UNIVERSITY OF MINNESOTA

CENTER FOR TRANSPORTATION STUDIES

INTELLIGENT TRANSPORTATION SYSTEMS INSTITUTE

Better Understanding The Potential Market Of Metro Transit's Ridership And Services

Final Report

Prepared by:

Kevin J. Krizek
Ahmed M. El-Geneidy

Active Communities / Transportation (ACT) Research Group
Hubert H. Humphrey Institute of Public Affairs
University of Minnesota

CTS 06-09

HUMAN CENTERED TECHNOLOGY TO ENHANCE SAFETY AND TECHNOLOGY

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
CTS 06-09		

4. Title and Subtitle	5. Report Date
Better Understanding the Potential Market of Metro Transit's Ridership and Service	October 2006
	6.
7. Author(s)	8. Performing Organization Report No.
Kevin J. Krizek, Ahmed M. El-Geneidy	
9. Performing Organization Name and Address	10. Project/Task/Work Unit No.
Humphrey Institute of Public Affairs University of Minnesota 301 19th Ave S Minneapolis, MN 55455	CTS Project Number 2004060
	11. Contract (C) or Grant (G) No.
12. Sponsoring Organization Name and Address	13. Type of Report and Period Covered
Intelligent Transportation Systems Institute Center for Transportation Studies University of Minnesota 511 Washington Avenue SE, Suite 200 Minneapolis, MN 55455	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

http://www.cts.umn.edu/pdf/CTS-06-09.pdf

16. Abstract (Limit: 200 words)

Ridership is a key element in the transit industry. Conventional travel analysis focuses on two types of transit users: captive and choice riders. Captive riders are typically those who lack an alternative to transit; they therefore use it as their primary mode of transportation to reach their destination. Choice riders are those who have realistic alternatives (e.g., driving) but choose to use transit for various trips. Service reliability and availability affects the ridership of both populations. However, substantial increases in ridership are usually assumed to be derived only from choice riders. Populations not using transit may be further considered as two distinct populations: auto captives and potential riders. Auto captives are mainly auto users who don’t have transit as a potential mode of transportation or would not even realistically consider using transit. Potential riders are currently not using transit for certain reasons and/or concerns, but may consider the idea of using transit based on certain criteria.

This research analyzes results from two surveys conducted in the Twin Cities metropolitan region: one of existing riders and the other of non-riders. The aim is to understand the characteristics of both captive and choice riders, with an eye toward the factors that can increase ridership of the latter population. This research classifies riders and non-riders differently from previous research. In addition to the captivity of modes, the classification considers regularity of commuting. Accordingly, transit riders are classified as one of four categories: captive riders with regular commuting habits, captive riders with irregular commuting habits, choice riders with regular commuting habits, and choice riders with irregular commuting habits. Similarly, there are four types of non-riders: auto captives with regular commuting habits, auto captives with irregular commuting habits, potential riders with regular commuting habits, and potential riders with irregular commuting habits. Using the survey data to uncover such population, this research then comments on how using advanced forms of technology could increase the ridership from various populations.

17. Document Analysis/Descriptors		18.Availability Statement
Transit demand Transit ridership Captive riders Travel behavior Travel demand	Public transit Bus transit Urban transportation Commuting	No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	41	

Better Understanding the Potential Market of Metro Transit's Ridership and Services

Final Report

Prepared by:

Kevin J. Krizek
Ahmed M. El-Geneidy

Active Communities / Transportation (ACT) Research Group
Hubert H. Humphrey Institute of Public Affairs
University of Minnesota

October 2006

Published by:

Center for Transportation Studies
200 Transportation and Safety Building
511 Washington Ave SE
Minneapolis, MN 55455

Table of Contents

Chapter 1: Introduction 6
Introduction 6
Data 6
Objective 6
Research Questions 7
Organization 8
Chapter 2: Literature Review 9
Introduction 9
Riders and Non-Riders 9
Demand for Transit 10
Technologies 12
Technologies and Demand 13
Chapter 3: Research Methodology and Data 15
Introduction 15
Rider Survey 15
Non-Rider Survey 16
Analysis Methodology 17
Chapter 4: Analysis and Discussion 19
Introduction 19
Rider Analysis 19
Non-Rider Analysis 24
Discussion 30
Technology and Ridership 32
Chapter 5: Conclusion 34
Role of Technology 35
Overall 36
References 37

List of Figures

Figure 1: Direction of commute for riders 16
Figure 2: Distribution of non-riders 17
Figure 3: Cluster Analysis for Riders 23
Figure 4: Non-riders cluster analysis 30
Figure 5: Transit Market Segmentation 31

List of Tables

Table 1: Factor Analysis for Riders Survey 21
Table 2: Cluster analysis 22
Table 3: Factor Analysis for non-riders survey 27
Table 4: Cluster analysis for non-riders survey 28

Summary

Ridership is a key element in the transit industry. Conventional travel analysis focuses on two types of transit users: captive and choice riders. Captive riders are typically those who lack an alternative to transit; they therefore use it as their primary mode of transportation to reach their destination. Choice riders are those who have realistic alternatives (e.g., driving) but choose to use transit for various trips. Service reliability and availability affects the ridership of both populations. However, substantial increases in ridership are usually assumed to be derived only from choice riders. Populations not using transit may be further considered as two distinct populations: auto captives and potential riders. Auto captives are mainly auto users who don't have transit as a potential mode of transportation or would not even realistically consider using transit. Potential riders are currently not using transit for certain reasons and/or concerns, but may consider the idea of using transit based on certain criteria.

This research analyzes results from two surveys conducted in the Twin Cities metropolitan region: one of existing riders and the other of non-riders. The aim is to understand the characteristics of both captive and choice riders, with an eye toward the factors that can increase ridership of the latter population. This research classifies riders and non-riders differently from previous research. In addition to the captivity of modes, the classification considers regularity of commuting. Accordingly, transit riders are classified as one of four categories: captive riders with regular commuting habits, captive riders with irregular commuting habits, choice riders with regular commuting habits, and choice riders with irregular commuting habits. Similarly, there are four types of non-riders: auto captives with regular commuting habits, auto captives with irregular commuting habits, potential riders with regular commuting habits, and potential riders with irregular commuting habits. Using the survey data to uncover such population, this research then comments on how using advanced forms of technology could increase the ridership from various populations.

Chapter 1: Introduction

Introduction

In 2000 Metro Transit, the local transit provider for the Twin Cities region, served more than 73,000 unlinked passenger trips. In 2003, this number fell to slightly more than 67,000 unlinked passenger trips. These numbers indicate a decline in demand for public transit service in the Twin Cities during this period—a decline not found in other major transit agencies around the country. In 2005, the opening of the Hiawatha Light Rail line led to a 30 percent increase in transit ridership relative to the previous year. It is important to note that Metro Transit is facing other challenges that relate to serving a diverse audience in the Twin Cities, which includes people of all ages and backgrounds with varying riding habits, needs, and preferences.

This research has two main goals. The first is to provide better knowledge of the composition of the travel market in the Twin Cities metropolitan area, especially as it relates to transit-related services. The second is to better understand characteristics of the population not using transit and shedding light on information that may attract them to the public transit market.

Data

This work is based on survey data collected by Metro Transit. The data emplyed includes the: (a) 2001 survey for current riders, and (b) the 1999 survey for non-riders (the data for both surveys were collected by Periscope). The former provides information on existing use; the latter provides insights into how to better attract residents not currently using the Metro Transit services. These data sources represent extremely rich surveys which, after critical analysis, yield useful information to help: (a) increase the efficiency of existing service, (b) suggest ways to use technology enhancements to boost ridership, and (c) learn of different market segments of travelers.

Objective

The overall objective of this research is to employ a market segmentation approach to shed light on distinct groups within the population that share similar sets of values or attitudes toward travel (generally) or transit (specifically). The research focuses on examining attitudes and preferences of current and potential riders. Specific objectives of this research project are summarized below:

- To identify distinct segments of the Twin Cities market, which differ in their attitudes toward everyday travel and the choice of behavior (using existing transit ridership data sources).
- To identify and suggest ways in which technology improvements/enhancements could most effectively and strategically enhance service.
- To suggest ways in which an increase in technology use could most effectively monitor existing patronage.
- To better understand the values that different travelers place on their everyday travel by transit.
- To uncover ways Metro Transit can best supplement existing service.
- To uncover ways Metro Transit can improve or enhance their survey.

Research Questions

Conventional analysis of transit use articulates two types of transit users: captive and choice riders. Captive riders are those who rely mainly on transit as their main mode of transportation, while choice riders are those who have alternative modes to use to reach their desired destinations yet they prefer to use transit (Jin, Beimborn, and Greenwald 2005). In a similar vein, populations *not* using transit may be further considered as two distinct populations: potential riders and auto captives. Potential riders are currently not using transit for a variety of reasons and/or concerns, but may consider the idea of using transit based on certain criteria. On the other hand, auto captives are exclusively auto users who fail to have transit as a potential mode of transportation or would not even realistically consider using transit. Meanwhile travel behavior research defines commuters differently as regular and irregular commuters. The first are regular commuters who mainly include workers and/or students that regularly travel to the same destination on regular basis. The second are irregular commuters (or other travelers) who tend to have less frequent or more irregular travel patterns.

Using these populations as the basis for potential markets for transit use, this research aims better understand their characteristics and suggest overall improvements that could be made recruit transit use. It further understands the characteristics of each of these groups and the factors affecting their potential transit use. Three central questions are posed:

1. What do we know of each of these populations?
2. What are the prospects for increasing the number of choice riders?
3. What role can technology play in attracting more choice riders?

Organization

This research project carries out a market segmentation of travelers. These market segments are useful in pointing to instances where additional data/information should be targeted (through more advanced data collection means using available technology) as well as strategic planning of services according to these market segments. The next chapter includes a literature review on the types of transit riders and non-riders, transit demand, different technologies available in the transit industry, and the effects of these technologies on the demand for transit service. The third chapter examines the research methodology and the type of data used in the analysis. Chapter 4 discusses the analysis; Chapter 5 describes conclusions and recommendations.

Chapter 2: Literature Review

Introduction

Any research discussing the variety of types of transit (and non-transit) users requires that several strands of information be woven together. The first strand examines transit ridership, and regular and irregular commuting patterns. This provides the necessary background to define and analyze various types of transit riders. The second strand investigates the affect of various factors on transit demand. The section reviews common factors such as cost, number of potential riders, access, and elasticity. The final strand explores current transit technology and its potential to increase ridership through improvements in service and reliability.

Riders and Non-Riders

Relying on the previously described populations, captive versus choice riders, the former usually exceeds the latter in terms of overall magnitude. For example, the Chicago Transit Authority (CTA) reports that more than two-thirds of its riders were choice (Chicago Transit Authority, 2001); this number hovers around three-quarters as reported by the transit agency (Tri-County Metropolitan District of Oregon, TriMet) in Portland. Alternatively, Horowitz (1984) assumed the number of captive riders is much higher compared to choice ones while conducting a demand model for a single transit route. The literature often associates the population of transit captive riders with various demographic characteristics, for example: low income, elderly, people with disabilities, children, families whose travel needs cannot be met with only one car, and those who chose not to own or use personal transportation (S. Polzin *et al.*, 2000).

Notwithstanding the above, a survey conducted after the opening of the Orange Line in Chicago, part of the CTA rail service, revealed that 25 percent of the users of this line were new to transit. This population was largely represented by former automobile commuters or those people who took new trips for which the automobile was available (LaBelle & Stuart, 1996). In general, new transit users are derived from the potential rider population, while losses in transit ridership are targeted to have come from choice riders (due to changes in demographic characteristics (e.g., change in income or car ownership) of the riders).

In order to understand the transit market it is important to understand the demand for transit and the factors that affect such demand to switch a potential rider to a choice rider. In the following section discusses the demand for transit service, enabling the understanding of the factors affecting elasticity of demand.

Demand for Transit

Factors affecting passengers' decision to use transit versus other modes are affected by several costs, including monetary costs (i.e., fares), the cost of travel time, the cost of access and egress time, effort, and finally, the cost of passenger discomfort. The Transit Capacity and Quality of Service Manual (TCQSM) provides a comprehensive approach to understanding the transit trip decision making processes, which includes several transit availability factors. These factors address the spatial and temporal availability of service at both ends of the trip (origins and destinations) (Kittelson & Associates, 2003). Not surprisingly, the presence or absence of transit service near origin and destination is found by Murray (2001) to be a major factor in choosing transit as a mode for travel.

For passengers, transit trips have three main components: (1) walking time, (2) waiting time, and (3) travel time in the vehicle. Passengers value their waiting time the most, at a level two to three times that off in-vehicle-time (Mohring *et al.*, 1987). Walking time can be divided to access time to the bus stop at the trip origin and egress time at the trip destination.

In general transit demand relates to the number of potential users along a route (e.g., place of residence, place of work, and various transit amenities such as park and ride or transfer). Levinson (1985) developed a model to forecast ridership along bus transit routes predicted by the following factors: passenger activity, population, employment, travel time, and demand elasticity factors. The virtues of the Levinson study is that it provides a reasonable approach to understanding the demand for transit even with limited data availability at the time it was completed. The work estimates bus ridership as a function of car ownership and walking distance to bus stops. His model implies the idea that transit riders are captive or not; he therefore includes variables such as travel time (to pick up preferences for choice riders) and demographic variables (to pick up characteristics of non-choice riders).

Much research also relates ridership to access; the more accessible the bus stops are the higher the use (Hsiao ***et al.***, 1997; S. E. Polzin ***et al.***, 2002). This might not always be the case, however, since ridership depends on additional variables such as service variability and /or socio-demographic information. The variability and frequency of service represents two basic factors that affect demand at a stop. This will be discussed in greater detail in this section.

Several studies suggest contradictory outputs regarding the elasticity of demand for transit. Some studies indicate that average running time increases passenger demand more than other variables (Lago *et al.*, 1981; Rodriguez & Ardila, 2002). However such conclusions are mostly based on captive riders. Other studies indicate that passengers are more sensitive to out of vehicle time (Kemp, 1973; Lago & Mayworm, 1981; Mohring et al., 1987; Pushkarev & Zupan, 1977). Passenger demand is elastic when comparing it to time, while it is inelastic when measuring it to changes in fare. Two comprehensive studies regarding the elasticity of demand with respect to fare change found that demand for transit service is inelastic when it comes to changes in price (Goodwin, 1992; Oum *et al.*, 1992). The value associated to time is usually higher than the fare (Mohring et al., 1987).

Domencich, Kraft, and Valette (1968) estimate the elasticities of demand for public transit in relation to all aspects of time and cost. They found that passenger demand will decrease by 3.9% for a 10% increase in travel time, while demand will decrease by 7% for each 10% increase in access, egress, and waiting time. These findings were reported and validated later by Kraft and Domencich (1972) and O'Sullivan (2000). Although it combines both wait time and access into one category the study is still notable as being one of the few to address this topic. The differences between these two studies may exist due to issues of sample size and units of analysis, in addition to locations where the studies were conducted. Generalization based on this research is difficult, yet the overlap in the findings can be used as indicators for expected changes in passenger demand due to potential improvements in the current transit service. Both captive and choice riders are affected by the changes in the service. Choice riders tend to be more sensitive since they represent the majority of the riders and if service declines, they have an alternative. Potential riders can be attracted by improvements in the levels of service and decline in both in-vehicle and out of vehicle time.

Technologies

In 2000 the U.S. government ceased its intentional degradation of the civilian global positioning system (GPS) signal, called Selective Availability (SA), which was used to protect military operations. SA distorted the accuracy of any GPS system, making it very hard to use a GPS to accurately locate a vehicle on a road (Longley *et al.*, 2001). Currently off-the-shelf GPS systems have an accuracy range from three to ten meters. Various transit agencies around the world and in the U.S. started using GPS systems in the early 1990s yet such systems were only widespread post 2000. Most U.S. agencies now have some sort of GPS system as part of an enhanced automatic vehicle location (AVL) system. AVL systems are used to monitor and archive the location of vehicles on the road and send such information through radio or wifi waves to transit management centers (McQueen & McQueen, 1999).

For example, in 1998 TriMet in Portland implemented the bus dispatch system (BDS) which included GPS-based AVL technology and more widespread deployment of Automatic Passenger Counters APCs. The BDS provides bus operators with real time information on schedule adherence, while extensive archived operations and passenger data provides operations managers, field supervisors, service planners, schedulers, maintenance managers, and market researchers with the information they needed to adapt to changes in the operating environment. Thus, despite worsening conditions, a number of service performance and quality indicators (e.g., on-time performance, running times, headway maintenance, recovery/layover requirements) had either stabilized or improved over the latter part of the decade (Strathman *et al.*, 2000). In light of these outcomes, TriMet has been recognized as an industry leader for its ability to recover data with advanced technology and to effectively translate that data into higher quality and more efficient bus service (Furth *et al.*, 2003). Reports from TriMet’s annual ridership also reflect these improvements.

Metro Transit, the local transit authority in the Twin Cities region, implemented an AVL system with similar characteristics in 1999 and tested it through 2002 under a project named Orion. Metro Transit upgraded Orion in 2005 to a fully functional system that enables archiving. The current AVL system offers a different opportunity since it depends mainly on the radio system, which sends bus AVL information every 60 seconds (as opposed to other stop based systems). Such information enables the conduction of microscopic analysis and better understanding of the externalities that affect bus service throughout the trip. Accordingly, improvements in reliability can be recommended through the analysis of such information. The use of such information has been limited to evaluate live on time performance of vehicles at the transit management center. Yet the use of such data for understanding travel demand or help in leveraging service is currently only in its infancy. Metro Transit has a limited number of buses equipped with APC's (10%), which may be a barrier in better understanding demand in the region. The newly implemented smart pass system may be a useful alternative for understanding and monitoring passenger activity and accordingly understanding the transit market of frequent passengers.

Technologies and Demand

The relationship between transportation technologies and passenger demand is indirect. Passenger demand is mainly affected by either the in-vehicle or out-of-vehicle times, and technologies can help decrease both. In the early 1990s, London Transport Buses, the local transit agency for the greater London region, implemented a next arrival system (countdown). A next arrival system relies mainly on GPS and AVL information sent from the buses to the management center. The center uses that information to determine the current location of the bus and generate an approximate arrival time at certain stops in the system. The management center sends the expected arrival time to mounted displays at the stops to inform passengers regarding the expected arrival time of the bus. A study was conducted to evaluate such a system and measure passenger satisfaction (Smith *et al.*, 1994). The study found passenger satisfaction increased in terms of on-time performance, although actual service did not change. Passengers tend to value more the information being delivered to them. Currently various agencies in the

U.S. have installed transit trackers along rail and bus stations to increase levels of satisfaction and accordingly demand. With the wide spread use of the World Wide Web some agencies provide this service to every stop along the system. Passenger can access the information either through the transit agency web site or through phone services.

Chapter 3: Research Methodology and Data

Introduction

This research is based on available data collected by Metro Transit, in particular, the Rider and Non-Rider surveys which were recently administered. These surveys include the, (a) 2001 survey for current riders, and (b) the 1999 survey for non-riders. The former provides information on existing use; the latter provides insights into how to better attract people who are not currently using the services provided by Metro Transit.

Rider Survey

The current rider survey was conducted by Metro Transit in 2001 and included 83 questions. The questions covered a variety of topics including origins, destinations, rider satisfaction, and concerns about the system. Figure 1 shows a cross tabulation for the origin and destination—broken down by the two central cities and their suburbs—of each respondent at the time when the survey was conducted by city. The majority of the survey riders were either coming from or going to Minneapolis. This seems logical since the city of Minneapolis has the greatest number of routes serving it in the Twin Cities region. The figure reveals two other differences between Minneapolis and St Paul riders. Minneapolis and Minneapolis Suburb riders primarily commute within Minneapolis and its suburbs. In comparison, St. Paul and St. Paul Suburb riders seem to commute equally between Minneapolis and St. Paul. Another difference is the number of Minneapolis transit riders is much larger than the population of St. Paul riders. The 83 questions also included questions related to riders' perception of safety and cleanness of the service, an evaluation of drivers' attitudes, the importance of customer support services, opinion and concern of transit service reliability and on-time performance, and a set of socio-demographic indicators. Additionally, the survey asked a key question concerning the number of years the rider has been using transit. This sample included 4,408 observations. Several questions, however, were eliminated since many of the responses were not in the form of interval data and therefore were not compatible with the analysis methodology. The final set of questions used in the analysis was based on the applicability and the factor loading.

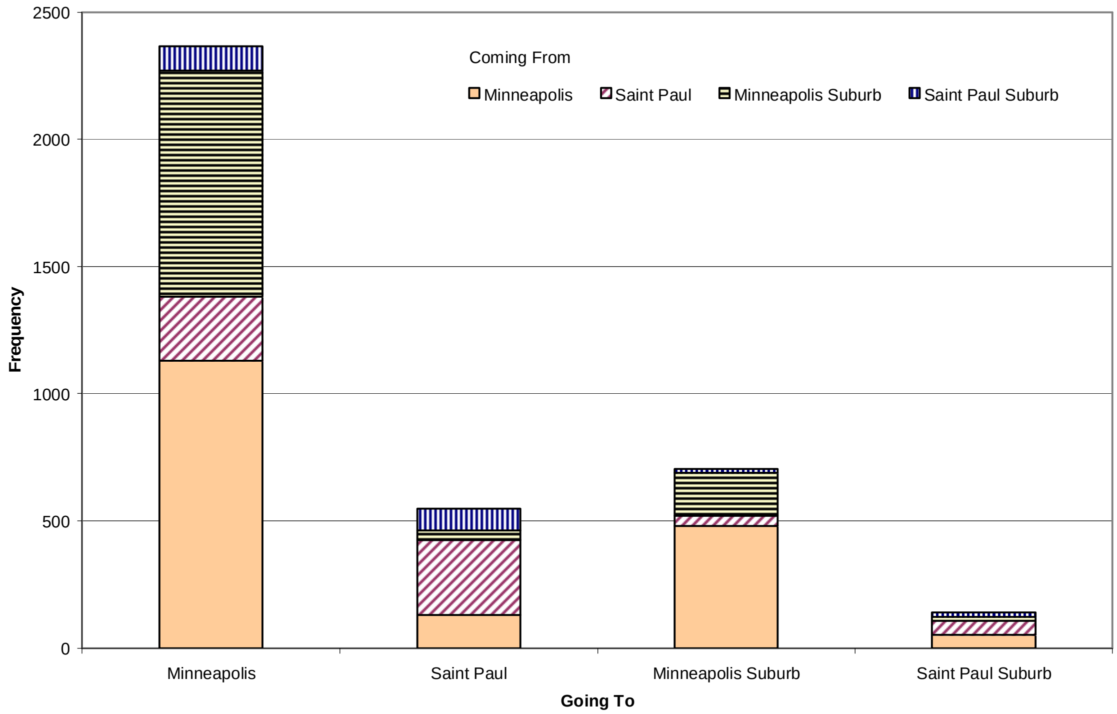

Figure 1: Direction of commute for riders

Non-Rider Survey

Metro transit selected conducted non-rider survey through random digit dial phone interviews. The first question was "are you currently using Metro Transit?" If the respondent answered yes, the interview was terminated, if no the interviewer preceded with the remaining set of questions. Metro Transit conducted 500 phone interviews in the months of November and December 1999. Each interview included 138 questions directed to non-riders, covering a variety of topics including: reason not using transit, safety and comfort of using transit, concerns related to drivers attitude, concerns related to amenities, concerns related to the commute characteristics, concerns of service reliability if using transit is an option, the level of attractiveness of the current service, and various socio-demographic and economic characteristics. Figure 2 shows the distribution of the surveyed population in the Twin Cities region by zip code.

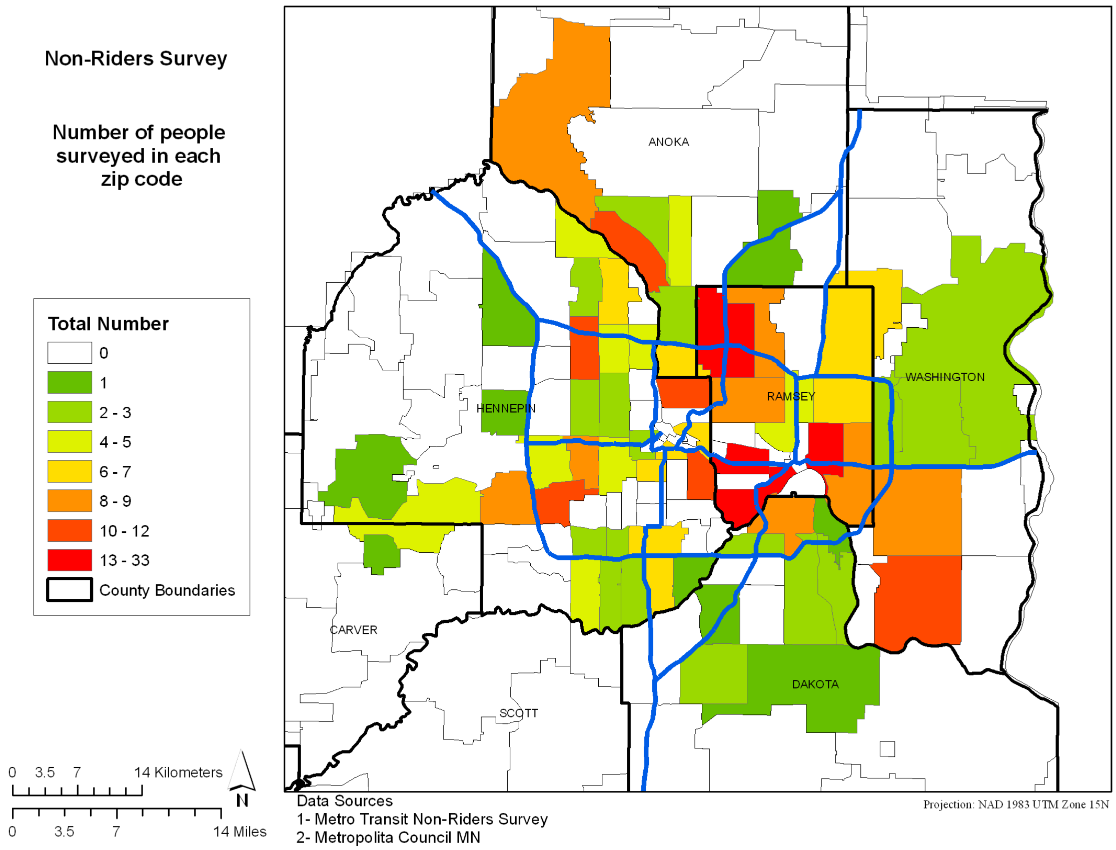

Figure 2: Distribution of non-riders

One can make several observations concerning non-rider survey respondents from Figure 2. St. Paul has several zip codes with large concentrations of non-riders. This reflects the numbers presented earlier in Figure 1, fewer people in St. Paul use transit. On the other hand, a larger number of zip codes in Minneapolis zero respondents. This is especially true in south Minneapolis, the area with perhaps the largest coverage and most frequent service in the Twin Cities. Since a random process selects phone numbers, the chance of calling a non-rider randomly in this area is lower than in many of the surrounding areas.

Analysis Methodology

Using the survey data described earlier in this chapter, the next step is to employ two statistical procedures to uncover the characteristics of the riders and on-riders. The first approach uses factor analysis to learn how each of our measures initially relates to one another. Factor analysis (or principal component analysis) is a statistical technique to extract a small number of fundamental dimensions (factors) from a larger set of intercorrelated variables measuring various aspects of those dimensions. It is used to study the patterns of relationship among many variables with the goal of discovering something about the nature of the measured variables that affect them. By doing so, we are able to better understand how specific elements within one dimension (e.g., waiting time for the next bus) relate to outcomes in another dimension (e.g., drivers behavior), thereby capturing possible interdependencies (Maruyama, 1998). While factor analysis is widely used in social science research, to our knowledge it has limited use in the transit literature. Of the few studies uncovered, Syed and Khan (2000) identified key factors that serve as determinants of public transit ridership from attitude survey responses in 1995. They identified eight key factors that determine transit use: (1) bus information, (2) on-street service, (3) station safety, (4) customer service, (5) safety in route, (6) reduced fares, (7) cleanliness, and (8) general attitude. This research uses a similar approach to understand the factors affecting both riders and non-riders, and relate it to transit service.

Using the factor analysis as the basis for the "reduced-form" data, the second approach uses cluster analysis to understand how each of the factors combines to represent different types of riders and non-riders. The primary questions posed in this part of the research is, do clusters emerge from the analysis of factor interactions to reveal ridership behavior?

Chapter 4: Analysis and Discussion

Introduction

Our approach in this application is to consider—in an integrated manner—various decisions that an individual faces about their mode of transportation, aspects of service they value, their travel patterns, and demographic characteristics. We analyze the surveys for riders and non-riders separately, using the same statistical analysis method which enables us to uncover aspects of transit service each group values.

Rider Analysis

This section focuses on current users of the transit system in efforts to understand the principal factors affecting their use and then classifying them into groups based on such information. Our initial goal was to determine the extent to which responses to survey questions relate to one another and in what manner. We identified responses from 33 questions and conducted principal components factor analysis. The analysis revealed eight factors with eigenvalues greater than one and after inspection, we decided to retain all eight values. The results of the factor loadings are displayed in table 1 and the variables are listed in order of the size of their factor loadings (i.e., coefficients). Within each of the eight blocks of variables, the high values (above about 0.5 in absolute value, indicated in bold) are generally all in a single column. A separate column represents each of the eight blocks (aka factors). Cumulatively, theses eight factors extracted explain almost 62 percent of overall variation in the data.

After inspecting the content of each factor, we label them accordingly, including those pertaining to: (1) driver's attitude, (2) customer service, (3) type of service, (4) reliability, (5) income and value of time, (6) clean and comfort of buses, (7) safety, and (8) personal.

- The first factor focuses on driver's attitude and behavior, including professional appearance, attitude in terms of operating the bus responsibly and safely, courteousness and helpfulness and calling for stops and intersections.
- The second factor measures the effect of customer service in terms of the accuracy of information being delivered to riders either through phone calls or onboard the bus. It also includes the courteousness of customer support personal and the amount of time spent on phone to retrieve transit information.

- The third factor, type of service, captures factors that apply principally to express service (which differs from regular bus routes in terms of speed and the number of stops). Such service is available in the Twin Cities near park and ride locations and runs parallel to several routes. Express service routes have a limited number of stops along major arterials with a section operating along freeways. Additionally, in the Twin Cities region express service operates along various freeways with the right to operate in the freeway shoulders during congestion. Accordingly express service is a major attractor to riders who are trying to avoid congestion. The travel time factor includes the availability of more express service, time of operation during the day, type of bus used as express, location of the park and ride facilities, amenities nearby park and ride facilities, and finally a faster method of payment.
- The reliability of the transit service, the fourth factor, is a measure of the user's level of satisfaction in term of timeliness. (It is worth nothing that reliability is a term with differing interpretations based on perspectives of the user versus the operator. From a passenger's perspective, a reliable transit service can be measured through on-time performance. From an agency's perspective it is a variability issue.) Transit service reliability for riders is determined in this analysis through a direct question on service reliability and a couple of other questions measuring it indirectly. These questions include schedule adherence, rider's satisfaction of the service and trip length, and the likeliness of recommending transit to others.
- The fifth factor includes the measures characteristics of the rider and their value of time, including household income, the number of working automobiles, comfort of any needed transfer, and time spent during such process.
- The sixth factor considers the cleanness and comfort of the bus.
- The seventh factor measures the safety of using the service. The safety includes feeling safe during both in vehicle and out of vehicle time.
- The eighth factor is the personal factor including the number of years of using the service and respondent age.

Table 1: Factor Analysis for Riders Survey

	Question	1	2	3	4	5	6	7	8
Driver's Attitude	Drivers present a professional appearance	**0.73**	0.05	0.00	0.22	0.07	0.09	0.16	-0.02
	Drivers operate buses in a safe and responsible manner	**0.71**	0.08	-0.03	0.17	0.06	0.14	0.16	-0.01
	Drivers call out street names at transfer points and intersections with stop lights	**0.58**	0.01	0.06	0.20	-0.01	0.25	-0.09	-0.04
	Drivers are courteous	**0.86**	-0.04	0.01	0.20	0.00	0.02	0.09	-0.01
	Drivers are helpful	**0.80**	0.01	0.03	0.12	0.07	0.04	0.04	-0.02
Customer Service	Clear, accurate information: Info Line	0.02	**0.88**	0.06	0.05	0.18	0.00	0.03	-0.04
	You are able to access route or schedule information using the MT Information Line	0.02	**0.84**	0.09	0.06	0.18	0.00	0.02	-0.01
	Courteous customer service on MT info line	0.06	**0.83**	0.05	0.05	0.10	-0.03	0.03	0.00
	Clear, accurate information: Bus Line	0.00	**0.70**	0.15	0.07	0.16	0.07	-0.06	-0.01
	Reduction in time spent waiting to get bus information by phone	-0.01	**0.66**	0.29	-0.15	0.15	0.10	-0.02	0.07
Type of Service	Longer bus service hours	-0.02	0.09	**0.82**	-0.13	-0.02	-0.02	0.14	0.02
	More express bus routes	0.01	0.09	**0.82**	-0.18	-0.02	-0.03	0.12	-0.03
	Coach buses for longer express commutes	0.00	0.12	**0.76**	-0.04	0.01	-0.06	0.00	0.00
	Park & Ride amenities such as a convenience store, daycare facility, or dry cleaner	0.02	0.15	**0.59**	0.14	-0.07	0.03	-0.08	-0.17
	Express bus hours of operation are sufficient	0.06	-0.04	**0.54**	0.36	0.07	-0.01	0.03	0.05
	Park & Ride lots are conveniently located	0.01	0.03	**0.53**	0.41	-0.20	-0.05	-0.11	-0.16
	Faster ways to pay your fare	0.01	0.10	**0.50**	0.02	0.04	0.01	-0.13	0.04
Reliability	Overall, you are satisfied with Metro Transit bus service	0.19	0.08	-0.03	**0.67**	0.05	0.11	0.20	-0.02
	Buses run on schedule	0.29	-0.04	0.03	**0.67**	0.04	0.07	0.04	0.01
	Buses are reliable	0.33	0.00	0.03	**0.61**	0.05	0.23	0.22	-0.04
	You are likely to recommend Metro Transit bus service to family, friends, or co-workers	0.18	0.06	0.06	**0.57**	-0.04	0.06	0.16	0.08
	Trip length is satisfactory	0.15	0.03	-0.03	**0.56**	-0.04	0.36	0.03	0.08
Income and Value of Time	Approximately what was your family's total income last year?	-0.01	-0.23	0.08	0.13	**-0.67**	-0.11	0.07	0.13
	How many working automobiles do you have available for your use?	-0.01	-0.20	0.15	0.19	**-0.62**	-0.14	-0.02	-0.13
	You are comfortable transferring from one bus to another to complete your trip	0.09	0.21	0.04	0.10	**0.82**	0.04	0.06	-0.03
	Time waiting for transfer buses is not excessive	0.08	0.16	0.10	0.22	**0.80**	-0.01	-0.01	-0.01
Clean and Comfort	Buses are clean	0.38	-0.05	0.02	0.35	-0.03	**0.40**	0.19	-0.16
	Seats are comfortable	0.18	0.07	-0.06	0.18	0.16	**0.84**	0.06	0.01
	Buses are comfortable	0.26	0.06	-0.03	0.27	0.14	**0.81**	0.11	-0.01
Safety	You feel safe while waiting for the bus during the day	0.13	0.01	-0.02	0.25	0.00	0.07	**0.83**	-0.04
	You feel safe while riding on buses during the day	0.22	-0.01	-0.01	0.26	0.00	0.11	**0.80**	-0.05
Personal	How long have you used our bus service?	-0.09	0.09	0.02	-0.08	0.03	0.02	0.02	**0.82**
	What is your age?	0.01	-0.09	-0.12	0.17	-0.08	-0.04	-0.11	**0.79**

Having identified how each of the responses relates to one other, the second approach is to employ iterative cluster analysis to identify groupings of riders with similar concerns related to the transit service characteristics. In this context, these groupings are referred to as riders type (captive and/or choice). The clustering uses the K-means statistical routine in the SPSS statistical package and the analysis is based on the difference and similarity between the factor scores output for each of the eight variables. An important issue to address up front is the most appropriate number of rider types to accommodate the full range of known types of riders. A combination of four factors ultimately guided our decision: (a) statistical output, (b) the manner in which the output is transferable for transit policy, (c) lessons from past research efforts, and (d) common sense and intuition. Since the prevailing literature suggests two types of riders—choice and captive—we started with two clusters. The output using two clusters is dominated by the personal factor, which had the lowest loading in the factor analysis. Accordingly, we sought greater variation our ability to surmise about these two groups. We therefore sought four clusters, splitting both choice and captive riders, but also accounting for regular and irregular riders. The values of the cluster centers for each type of rider (regular captive, irregular captive, regular choice, and irregular choice) are presented numerically in Table 2 and graphically in Figure 3.

Table 2: Cluster analysis

	Choice Riders		Captive Riders	
	Regular	Irregular	Irregular	Regular
Driver's Attitude	-0.14	0.22	0.17	-0.13
Customer Service	0.44	-0.38	0.01	-0.21
Type of Service	0.35	-0.60	0.24	-0.09
Reliability	0.18	-0.10	-0.31	0.09
Income and Value of Time	0.73	0.48	-0.15	-1.15
Comfort	0.34	0.25	-1.50	0.44
Safety	0.21	-0.56	0.10	0.15
Personal	0.39	-0.77	-0.01	0.18

The height and direction of each bar represents the value of the cluster center for each of the previously defined eight factors. Figure 3 shows the defining characteristics of the clusters along with the percentage of individuals assigned to each individual cluster. A general observation is that captive riders represent 46 percent, while choice riders represent 54 percent of the surveyed population.

Regular choice riders (32 percent) are affected by all the factors except for driver's attitude. Within the transit industry it is known that drivers change routes every three to four months and are given the choice to change the time of their operation and the route they serve frequently. Accordingly for a person who rides the bus on regular basis, the impact of the driver's attitude is minimum compared to the other factors. Reliability, value of time, and type of service has the greatest effect on regular choice riders. The naming of this group is derived from the both the personal factor and that of the driver's behavior. Irregular choice riders (22 percent) are those who tend to choose transit as an alternative to other modes. They care about the driver's attitude, they are searching more for comfort in the trip, and they value their time more than captive riders. Their personal factor indicates that they are people who tend to use transit in an irregular basis. Since they care about the driver's attitude the most, this reflects their level of experience with the transit system. A regular rider will notice that riding along with the same driver over a year on a daily basis is something rare.

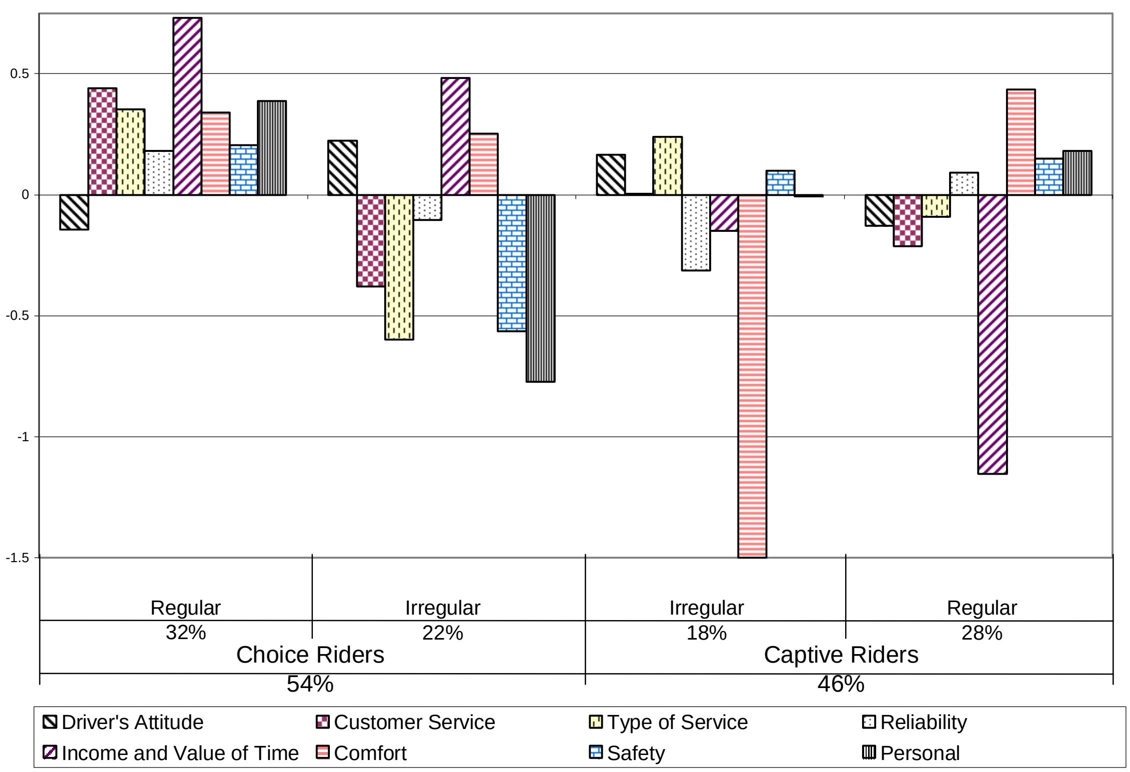

Figure 3: Cluster Analysis for Riders

Figure 3 also shows the division of captive riders into regular and irregular ones. Irregular riders are people who tend to use transit occasionally and they do not have other alternatives. The factors affecting them are the driver's attitude, type of service, customer support, and safety. Finally, the fourth type of riders is the regular captive. Regular captive riders are those who do not have any other option but transit. Since they are regular users they do care about reliability of the service, bus comfort, and safety. The personal factor indicates they are regular users of the service.

Comparing the percentages of captive and non-captives in the Twin Cities region to other metropolitan areas in the United States, where choice riders compose around 70-80 percent of the entire ridership, it is clear that more choice riders (regular and irregular) can be attracted to the Metro Transit system through improvements in the system.

Non-Rider Analysis

For non-riders, we completed a similar process to uncover factors that relate to one another and to group sample into different classifications. For analysis, we selected 36 questions from the non-riders survey to capture their perceptions of transit as a mode of transportation. Based on this survey data, the factor analysis suggests 11 different factors, all with an eigenvalue greater than 1. Table 3 lists the variables in order of the size of their factor loadings (i.e., coefficients), shown for each of 11 different blocks of variables (aka factors), representing (1) safety and comfort, (2) driver's attitude, (3) amenities and special requests, (4) commute characteristics, (5) reliability, (6) location and type of service, (7) service attractiveness, (8) travel cost, (9) children, (10) travel time, and (11) personal. High values (above about 0.5 in absolute value, indicated in bold) are all in a single column. Cumulatively, the 11 factors extracted explain almost 71 percent of overall variation in the data.

- The first factor that affects non-riders is the safety and comfort of the provided service. The safety aspect of the factor originates from questions related to safety at the bus stop and along the trip, while the comfort portion originates from cleanliness of the bus and bus stop, the availability of shelters, and the comfort of seating and temperature inside the bus.

- Similar to the findings of the riders, driver's attitude is found to have an effect on non-riders. Driver's attitude is derived form questions related to the driver's courteousness, helpfulness, competency, and accuracy of stop announcement.
- The third factor is the presence of various amenities the bus stops and special requests related to services that can be provided at work locations. The specialized requests include the availability of service during emergency and late night hours; the availability of service to shopping areas during lunch hours, the presence of a car provided by the employer for work and emergency trips and personalized help in understanding schedules and finding routes.
- The fourth factor is the characteristics of the regular commute, which includes questions related to distances and travel time from the non-riders home to various destinations.
- The fifth factor is the reliability of the transit service provided. For non-riders reliability includes on-time performance, frequency of service, clearness of stop announcements, and visibility of bus numbers on the outside of the bus.
- The location and type of service is another factor affecting non-riders. The location of service includes distance to the nearest bus stop from the non-rider's origins and destinations. Type of service includes light rail, and high frequency service with short headways.
- The attractiveness of service, the seventh factor, is derived from incentives to use the service, either from employers through reduced fairs or through free service provided by the agency during congestion periods. Attractiveness also includes the acceptance of non-riders to use transit as a mode of transportation.
- The eighth factor affecting non-riders is travel cost and is originated from two questions. The first asks about the actual cost of parking that non-rider pays for parking at work. The second asks non-riders to estimate the current cost of using Metro Transit system.
- Having to transport kids from and to daycare or school is the ninth factor.

- The tenth factor is travel time, derived from a question comparing travel time using transit to other modes of transportation.
- The last factor relates to the personal preference of non-riders. This preference originated from a question stating “people like me do not ride transit.” This cluster is important in differentiating between the various types of non-riders (auto captives and potential riders).

Table 3: Factor Analysis for non-riders survey

		1	2	3	4	5	6	7	8	9	10	11
Safety and Comfort	Safety from crime on buses	**0.82**	0.30	0.02	-0.01	-0.05	-0.05	0.18	0.03	-0.04	0.10	0.11
	Safety at the bus stops	**0.81**	0.16	-0.01	0.06	0.16	-0.09	0.04	-0.04	0.01	0.17	0.02
	Availability of shelters where you wait for the bus	**0.65**	-0.15	-0.18	0.04	0.38	-0.04	0.09	0.00	0.00	0.05	-0.10
	Cleanliness of the buses	**0.62**	0.42	-0.05	-0.02	0.10	0.12	0.11	0.03	-0.08	0.07	0.08
	Cleanliness of the bus stops	**0.61**	0.29	-0.02	0.03	0.29	0.12	-0.01	0.02	-0.02	-0.09	0.15
	Comfort of the bus such as seating and temperature inside the bus	**0.56**	0.31	-0.15	-0.08	0.38	-0.04	0.11	0.04	-0.09	-0.25	0.22
Driver's Attitude	Courteousness of the bus drivers	0.23	**0.84**	0.09	-0.17	0.14	-0.04	0.16	-0.01	0.10	0.04	0.08
	Helpfulness of the bus drivers	0.22	**0.83**	-0.03	-0.18	0.19	-0.04	0.19	-0.06	0.01	0.05	-0.06
	Driving competency of the bus drivers	0.21	**0.79**	-0.14	0.01	0.03	0.10	-0.01	-0.01	-0.14	0.08	0.23
	Accuracy of the bus stop announcements	0.31	**0.56**	0.00	0.07	0.47	0.07	-0.07	-0.04	-0.26	-0.08	-0.08
Amenities and Special Request	Guaranteed ride home in emergencies during work hours or if you had to work late	-0.09	0.03	**0.77**	0.07	-0.07	0.09	0.12	0.15	0.04	-0.08	0.09
	Shuttle or van service to shopping centers or stores during lunch breaks	-0.06	-0.12	**0.72**	0.12	0.07	0.03	0.13	0.03	0.06	-0.05	-0.25
	Employer-provided car for work purposes or emergencies while at work	0.01	0.00	**0.69**	0.08	-0.06	0.11	0.07	-0.15	0.39	-0.04	0.02
	Personalized help finding bus routes or scheduling information	-0.05	-0.04	**0.67**	0.09	-0.12	0.23	0.15	-0.02	-0.28	0.13	-0.02
	More amenities such as day care, coffee shops at Park-and-Ride lots	-0.11	0.06	**0.55**	0.35	0.15	0.18	-0.03	-0.21	0.30	0.28	0.04
Commute Characteristics	How many miles do you typically commute to work or school one way?	0.07	-0.14	0.09	**0.90**	0.02	-0.07	0.11	-0.03	0.04	-0.09	0.01
	How long does it take you to commute to work or school one way in a typical day?	0.02	-0.02	0.05	**0.84**	0.04	0.01	0.09	-0.15	0.17	0.00	0.08
	Approximately how far is it from your home to the nearest bus stop or shelter?	-0.01	-0.07	0.18	**0.78**	-0.04	-0.02	-0.09	0.05	-0.04	0.06	-0.06
	How long do you think it would take you to commute to work or school using a bus?	-0.05	-0.03	0.02	**0.54**	0.06	-0.09	0.00	-0.09	0.12	-0.64	0.01
Reliability	Frequency of service or time between buses	0.30	0.11	-0.01	-0.02	**0.74**	-0.13	0.09	0.05	0.11	0.15	0.00
	Visibility of route numbers or names on the outside of the bus	0.15	0.21	-0.03	0.08	**0.59**	0.04	-0.19	-0.18	-0.20	0.19	0.27
	On-time performance	0.38	0.33	-0.20	-0.01	**0.57**	-0.10	0.15	-0.01	-0.07	0.03	0.22
	Clarity of the bus stop announcements	0.32	0.43	0.05	0.02	**0.51**	0.03	-0.16	0.01	-0.28	-0.17	-0.10
Location and Type of Service	There should be bus service within a few blocks of my home	-0.15	0.08	-0.01	-0.01	0.18	**0.70**	0.28	-0.10	-0.17	0.06	0.14
	There should be direct service by bus to my destination	0.00	0.10	0.15	0.13	-0.13	**0.69**	0.12	-0.01	-0.07	0.01	-0.21
	There should be a bus arriving every 5 to 15 minutes at bus stops	0.01	-0.06	0.21	-0.18	-0.17	**0.67**	-0.01	-0.05	0.09	-0.13	-0.04
	Public transportation should invest in light rail trains to increase the options for commuting	0.07	-0.12	0.33	-0.07	-0.06	**0.62**	-0.22	-0.14	-0.13	0.14	0.34
	It is more important to improve public transportation like buses	0.12	0.07	-0.07	-0.07	0.14	**0.60**	0.47	0.32	0.15	-0.12	-0.13
Service Attractiveness	If freeway congestion were high and local bus service was free, how often would you use it	0.15	0.12	0.17	0.22	0.03	0.11	**0.70**	-0.14	-0.08	0.16	0.03
	Discounted or reduced fares	0.03	0.03	0.46	-0.04	-0.19	0.05	**0.65**	-0.01	-0.21	0.05	0.08
	How appealing, overall, is the idea of using the bus?	0.31	0.19	0.19	-0.06	0.08	0.26	**0.64**	-0.04	0.09	-0.04	0.18
Travel Cost	How much do you think a ride on Metro Transit would cost	-0.05	-0.08	-0.02	-0.06	0.15	-0.02	-0.03	**0.79**	0.14	-0.02	0.18
	How much do you, personally, pay daily to park for work?	0.08	0.02	0.02	-0.09	-0.22	-0.08	-0.07	**0.75**	-0.12	0.11	-0.15
Children	I have to transport and pick up children from daycare or school before or after work	-0.08	-0.11	0.14	0.19	-0.11	-0.10	-0.11	0.06	**0.74**	0.04	-0.03
Travel Time	Travel time by bus versus other types of transportation	0.23	0.10	0.02	0.11	0.31	-0.15	0.18	0.07	0.14	**0.68**	-0.04
Personal	People like me don't ride the bus	-0.21	-0.17	0.07	-0.05	-0.14	0.06	-0.17	-0.05	0.00	0.05	**-0.76**

We then employ an iterative cluster analysis to identify groupings of non-riders with similar concerns related to the transit service and personal characteristics. These groupings are referred to as different types of non-riders (auto captives and/or potential riders). The clustering uses the K-means statistical routine in the SPSS statistical package and is based on the difference and similarity between the factor scores output for each of the eleven variables. Four clusters are identified for non-riders. The types of non-riders can be auto captives who have an irregular commute pattern, auto captives with regular commute patterns, potential riders with regular travel patterns, and potential riders with irregular travel patterns.

The values of the cluster centers for each type of non-riders (regular commuters and auto captive, irregular commuters and captive, regular commuters and potential riders, and irregular commuters and potential riders) are presented numerically in Table 4 and graphically in Figure 4. The height and direction of each bar represents the value of the cluster center for each of the previously defined eleven factors. Figure 4 shows the defining characteristics of the clusters along with the percentage of individuals assigned to each individual cluster. It is observed that, in general auto captives represent 47 percent, while potential riders represent 53 percent of the surveyed population.

Table 4: Cluster analysis for non-riders survey

	Auto Captives		Potential Riders	
	Irregular	Regular	Irregular	Regular
Safety and Comfort	-0.38	-0.31	-0.07	0.59
Driver's Attitude	-0.47	-0.03	0.25	-0.13
Amenities and Special Request	-0.12	-0.20	-0.25	0.55
Commute Characteristics	-0.82	0.15	-0.39	0.13
Reliability	1.20	-0.02	-0.20	0.14
Location and Type of Service	-0.07	0.16	-0.02	-0.23
Service Attractiveness	-0.21	-0.41	0.31	0.41
Travel Cost	6.29	-0.18	0.13	-0.16
Children	1.14	0.10	-0.57	0.27
Travel Time	-0.07	0.07	0.57	-0.60
Personal	1.45	0.50	-0.84	-0.16

Auto captives are the type of commuters who are not willing to change their travel mode to use transit. Both regular and irregular commuters who are auto captives answered positively for the question stating *"people like me do not ride transit"* and negatively to the question stating "*How appealing, overall, is the idea of using the bus*." The primary concerns for irregular auto captive commuters are driving children to school and or daycare, reliability of the service, the cost of traveling with transit, and the amount paid for parking fees at their destinations. Irregular auto captive commuters only represent 1 percent of the surveyed population. Regular commuters whom we consider auto captives represent 46 percent of the surveyed population. They tend to have similar concerns as irregular commuters in term of driving children to schools, but their primary concern is the characteristics of the commute (they tend to travel more distances than irregular commuters). Additional concerns are the location and type of service provided (how far the stops are from their origins and destinations and the frequency of service), and travel time.

Potential riders are mainly commuters who answered negatively to the question "*people like me do not ride transit*" and positively to the question "*How appealing, overall, is the idea of using the bus*." Potential riders are commuters willing to change their commuting behavior incase some specifications are present in the current transit service. They can be classified into two categories, regular and irregular commuters.

Irregular commuters whom we classify as potential riders are mainly concerned with the driver's attitude, the cost of the service, and travel time. Regular potential riders tend to be concerned with the safety and comfort of the service and amenities related to the service and some special requests (special requests include the availability of high frequency services during peak and off peak for emergencies and the availability of shuttle vans at work locations to shopping areas). Other concerns include commute characteristics, reliability of service, and dropping children to daycares and schools as part of their commute. Irregular potential riders compose 25 percent of the surveyed population, while regular potential riders compose 28 percent of the same population.

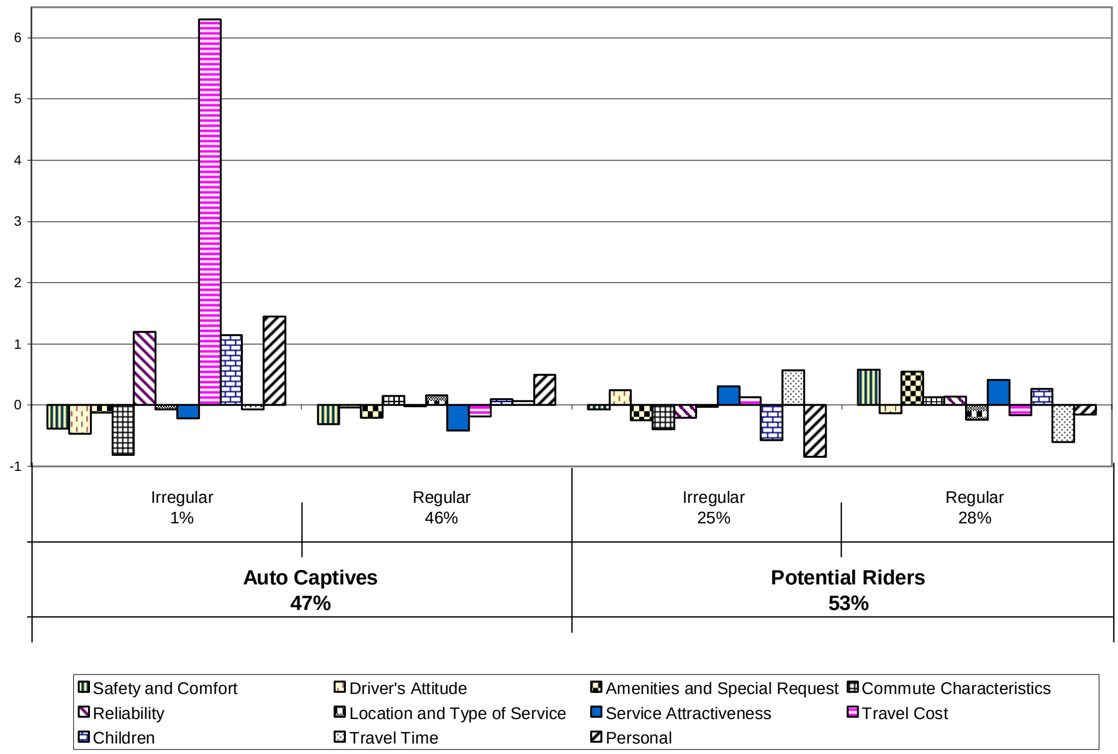

Figure 4: Non-riders cluster analysis

Discussion

Based on the previous analysis, the market for existing transit services can be divided into eight different types of commuters with different preferences. We also divide commuters into two groups: regular and irregular. Regular commuters tend to travel on standard basis between origins and destinations everyday, while irregular commuters have commuting needs that vary daily. Both regular and irregular commuters are part of the larger population that includes riders and non-riders. Accordingly, riders can be further divided into captives and choice ones, while non-riders can be divided into auto captives and potential riders. Figure 5 demonstrates the segmentation of the transit market. Similarities in the concerns do exist between choice riders (from the riders analysis) and potential riders (from the non-riders analysis).

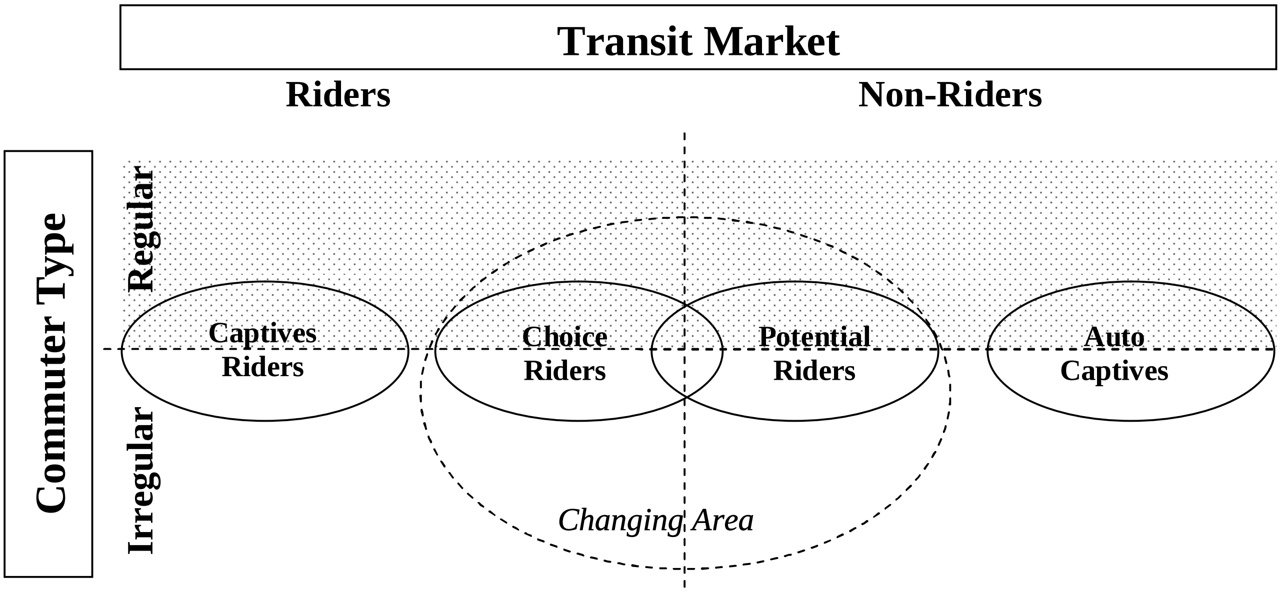

Figure 5: Transit Market Segmentation

We name the area including both choice riders and potential riders as the *changing area*. The *changing area* is the segment of the transit market that an agency can either attract riders from or lose riders to. It is also important to note that other types of travelers might exist, but are not included in this analysis due to the small segment they represent (e.g., bicyclers and walkers) and the lack of appropriate data to analyze them. Irregular commuters whom we consider choice and/or potential riders are concerned with the driver's attitude and travel time. Since regular commuters, whom we consider potential and/or choice riders, have regular commuting habits they have different concerns. Their concerns are the safety and comfort of the service provided, reliability of the transit service, the type of service and the amenities available nearby transit stations including park and ride facilities, and some special requests in terms of service frequency and its type. Any transit agency should try to gain as much area as possible in the *changing area* zone to add more riders to its system. It is important to note that the better the performance of a transit agency, the higher the share of choice riders in the *changing area* zone. It is clear from the studied population that Metro Transit's riders share of the *changing area* zone is limited compared to other agencies around the United States. Increasing the share of choice riders in the *changing area* zone can be achieved through improvements in the performance of the transit system. Improving the transit performance can be achieved through better understanding and usage of the various technologies being implemented by transit agencies.

Technology and Ridership

The availability of an AVL system that is widely implemented by transit agencies can help in increasing the number of regular and irregular commuters. For example, the irregular commuters in the *changing area* zone, including choice and potential riders, are concerned with the driver's attitude factor. Driver's attitude includes clarity and accuracy of stop announcement which can be improved through automating stop announcements based on the current bus location.

Automation of stop announcement will eliminate any errors in terms of the accuracy and clarity of the announcement. This is achievable using an AVL system, especially the GPS component. The same system can also monitor the performance of the driver (on-time performance and delays) for supervision interference and training purposes. Regular commuters, including choice and potential riders, in the *changing area* zone have concerns with the safety from crimes while riding the bus. Currently many agencies install cameras onboard their buses to monitor vandalism, which can be useful as another way to increase the level of safety.

Transit service reliability is a key in attracting regular potential riders and changing them to be regular choice riders. TriMet, the local transit authority in Portland, Oregon succeeded in improving the levels of reliability and especially running times, headways, and on-time performance through implementation of a bus dispatch system that monitors the system (Strathman *et al.*, 1999). Similarly, Metro Transit can use current technologies to achieve improvements in reliability, which will eventually show as an increase in riders' satisfaction. Metro Transit can achieve improvements in reliability through monitoring and analyzing the existing data, obtained from the AVL and APC systems, to identify the major contributors to any decline in reliability. Improvements in reliability are expected to attract potential riders and especially regular commuters. It is also expected to increase satisfaction among existing regular choice riders.

Shorter travel time and frequency of services is another factor affecting regular choice riders. Several methods can improve travel time. Passenger activity, number of stops being served, congestion, bus type, drivers experience, and number of signalized intersections are the main factors affecting running time and causing its increase. Using smart cards as a method of payment can help decrease passenger boarding time and accordingly the overall travel time for all users. Various research projects studied the effect of the number of signalized intersections, and recommendations were made that transit signal priority (TSP) can help resolve the effects of traffic signals on travel time. Metro Transit addressed the increase in travel time caused by congestion along express service routes through a bus only shoulder policy. The bus only shoulder is a policy that allows transit to operate express buses using the freeway shoulders if the mainline speed decreases to certain levels. This policy is a critical solution since not all drivers are comfortable in doing so, yet current technologies under development for snowplows and guidance systems, which are used to guide drivers in these cases, can be used for buses too.

The next arrival or count down system that uses displays at bus stops and transit center has potential for increasing rider satisfaction. Most potential riders asked for specific needs in term of help in understanding schedules and how to make specific personal trips. Having a next arrival system either online or by phone can help in attracting potential riders, both regular and irregular commuters.

It is clear from the previous discussion that increasing the transit share in the *changing area* zone of Figure 5 is achievable through implementation and use of various technologies. It is important to note that any improvement in the current system through technologies beside increasing the transit share in the *changing area* zone it can help in increasing satisfaction of current regular and irregular commuters either captive and choice riders.

Chapter 5: Conclusion

The overall objective of this research was to employ a market segmentation approach to uncover population groups that share similar sets of values and attitudes toward travel (generally) and transit (specifically). The primary focus was on the attitudes and preferences of current and potential riders. Thus, rather than basing any classification strictly on patterns of use, the approach employed here classified riders and non-riders examine their perspectives towards transit service. To do so we used two surveys conducted by Metro transit, a rider and non-rider survey, as the source of information for this analysis.

In addition to mode captivity, we considered the regularity of commuting habits.—a different strategy used in understanding the transit market. We classified transit riders in four categories: captive with regular commuting habits, captive with irregular commuting habits, choice with regular commuting habits and choice with irregular commuting habits.

Similarly, we classified transit non-riders into four categories: auto captives with regular commuting habits, auto captives with irregular commuting habits, potential riders with regular commuting habits and potential riders with irregular commuting habits. The primary focus is to better understand the attitudes and preferences of current and potential riders. These surveys provide an opportunity to understand better the transit market in the Twin Cities region by separately analyzing these two groups. The data resulted in a number of factors explaining the preferences and attitudes of users and non-users.

Travel market segmentation is a unique way to understand the transit market and the eight types of commuters who comprise the transit market yields a different perspective on an age-old phenomenon. Understanding their attitudes and preferences is an important aspect of retaining current riders and attracting new ones. Providing quality service that addresses the needs of captive years is important since they use the system daily. Auto captives rely on their car as a primary transportation mode, likely because transit service is not possible from their origin to destination. Understanding the preferences of the *changing area* could have the most significant impact on transit ridership.

Role of Technology

The second purpose of this research was to place such analysis in the context of available technology that could serve to influence each of the populations and potentially increasing ridership. For example, Metro Transit has implemented an AVL system that has been mainly used for monitoring on-time performance. There has not been any usage of the current AVL system in offline analysis. Using this abundance of archived ITS data to analyze the performance of the existing system in term of reliability can lead to major improvements in the transit service performance and accordingly in riders satisfaction, which might lead to an increase in ridership from the regular and irregular potential rider population. Such monitoring and analysis of the current service can be used as a decision support system to recommend modifications in any of the existing routes. Modifying service in terms changes to address reliability issues is important to both types of potential users.

Recent technological advancements provide an opportunity to address several of the attitudes and preferences identified herein. For example, installing cameras inside buses will increase security and should reduce vandalism. Automating stop announcements could help riders with disabilities or people unfamiliar with the route. Encouraging the use of swipe cards could decrease travel time by reducing the delay during passenger boarding. A next arrival system that displays the time until arrival at transit centers and bus stops is quickly becoming a common way to improve service by increasing reliability. A next arrival system, which uses information from GPS and AVL systems, could address important issues for many choice riders that seek reliable service. Displaying the next arrival time at a stop might help them choose different routes if the waiting time is to long. Using technology to decrease the time spent in and out of transit could increase ridership without affecting service. Ultimately, implementing new forms of technology could provide alternative means to increase ridership when expanding coverage is not an option.

Overall

Based on this analysis, the not-so-good news is that percentage of choice transit riders in the Twin Cities is low compared to other transit agencies. The good news, however, is that Metro Transit has a good opportunity to increase the number of choice riders using their system. This research has shown that choice riders exhibit certain attitudes, some negative, towards transit and preferences for travel, often auto-oriented.

Metro Transit could, for example, use these factors to understand better the preferences of both choice and potential riders. This research discovered trends between the two groups that, when considered, could attract potential riders and influence choice riders to become more regular transit commuters.

References

Chicago Transit Authority. (2001). CTA 2002 budget continues commitment to customers and service. *CTA Press Release* Retrieved November, 1, 2005, from http://www.transitchicago.com/news/archpress.wu?action=displayarticledetail&articleid=102832

Domencich, T. A., Kraft, G., & Valette, J. (1968). Estimation of urban passenger travel behavior: An economic demand model. *Highway Research Record, 238*, 64-78.

Furth, P., Hemily, B. J., Muller, T. H. J., & Strathman, J. G. (2003). *Uses of archived AVL-APC data to improve transit performance and management: Review and potential* (TCRP Web Document No. H-28). Washington DC: Transportation Research Board.

Goodwin, P. B. (1992). A review of new demand elasticities with special reference to short and long run effects of price changes. *Journal of Transport Economics and Policy, 26*(2), 155-163.

Horowitz, A. (1984). Simplifications or single-route transit-ridership forcasting models. *Transportation, 12*(3), 261-275.

Hsiao, S., Lu, J., Sterling, J., & Weatherford, M. (1997). Use of geographic information system for analysis of transit pedestrian access. *Transportation Research Record, 1604,* 50-59.

Jin, X., Beimborn, E., & Greenwald, M. (2005). *Impacts of accessibility, connectivity and mode captivity on transit choice*. Milwaukee, WI: Center for Urban Transportation Studies, University of Wisconsin-Milwaukee.

Kemp, M. A. (1973). Some evidence of transit demand elasticities. *Transportation, 2*(1), 25-51.

Kittelson & Associates. (2003). *Transit capacity and quality of service manual*. Washington DC: U.S. Department of Transportation.

Kraft, G., & Domencich, T. A. (1972). Free transit. In M. Edel & J. Rothenberg (Eds.), *Readings in urban economics* (pp. 459-480). New York: Macmillian Company.

LaBelle, S., & Stuart, D. (1996). Diverting automobile users to transit: Early lessons from the chicago transit authority's orange line. *Transportation Research Record*(1503), 79-87.

Lago, A. M., & Mayworm, P. D. (1981). Transit service elasticities. *Journal of Transport Economics and Policy, 15*(2), 99-119.

Lago, A. M., Mayworm, P. D., & McEnroe, M. (1981). Ridership response to changes in transit services. *Transportation Research Record, 818*, 13-19.

Levinson, H. (1985). Forecasting future transit route ridership. *Transportation Research Record, 1036*, 19-28.

Longley, P., Goodchild, M., Maguire, D., & Rhind, D. (2001). *Geographic information systems and science*. West Sussex, England: John Wiley & Sonc, Ltd.

Maruyama, G. (1998). *Basics of structural equation modeling*. Thousand Lakes, California: SAGE Publications.

McQueen, B., & McQueen, J. (1999). *Intelligent transportation systems architectures*. Boston, MA: Artech House.

Mohring, H., Schroeter, J., & Wiboonchutikula, P. (1987). The value of waiting time, travel time, and a seat on a bus. *Rand Journal of Economics, 18*(1), 40-56.

Murray, A. (2001). Strategic analysis of public transport coverage. *Socio-Economic Planning Sciences, 35*, 175-188.

O'Sullivan, A. (2000). *Urban economics* (4th ed.). New York: McGraw-Hill Companies, Inc.

Oum, T. H., Waters II, W. G., & Yong, J. (1992). Concepts of price elasticities of transport demand and recent empirical estimates: An interpretative survey. *Journal of Transport Economics and Policy, 26*(2), 139-154.

Polzin, S., Chu, X., & Rey, J. (2000). Density and captivity in public transit success observations from 1995 nationwide personal transortation study. *Transportation Research Record*(1735), 10-18.

Polzin, S. E., Pendyala, R. M., & Navari, S. (2002). Development of time-of-day-based transit accessibility analysis tool. *Transportation Research Record, 1799*, 35-41.

Pushkarev, B. S., & Zupan, J. M. (1977). *Public transportation and land use policy*. Bloomington, IN: Indiana University Press.

Rodriguez, D., & Ardila, A. (2002). An empirical exploration of bus travel time and dwell times in highly competitive exclusive busway. *Journal of Public Transportation, 5*(1), 39-60.

Smith, R., Atkins, S., & Sheldon, R. (1994). *London transport buses: ATT in action and the London countdown route 18 project.* Paper presented at the First World Congress on Applications of Transport Telematics and Intelligent Vehicle-Highway Systems, Paris, France.

Strathman, J. G., Dueker, K. J., Kimpel, T. J., Gerhart, R. L., Turner, K., Taylor, P., et al. (2000). Service reliability impacts of computer-aided dispatching and automatic location technology: A tri-met case study. *Transportation Quarterly, 54*(3), 85-102.

Strathman, J. G., Dueker, K. J., Kimpel, T. J., Gerhart, R. L., Turner, K., Taylor, P., et al. (1999). Automated bus dispatching, operations control, and service reliability. *Transportation Research Record, 1666*, 28-36.

Syed, S., & Khan, A. (2000). Factor analysis for the study of determination of public transit ridership. *Journal of Public Transportation, 3*(3), 1-17.