy vehicles; or using a fixed centenary system useable by other forms of transportation" (National Transit Database 2004). Here, our assumption is that such systems are more capital intensive and have higher operational costs. Besides controlling for FGs as a more capital-intensive service, we also control for whether an agency operates another mode of transportation in addition to buses.

An important component in determining whether an agency receives federal funding is its ability to match dollar-for-dollar with local revenue (Smirnova, Leland, and Johnson 2005). For this reason, we include several measures to capture the federal matching capacity of a transit agency. First, we hypothesize that having a higher ratio of local to federal funding will be positively correlated with our efficiency indicators, particularly cost and service efficiency, because this tax ratio indicates the transit agency's ability to match funds. Another way a transit agency can raise matching funds is through issuing bonds. To control for this, we include a ratio of the amount expended on bond payments in fiscal year 2004 to the federal funding acquired during 2004. Finally, we control for the type of service provided by a transit agency.

The following equation paraphrases our model in general form:

$$Y_i = \alpha + \beta_{1i}SP_i + \beta_{2i}B_i + \beta_{3i}T_i + \beta_{4i}D_i + \beta_{5i}M_i + \beta_{6i}FG_i + \beta_{7i}DO + \beta_{7i}R_i + \varepsilon_i \quad (1)$$

where:

Y represents our vector of dependent variables which measures different aspects of efficiency and effectiveness, such as the farebox recovery ratio

SP_i is a dummy variable that equals "1" if a transit agency is a special-purpose government

B_i is a dummy variable representing whether an agency paid bond interest during the fiscal year

T_i represents the ratio of local funding to federal funding

D_i is the density of the service area

Table 6. One-Way ANOVA Results

Latent Concept	*Performance Indicators*	*ANOVA Significance Results*
I. Vehicle utilization	1. RVM per vehicle operating in maximum service (RVM/VOMS) 2. RVH per vehicle operating in maximum service (RVH/VOMS)	0.058 0.304
II. Labor productivity	3. RVM per total employee hours (RVM/TEH) 4. RVM per total employee hours(RVH/TEH)	0.003** 0.022*
III. Service efficiency	5. Operating expenses per RVM (OPEX/RVM) 6. Operating expenses per RVH (OPEX/RVH)	0.006** 0.039*
Service effectiveness	7. Passenger trip per RVH (PASST/RVH) 8. Passenger trip per RVM (PASST/RVM)	0.088* 0.078*
IV. Cost efficiency	9. Farebox recovery ratio (Fare/OPEX) 10. Fare revenues per passenger trip (Fare/PASST)	0.002** 0.937
Cost effectiveness	11. Operating expense per passenger mile (OPEX/PASSM) 12. Operating expense per unlinked passenger trip (OPEX/PASST)	0.303 0.382

Notes: The results represented are based on two-tailed test of significance, using one-way ANOVA function in SPSS 13.0 program.
* $p<0.05$; ** $p<0.01$

M_i is another dummy variable that stands for whether the transit agency operates an additional mode of transportation

FG_i is a dummy variable that represents whether the agency's bus system operates on a fixed guideway

DO_i stands for agencies that directly operate all of their services

R_i is a regional variable, where 1=the South, and all other regions are 0s.

Results

The results of various tests performed to estimate our model are discussed in this section.[2]

We use several different tests to triangulate the information derived from our data. Since our dataset contains several dependent variables, the first test that we perform is a one-way ANOVA test. This test allows us to compare the means of several variables with respect to certain categorical variables, in our case, special-purpose versus general-purpose governments.

Labor productivity, service efficiency, and farebox recovery ratios are significant for all measures, with $p<0.001$ and 0.05. In addition, vehicle utilization (RVM/VOMS) and both of the service effectiveness variables have marginal significance levels of $p<0.10$. The results are presented in Table 6. Cost effectiveness indictors and fare revenues per passenger trip measures were not significant.

The results of this test are triangulated with a t-test, which treats special-purpose and general-purpose governments as two separate groups and assumes unequal variances. The t-test gives essentially the same results as one-way ANOVA. One-way ANOVA, while robust, is a simple test of the difference in means that does not control for the various exogenous factors. The only conclusion that we can reach with such tests is that special-purpose and general-purpose governments perform differently on the set of efficiency and effectiveness measures listed in Table 5, but we cannot tell whether special purpose or general purpose are more efficient and/or effective. For this reason, we employ multiple regression to test our model directly. Multicollinearity tests indicate that controlling for fixed guideways and bond ratios represent a major challenge in producing coefficient estimates that are efficient and unbiased. Fixed guideway is highly correlated with mode and the form of government variables. The variable for issued bonds is highly correlated with the form of government and tax-matching ratio. Thus, we run the tests that both include and exclude them. The results were more or less stable with the unstandardized regression coefficients changing within standard errors from model to model (Berry and Feldman 1985). We delete both of these variables from the final model.

We use the following equation for our final model:

$$Y_i = \alpha + \beta_{1i} SP_i + \beta_{2i} T_i + \beta_{3i} D_i + \beta_{4i} M_i + \beta_{5i} DO + \beta_{6i} R_i + \varepsilon_i \qquad (2)$$

The results of our statistical analysis are reported in Table 7.[3] The table is organized by efficiency and effectiveness measures similar to Table 5. For different

Table 7. Regression Results

	Efficiency Measures						*Effectiveness Measures*					
	Labor Productivity		*Service Efficiency*		*Cost Efficiency*		*Vehicle Utilization*		*Service Effectiveness*		*Cost Effectiveness*	
	RVM / TEH	*RVH / TEH*	*OPEX / RVM*	*OPEX / RVH*	*Fare / OPEX*	*Fare / PASST*	*RVM / VOMS*	*RVH / VOMS*	*PASST / RVH*	*PASST / RVM*	*OPEX / PASSM*	*OPEX / PASST*
Adjusted R^2	15%	8%	47%	40%	11%	18.5%	7%	7%	27%	33%	8%	8%
Form of government (SP=1)	-0.52*	-0.02	0.62**	5.91*	0.03*	0.07	-1281.37	10.08	*1.84*	*0.19*	-0.20	-0.30
Ratio of local to federal taxes	0.04	1.55E-03	0.16**	2.71	622.3E-6	0.06**	148.57	0.73	0.21	0.01	0.06**	0.25**
Density of service area	-2.11E-04**	-1.31E-07	308.0E-6**	1.3E-3**	8.5E-6**	-2.7E-6	-16.2E-3	0.09**	1.8E-3**	206.6E-6**	4.0E-6	-172.9E-6
Additional mode (M=1)	-0.71**	-0.05**	1.06**	12.56**	0.02*	0.06	-1447.99	-86.98	4.21**	0.39**	-0.09	-0.17
Region (South=1)	0.46*	0.02	-1.24**	-15.74**	0.02*	-1.4E-3	6043.78**	365.93**	-1.57	*-0.16*	-0.31**	-0.38
Type of service (DO=1)	0.27	*0.03*	-0.97**	-14.22**	-0.03**	-0.14*	234.98	-23.28	-4.02**	-0.29**	0.12	-0.12

Notes: Entries are unstandardized regression coefficients, * $p<0.05$; ** $p<0.01$. Italicized coefficients have $p<0.10$, which is not significant but marginally close. All models are significant at $p<0.001$ level.

performance indicators, our model predicts from about 7 to 47 percent of the total variance at a statistically significant level ($p<0.001$). The form of government matters for labor productivity when measured by RVM. In fact, special-purpose governments are less efficient than general-purpose governments in this respect. However, we note that Giuliano (1980) had similar results for special-purpose governments. She determined that this could be a result of general-purpose governments underestimating their total employee hours because of shared personnel with the other departments.

The other efficiency indicator for which form of government matters is service efficiency measured by RVM and farebox recovery ratios. Special-purpose governments have larger farebox recovery ratios and spend more per RVM than general-purpose governments. This is likely attributed to the fact that special-purpose governments have different fare structures and different network structures than general-purpose governments. They also typically have different financing structures. In addition, general-purpose governments tend to underreport costs in areas such as personnel, where functions are shared among different departments. Therefore, general-purpose governments' operating expenses may appear more efficient than they actually are because the true costs are not fully disclosed (Fielding, Glauthier, Lave 1978). Another variable that supports a difference in network structure is service effectiveness measured by RVM.

Service area density is significant in almost all of our models, but it is a very small value. By far the most interesting finding is the influence of additional modes of transportation and the type of service provided. If a special-purpose government transit agency has to operate an additional mode of transportation, then it has both higher service efficiency and effectiveness levels. It also has a higher farebox recovery ratio, but lower labor productivity. This could indicate that such an agency would have high farebox revenues from both modes of transportation and a larger labor force to serve both of these modes. At the same time, there could be certain economies of scope in performing several modes of transportation under the same agency. We think this is an area worth researching, but it is beyond the scope of this particular research design, which focuses only on bus service.

Transit agencies that directly operate services are less effective and less cost efficient, but have higher levels of service efficiency than those agencies that contract out services. These three sets of measures are reported in the National Transit Database's annual publication for 2004 (National Transit Database 2004). This finding indicates that there are certain performance advantages in contracting out transit services, and is an interesting topic for future research.

Discussion

We assert that the boundaries citizens draw when they create special-purpose governments or city or county governments matter in American politics. Boundaries define the limits of particular arrangements of political power, types and levels of service delivery, ability to secure dedicated funding, characteristics of political participation, and accountability and certain arrangements for funding the work of the local government. For this study in particular, we argue that institutional arrangements for transit districts make a difference in the level of efficiency and effectiveness in administering public bus service. As public transit becomes more and more important to our economy and budgetary resources continue to be scarce, we need to better understand which type of governing system achieves optimal efficiency.

While controlling for federal funding, contracting out, region, population density, additional modes of transportation, and region, we find that special-purpose governments are more likely than general-purpose governments (cities and counties) to have a higher farebox recovery ratio than general-purpose governments as well as high service effectiveness as measured by RVM. At the same time, they have lower labor productivity and service efficiency than general-purpose governments. This finding could be the result of transit agencies housed in general-purpose governments underestimating their true labor costs by not reporting labor expenses shared with other departments. When these efficiency and effectiveness indicators are measured by RVH, there is no statistically significant difference between special-purpose and general-purpose governments. One likely explanation for this is that RVM are more sensitive and representative of the network structure operated by an agency and thus these measures capture the geographic flexibility of special-purpose governments.

Perry and Babitsky (1986) found that special-purpose governments stand out as more effective in generating revenues than general-purpose governments using data from more than 20 years ago. This also could explain why, for the other efficiency and effectiveness indicators, our major explanatory variable was not statistically significant. In effect, we control for the major factor that we think leads to increased efficiency in public transit, which is the ability of special-purpose governments to raise additional funds through local taxes. In fact, this variable significantly increases the cost effectiveness of transit agencies.

We also discover that governments that contract out for some or all of their services are also more efficient, except in terms of service efficiency, than those public agencies that directly operate all of their services. When a service is something that can easily be quantified and monitored, contracting out for some or all bus services can maximize efficiency. This is counter to the findings of Perry and Babitsky (1986) that contract-managed systems operate no more efficiently than publicly managed systems. We believe the difference between our findings and theirs on this variable is due to three factors: (1) the data utilized in their study are considerably older and contains half the number of transit agencies utilized in this study; (2) the world of contracting may have become more sophisticated, relying less on fixed-cost or percentage of revenue contracts that provide few incentives for efficiency; and (3) they did not use farebox recovery ratios as an efficiency measure, instead they focused on revenue generation for operating expenses and exclude capital expenses. This has important implications for transit administrators, elected officials, and citizens involved in bus service delivery. However, it is important to note that our results cannot be generalized to other areas of public transit such as light or heavy rail or purely privatized bus systems.

Conclusion

Our empirical results support the viewpoint that organization form is related to the efficiency of bus service delivery. Future research could include multiple years of data to determine if efficiency varies over time. This poses a considerable challenge to researchers because NTD reporting requirements have not been uniform over the past 24 years. A second area for future research would be to analyze the variables that specifically relate to the different types of governance systems (such as whether boards are elected or appointed), and measure their influence on a larger set of efficiency and effectiveness indicators. Both of these areas should be investigated to better inform transit policymaking.

Endnotes

[1] Modern-day public bus systems are largely public, and only a small percentage are privatized. Because the goals of private systems may be radically different

from publicly owned and managed systems, we choose to exclude them from our research.

[2] The preliminary tests run on the model indicate that operating a fixed guideway for bus services is highly correlated with operating additional modes of transportation as well as the form of government. At the same time, bond ratios are also highly correlated to the ratio of matching funds and form of government. For this reason, we excluded these variables to avoid multicollinearity (Fox 1991). This is also consistent with the literature on special-purpose governments (Sbragia 1996).

[3] Careful examination of our data has led us to exclude three agencies that have very few passenger trips and passenger miles compared to their operating expenses. These agencies also have very low farebox revenues when compared to the other agencies, and are supported by a higher proportion of local taxes than the rest of the agencies studied. We exclude these extreme cases, based on Cook's D measures. The final regression results reported do not include these cases. However, the regression results are not different if we leave the cases in, for all performance indicators but cost-effectiveness measures.

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Encouraging Sustainable Campus Travel: Self-Reported Impacts of a University TravelSmart Initiative

Geoff Rose, Monash University

Abstract

At the start of the 2004 and 2005 academic years, a voluntary travel behavior change program targeted incoming first-year students at the Clayton Campus of Monash University in Melbourne, Australia. Analysis of before and after travel surveys identified a significant effect in terms of reducing single occupant commuting and increasing public transport use. Nearly one in four of the students who participated in the TravelSmart initiative indicated it had influenced them to the extent of thinking about using, trying, or regularly using alternatives to solo driving to campus. The information provided about public transport services was the most valued element of the program. A range of barriers to further behavior change are identified to overcome a number of those impediments and thereby increase the use of environmentally friendly modes for commuting to campus.

Introduction

Voluntary travel behavior change programs, an emerging category of the Travel Demand Management (TDM) initiative, are "designed to enable individuals to become more aware of their travel options and, where possible, exercise choices that reduce the use of private motor vehicles (Rose and Ampt 2003). These programs go beyond simple awareness-raising to deliver sustainable change in individual's travel behavior.

Consistent with TDM initiatives underway in a number of Australian states, the Victorian Department of Infrastructure (DOI) initiated a TravelSmart program (DOI 2004) to "reduce the negative impacts of car travel through a reduction in vehicle trips and kilometers traveled, achieved through voluntary changes by individuals, households and organizations towards more sustainable travel choices." The Victorian TravelSmart program does not rely on the provision of additional transport or other infrastructure, or improvements in the level of service of public transport services. Rather, the program seeks to facilitate change within the existing urban transport and land-use systems. The program involves initiatives targeted at educational institutions, workplaces, and communities. Universities cut across these application contexts since they are workplaces for large numbers of academic, research, and general staff and centers of learning for students. They act as large traffic generators with travel patterns dominated by commuting trips (Tolley 1996).

This article focuses on a TravelSmart initiative run at Monash University's Clayton Campus, the largest of the eight Monash campuses with a total student and staff population of about 30,000. The campus is located in the outer suburbs of Melbourne (a city of about 3.5 million), approximately 18 km (11 miles) from the city center. Described by one commentator as Australia's first "drive-in university" (Davidson 2004), the campus is close to the Monash Freeway, a major radial facility, and is served by a number of bus routes. Connecting buses provide a link to two nearby suburban railway stations that are located on the same radial train line. The TravelSmart initiative promoted use of "green" travel modes (walking, cycling carpooling, and public transport) and reduced reliance on single occupant vehicles for access to campus.

The article provides insight into the impact of the initiative run at the start of the 2004 and 2005 academic years and identifies remaining barriers to change in the context of travel to campus. This study complements other research focused on university campuses that primarily explores the scope for pricing, infrastructure, and service improvements to promote more sustainable travel choices (Toor and Havlick 2004; Shannon et al. 2006).

The TravelSmart initiative run at the campus is described in the next section, followed by an outline of the methodology used in this study. Results from travel surveys conducted in 2003, 2004, and 2005 are then used to obtain insight into the impacts of the TravelSmart program and remaining barriers to behavior change. The final section summarizes the conclusions and identifies implications for programs targeting university students.

The Campus TravelSmart Initiative

The Monash University TravelSmart initiative focused on first-year students. This is an important target market for a travel behavior change program since these students, by necessity, are going through a process of travel behavior change in the transition from secondary to tertiary education (Cooper and Meiklejohn 2003). The program is a variant of "individualised marketing" (Brög and Schadler 1998), in that tailored travel information is provided to program participants, although in this case it involves face-to-face contact and interaction rather than mail delivery. The program is delivered at the time of first contact and does not involve interaction over time or tailored feedback on the basis of a detailed travel survey as in the travel blending travel behavior change program (Rose and Ampt 2001).

Since this program is delivered at a single point in time, it could be regarded as a "one-shot" travel behavior change program (Taniguchi and Fujii 2007). However, unlike the approach taken by Taniguchi and Fujii, participants do not complete a travel survey in advance; there is only a verbal indication given by students of their likely travel mode to campus. In addition, participants are not asked to make a behavioral plan as a basis for changing their travel behavior. The Monash TravelSmart program does have parallels with the EcoTravel Coordinator Program described by Nakayama and Takayama (2005) in that both programs are delivered through personal interaction although the EcoTravel coordinators interacted through a series of meetings to help participants reduce their car use.

The TravelSmart program was delivered as part of the enrollment process, conducted in late January,[1] which involves incoming first-year students completing an on-campus enrollment process. As students proceed through the enrollment hall, they complete necessary paperwork, have photos taken, and receive their ID cards. The last section of the enrollment hall is organized by student associations and it was here that the incoming first-year students were exposed to TravelSmart.

The TravelSmart desk was staffed by up to seven trained TravelSmart officers. Students who agreed to be involved were asked to complete a brief intercept survey that formalized their enrollment in the TravelSmart program. The TravelSmart officers then provided students with their TravelSmart pack containing:

- generic cover letter;
- local area map showing bus, walking, and cycling routes;
- Melbourne public transport map;
- student public transport concession card application form (applicable to domestic students who are eligible for the card on payment of an annual fee of about $AUD80 [$USD66] in 2004, which then entitled them to the standard concession fares on public transport that are half the regular fares. The fee was reduced to $AUD8 [$USD6] in 2005 when it was only intended to cover the administrative cost to the public transport authority of issuing the card.); and
- carpool postcard providing information on the benefits of carpooling and links to further information including the carpool matching service.

After a conversation with the student, the TravelSmart officer also added to the pack:

- appropriate bus and/or train timetables;
- a daily public transport ticket, appropriate for a journey from home to the university (this component was included in 2004 but not in 2005); and
- other information as required (e.g., cycling information).

This active dialogue with the students (see Figure 1) meant that the information was tailored to the needs of the individuals. Importantly, the staff delivering the program had participated in a one-day training session, involving extensive role-play exercises, which emphasized the use of persuasion principles developed in psychology when discussing travel options with students. This training exercise drew on the six psychological principles of persuasion (reciprocation, commitment and consistency, authority, social proof, liking, and scarcity), which have been found to be effective in encouraging uptake of other TravelSmart initiatives (Seethaler and Rose 2006).

Study Methodology

This study draws on a series of travel surveys, some conducted as part of the TravelSmart initiative and others undertaken independently. Each survey was undertaken over the Internet using an announcement email that explained the purpose of the study and provided a link to the website where students could complete the survey.

Figure 1. Delivery of the Monash University Campus TravelSmart Program to Enrolling First-Year Students

The first component of the study draws on general travel surveys conducted in 2003 (before TravelSmart was run) and again in 2004 (after the TravelSmart initiative). These two databases provide an opportunity to quantify changes in mode choice over a period where TravelSmart was the primary intervention affecting travel to campus. The general travel survey sought information on travel to campus on each day of a one-week survey period. The general travel surveys conducted in 2003 and 2004 asked respondents to indicate how they traveled to campus each morning of the survey week. Respondents who used more than one method of transport, were asked to indicate the mode used for the longest (distance) part of their journey. Since the survey obtained information on linked trips, it is likely to underestimate the extent of walking and cycling (which can be, for example, used for some legs of a linked public transport trip). This represents a trade-off in survey methodology with the linked trip format producing a simpler survey instrument, and most likely higher response rates, while not providing the same rich data that could be obtained from a detailed travel and activity survey.

The analysis of this data focuses on first-year students since they were the target of the TravelSmart initiative. The "before" travel survey was conducted in second semester 2003 (October 2003) at a time when it could be expected that the travel patterns of the first-year students would have stabilized. The 2004 "after" survey was conducted in the first semester (May 2004) just after there had been an expansion of car parking capacity in one campus precinct. It is therefore possible that the 2004 survey may reflect higher car use as a result of the improvement in car parking availability. No major revisions to regular public transport services occurred during the 2003 to 2004 period apart from changes in frequency of the free intercampus shuttle bus that runs between the Clayton and Caufield campuses (a distance of about 8 km or 5 miles). That service was operated with 24-seat minibuses and the headway was halved from 30 minutes in 2003 to 15 minutes in 2004. The capacity increase was undertaken to overcome problems with students being left behind when the bus was full and consequently having to wait for the next service.

The second component of the study relies on a special-purpose evaluation questionnaire distributed to those students who received the TravelSmart initiative. The records made at enrollment enabled the students who had received the TravelSmart pack to be identified. A free drawing for movie tickets was used as an incentive to participate in the survey. When the survey was designed, the recommendations of the Tapestry project in Europe (Tapestry 2003) were considered in detail and the survey included travel, demographic, and enrollment status questions covering:

- current travel patterns;
- assessment of the impact of the TravelSmart program on travel behavior;
- value of individual components of the TravelSmart program;
- barriers to travel by walking, cycling, public transport, and carpooling;
- home-suburb and postcode details;
- enrollment status;
- age;
- gender; and
- whether the respondent held a current student concession card for public transport.

Profiling the Survey Respondents

Before considering the travel behavior dimensions of the survey responses, it is appropriate to highlight the sociodemographic characteristics of the respondents. Table 1 summarizes information on the number of responses and the response rates for the general travel surveys for first-year students who were the target group for TravelSmart. The response rate from first-year students was higher in 2004 than 2003 (21% vs. 15%). Female response rates are marginally higher than male response rates. The international student response rate doubled from 2003 to 2004 (from 10% to 19%).

While these response rates (along with response rates of a similar magnitude reported below for the targeted TravelSmart surveys) are not unusual for transport surveys (Richardson et al. 1995), caution should be used in interpreting the results due to the risk of nonresponse bias. Recent research conducted at the University of Western Australia (Shannon et al. 2006) achieved response rates close to 50 percent by using a hardcopy letter for recruitment and inviting participants to access an on-line questionnaire. Alternative recruitment methods could provide scope to lift response rates in surveys conducted at Monash or other tertiary institutions.

Table 1. Number of Respondents and Response Rates for General Travel Surveys

	2003			2004		
	DOM	INT	Subtotal	DOM	INT	Subtotal
Male	211 (14%)	49 (10%)	260 (13%)	311 (18%)	89 (21%)	400 (19%)
Female	338 (19%)	58 (11%)	396 (17%)	433 (24%)	83 (17%)	516 (22%)
Subtotal	549 (17%)	107 (10%)	656 (15%)	744 (22%)	172 (19%)	916 (21%)

Note: DOM = Domestic, INT = International

Table 2 profiles the respondents to the surveys that targeted TravelSmart students. The response rate was lower in 2005 than 2004 (15% vs. 22%). This most likely reflects the poorer targeting of the survey recruitment email in 2005. In 2004 it was sent to only those students who had participated in the TravelSmart initiative. In 2005 it was sent to all students and by matching IDs to the records kept at enrollment, it was possible to identify those students who had participated in the TravelSmart initiative at the start of that year. The response rate at Monash University was, however, higher than the 8 percent and 11 percent values recorded at two other universities in Melbourne at the same time, using the same survey methodology and questionnaire. The low response rates, however, caution about generalizing the results of the surveys across the target population. Table 2 highlights that in each year, females were slightly overrepresented since they comprised 60 percent of the responses but represent about 51 percent of first-year enrollments. The proportion of respondents with a concession card was 20 percent higher in 2005 than in 2004. This no doubt reflects the removal of the fee for the card, which came into effect at the start of 2005.

Table 2. Respondent Profile for 2004 and 2005 TravelSmart Surveys

	2004	2005
Target population	2,616	2,977
No. of respondents	573	458
Response rate	22%	15.4%
Purchased a public transport concession card	49%	69%
Male/Female	40%/60%	40%/60%

Before and After Evaluation

Figure 2 shows the changes in mode shares from 2003 to 2004 for all first-year students. The results reflect weighted mode shares with the weights calculated as the inverse of the response rates for demographic groupings (based on gender and domestic vs. international student enrollment status) for five residential zones defined as concentric rings radiating out from campus (Rose 2005). The weights were used to expand the sample to reflect the population of first-year students.

Figure 2 highlights that the number of students driving alone to campus dropped from 40 percent in 2003 to 31 percent in 2004. The number traveling as a passenger in a car, either as part of a carpool or dropped off at the university, increased from 7.7 percent to 11.9 percent. Bus use was also up, from 19.5 percent in 2003 to 25.4 percent in 2004. These changes in mode share were subjected to statistical analysis by testing the hypothesis that there was no difference in the mode share between 2003 and 2004. The difference in mode share proportions was tested using a Z test (Montgomery et al. 1998). As shown in Table 3, the results indicate a statistically significant reduction of 9.2 percent in car driver mode share along with statistically significant increases in car passenger drop off (up 2.8%) and bus (up 5.9%).

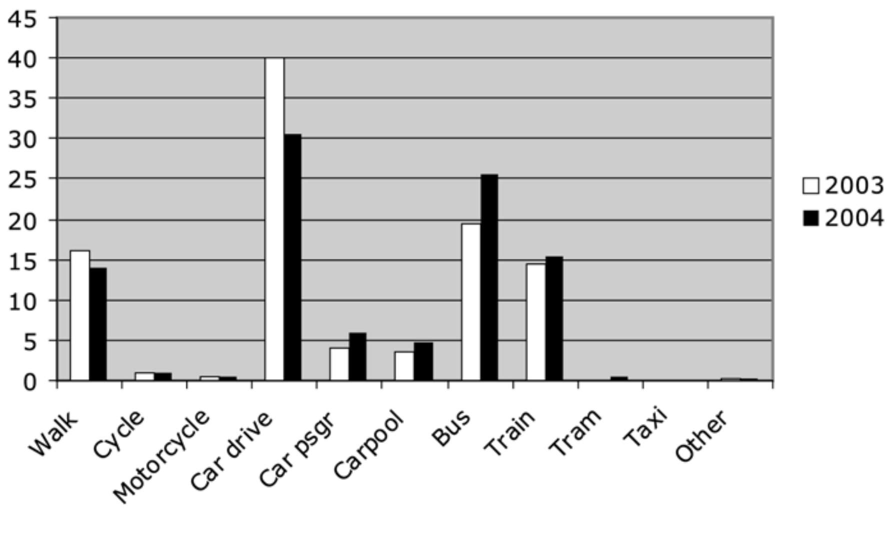


Figure 2. Mode Shares for All First-Year Students

Table 3. Statistical Testing of Change in Mode Share 2004 vs. 2003

	All Students		*Domestic Students*		*International Students*	
Mode	Mode Share Difference*	Z Score	Mode Share Difference*	Z Score	Mode Share Difference*	Z Score
Walk	- 2.3 %	- 1.25	-0.1	- 0.05	-5.7	- 0.94
Bicycle	+ 0.3 %	0.41	+ 0.2	0.4	+ 0.3	0.18
Motorcycle	- 0.2 %	0.54	-0.2	- 0.60	NA	NA
Car driver	- 9.2 %	- 3.8	-12.5	- 4.51	-2.3	- 0.60
Car passenger drop off	+ 2.8 %	2.4	+ 3.1	2.24	+ 1.6	0.72
Carpool	+ 1.4 %	1.37	+ 1.9	1.55	-1.0	- 0.92
Bus	+ 5.9 %	2.8	+ 2.9	1.23	+ 15.5	3.16
Train	+ 0.06 %	0.34	+ 3.8	2.05	-8.6	- 1.62
Tram	+ 0.4 %	1.42	+ 0.5	1.46	NA	NA
Taxi	+ 0.1 %	0.55	+ 0.1	0.69	+ 0.1	-.39

Note: Mode share difference is mode share in 2004 minus mode share in 2003. Dark shading indicates a statistically significant difference at the 95 percent confidence level, Z critical = 1.64. Light shading indicates one result that is significant at a 94 percent level.

When domestic and international students are considered separately, some subtle differences emerge. In general, the lower number of responding international students means that it is more difficult to reject the null hypotheses of no change in mode shares between 2003 and 2004. The exception is the 15 percent increase in bus use and the 9 percent reduction in train use, which, even with the small sample size, are statistically significant at the 95 percent level (or almost so in the case of the reduction in train mode share). For international students the small reduction in car driver mode share (down 2.3%) is not statistically significant. In contrast, a statistically significant drop in use of the car driver mode occurs for the domestic students along with a statistically significant increase in train use. Recall that the survey sought information on linked trips with students asked to indicate the mode used for the longest distance part of the journey. The increases in domestic students using the train would also mean increased bus use for the connecting shuttle services between the station and Clayton campus. Since international students are not eligible for the public transport concession card, they find the free intercampus shuttle bus (connecting the Caufield and Clayton campuses) attractive. A review of that service conducted in mid-2004 (TNK Consultants 2004) found that international students made up about two thirds of the users of the intercampus bus with over half of the riders using that service to get to their home campus (i.e., it was used for commuting). As noted earlier, that shuttle bus operated on an improved frequency in 2004. The increased bus mode share for international students may be partly attributable to those service changes rather than the TravelSmart program. That would be less of an issue for the domestic students who account for only a third of the intercampus bus users.

These results imply a statistically significant change in the modes used by first-year students to travel to campus in 2004, after the TravelSmart initiative had been run, compared to 2003. Apart from changes in the service level of the intercampus bus, no other major changes were made to public transport services of relevance to this study. The intercampus bus service changes may have impacted the behavior of international students, however, overall the results suggest that the TravelSmart program had reduced the use of solo driving to campus and increased use of alternative travel modes.

Exploring Travel Behavior Impacts

This section examines in greater detail the behavior of students who had participated in the TravelSmart initiative. Survey results are reported for two groups. First, for all respondents (referred to as ALL) and secondly for those respondents who live close to campus (referred to as NEAR). The boundary for the latter grouping was taken as the boundary of the local government area for the City of Monash (roughly a 6-km, 3.7-mile, radius).

The student's current travel behavior was examined with a question that provided seven response alternatives, ranging from not considering use of environmentally friendly modes to always using those modes. The response categories, which reflect the modifications in behavior change increasingly being used in the field of voluntary travel behavior change research (Shannon 2006; Rose and Marfurt 2007), were defined as follows:

- I am not even considering using public transport, walking, cycling or carpooling to campus (Not considering).
- I am thinking about using public transport, walking, cycling, or carpooling to campus but I am not ready to give any of those options a go (Thinking about).
- I am doing things to get myself ready to try using public transport, walking, cycling, or carpooling to campus (Getting ready).

- Once or twice I have tried using either public transport, walking, cycling, or carpooling to campus (Have tried).
- I am an occasional (less than once a week) user of public transport, walking, cycling, or carpooling to campus (Occasional user).
- I am a regular (at least once a week) user of public transport, walking, cycling, or carpooling to campus (Regular user).
- I always use either public transport, walking, cycling, or carpooling to travel to campus (Always use).

Figure 3 presents the results for use of environmentally friendly modes from the 2004 and 2005 surveys. In both years students who had received the TravelSmart program material reported their travel. Since the 2005 survey was sent to all students, it is also possible to report travel behavior of students who did not receive the program material. The results presented in Figure 3 suggest that the majority of respondents who received the TravelSmart program material either always use environmentally friendly modes or are occasional or regular users. Students living near the university are more likely to be users of environmentally friendly modes. The Getting ready category had very few respondents, suggesting that there are essentially two groups of students: the users (right-hand side of Figure 3), reflecting those in the "action" or "maintenance" stage of behavior change); and the nonusers/thinking about it (left-hand side of the figure), reflecting the "precontemplation" and "contemplation stages" of behavior change). About 7 percent of students have tried traveling to campus on environmentally friendly modes but have not progressed to be even occasional (less than once per week) users.

While the 2005 responses exhibit a similar pattern to 2004, some differences exist. Students were more likely to indicate they always used environmentally friendly modes in 2005 compared to 2004 (up by about 10%). The stronger result in 2005 could also be due to the reduction in cost of the student concession card (from $AUD80 to $AUD8) although this was only available to domestic students. The comparison between the TravelSmart and non-TravelSmart students reveals a large difference in mode usage. In both the ALL and NEAR categories, the proportion of students who report regularly or always using environmentally friendly modes is about 15 percent higher for the TravelSmart group. A Z test (Book and Epstein 1982) on the 2005 data confirmed a statistically higher proportion of the TravelSmart students regularly or always use environmentally friendly modes (Z score for ALL students = 4.83, for NEAR students Z = 3.12, critical Z at a 5% significance level = 1.96) compared to the students who did not receive the TravelSmart

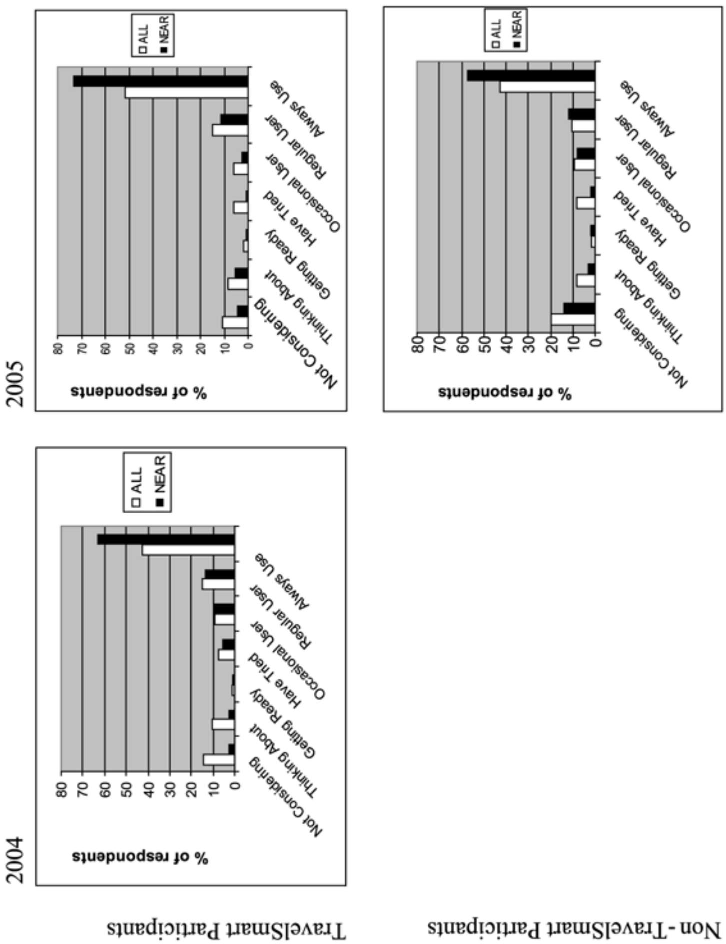


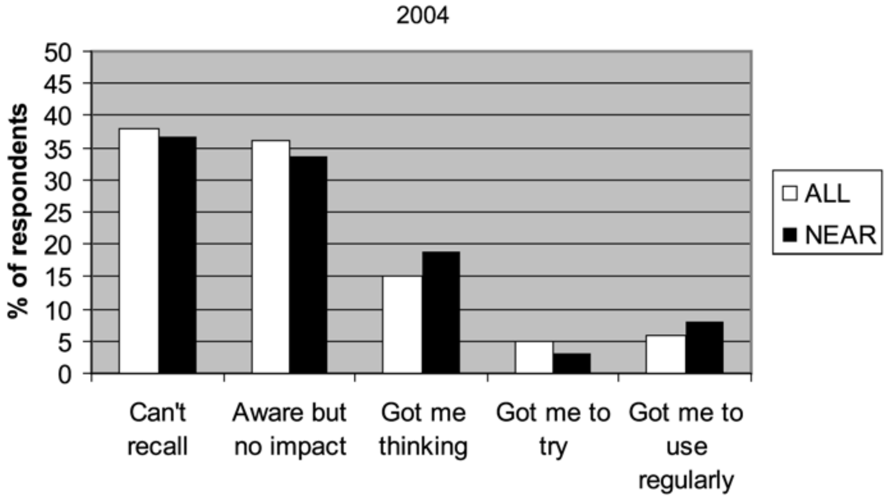
Figure 3. Use of Environmentally Friendly Modes

initiative. This reinforces the result reported in the previous section and provides further evidence that the TravelSmart program results in greater use of environmentally friendly modes to commute to campus.

To place these responses into perspective, the 2004 travel survey (described in the previous section) found that 61.7 percent of trips to campus during the survey week were on environmentally friendly modes (walk, bicycle, carpool, or public transport). By comparison, taking the Regular and Always use responses in Figure 3, the totals for ALL respondents is 58 percent and for those respondents living near to the University (NEAR) it is 77 percent. This suggests that the behavior reported by the responding registered TravelSmart students (at a 22% response rate as noted earlier) is representative of the first-year students.

Respondents were asked about the extent to which TravelSmart had influenced their mode choice decisions. The results, as shown in Figure 4, highlight only slight differences in responses as a function of residential location and across years. Nearly one in four respondents (25%) indicated that the TravelSmart initiative had influenced them to the extent of thinking about using, trying, or regularly using environmentally friendly modes. The impact of the program was higher for students living close to campus with nearly one in three (30%), indicating it had influenced them to the extent of thinking about using, trying, or regularly using environmentally friendly modes. The analysis reported earlier in this section highlighted use of environmentally friendly modes was 15 percentage points higher for those students who participated in the TravelSmart program than for those who did not. It is possible, given the responses shown in Figure 4, that students underestimated the impact of the program on their travel behavior. A higher proportion of respondents in 2005 could not recall the initiative, up nearly 10 percent on the 2004 result. Since TravelSmart is presented at one point in time as part of enrollment at the start of the year, it is not surprising that a large proportion of students do not recall it when asked six months later. Other research in the context of one-off ride to work events (Rose and Marfurt 2007) has highlighted the need for reinforcement and maintenance activities to sustain travel behavior change.

It is important to consider the delivery costs of the program as well as its cost effectiveness. It cost about $AUD30,000 p.a. ($USD25,000) to run the TravelSmart initiative at Monash University. Since the program was delivered to almost 3,000 students that equates to a cost per student contacted of about $AUD10 ($USD8) per person. Table 4 summarizes a range of cost-effectives metrics drawing on the percentages shown in Figure 4(b) and allocating the costs to progressively smaller



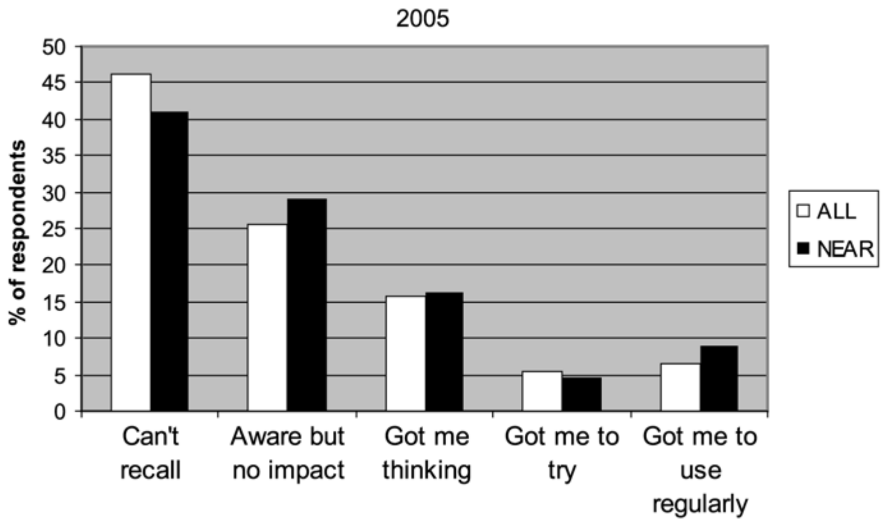


Figure 4. Perceptions of the Impact of TravelSmart on Use of Environmentally Friendly Modes

percentages of the student population depending on the program impact. When the program costs are allocated only to those students stimulated to use environmentally friendly modes (6.4% of the target population as shown in Figure 4b), the cost is $AUD157 ($USD130) per person. That is a comparable cost to areawide delivery of community-based TravelSmart initiatives that target households.

Table 4. Program Delivery Costs per Student (2005)

Target Group	*Number of Students Impacted*	*Cost per Student*
All students	2,977	$AUD10 ($USD8)
Those stimulated to think about, try, or use environmentally friendly modes	27.5 % of 2,977 = 818	$AUD37 ($USD30)
Those stimulated to try or use environmentally friendly modes	11.7 % of 2,977 = 348	$AUD86 ($USD70)
Those stimulated to use environmentally friendly modes	6.4 % of 2,977 = 190	$AUD157 ($USD130)

We next consider how respondents valued different parts of the TravelSmart program (Figure 5). Note that multiple responses were allowed since respondents were asked to indicate any items that were of value to them. Two items stand out in Figure 5 in relation to the 2004 initiative: the provision of information about public transport and the free public transport tickets. Tickets were not included in the 2005 initiative and yet the results presented in Figure 4 do not suggest that withdrawal of this incentive impacted the effectiveness of the program. Students living near the university also indicated that the information on walking and cycling to campus was of value with that information being identified as valuable by a higher proportion of respondents in 2005 compared to 2004. For students living further away from campus, the information on carpooling was valued. About 10 percent of the responses highlighted that value was obtained from "the publicity the initiative generates about using alternatives to the car" and "being part of an initiative which promotes alternatives to the car."

Remaining Barriers to Behavior Change

We now examine the responses in relation to factors that discourage or prevent respondents from walking, cycling, taking public transport, or carpooling to the university more often. For each mode, respondents were asked to indicate the top three items from a predefined list. Only those barriers associated with at least 10 percent of the responses are considered here since they represent the major barri-

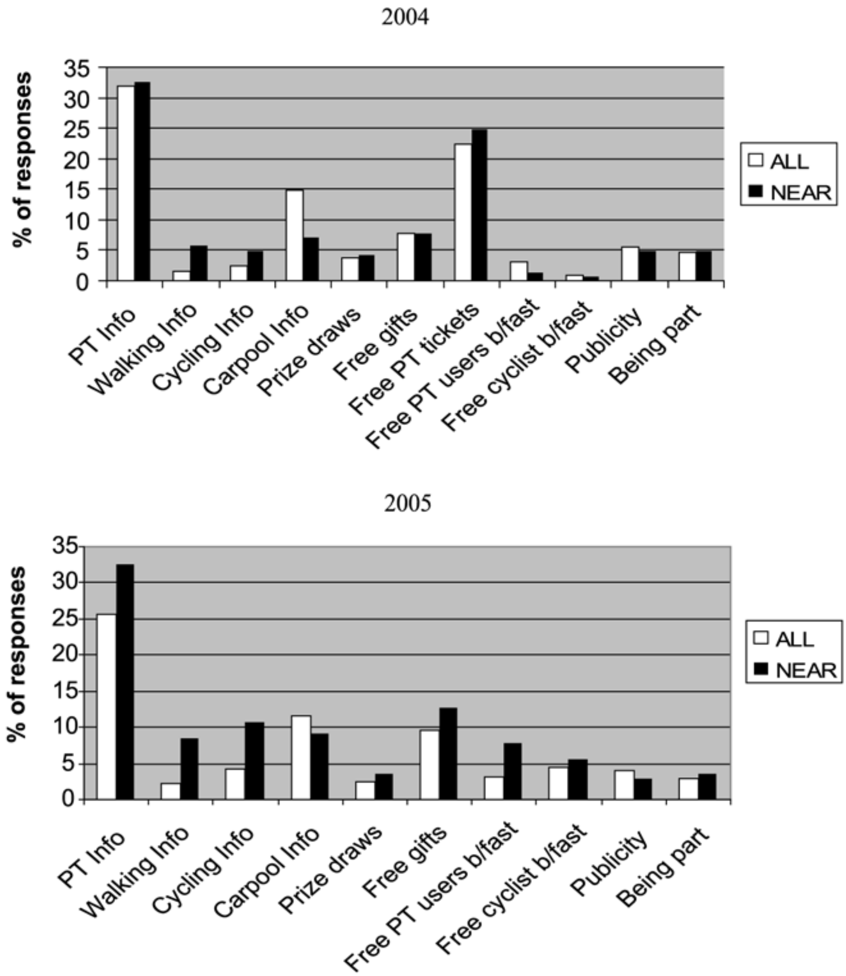


Figure 5. Elements of TravelSmart Program Valued Most by Respondents

ers nominated. The results presented relate to the 2005 responses since there was little difference in the pattern of responses from 2004 to 2005. While the results presented in these figures relate to all TravelSmart respondents, little difference was noticed in the pattern or relative importance of the barriers when the analysis was restricted to infrequent and nonusers of environmentally friendly modes.

In relation to walking (Figure 6), differences exist in the responses between ALL respondents and those who live NEAR the university with an obvious difference being the perception of walking distance as a barrier. For respondents living near campus, there are two main barriers (both comprised about 20 percent of the responses): weather and need to carry materials/books and other things. Concerns about walking in the dark (about 15% of responses) could be addressed by improved footpath lighting. Lack of safe, convenient places to cross busy roads was only mentioned as a barrier in about 5 percent of the responses. While this barrier could be lowered with appropriate engineering treatments, it does not appear to be a major impediment to increasing walking to campus.

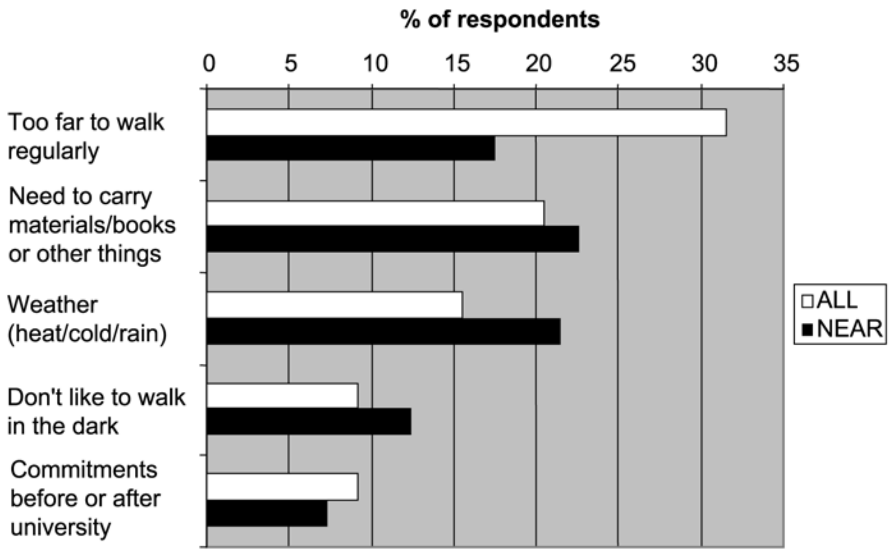


Figure 6. Walking Barriers

Less variation occurs in the responses of ALL and NEAR respondents to cycling barriers (Figure 7) except for the issue of riding distance, which is a greater barrier for those living further from campus. Not owning or having access to a bike was perceived as a major barrier particularly by respondents living near the university. This highlights the importance of initiatives such as the Bike Recycle project, now being funded as part of the University's Alternative Transport Fund, which makes low-cost bikes available for purchase by students at the start of the year. Other initiatives that increase ownership or access to a bike may also be worth considering.

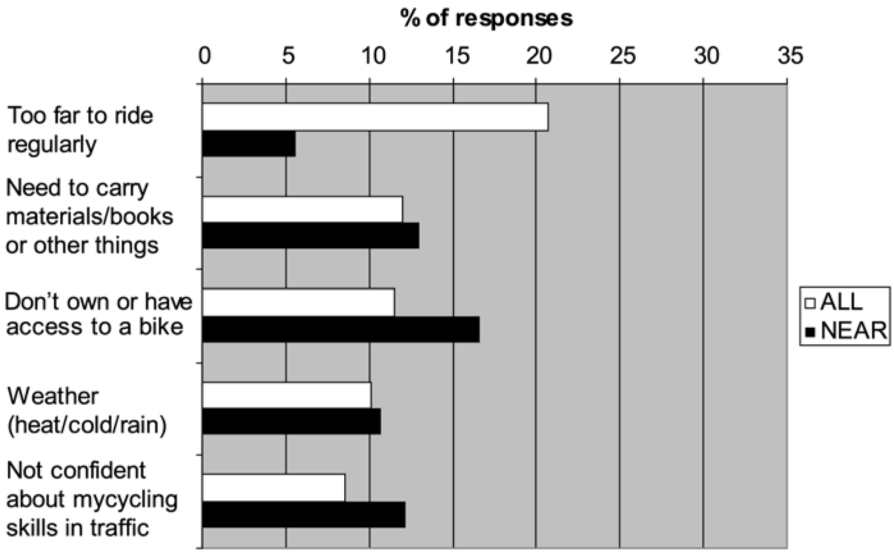


Figure 7. Cycling Barriers

Three other cycling barriers each accounted for slightly over 10 percent of the responses: not confident about cycling skills in traffic, weather, and the need to carry materials/books. The issue of cycling skills development can obviously be addressed through training courses such as the Cycle In course funded by the University's Alternative Transport Fund. The issues of weather and carrying materials can be addressed with appropriate clothing and/or equipment and perhaps there is potential to provide information about the availability of those items or some form of subsidy scheme to assist with their purchase. Interestingly, weather featured less as a barrier to cycling than it did for walking, even for nearby respondents. Similarly, commitments before and after university were only half as important as a barrier for cycling compared to walking.

There is little difference in the perceived public transport barriers between ALL respondents and those who live NEAR campus (Figure 8). Frequently cited barriers such as "takes too long," "limited service availability," "lack of direct services," and "expense" (particularly for students located near to campus) are not easy to address and relate to the extent of public transport services offered and subsidies provided. Expansion of public transport services is unlikely to be a low-cost option although opportunities to draw on spatial analysis of student travel patterns to better tailor existing services to their needs may exist.

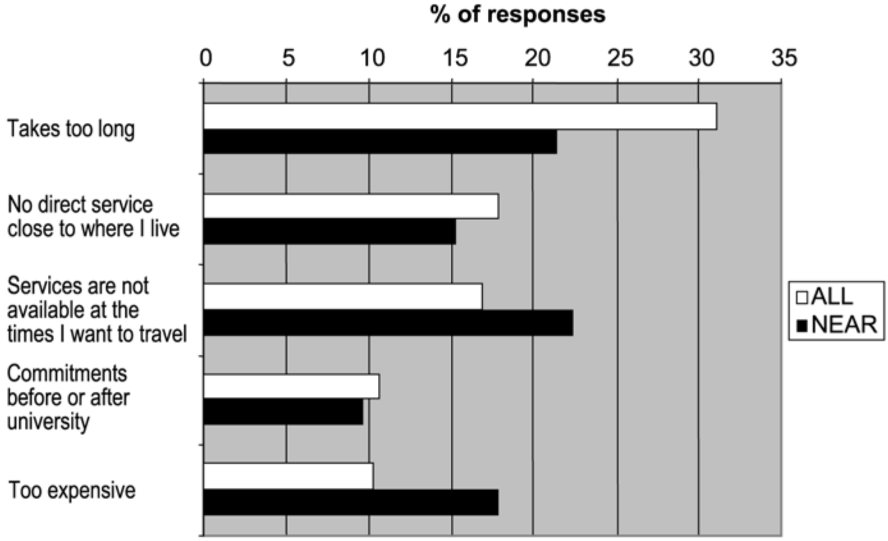


Figure 8. Public Transport Barriers

The lowest perceived public transport barrier (about 4% of responses) was lack of information or knowledge on how to get to the university by public transport. Provision of information about existing public transport services, a key feature of the TravelSmart initiative, therefore appears to be effectively disseminated through the combination of printed timetables and route maps along with the personalized advice provided at the time of presenting the TravelSmart program. The latter component may be important in assisting students to interpret the route and timetable information. It is also possible that the existing information may not be adequately framed to influence perceptions of different modes. Research undertaken in Western Australia indicated that Perth residents overestimated the time by public transport by 45 percent while underestimating the journey time by car by 16 percent (Socialdata Australia, 2000).

In addition to provision of information on public transport services, travelers should be made aware of the true car journey times to improve public transport's attractiveness as a modal alternative. In relation to the issue of expense, particularly for students living near campus, the subsidized public transport pass schemes (known as UPASS in the United States) should be explored as they have proven successful in boosting public transport ridership (Toor and Havlick 2004). While schemes of this type could overcome the financial barrier, it is also possible that they will stimulate the use of public transport by nearby residents at the expense of walk and bike modes.

Little difference exists in the perceived barriers to carpooling between all respondents and those who live near campus (Figure 9). Three barriers stand out: not having anyone to carpool with, not wanting to be tied to a schedule, and lack of flexibility. The first of those can be addressed by greater promotion of the carpool matching service. It is possible that respondents perceive the carpool option to be less flexible than it really is. A topic for future study is the promotion of positive experiences of existing carpoolers as role models. It is worth noting that the issue of "commitments before/after university" was consistently nominated as a barrier in about 10 percent of responses in relation to public transport and carpooling while only half that proportion of the responses indicated that it was a barrier for cycling.

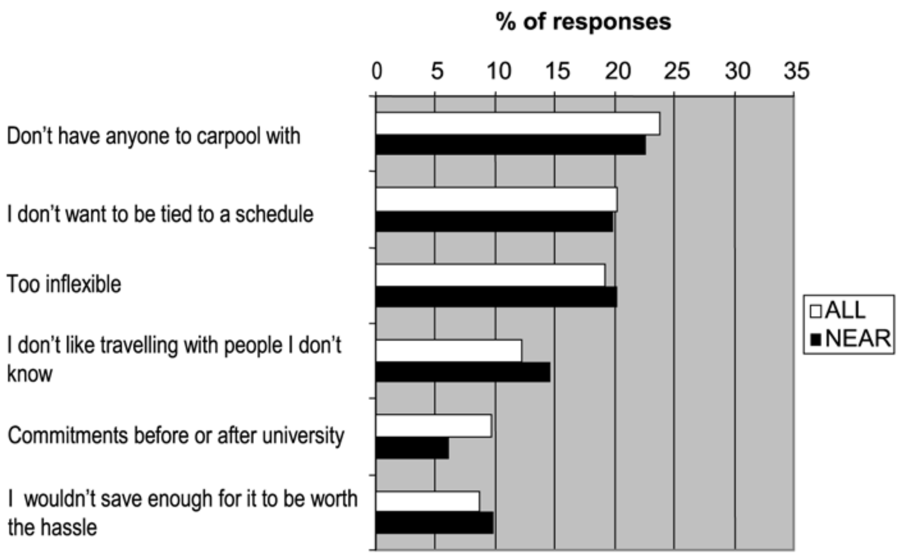


Figure 9. Carpool Barriers

Conclusions and Recommendations

Travel survey results suggest statistically significant changes in mode choice between 2003 and 2004 with a reduction in car driver trips of about 9 percent and an increase in public transport trips of about 6 percent. Nearly one third of all students who registered for the TravelSmart program indicated that it had influenced them to the extent of thinking about using, trying, or regularly using environmentally friendly modes (carpool, public transport, walk, or cycle). A statistically higher proportion of students who participated in the program in 2005 reported either regularly or always using environmentally friendly modes compared to those students who were not exposed to the program. The provision of information about public transport was particularly effective since only a very small percentage of respondents indicated that they lacked adequate information about public transport options for commuting to campus.

Barriers remain that are an impediment to further behavior change. Some of those (e.g., aspects of public transport service provision) will require substantial investment or service redesign to address. Others (e.g., availability of low-cost bicycles, education/training on riding in traffic, and equipment for carrying items on a bike and clothing for dealing with variations in weather) can be addressed much more cost effectively. The carpool matching service could be better promoted and greater use could be made of carpooling "role models" to highlight the relative advantages, and address perceived disadvantages with that mode.

Overall, these results suggest that the Monash TravelSmart initiative was effective in encouraging behavior change even though the reduction in the student concession card fee and improvements in the intercampus shuttle bus were confounding effects. Future development of the TravelSmart initiative could focus on the provision of services or information to address the remaining perceived barriers to behavior change. In addition, a follow-up with the students over time to examine the longer terms impacts of the TravelSmart initiative is encouraged. Future projects could also aim to lift the response rates to the travel questionnaires by varying the methods of recruitment.

Endnote

[1] The academic year in Australia runs from late February to mid-October.

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Faith-Based Organizations: A Potential Partner in Rural Transportation

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Abstract

Disability advocates frequently suggest that faith-based organizations (FBO) may be potential providers of transportation for people with disabilities living in rural communities. We conducted a national survey of rural FBOs in the United States to explore their capacity and interest in being involved in local transportation. We randomly selected 716 FBOs located within 15 miles of a rural center for independent living. Forty percent (N = 288) of these responded to our mailed survey. Responding faith communities averaged 300 worshiping adults with an average of 9.5 percent being judged to have a significant disability. Overall, respondents indicated they were neither willing nor unwilling to become involved in providing transportation to either the general public or to people with disabilities. Nevertheless, 32 percent of respondents said they would be willing or very willing to do so. Respondents reported that their congregations owned a total of 146 vehicles, 18.5 percent of which were judged to be accessible. Results are discussed in terms of the need to understand faith communities and their orientation to community service.

Introduction

Some 12 million people, 41 percent of the U.S. rural population, live in counties with no public transportation (Rural Transit Assistance Program 1995; Community Transportation Association of America 1995) The lack of transportation in rural areas is one of the most significant and persistent problems reported by people with disabilities and those who serve them (Arcury, Preisser, Gesler, & Powers 2005; Association of Programs for Rural Independent Living 2001; Jackson, Seekins, and Offner 1992; Gonzales, Seekins, and Kasnitz 2000; National Council on Disability 2005).

One contributing factor of the lack of rural transportation has been the inequitable allocation of resources to rural communities, with 95 percent of federal funds going to subsidize transportation for the 75 percent of the population living in cities and 5 percent going to support transportation for the 25 percent of the population living in rural areas (Seekins, Spas, and Hubbard 1999). While addressing this inequality directly through advocacy is an important step for improving transportation in rural communities (Association of Programs for Rural Independent Living 1999, 2001; Jeskey and Bush 2002; Zeilinger 2000), it is also important to develop methods and strategies that rural communities can use to deliver transportation services (Bernier and Seekins 1999; Seekins, Kasnitz, Gonzales, & Stombaugh 2002).

In the ongoing debate about the lack of rural transportation, rural advocates, program planners, policy-makers, and people with disabilities often raise the possibility of turning to Faith-Based Organizations (FBO) for assistance (Association of Programs for Rural Independent Living 1999; Jeskey and Bush 2002). These advocates presume that many FBOs, if not most, own vehicles for transporting members and may be willing to provide basic transportation for people with disabilities.

Recently, national policy-makers have emphasized involving FBOs in human services (Chaves 1999; Montiel 2003). Indeed, Seekins, Enders, Pepper, & Sticka, 2007, found that 10 percent of recipients of Section 5310 funding to provide transportation services to elderly and persons with disabilities were FBOs. Involving FBOs in providing human services is controversial, however (Eck 2001). Proponents argue that FBOs are ubiquitous, and many have a service mission that could extend scarce social resources. Opponents express concerns about issues of the separation of church and state. Pragmatically, researchers also point out that several of the largest social service providers in the United States are FBOs and that they are among the largest recipients of federal funding.

Sider and Unruh (2004) note a lack of agreement on what constitutes an FBO. They describe the characteristics of six types of human service organizations, ranging from faith-permeated to secular programs. One major distinction involves the involvement of FBOs in services directly or through a separate organization.

Chaves (1999) reported findings from the National Congregation Study that used a hypernetwork procedure to generate a national random sample of congregations. He found that 57 percent of congregations have some social service project, but that only 11 percent reported receiving outside funds for those projects and only 3 percent received government funds for those projects. Chaves noted that, while 36 percent of congregations would apply for government funds to support social service projects, 15 percent had policies against doing so.

Chaves also found that very large congregations (more than 900 regularly-attending members) appeared far more willing to be involved in government-sponsored programs to provide social services. He noted that the median congregation has only 75 regular members and an annual budget of $55,000, and suggests that substantial increases in delivery of social services by congregations can occur only through increases in government funding to do so.

In addition, Chaves reported that 64 percent of predominantly African-American congregations expressed willingness to apply for government funds compared with only 28 percent from predominantly white congregations. Further, he explained that liberal to moderate congregations are more willing to be involved in government programs than conservative or evangelical ones.

Little is known about the extent to which FBOs own vehicles, however, or about the extent to which they provide accessible community transportation. In a series of informal conversations with a variety of members from several faiths, not one reported that their church or synagogue owned a vehicle to transport even their own members. Conversely, we found that 10 percent of recipients of Section 5310 funds reported being FBOs (Seekins 2006).

Undoubtedly, many FBOs do own vehicles and do provide transportation at least to their members (many with disabilities). There may be a variety of barriers to these FBOs providing community transportation, however. These barriers are not yet clearly identified or understood. Given the frequent mention of FBOs as a potential solution to rural transportation concerns of people with disabilities

(Jeskey and Bush, 2002) and the lack of information about FBOs, there is a need to explore the roles of these organizational resources in rural community transportation.

The purpose of this study was to assess the potential involvement of rural FBOs in providing community transportation (to work, recreation, etc.) for people with disabilities. To the authors' knowledge, this is the first national study of the role of churches in providing rural accessible transportation. As such, it is an exploratory study. The primary questions of interest included: What is the capacity and willingness of rural FBOs to provide accessible transportation? What are the barriers to their participation in community transit programs? We developed six main exploratory hypotheses to guide our analysis, including:

1. Faith communities (FCs)[1] in larger rural towns would have more members than those located in smaller communities but the proportion of members with disabilities would be equal across size.
2. Larger FCs would be more likely to own and operate vehicles.
3. The larger the FC, the more likely it is to operate programs that serve non-members.
4. The more control an FC exerts over a service program, the more likely that religion will be integrated into the service program.
5. The quality of public transportation will be rated lower by FCs in smaller rural towns.
6. Smaller FCs will report more barriers to service than larger ones.

Method

Sample

A large number of FBOs exist in the United States. The American Church List (2006) reports 365,312 churches in the United States with a phone-book listing. Of those, approximately 119,823 are located in nonmetropolitan counties. The largest denominations include Baptist (86,434 churches), Church of Christ (59,336 churches), Adventist (43,571 churches), Pentecostal (38,959 churches), Methodists (32,242 churches), Evangelical (25,847 churches), and Catholic (22,278 churches). Smaller groups include the Latter Day Saints (7,952 churches), Episcopal (7,116 churches), Jewish (2,871 synagogues), Metaphysical (2,434 churches), and a miscellaneous group with some 56,400 churches. Rothauge (1983) classifies congregations by size, including family churches that have 1–50 members; pastoral churches, 51–150 members; program churches, 151–350 members; and corporate churches, 351 or more members. This vast number and variety of FCs creates challenges in developing research samples (Chaves 1999).

Our data analysis plan suggested that the most stringent statistical test would involve an ANOVA with five factors each of region and religion. Assuming a relatively small effect size of .18 and adopting a significance level of .05, we required 375 respondents for an acceptable level of power (.80). Estimating a 60 percent return rate, we selected a pool of 625 respondents to obtain the needed sample of 375.

We chose to survey congregational leaders. First, we surveyed 89 centers for independent living (CILs) located in nonmetropolitan counties and serving rural areas (Seekins 2006). Next, we used the online Yellow Pages to identify FBOs within a 15-mile radius of the address of the main office of the 62 responding CILs. This yielded a listing of 3,334 FBOs. Two authors reviewed the list and eliminated duplicate addresses and entries that were not local congregations (regional administrative offices, training centers, etc.). This produced a list of 2,535 FBOs. Next, we listed the churches grouped by the respective 62 CILs that had responded to the previous survey. Two researchers then randomly selected up to 12 churches associated with each CIL. The researchers selected a sample of 716 churches.

Procedures

We conducted a series of interviews and focus groups with transportation experts, providers, and consumers to identify initial issues of importance. Next, we conducted a literature review to identify additional issues and data collection methods. Third, we drafted a survey questionnaire. Representatives of transportation networks and FBOs reviewed the draft instrument for content. Fourth, we conducted a "talk aloud" procedure in which four potential respondents (congregational leaders) from local FBOs read the survey aloud to the researchers and talked about their interpretation of the question and the meaning of their answers. We revised the survey instrument and instructions accordingly.

The final questionnaire included six questions about the demographics of a congregation (title of respondent, religious foundation, number of worshiping adults, etc.), two questions about the general orientation of the congregation to community outreach activities designed to help classify the congregation using the Sider and Unruh (2004) typology, eight questions about transportation issues (number of vehicles, quality of local transportation), two questions about barriers to conducting transit programs, and an open-ended question about their general views of these issues.

We conducted a small pilot test with 20 FBOs selected from the area of the CIL located in the smallest metropolitan area to compare phone versus mail-based survey procedures. We found that making a connection with respondents by phone was very difficult and time consuming, and produced few responses compared to the mailed survey.

We used Dillman's (2000) mail survey procedures. First, we mailed a postcard to the congregational leader of each selected FBO that briefly described the study, how they were selected as a respondent, and explained that they would receive a survey in the mail within two weeks. Next, we mailed survey packets to the 716 selected respondents. Each survey packet included a letter that concisely outlined the study's purpose and reiterated how the respondent was selected. In addition, the packet included a four-page bifolded questionnaire and a self-addressed return envelope.

In response to our first mailing, we received 290 returned surveys; 169 completed and 33 uncompleted.[2] Eighty-eight (12.3%) were returned undeliverable. One month after the initial mailing, we mailed a second survey packet to the 426 nonrespondents and received an additional 86 completed surveys. Of those 86, 75 were completed and 11 were uncompleted.

Data Analysis Methods

We used descriptive statistics to explore the demographics, capacity, and involvement of respondents. We used tests of correlation to examine the relationships between size of congregation and involvement, and similar questions. We employed ANOVA to examine differences in capacity and interest by region, faith, and denomination.

Results

We received a total of 288 of 716 (40%) randomly selected respondents. An additional 88 were returned as undeliverable, for an effective response rate of 45.8 percent. Of the 288 returned surveys, 244 (84.7%) were completed and 44 (15.3%) were uncompleted. Forty-five responses (19%) were from rural towns of less than 2,500, 59 (25%) from small towns of 2,500 to 10,000, and 137 (57%) from larger towns of 10,000 to 50,000. Most (98.4%) respondents reported their faith community was based on Christianity.

Table 1 presents membership of FCs responding to the survey across both Rothauge's typology and geography. The average number of worshiping adults across FCs was 299.5, with a median of 100 and a range of 6 to 5,000. The mean number of worshiping adults with significant disability was estimated to be 19.5 (9.5%) with a median of 7.5. Larger FCs had more members (χ^2 (6, N = 230) = 21.42, p = .002) but did not have a greater proportion of members with disabilities χ^2 (2, N = 234) = 4.67, p =.097. However, there is a significant trend for smaller FCs to have more members with disabilities r (225) = -.201, p = .002.

Table 1. Church Membership by Rothauge's Typology Across Rural Categories

	Rural Town (2,500 or less)	*Small Town (2,500–10,000)*	*Large Town (10,000–50,000)*	*Total*
Family church (1-50)	16 (7%)	17 (7.4%)	29 (12.6%)	62 (27%)
Pastoral church (51-150)	22 (9.6%)	24 (10.4%)	37 (16.1%)	83 (36.1%)
Program church (151-350)	5 (2.2%)	9 (3.9%)	27 (11.7%)	41 (17.8%)
Corporate church (351 or more)	2 (1%)	6 (2.6%)	36 (15.7%)	44 (19.1%)
Total	45 (19.6%)	56 (24.3%)	129 (56.1%)	230 (100%)

About a third of the respondents indicated that their FC owned one or more vehicles. Seventy-four respondents reported owning a total of 146 vehicles, of which 27 (18.5%) were reported to be equipped with a lift or ramp that could transport people who use wheelchairs, scooters, or other mobility devices.

Of those that owned vehicles, most owned very few. Accordingly, we recoded the data to reflect whether an FC owned one or more vehicles or did not own a vehicle. Table 2 presents vehicle ownership across Rothauge's typology. We did not find statistical evidence of a difference in ownership between the different types of FCs.

The more vehicles an FC reported owning, the more likely they were to report operating accessible vehicles χ^2 (1, N = 177) =10.21, p = .001). Similarly, as the size of the geographic area served increased, the number of vehicles reported being owned increased χ^2 (2, N = 224) 8.03, p = .018; as did the number of accessible vehicles χ^2 (2, N = 179) 7.58, p = .023. The distribution of the number of vehicles owned, however, is skewed toward the low end and limits the ability to generalize these findings.

Table 2. Vehicle Ownership by FCs Across Rothauge's Typology

	Do Not Own a Vehicle	*Own One or More Vehicles*	*Total*
Family church (1–50)	46 (21.4%)	13 (6%)	59 (27.4%)
Pastoral church (51–150)	49 (22.8%)	26 (12.1%)	75 (34.9%)
Program church (151–350)	26 (12.1%)	14 (6.5%)	40 (18.6%)
Corporate church (351 or more)	23 (10.7%)	18 (8.4%)	41 (19.1%)
Total	144 (67%)	71 (33%)	215 (100%)

We asked whether the respondent provided any outreach programs to community residents who were not members of the church and whether they provided transportation to members. A total of 133 (55.2%) respondents reported that they provided outreach programs to nonmembers, and 132 (55.2%) reported providing transportation to members. More FCs reported providing transportation to their members than reported owning vehicles. Anecdotally, several respondents reported organizing volunteers informally to provide rides to other members. There was no statistical evidence of differences between churches across the size of the geography served χ^2 (2, N = 238) = 3.771, p = .152. Larger FCs were, however, more likely to provide outreach programs χ^2(3, N = 230) = 14.71, p = .002. Table 3 portrays the provision of outreach services across Rothauge's typology. In essence, the size of the FC is more important in the provision of outreach services than the size of the community served.

Table 3. Provision of Outreach Programs to Nonmembers Across Rothauge's Typology

	Do Not Provide Outreach	*Provide Outreach to Nonmembers*	*Total*
Family church (1–50)	39 (63%)	23 (37%)	62 (100%)
Pastoral church (51–150)	37 (45%)	45 (55%)	82 (100%)
Program church (151–350)	14 (34%)	27 (66%)	41 (100%)
Corporate church (351 or more)	13 (29%)	32 (71%)	45 (100%)
Total and average	103 (44.8%)	127 (55.2%)	230 (100%)

For those who reported operating any community outreach programs that provided social services to local members who were not members of their FC, we asked how much the FC controlled those service programs and activities, and how much religious content was integrated into those community service activities. The more control exerted by the FC, the more likely religious content was integrated into the services r (131) = .344, p = .000.

We also asked a series of questions about the quality of public transportation for the general public and for people with disabilities in the area served by the FC. On average, respondents rated the quality of public transportation as 1.47 on a 5-point scale, where 0 was poor and 4 was excellent. Respondents rated transportation for people with disabilities as 1.58 on a similar scale. Respondents in smaller rural communities rated the quality of transportation for the general public lower than respondents from larger communities ($\chi^2(4, N = 237) = 16.28, p = .003$), but there was not a significant difference in the rating of the quality of transportation for people with disabilities across communities of different sizes. Table 4 summarizes those ratings across rural geography.

Respondents were asked to rate the willingness of their FC to become involved in providing transportation to people with disabilities and to the general public who lack their own means of transportation on a 5-point scale, where 0 was not willing and 4 was very willing. Overall, respondents indicated that they were neither willing nor unwilling to become involved in providing transportation to people with disabilities (an average rating of 1.96) or the general public (an average of 1.47 on

Table 4. Rating of Quality of Transportation for the General Public and People with Disabilities

	Average Rating of Quality of Public Transportation for General Public	*Average Rating of Quality of Public Transportation for People with Disabilities*
Rural town of 2,500 or less	.95	1.16
Small town of 2,500–10,000	1.44	1.54
Large town of 10,000–50,000	1.66	1.73
Overall	1.47	1.58

Ratings ranged from 0–4, where 0 equaled poor and 4 equaled excellent.

a similar scale). Nevertheless, 32 percent of respondents said they would be willing or very willing to become involved in providing transportation to people with disabilities, and 19 percent responded affirmatively about the general public.

We received an average of 4.2 responses from FBOs for each of 57 CIL service areas, ranging from 3 CIL service areas for which there was 1 responding FBO to 2 for which there were 8. No FBOs submitted responses for 5 CIL service areas. The rating of the quality of public transportation for all individuals and for people with disabilities by CILs average .9 and .8, respectively, on a 5-point scale where 0 was poor and 4 was excellent. We examined the relationship between ratings of the quality of public transportation for all people and for people with disabilities by the CILs and the FBOs in the same area. First, we calculated average ratings for the FBOs associated with each CIL. Next, we conducted a Spearman correlation of these ratings between CILs and FBOs. There was not a statistically significant correlation of ratings between these two groups.

We expected that FBOs might face several barriers to providing transportation to people with disabilities who are not members of their church. Table 5 presents the distribution of the barriers reported by respondents across Rothauge's categories of size. We conducted an analysis of variance to examine the sum of these barriers and found no significance $F(3, 221) = 2.530$, p, = .058. Similarly, Table 6 presents the supports respondents indicated that they needed to be in place in order to become involved in local transportation.

Table 5. Barriers to Involvement in Providing Transportation by Rothauge's Typology

	Not in Mission	*Liability*	*Stretch*	*Lack Skills*	*Lack Staff*	*Lack Money*	*Gvmt.*	*Church Policy*
Family church (1–50)	19 (37.1%)	36 (60.0%)	33 (55.0%)	30 (50%)	50 (83.3%)	55 (91.7%)	24 (40.0%)	5 (8.3%)
Pastoral church (51–150)	33 (40.7%)	46 (56.8%)	47 (58.0%)	47 (58.0%)	62 (76.5%	74 (91.4%)	30 (37.0%)	5 (6.2%)
Program church (151–350)	19 (39.0%)	18 (43.9%)	21 (51.2%)	20 (48.8%)	30 (73.2%)	35 (85.4%)	10 (24.4%)	2 (4.9%)
Corporate church (351 or more)	17 (39.5%)	20 (46.5%)	13 (30.2%)	18 (41.9%)	28 (65.1%)	34 (79.1%)	14 (32.6%)	3 (7.0%)
Overall	91 (38.4%)	127 (53.6%)	117 (49.4%)	121 (51.1%)	178 (75.1%)	207 (87.3%)	81 (34.2%)	16 (6.8%)

Table 6. Requirements for Becoming Involved in Providing Transportation by Rothauge's Typology OR Rural Categories

	Council Approval	*Funding*	*Freedom from Interference*	*Inter-denominational Sponsor*
Family church (1–50)	25 (41.7%)	38 (63.3%)	22 (36.7%)	10 (16.7%)
Pastoral church (51–150)	43 (53.8%)	62 (77.5%)	32 (40.0%)	19 (23.8%)
Program church (151–350)	21 (51.2%)	30 (73.2%)	16 (39.0%)	9 (22.0%)
Corporate church (351 or more)	27 (61.4%)	38 (86.4%)	11 (25%)	14 (31.8%)
Overall	121 (51.1%)	175 (73.8%)	83 (35%)	54 (22.8%)

Discussion

This study reports on the findings of a national survey of rural FBOs. We found that respondents rated the quality of public transportation in their communities as poor to adequate, a relatively comparable assessment to those made by the CILs serving the same areas. About one third of the respondents were either willing or very willing to become involved in providing transportation to people with disabilities who were not members of their congregation. However, the data indicate that these rural congregations owned few vehicles, and that a very small proportion of those were equipped with lifts or ramps that would permit a person who used a wheelchair or scooter to ride.

We found that FBOs in larger communities tended to have more members than those in smaller communities. The data showed a trend toward a significant difference in the proportion of worshiping members who were judged to have significant disabilities, with rural congregations tending to have a slightly higher proportion. This is consistent with the overall demographics of people with disabilities.

We found that larger FBOs were more likely to own and operate vehicles and that those with more vehicles did tend to have more accessible vehicles. There were not statistical differences in the rate of ownership between FBOs in larger and smaller communities; rather, the key variable in ownership appears to be the size of the congregation.

Our analysis showed that the larger the FC, the more likely it was to operate community service programs that served nonmembers. As with vehicle ownership, however, the size of the community did not predict the likelihood of serving the community. Again, the size of the congregation appears to affect the likelihood of providing outreach services to nonmembers.

For those respondents who reported operating an outreach program that provided services to nonmembers, we asked a series of questions about the degree of integration of religion into those services. Our data showed that the more programmatic and financial control exerted over the outreach program by the FC, the more likely religious content was to be integrated into the community service activities.

Finally, FBOs reported that the major barriers facing them in any effort to become involved in providing transportation to people with disabilities in their communities were the lack of financial resources to do so, lack of staff to manage or provide such services, concerns about liability, lack of skills and knowledge about disability and transportation issues, and concerns that such involvement would stretch the time commitments of the congregation. Only about a third of respondents indicated that it was simply not in their mission or that they were concerned about becoming entangled in government programs.

Similarly, respondents indicated that the most significant requirement for their involvement was financial resources. Just over half reported that they would need their council's approval. One third reported that they would need assurances of avoiding government interference in their church. Finally, some indicated that they would only participate if the program was part of an interdenominational effort.

One limitation of the study reflects potential response bias. Several surveys were returned uncompleted with comments that the respondent judged completing such surveys as a distraction from their duty to promote spiritual development and worship. This position reflects an internal orientation in which the sole duty of worship is spiritual development—as opposed to a social gospel orientation in which good works are encouraged as an expression of worship (Chaves 1999). It is possible that many nonrespondents who hold similar beliefs did not even bother to return an uncompleted survey. As such, the results of this survey may represent a bias to congregations with a social gospel foundation and not all congregations.

This observation points to the importance for disability advocates and community planners to understand the orientation and limitation of FCs before approaching them for support in providing community services. While any congregation leader can be approached about becoming involved, their reactions may differ significantly. Some FCs—those that are larger and those with a more liberal theology—are likely to have greater capacity or be more interested. Others FCs—those that are smaller or those with a more fundamental theology—are likely to face more limitations to becoming involved or be less interested in secular activity. Careful consideration of these factors can reduce the likelihood of misunderstandings and frustration.

Another limitation to this study is that it surveyed only rural FBOs operating within the service area of a CIL located in a nonmetropolitan county. While this allowed for a sample of FBOs to compare to the CIL respondents from a previous study and provided a sample framework, it may also reflect an economic and geographic bias based on the locations of those CILs. Moreover, it focuses only on rural communities. There is no comparison to FBOs in larger, metropolitan areas.

FBOs are an important element in nearly every rural community. Given that many people in rural communities are in desperate need of transportation and left literally praying for a ride, it is only natural that rural residents turn to those who may feel a religious duty to serve their fellows. These data will contribute to understanding the potential for FBOs to contribute to solving the rural accessible transportation problem and the limitations they face in doing so. This research may also point to best-practice models for FBO involvement in responding to disability and the national conversation about the role of FBOs in providing public services.

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Endnotes

[1] Focus group participants suggested we use the term "faith community" to embrace a broader array of arrangements than is captured by the terms church or congregation. We use all relevant terms in this report, as appropriate.

[2] We asked respondents to return the survey in the self-addressed return envelope even if they did not complete it so that we would not contact them about it again.

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