AN ANALYSIS OF CASUAL CARPOOL PASSENGER BEHAVIOR IN HOUSTON, TEXAS

A Thesis

by

JUSTIN R. WINN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2005

Major Subject: Civil Engineering

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Approved as to style and content by:

Mark W. Burris (Chair of Committee)	Conrad L. Dudek (Member)
Katherine F. Turnbull (Member)	David Rosowsky (Head of Department)

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ABSTRACT

An Analysis of Casual Carpool

Passenger Behavior in Houston, Texas. (May 2005)

Justin R. Winn, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Mark Burris

In the last thirty years, determined travelers have developed a new method of travel that allows them to receive the benefits of traveling on the HOV lane without forming traditional carpools. This new mode is known as casual carpooling (also known as "slugging"). Casual carpools are impromptu carpools formed among strangers in order to meet the occupancy requirements of HOV lanes.

In this research, survey respondent data from Houston, Texas were used to evaluate the behavior of casual carpool passengers. At the time of this research, there were approximately 500 casual carpool passengers in Houston each day during the morning peak period. These passengers gained time savings of up to 13 minutes over the alternative of driving alone on the main lanes.

Statistical models were used to evaluate the factors that influence travelers to choose casual carpooling. The results of the analyses indicated that travelers on commute trips were more likely to casual carpool. The results also indicated that casual carpoolers in Houston made more trips per week, were between the ages of 25 and 34, and had

occupations that were either professional/managerial or administrative/clerical. Additionally, Houston travelers that had incomes between $25,000 and $35,000 and were between the ages of 55 and 64 were significantly less likely to casual carpool.

The research results provided insight into some of the factors that influenced the decision to casual carpool. It is important to understand the types of travelers that casual carpooled, and the information learned in these analyses can be used to better evaluate HOV and HOT lane use and performance. Casual carpool passengers can comprise a significant portion of HOV/HOT lane person movement and should be considered when considering HOV or HOT lane implementation. However, further research in this area is necessary to better understand these travelers.

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CHAPTER I

INTRODUCTION

1.1 Overview

As congestion has worsened in our nation's metropolitan areas, transportation professionals have explored various methods of increasing the efficiency of the transportation infrastructure. One such method is the implementation of high occupancy vehicle (HOV) lanes. The primary goals of HOV lanes are to promote carpooling and increase person movement along congested corridors *(1)*. HOV lanes promote the increase of person movement through higher vehicle occupancies by providing a travel time savings to carpools *(1)*. HOV lanes are typically built on congested freeways, and allow vehicles that meet specified occupancy requirements to bypass the delays associated with driving alone on the general purpose lanes of the freeway.

In the last thirty years, determined travelers have developed a new method of travel that allows them to receive the benefits of traveling on the HOV lane without forming traditional carpools *(2)*. This new mode is known as casual carpooling (also known as "slugging"). Casual carpools are impromptu carpools formed among strangers in order to meet the occupancy requirements of HOV lanes.

This thesis follows the style and format of *Transportation Research Record*.

The process of forming casual carpools is relatively simple. Those who wish to be casual carpool passengers will typically meet in a public area, usually one that has ample available parking, nearby public transit as an alternate mode, and is relatively close to the HOV facility. Drivers (also known as "body snatchers") arrive and pick up enough passengers to meet the HOV lane eligibility requirements. The drivers will then travel along the HOV lane and then drop off the passengers in a public location, typically in the downtown area of a city. The details of the casual carpool process will vary slightly depending on the location.

Currently, casual carpooling occurs in only three metropolitan areas in the United States:

- Washington, D.C. *(2, 3, 4)*,
- San Francisco, California *(5, 6)*, and
- Houston, Texas *(7)*.

These three locations have very different characteristics. Slugging in the Washington, D.C. has existed for over 30 years, and in that time the system has become well organized. There are a large number of pickup and drop off locations, and a website, (http://www.slug-lines.com), was created as an information hub for local slugs and bodysnatchers. Conversely, slugging in the San Francisco Bay area occurs in only a single location. Passengers and drivers meet in the morning peak period to form carpools and cross the Bay Bridge. Passengers are usually dropped off in the downtown area and typically utilize transit for their return trips. Casual carpooling in Houston,

Texas, occurs at three locations, all of which feed the downtown area. Passengers meet at park and ride locations on I-10 and US 290 that have direct access to the HOV lanes. Drivers arrive throughout the morning and pick up the necessary number of passengers to meet the HOV occupancy requirement.

Despite its presence for over three decades, casual carpooling has yet to expand beyond these three cities. Casual carpooling can increase person movement along congested corridors and can provide substantial travel time savings for its users. However, it is not marketed or regulated in any way by transportation officials. As these carpools are formed among strangers, there are numerous liability issues that would surround agency support of casual carpooling. This does not mean that the effects of casual carpooling and characteristics of its users are not important to transportation engineers and planners. With the potential to increase person movement and provide better HOV utilization, casual carpooling could represent a significant portion of daily HOV lane travelers. It is important to examine what characteristics casual carpoolers share and the reasons they choose to casual carpool.

1.2 Problem Statement

Although casual carpooling has existed in the United States for over 30 years, very little information is available regarding this mode of travel. At the time of this research, casual carpooling was not regulated in any way. However, it is important to understand the characteristics of those travelers that chose to casual carpool and the factors

influencing their decision. Familiarity with these characteristics can help transportation professionals better understand casual carpooling and its relationship with HOV lane design and operation.

In this research, the current practice of casual carpooling in the United States was examined. Then, the effect that casual carpooling had on HOV and high occupancy toll (HOT) lane use in Houston, Texas and the time savings gained by those choosing to casual carpool was examined. Additionally, survey data were used to examine the socio-economic and commute characteristics of casual carpool passengers and to estimate mathematical models that further examined how casual carpoolers were significantly different from other travelers.

Although there may be many differences between casual carpool drivers and casual carpool passengers, this research effort was focused on passengers. The data used in this research came from surveys distributed to passengers, and no surveys were distributed to drivers (see Appendix A).

1.3 Research Objectives

The goal of this research was to explore casual carpooling and learn more about its effect on the transportation infrastructure as well as the characteristics of those travelers choosing this mode. The specific objectives were to:

- Review the current practice of casual carpooling in the United States,
- Determine the benefits, including time savings gained by casual carpool passengers,
- Determine characteristics of casual carpool passengers, and
- Identify factors that significantly influence travelers' decision to choose casual carpooling and provide recommendations for future research.

This research expands the current literature on casual carpooling. By learning more about casual carpooling, a broader understanding of traveler behavior was gained. This will allow transportation professionals to make more informed decisions in the future.

1.4 Organization

This thesis is organized into 5 chapters. An introduction to the origin and typical formation of casual carpools, the research problem statement, and the research objectives are included in Chapter I. Chapter II is a literature review covering HOV lanes and the current practice of casual carpooling in the United States. In Chapter III, the data collection and reduction processes including the calculation of travel time savings for casual carpool passengers in Houston are described. The data analysis performed, including the calculation of descriptive statistics and identification of significant variables in the data collected on casual carpool passengers in Houston is covered in

Chapter IV. It also includes the results of the discrete choice model analysis. Chapter V contains conclusions and recommendations based on the research results.

CHAPTER II

LITERATURE REVIEW

2.1 HOV Lanes

HOV lanes are occupancy restricted lanes along a corridor which may or may not be barrier separated from the general purpose lanes. They have been in use for over thirty years in the United States. The first application of HOV lanes was on the Shirley Highway (I-395) in northern Virginia in 1969, and there are now approximately 2,000 miles of HOV lanes in the U.S. (*1*). Most of the HOV systems in the U.S. are located in the metropolitan areas of Houston, Dallas, Seattle, Los Angeles, San Francisco, Newark, New York City, and Washington, D.C. (*1*).

The goal of HOV lanes is to promote increased vehicle occupancies and greater person movement through a corridor (*1*). Most HOV lanes are open to buses, vanpools, and passenger vehicles that meet a specified occupancy requirement. These higher vehicle occupancies are encouraged by offering travel time savings for HOV lane users. Travel speeds are typically much higher on HOV lanes than general purpose lanes during peak periods, thereby offering significant travel time savings over the general purpose lanes. The use of carpooling can lead to improved person movement through a corridor which makes more efficient use of the roadway system. HOV facilities are necessary for the success of casual carpooling. HOV lanes provide the travel time savings incentive needed for drivers to choose to pick up and drop off passengers.

2.2 HOT Lanes

High Occupancy/Toll (HOT) lanes combine HOV lanes and variable pricing by allowing access to the HOT lane by either meeting an occupancy requirement or by paying a specified toll. Under a variable pricing system, the toll to be charged varies based on the congestion of the facility. By adding variable pricing to an HOV lane, it allows for more efficient use of the roadway. The toll for access can be changed to maintain the desired demand on the HOT lane, which allows it to stay at an acceptable level of service throughout the day while encouraging full utilization of the HOT lane.

Variable tolls on HOT lanes can be applied using predetermined pricing structure or dynamic pricing. Under a predetermined pricing structure, a set pricing schedule that outlines the toll by time of day is used. This type of pricing system can be updated periodically as demand on the facility changes. Under a dynamic variable pricing system, the toll is changed based on the current demand for the facility.

There are currently only four HOT lanes operating in the United States:

- SR 91 Express Lanes in Orange County, California,
- I-15 FasTrak near San Diego, California,
- I-10 Katy Freeway HOT Lane in Houston, Texas, and
- US 290 Northwest Freeway HOT Lane in Houston, Texas.

Casual carpooling in Houston occurred exclusively along the two HOT lane corridors at the time of this research and may have contributed significantly to the traffic volumes on those HOT lanes. The presence of casual carpooling could influence the amount of traffic using the HOT lanes, affecting the congestion on the lane and possibly the toll charged to vehicles without the required occupancy. It is important to consider the casual carpooling mode and its possible impact on HOT lane implementation.

2.2.1 SR 91 Express Lanes

The SR 91 Express Lanes is a four-lane two-directional HOT facility located in the median of SR 91 in Orange County, California, near Los Angeles (*8*). It was the first HOT facility constructed in the U.S. Tolls on the express lanes are charged based on a fixed toll schedule under which the toll changes every hour. All tolls on the express lanes are collected electronically using FasTrak transponders. Drivers in vehicles with three or more occupants can use the lanes for free with the exception of Friday evening when they must pay 50 percent of the toll (*9*).

2.2.2 I-15 FasTrak Lanes

The I-15 FasTrak Lanes are two reversible HOT lanes located in the median of I-15 north of San Diego, California. The facility opened in 1996, and in 1998 dynamic pricing was introduced (*10*). The toll is changed throughout the day based on the current congestion level on the facility. The tolls typically range from $0.50 to $4.00 but during very congested periods can reach as high as $8.00. Tolls are paid only by drivers in

single occupant vehicles (SOVs), and drivers in HOV2+ vehicles travel free of charge throughout the day (*11*).

2.2.3 I-10 and US 290 HOT Lanes

The first HOT lane in Houston was implemented in 1998 with the beginning of the QuickRide program. Enrollment in the QuickRide program requires a $2.50 monthly service charge and a transponder and hangtag to be installed in the vehicle. During the peak morning and evening periods (6:45 to 8:00 AM and 5:00 to 6:00 PM), the vehicle occupancy requirement to use the HOV lanes is increased to 3+, but drivers in HOV2 vehicles that are enrolled in QuickRide can access the lane for a $2 toll. Drivers choose whether to pay the toll based largely on their value of travel time savings. If their value of travel time savings is large enough, it will be worth the $2.00 toll to use the HOT lane with only one passenger. After the success of the program on the I-10 HOV lane, the program was expanded in 2000 to include US 290. Additionally, these two HOT facilities were the only locations in Houston where casual carpooling was occurring at the time of this research.

2.3 Value of Travel Time Savings

One important, but difficult to measure, traveler characteristic that significantly influences the use of casual carpooling is the traveler's value of travel time savings. Travelers place a value on the amount of time it takes for them to make a trip, but this value can be difficult to monetize. Researchers have adopted a few methods of

determining value of time, and the most common methods are revealed and stated preference surveys (*12*). Revealed preference surveys are used to ask travelers about the trips that they have made. Stated preference surveys are used to ask travelers about potential trips.

Travelers' values of time can vary depending on a number of factors including trip purpose, driving conditions, and socio economic characteristics. All of these add to the complexity of determining the value of travel time and must be considered when calculating values of time.

Based upon research in the area, values of time typically range from 20 percent of the wage rate (*13*) to 50 percent of the wage rate (*14*). Additionally, research has shown that drivers place a value not only on travel time but reliability of travel time as well (*15*). Travelers place a higher value on trips with less uncertainty in their length of travel time.

The value of travel time savings may also play a large role in a traveler's decision to casual carpool. It is possible that casual carpooling provides enough travel time savings to offset the relative costs of forming the carpool. There are many costs that can influence a traveler's decision, and time savings can be a significant one. The amount of weight that travel time has on a traveler's mode choice depends upon that person's value of time. The influence of the time-value of money can greatly affect travelers' decisions and is important in the understanding of travel behavior and mode choices.

2.4 Casual Carpooling

Casual carpooling has existed in the United States for many years. Its origins can be traced back to the implementation of HOV lanes in Washington, D.C. around 1971 (*2*). HOV/HOT lanes are one of the common threads among the three casual carpooling locations in the U.S. The existence of HOV lanes provides the necessary travel time savings incentive to encourage casual carpool formation. Casual carpool formation sites are typically located close to an HOV lane entrance. Additionally, formation sites are generally located near transit stops. This provides a much-needed alternative travel mode due to the uncertainty of casual carpooling. If a traveler is unable to join a casual carpool, he or she needs a reliable alternative mode to ensure that he or she arrives at his or her destination on time. Currently, casual carpooling occurs in three locations in the United States: San Francisco, California, Washington, D.C., and Houston, Texas.

2.4.1 San Francisco, California

Casual carpooling has existed in the east bay area of San Francisco for over 20 years. It began in the 1970s, and is believed to have grown in popularity due to either transit interruptions caused by labor strikes resulting in transit shutdowns or the energy crisis (*5*). Commuters in the Bay Area began to use casual carpooling in order to bypass the heavy congestion on the Bay Bridge during the peak hours. Drivers in vehicles with three or more people, or two-seat vehicles with two people, can use the bridge toll-free. Additionally, motorcyclists and drivers in clean air vehicles are exempt from paying the

toll. These drivers gain access to the bridge via toll-free lanes located at either end of the toll plaza.

Beroldo (*5*) outlined four conditions that led to casual carpooling's success in the San Francisco Bay Area:

- Sufficient driver time savings to warrant picking up and dropping off passengers
- Pick-up locations are easily accessed by both drivers and passengers
- Downtown San Francisco is a common drop-off point
- Good transit service exists for evening return trips

The Bay Bridge is heavily congested during morning and afternoon peak periods, and its HOV lanes offer significant time savings over the general purpose lanes. The pick-up locations are located near freeway ramps and/or residential locations. They also have nearby parking or are located along major transit routes. The downtown area offers a common drop-off point because of the high employment density in the area. This provides a large number of passengers with common destinations. There is also very good transit service in the evening to provide passengers return trips to their homes or vehicles.

Results of a survey conducted in 1987 included a significant number of casual carpoolers that had previously used transit for their morning commute (*5*). The same results also

indicated that casual carpools relied almost exclusively on transit for evening return trips. In a 1998 casual carpooling update, researchers showed that casual carpoolers continued to rely heavily on transit for return trips, with only a slight decrease since the 1987 survey (*6*). In 1987, casual carpooling was utilized exclusively in the morning. However, by 1998, some drivers and passengers used casual carpooling in the evening as well. A survey conducted in 1998 by RIDES for Bay Area Commuters revealed that 9 percent of morning casual carpoolers used casual carpooling for the evening trip as well (*6*).

The 1998 survey results also show that most casual carpool participants in the San Francisco area used the mode four to five times per week and used it for more than one year. Additionally, most passengers chose casual carpooling to save money while most drivers chose casual carpooling in order to save time. The results also showed that the vast majority of casual carpoolers lived less than 5 miles from the pick-up location and that most either walked or drove alone to the pick-up location. The survey also indicated that most casual carpool passengers used transit previously and would use transit if casual carpooling was no longer available.

2.4.2 Washington, D.C.

Commuters have been utilizing casual carpooling in the Washington, D.C. area since the early 1970s (*2*). The advent of HOV facilities allowed drivers in carpools to bypass the heavy congestion of the general purpose freeway lanes. Casual carpools began to form

because of the mutual benefit to drivers and passengers. Initially, carpool formation points were located very close to bus stops. The existence of a back up mode was necessary in case a passenger failed to join a casual carpool. Over time, however, casual carpooling grew in popularity and, in some cases, moved away from bus stops.

Casual carpooling in the Washington, D.C. area occurs along the I-95/I-395 Shirley Highway corridor in northern Virginia. The Shirley Highway HOV lane is a 28-mile long lane that runs from Virginia Route 234 to Arlington, Virginia less than two miles from downtown Washington, D.C. HOV lanes on the Shirley Highway were opened in 1973 in response to gasoline shortages. Casual carpooling began as shrewd drivers began to pull up near transit waiting areas and ask if anyone needed a ride to the D.C. area (*4*). As this mode of travel grew in popularity, lines began to form that were specifically for casual carpooling. There are now approximately 20 carpool formation sites in Northern Virginia for the morning commute period (*16*).

Casual carpooling in the Washington, D.C./Northern Virginia area is completely non-regulated. Although the system works very efficiently, it has not been officially organized or sanctioned. However, the users themselves have created resources for others to access. The most prominent source of information for area commuters is the website, http://www.slug-lines.com. The website offers information on carpool formation locations, general rules of etiquette, the process of carpool formations, and a

message board. The website also has a "lost & found" for passengers who misplaced items during their commute.

In a study of casual carpooling, Spielberg and Shapiro (*4*) found that it was a very egalitarian activity, indicating no bias or preference on the basis of gender or race. Additionally, their survey results indicated that casual carpoolers accounted for approximately 10 percent of the person movement along the HOV lanes during the peak period and between 25 and 50 percent of carpool passengers. The results showed that unlike in San Francisco, many casual carpool passengers also formed casual carpools for the evening commute trip. However, they noted that transit was still frequently used for the return trip. Transit ridership was found to be significantly higher in the evening than in the morning peak periods.

2.4.3 Houston, Texas

The casual carpooling phenomenon appears to be newer to the Houston area than San Francisco or Washington, D.C. There is no documented evidence of when casual carpooling began in Houston, but newspaper interviews of casual carpool users indicated that the mode has been used for at least the past 14 years (*17*).

Casual carpooling in Houston occurs in three locations: the Kingsland Park and Ride lot, Addicks Park and Ride lot, and Northwest Station Park and Ride lot. The Kingsland and Addicks lots are located on I-10 (Katy Freeway) west of Houston, and the Northwest

Station lot is located on US 290 (Northwest Freeway) northwest of Houston (see Figure 2.1). Each park and ride facility is used primarily for transit and offers direct-connect ramps to an HOV lane. Casual carpool passengers form a line near the transit pickup locations and wait for drivers to arrive (see Figure 2.2). Drivers arrive periodically and pickup enough passengers to meet the current HOV lane occupancy requirement. If casual carpool passengers are unable to join a carpool, they also have the option of using transit, which runs throughout the day from the park and ride facilities. This is a necessary mode alternative for casual carpool passengers. The vast majority of casual carpool formation occurs between 6:00 AM and 9:00 AM (*7*). There is very little occurrence of casual carpooling during off-peak times, which may be due to the reduction of bus service during the off-peak hours. Bus headways increase significantly at 9:00 AM following the peak period, and casual carpoolers' reliance on transit as a back up mode may deter the practice during off peak times. The use of casual carpooling drops to near zero when the bus headways increase to over 20 minutes after 9:00 AM.

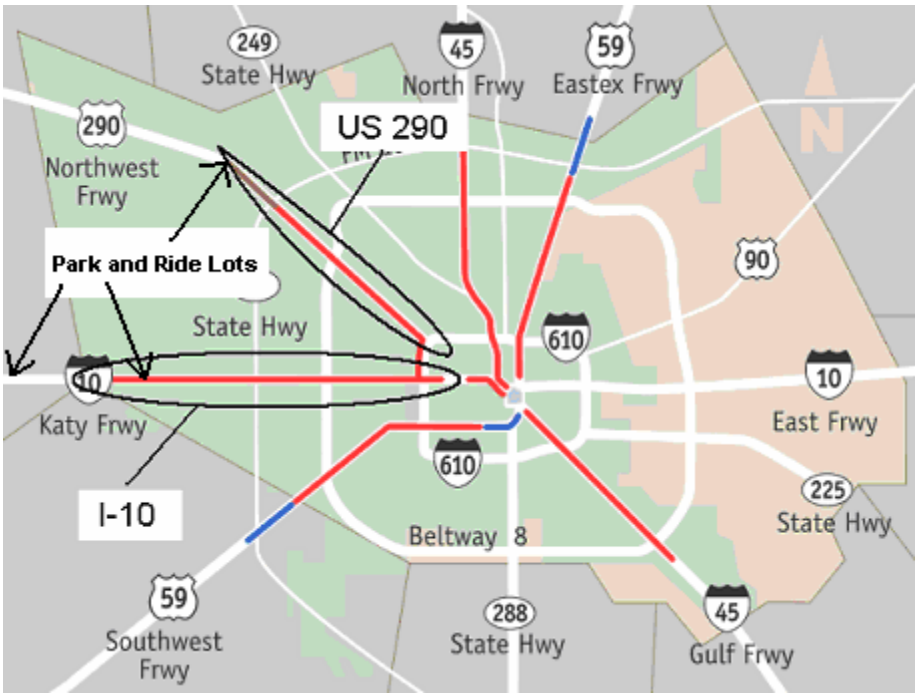

Figure 2.1. Houston's HOT Lanes.

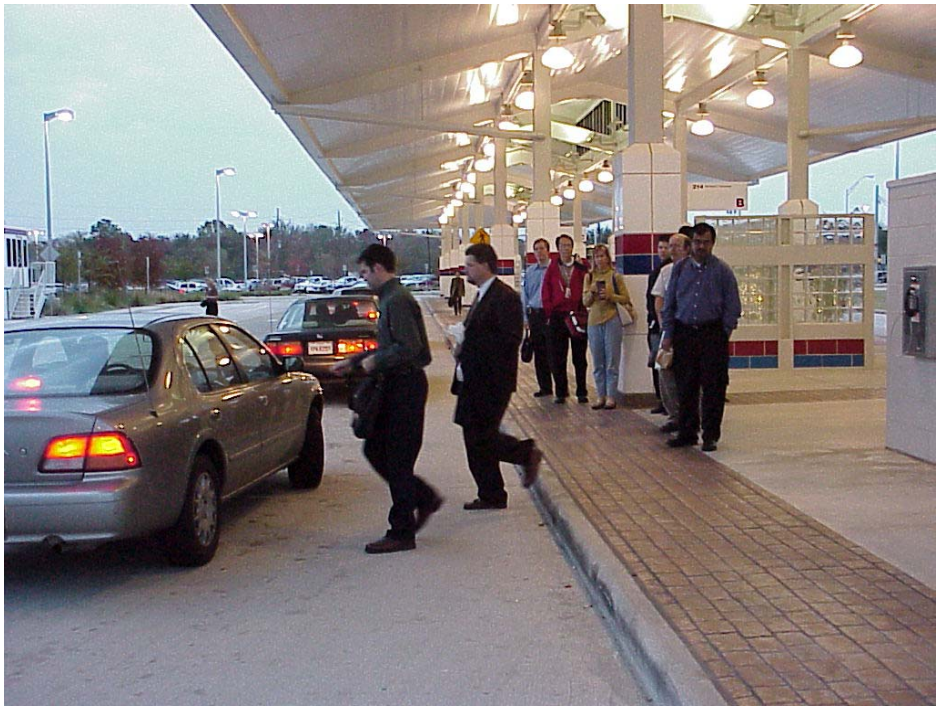

Figure 2.2. Casual Carpool Formation in Houston, Texas.

Casual carpooling in Houston occurs exclusively on the city's two HOT lanes. The vehicle occupancy requirement on I-10 and US 290 is HOV2+ for most of the day, but as part of the QuickRide program it is raised to HOV3+ from 6:45 AM to 8:00 AM and 5:00 PM to 6:00 PM on I-10 and from 6:45 AM to 8:00 AM on US 290. The lanes are closed temporarily during the middle of the day for direction reversal. During the HOV3+ periods, HOV2 vehicles may enter the lane only by paying a $2.00 toll. The QuickRide program was first implemented on the Katy Freeway HOV lane in 1998 and was expanded to include the Northwest Freeway HOV lane in 2000. QuickRide participants are required to open an account and mount a transponder and hangtag on their vehicle. They must also pay a $2.50 monthly service charge in addition to the electronically-collected tolls. Observations made by the author showed that the behavior of casual carpooling would change during the QuickRide periods. Observations by the author at the Addicks Park and Ride indicated that drivers would typically pick up only one passenger during the HOV2+ periods and two passengers during the HOV3+ period.

2.5 Comparison of Casual Carpool Locations

There are many commonalities between the three current locations of casual carpool formation. The primary commonality is the existence of available HOV facilities along heavily congested freeway corridors. The HOV lanes offer time savings incentives for drivers that make casual carpooling attractive. Additionally, the HOV facilities used by casual carpoolers also have occupancy requirements of 3 or more. The higher occupancy requirements may be more favorable as it avoids the stigma of getting into a

vehicle alone with a stranger. This is especially evident in Houston, where casual carpooling occurs solely on the two HOV lanes with occupancy requirements of 3, despite the proliferation of HOV lanes throughout the city. However, casual carpooling occurs in Houston during periods where the HOV lane allows two-occupant vehicles to travel for free. Therefore, the 3 or more requirement is not completely necessary.

Travelers at the three locations also share a dependence upon transit in some form. In San Francisco, transit is the primary mode used for evening return trips and is a backup mode in all three locations. Additionally, most casual carpool formation locations began at or near transit stops. Finally, the three locations also have a common drop-off point. Downtown San Francisco, downtown Washington, D.C., and downtown Houston are all areas with high employment densities that provide a large number of passengers with common destinations.

2.6 Summary

Casual carpooling is a unique phenomenon in transportation and little is known about the mode itself or the people who use it. The small number of locations where this type of activity occurs limits the available resources for expanding the knowledge base of the subject. However, the travelers who choose to casual carpool are influenced in some way to use this mode, and in this research, an attempt was made to better understand which factors lead to their decision, with emphasis on Houston casual carpoolers. Travel behavior is based upon maximizing personal utility, and in the case of casual carpoolers,

forming a casual carpool provided a greater utility to the travelers than other available modes. In following chapters, a number of mathematical and statistical methods were used to determine which factors increased the likelihood of travelers choosing to be casual carpool passengers.

CHAPTER III

DATA COLLECTION AND PRELIMINARY ANALYSIS

3.1 Introduction

The analysis of casual carpool passenger behavior required a large amount of data. Data needed to be collected that adequately represented the socio-economic characteristics of casual carpool passengers. Data regarding trips made by casual carpoolers was also needed, including trip purpose and time savings gained (if any). A large portion of the necessary data was collected by the Texas Transportation Institute through a survey that was handed out to casual carpool passengers as part of a larger traveler survey in November 2003 (*18*). However, additional data on corridor travel speeds and carpool headways was collected to estimate the time savings benefit gained by casual carpoolers.

3.2 Data Collection Activities

3.2.1 Survey of Casual Carpooling

In November 2003, as part of the Houston Value Pricing Project, a large survey was conducted by the Texas Transportation Institute on travelers on the Katy and Northwest Freeways in Houston, Texas (see Appendix A). Based on video license plate data, surveys were mailed to drivers using the general purpose and HOV lanes during both the peak and off-peak traffic periods. Each survey was designed specifically for the group that it would be distributed to (HOV Peak, Main Lane Off-peak, etc.). Additionally,

surveys were produced for transit users and casual carpool passengers. However, rather than being mailed to those travelers, transit passengers were surveyed on-board the bus, and surveys were handed to casual carpoolers at the three park and ride locations. All surveys included questions about trip purpose, time, and socio-economic characteristics. A series of questions specific to the use of casual carpooling was included in the survey. Additionally, a series of stated preference questions that asked the respondent to identify their preferred travel mode given specific travel time and fee (toll) options was included in all surveys. The complete survey can be found in Appendix A.

A total of 539 questionnaires were handed out by TTI researchers to casual carpool passengers at three park and ride facilities in Houston: Addicks and Kingsland on the Katy Freeway, and Northwest Station on the Northwest Freeway (see Table 3.1). Of these 539, 216 were returned, indicating a total response rate of approximately 40 percent. On the day the surveys were handed out, approximately 7 percent of casual carpool passengers refused to take a survey, indicating an estimated total of 578 casual carpool passengers that day. This number closely matched casual carpool passenger counts performed in June 2003. Therefore, even though relatively little is known about the total number of casual carpoolers in Houston, the 216 returned surveys is greater than one-third of all casual carpool passengers and is believed to be representative of the group. The survey responses were initially converted to an electronic file, indicating the responses to each question by each respondent.

Table 3.1. Casual Carpool Passenger Survey Responses.

Park & Ride Lot	Surveys Distributed	Surveys Returned	Response Rate
Katy Freeway (Addicks & Kingsland)	339	133	39.2 %
Northwest Freeway (Northwest Station)	200	83	41.5 %
Total	539	216	40.1 %

The final dataset used in the analysis also excluded a number of responses. For the primary data analysis, only trips beginning between 6:00 AM and 9:00 AM were included. This was done to focus on the time period during which the vast majority of casual carpooling occurred. A count of casual carpool passengers in June 2003 showed that casual carpooling primarily occurred between 6:00 and 9:00 AM (see Table 3.2). This eliminated 8 respondents from the set of casual carpooling data, leaving 208 respondents. Additionally, for the calculation of descriptive statistics and estimation of model coefficients, only respondents who indicated that they used casual carpooling at least 4 times per week were considered in order to focus the analysis on travelers who frequently casual carpool. This reduced the data set to 149 respondents for that portion of the analysis.

Table 3.2. Casual Carpool Passenger Counts, June 19, 2003.

Begin Time	Kingsland P&R	Addicks P&R	NW Station P&R	Total
5:30 AM	0	0	0	0
5:45 AM	0	0	0	0
6:00 AM	0	1	2	3
6:15 AM	2	2	5	9
6:30 AM	6	16	6	28
6:45 AM	13	16	19	48
7:00 AM	23	39	17	79
7:15 AM	38	35	21	94
7:30 AM	13	26	32	71
7:45 AM	10	29	14	53
8:00 AM	15	21	8	44
8:15 AM	4	19	6	29
8:30 AM	3	7	3	13
8:45 AM	2	5	2	9
9:00 AM	1	0	0	1
9:15 AM	0	3	0	3
TOTAL	**130**	**219**	**135**	**484**

3.2.2 Travel Speeds and Travel Times Along Casual Carpooling Corridors

The casual carpool survey included questions regarding travel time savings, but the responses to those questions indicated what travelers perceived to be their travel time savings on the HOV lane. In order to estimate the actual travel time savings gained by casual carpool passengers, travel time data along the HOV lanes as well as the general purpose lanes were required. Travel times along the corridor were calculated using average speed data for the HOV and general purpose lanes. The average speed data used for the calculation were obtained from TranStar, Houston's traffic management center. The data were collected daily along Houston's freeways using radio-frequency (RF) antennas. The antennas detected vehicles that were equipped with electronic toll collection transponders and recorded their unique identification numbers. Average travel speeds were calculated based on the average travel time between antennas. Speed data were collected continuously by TranStar personnel and were used to calculate the average travel speeds that were post on its website, http://traffic.tamu.edu (*19*).

The data used in this analysis were average speeds along the HOV and general purpose lanes for the entire 2003 year (not including weekends and holidays). The data were collected along joining sections on both freeways (see Tables 3.3 and 3.4). Each section is the distance between two RF antennas. The data used in the analysis contained 2003 average travel speeds by 15-minute periods for each section (see Tables 3.5 and 3.6 in Section 3.3.1).

Table 3.3. Katy Freeway Data Collection Sections.

General Purpose Lanes	Distance	HOV Lane	Distance
SH 6 to Eldridge	1.6 mi	SH 6 to Sam Houston	4.9 mi
Eldridge to Sam Houston	3.3 mi	Sam Houston to Bunker Hill	1.9 mi
Sam Houston to Blalock	2.5 mi	Bunker Hill to Silber	3.8 mi
Blalock to I-610	4.1 mi	Silber to I-610	0.9 mi
Total	**11.5 mi**		**11.5 mi**

Table 3.4. Northwest Freeway Data Collection Sections.

General Purpose Lanes	Distance	HOV Lane	Distance
West Rd. to Sam Houston	4.7 mi	West Rd. to Sam Houston	4.7 mi
Sam Houston to Fairbanks	2.1 mi	Sam Houston to Fairbanks	2.1 mi
Fairbanks to Pinemont	2.3 mi	Fairbanks to Pinemont	2.3 mi
Pinemont to 34th	2.1 mi	Pinemont to 34th	2.1 mi
34th to Dacoma	1.2 mi	34th to Dacoma	1.2 mi
Total	**12.4 mi**		**12.4 mi**

3.2.3 Travel Time Required to Join a Casual Carpool

To calculate travel time savings offered by casual carpooling, consideration needed to be made for the amount of time necessary to park at a carpool formation site and wait to

join a carpool. Parking and wait times at the carpool formation site were manually observed during a typical morning peak period. On Wednesday, June 30, 2004, three data collectors observed the parking and wait times at the Addicks Park & Ride location on the Katy Freeway. From 6:45 to 8:30 AM, data were collected for delay experienced by casual carpool passengers at the park and ride location. One person observed persons arriving at the facility and measured the amount of time necessary to walk from their cars to the casual carpool formation site. Forty-two persons were observed, and they took an average of 105 seconds to walk from their cars to the site (see Figure 3.1). The other two data collectors measured the amount of time that casual carpool passengers waited in the casual carpool line prior to getting in a vehicle (see Figure 3.2). At the Addicks facility, casual carpools form in a designated passenger pick-up location adjacent to the bus arrival location. The collected data were measured from the point when a passenger first arrived at the casual carpool queue until the vehicle they entered pulled away from the curb. There were 147 casual carpool passengers observed, and they experienced an average wait time of 144 seconds.

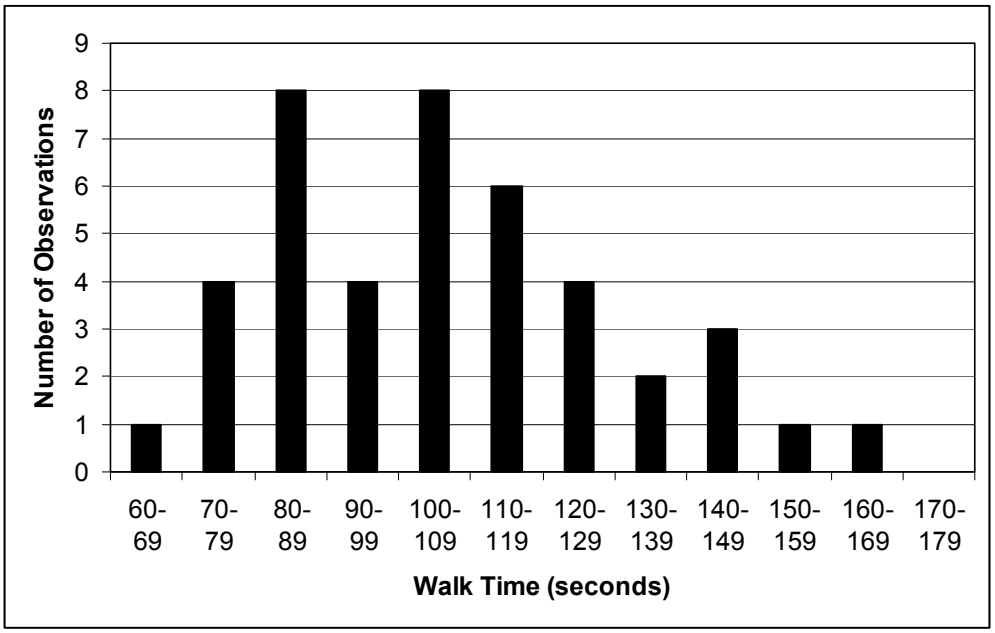

Figure 3.1. Distribution of Time Spent Walking to Casual Carpool Queue.

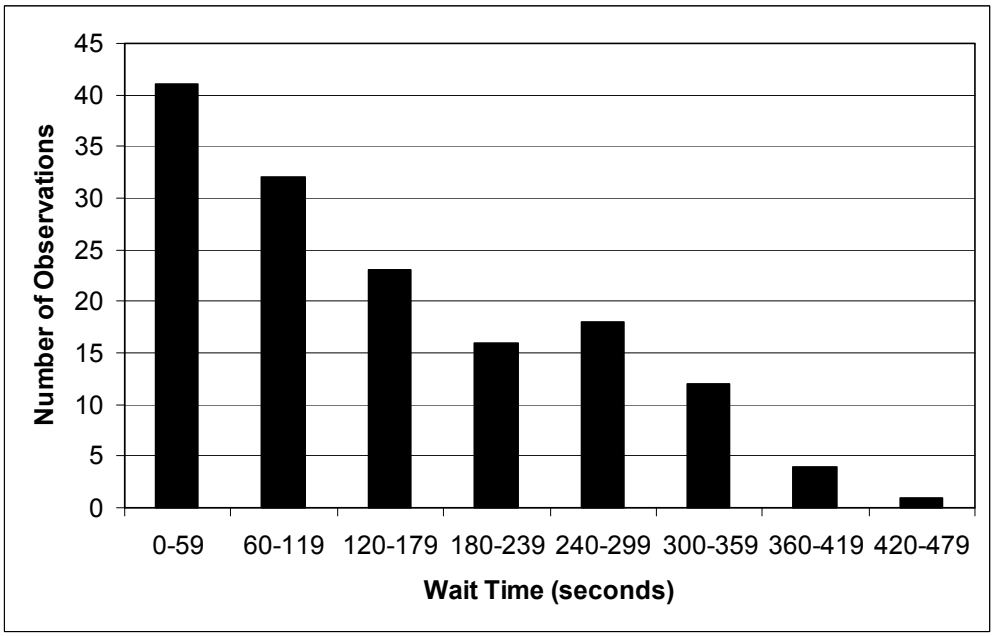

Figure 3.2. Distribution of Time Spent in Casual Carpool Queue.

The distribution of interarrival times for casual carpool passengers and drivers are shown in Figures 3.3 and 3.4, respectively. Both of these arrival types were assumed to be random, so both sets of data were assumed to follow a negative exponential distribution (*20*). A chi-square goodness-of-fit test indicated that the casual carpool passenger interarrival times did follow a negative exponential distribution ($\chi^2_{calculated} = 10.7 < \chi^2_{0.05} = 12.6$, df = 6), but the driver interarrival times did not ($\chi^2_{calculated} = 13.9 > \chi^2_{0.05} = 9.5$, df = 4). This may have been due to a nearby traffic signal or other traffic control devices regulating the arrival of drivers. The distribution of the time spent walking from a parked car to the casual carpool queueing area is shown in Figure 3.1, and the distribution of time spent in the queue is shown in Figure 3.2. An attempt was made to determine if the data fit a standard stochastic queueing model. However, this proved impossible based on the non-standard service process of the arriving vehicles. The number of casual carpoolers picked up by each driver (bodysnatcher) would vary between 1 and 2 depending on the number of occupants already in the arriving vehicle. This variation in service could not be applied to any standard stochastic queueing model. Therefore, the mean of the wait time was used in the calculation of travel time savings.

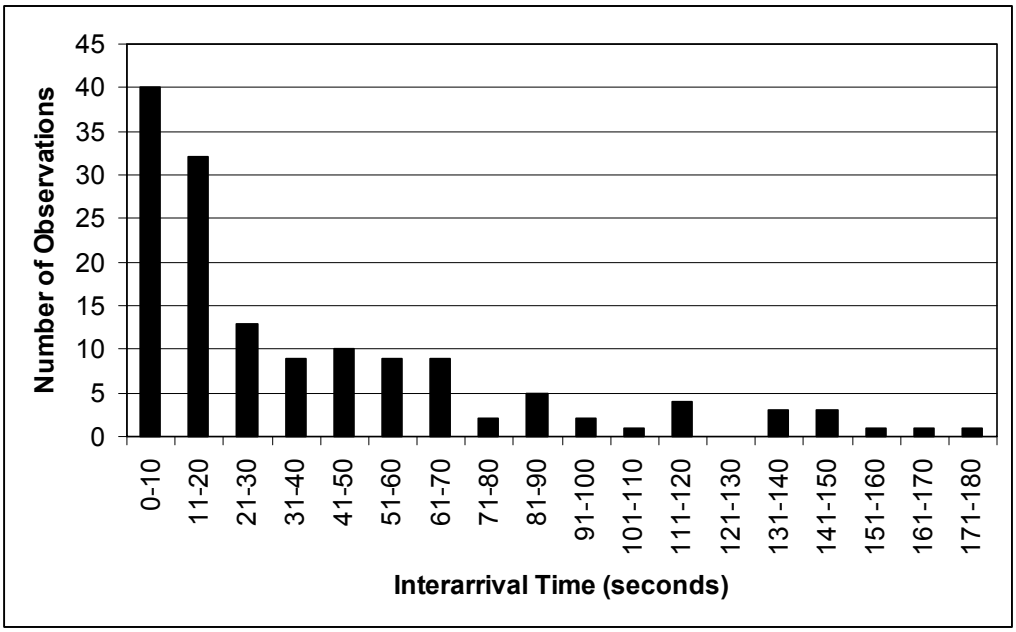

Figure 3.3. Interarrival Times of Casual Carpool Passengers.

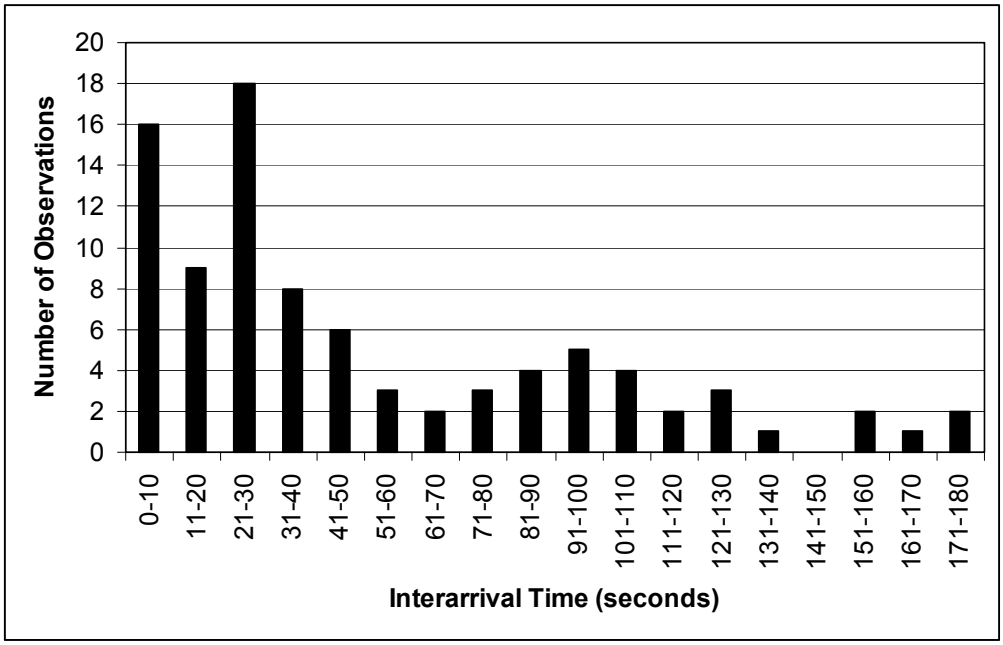

Figure 3.4. Interarrival Times of Casual Carpool Drivers.

3.3 Estimation of Differences in Travel Times by Mode

One of the primary factors that can influence mode choice is travel time. It is important to understand what travel time savings may be gained by casual carpooling rather than using an alternate mode. For this analysis, travel times were compared for the mode choices available to potential casual carpool passengers.

3.3.1 Travel Time Differential Between General Purpose and HOV Lanes

The travel time differential between the HOV lane and the general purpose lanes on the freeway was calculated by comparing the average travel speed on the HOV lane to the average speed on the general purpose lanes for each section of the freeway (see Tables 3.3 and 3.4). First, the travel time for each section was found using the following equation:

$$TT = \frac{d}{S} \tag{3.1}$$

where:

TT = travel time for the segment
d = the length of the segment
S = the space mean speed for the segment

Once the travel times were calculated for each main lane and HOV lane segment, total travel time savings was calculated using the following equation:

$$TTD = \sum_{i=1}^{n} TT_{Main} - \sum_{i=1}^{n} TT_{HOV} \tag{3.2}$$

where:

TTD = total travel time differential
TT_{Main} = travel times for main lane segments
TT_{HOV} = travel times for HOV lane segments
n = total number of segments (see Tables 3.3 and 3.4)

This calculation was repeated to yield approximate travel time differential for trips beginning at each of the three park and ride locations. Distance adjustments were made for the analysis segments containing the park and ride locations. The Addicks Park and Ride facility is located between SH6 and Eldridge, so the distance on this segment was changed in the calculation to reflect an accurate total distance for a trip originating at Addicks. This consideration was also made for the locations of the Kingsland and Northwest Station park and ride locations. The travel times along both the general purpose lanes and the HOV lanes as well as the travel time differential for trips beginning at each of the park and ride locations are shown in Tables 3.5, 3.6, and 3.7.

Table 3.5. Travel Times for Trips from Kingsland P&R to I-610.

Begin Time	General Purpose Lanes Travel Time (minutes)	HOV Lanes Travel Time (minutes)	Travel Time Differential (minutes)
6:00 AM	20:23	17:00	03:24
6:15 AM	25:06	18:13	06:54
6:30 AM	29:17	19:48	09:29
6:45 AM	32:24	20:23	12:01
7:00 AM	35:01	19:01	16:00
7:15 AM	39:26	18:46	20:40
7:30 AM	41:56	19:18	22:38
7:45 AM	41:00	19:03	21:57
8:00 AM	38:25	18:23	20:02
8:15 AM	37:23	17:55	19:28
8:30 AM	35:06	17:33	17:33
8:45 AM	31:19	17:06	14:13
9:00 AM	27:34	16:49	10:46

Table 3.6. Travel Times for Trips from Addicks P&R to I-610.

Begin Time	General Purpose Lanes Travel Time (minutes)	HOV Lanes Travel Time (minutes)	Travel Time Differential (minutes)
6:00 AM	12:16	10:26	01:50
6:15 AM	14:51	11:09	03:41
6:30 AM	17:41	12:07	05:34
6:45 AM	20:00	12:42	07:18
7:00 AM	21:54	11:48	10:06
7:15 AM	25:13	11:33	13:40
7:30 AM	27:27	11:46	15:41
7:45 AM	26:51	11:36	15:15
8:00 AM	25:12	11:25	13:47
8:15 AM	24:20	11:09	13:10
8:30 AM	22:32	10:55	11:36
8:45 AM	19:58	10:38	09:19
9:00 AM	17:22	10:25	06:56

Table 3.7. Travel Times for Trips from Northwest Station P&R to Dacoma.

Begin Time	General Purpose Lanes Travel Time (minutes)	HOV Lanes Travel Time (minutes)	Travel Time Differential (minutes)
6:00 AM	14:05	11:30	02:35
6:15 AM	18:28	12:11	06:16
6:30 AM	21:22	13:33	07:49
6:45 AM	23:47	14:29	09:18
7:00 AM	26:11	12:32	13:38
7:15 AM	29:30	12:13	17:16
7:30 AM	31:13	12:11	19:02
7:45 AM	28:44	12:14	16:30
8:00 AM	25:22	12:19	13:03
8:15 AM	23:01	11:52	11:09
8:30 AM	20:34	11:33	09:01
8:45 AM	18:00	11:18	06:42
9:00 AM	15:37	11:13	04:23

By using the average speed data, approximate travel time differentials along the Katy and Northwest Freeway general purpose lanes and HOV lanes were calculated. However, the actual time savings gained by casual carpool passengers needed to include the portions of the trip before and after the portion of the trip spent on the HOV lane. The use of casual carpooling required that travelers drive to the park and ride lot and wait for a carpool rather than drive directly to the freeway, and this will be examined in the next section. Conversely, it was assumed that the travel times after exiting the HOV lane were equal for casual carpools and those driving on the main lanes or using transit.

3.3.2 Analysis of Casual Carpooling Formation Times

The data collected at the Addicks Park and Ride lot were used to estimate the amount of time spent by casual carpool passengers to join carpools rather than simply drive alone on the main lanes of the freeway. This time included the additional time needed by casual carpool passengers to drive to the park and ride facility rather than drive directly to the freeway, the time spent parking a vehicle and walking to the casual carpool queue, and the time spent waiting in line for a carpool. The values used for these times in the analysis are shown in Table 3.8. The time to park and the time spent waiting in line are averages based on the data collected at the Addicks Park and Ride facility. Based upon the spacing of freeway entrances along the analysis corridors, it was assumed that the maximum additional time needed to travel to the park and ride would be ten minutes and that the average time would be five minutes. The five minute value was used to maintain a conservative estimate of travel time savings gained by casual carpooler passengers. It was believed that the five minute was likely an overestimation of the additional time needed. The times to park a vehicle and walk to the queue and waiting for a carpool were observed averages.

Table 3.8. Casual Carpool Formation Times.

Activity	**Time (minutes)**
Drive to Park and Ride	5:00
Park Vehicle and Walk to Queue	1:45
Wait for Carpool	2:24
Total	**9:09**

3.3.3 Transit Headways

For the comparison of casual carpooling and transit, it was necessary to determine the approximate time spent waiting for a bus because the wait time is the only travel time difference between the two modes. Users of transit and casual carpooling spend the same amount of time arriving at the park and ride lot and walking the queues. Additionally, casual carpool passengers and transit users incur similar travel times after being dropped off because casual carpool passengers are typically dropped off at or near bus stops. Bus headways for each of the three park and ride locations during the morning peak period were used to calculate average wait times. The average headways and time spent waiting for each facility along with the average headway are listed in Table 3.9. The average time spent waiting for a bus was assumed to be half of the average headway based on the assumption of random arrivals of transit passengers (*21*).

Table 3.9. Bus Headways and Wait Times.

Park and Ride Facility	Average Headway (minutes)	Average Wait Time (minutes)
Kingsland P&R	10:00	5:00
Addicks P&R	10:00	5:00
Northwest Station P&R	8:00	4:00

3.3.4 Comparison of Travel Times by Mode

The data collected from TranStar and the manually collected data from the Addicks Park & Ride were used to estimate the travel time savings gained by casual carpool passengers. The time savings calculation was used to compare the option of traveling as a passenger in a casual carpool to (1) using transit and (2) driving alone on the general purpose lanes. The time savings gained by using casual carpooling was calculated using the following equations:

$$TT_{Slugging} = TT_{HOV} + AT + PT + QWT \tag{3.3}$$

$$TT_{Transit} = TT_{HOV} + AT + PT + QWT \tag{3.4}$$

$$TTS_1 = TT_{Transit} - TT_{Slugging} \tag{3.5}$$

$$TTS_2 = TT_{Main\ Lanes} - TT_{Slugging} \tag{3.6}$$

where:

$TT_{Main\ Lanes}$ = travel time along freeway main lanes

TT_{HOV} = travel time along HOV lane

AT = additional time spent driving to park and ride (slugging and transit only)

PT = time spent parking and walking to park and ride (slugging and transit only)

QWT = time spent waiting for carpool or bus (slugging and transit only)

$TT_{Slugging}$ = the total trip time for the casual carpooling mode

$TT_{Transit}$ = the total trip time for the transit mode

TTS_1 = time savings gained by using casual carpooling instead of transit

TTS_2 = time savings gained by using casual carpooling instead of freeway main lanes

The result was a conservative estimate of travel time savings gained by casual carpool passengers in the morning peak periods for each of the three park and ride locations. The results of the travel time savings calculations are shown in Tables 3.10 and 3.11. For the comparison with driving alone, the time savings for each 15-minute period during the morning are displayed for each park and ride facility along with the June 2003 passenger counts for that time period. The times listed indicate the beginning of the 15-minute time period. For example, 7:15 AM means the time period from 7:15 AM to 7:30 AM. For the comparison with transit, the travel time savings was constant and independent from the trip begin time as both modes use the HOV lane.

Table 3.10. Time Savings (in minutes) Gained by Casual Carpool Passengers When Compared to Driving Alone on the General Purpose Lanes.

Trip Begin	Addicks Park & Ride		Kingsland Park & Ride		Northwest Station Park & Ride	
	Time Savings	June 2003 Count	Time Savings	June 2003 Count	Time Savings	June 2003 Count
6:00 AM	< 0	1	< 0	0	< 0	2
6:15 AM	< 0	2	< 0	2	< 0	5
6:30 AM	< 0	16	00:20	6	< 0	6
6:45 AM	< 0	16	02:52	13	00:09	19
7:00 AM	00:57	39	06:51	23	04:30	17
7:15 AM	04:31	35	11:32	38	08:07	21
7:30 AM	06:32	26	13:29	13	09:53	32
7:45 AM	06:06	29	12:48	10	07:22	14
8:00 AM	04:38	21	10:53	15	03:54	8
8:15 AM	04:01	19	10:19	4	02:00	6
8:30 AM	02:28	7	08:25	3	< 0	3
8:45 AM	00:11	5	05:04	2	< 0	2
9:00 AM	< 0	0	01:37	1	< 0	0

Table 3.11. Time Savings (in minutes) Gained by Casual Carpool Passengers When Compared to Using Transit.

Park and Ride Facility	Average Time Savings
Kingsland Park and Ride	2:36
Addicks Park and Ride	2:36
Northwest Station Park and Ride	1:36

The time savings gained by utilizing casual carpooling when compared to driving alone was found to be the greatest at 7:30 AM at all three park and ride locations. The maximum calculated time savings was for a trip beginning at 7:30 from the Kingsland park and ride facility. The time savings for that trip would be more than 13 minutes. In some of the cases, though, the time savings for casual carpooling was actually less than zero. A time savings less than zero indicates that the trip could actually be made faster by driving alone on the general purpose lanes rather than utilizing casual carpooling (given the conservative assumptions regarding the time needed to drive to the park and ride location). The assumptions of drive times to the park and ride facilities were made to ensure a conservative estimate of travel time savings. The time savings gained from casual carpooling would be greater for travelers who do not spend much additional time driving to the park and ride, such as those that live nearby or would drive past it if commuting alone. When compared to the passenger counts from June 2003, the results suggest that casual carpooling occurs more often during times of higher travel time

savings (see Figures 3.5, 3.6 and 3.7). This may indicate that travel time savings is a significant influence on the choice to casual carpool.

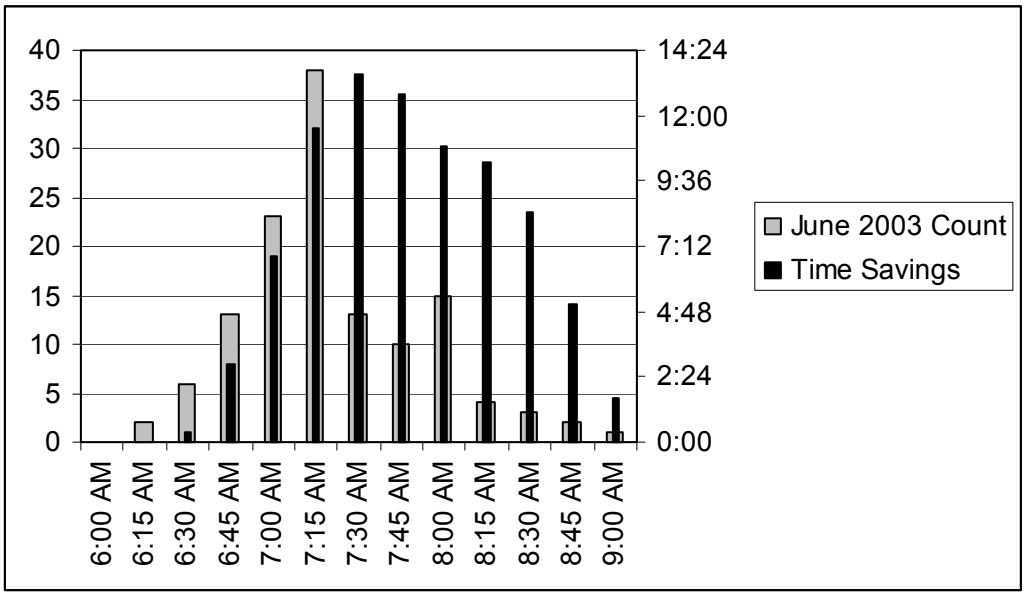

Figure 3.5. Comparison of Time Savings and Passenger Counts at Kingsland Park and Ride.

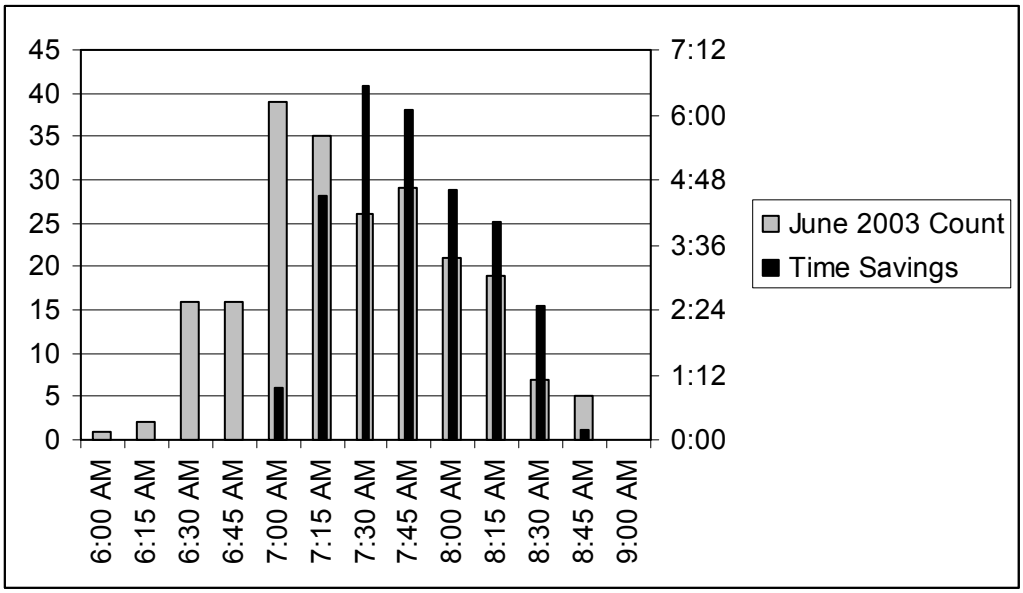

Figure 3.6. Comparison of Time Savings and Passenger Counts at Addicks Park and Ride.

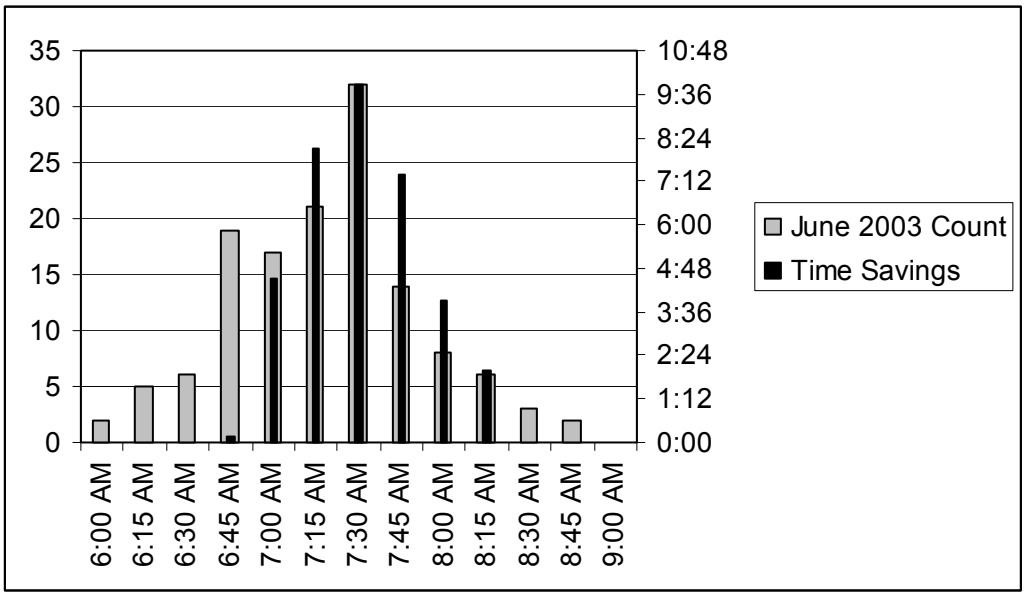

Figure 3.7. Comparison of Time Savings and Passenger Counts at Northwest Station Park and Ride.

The results of the comparison between casual carpooling and using transit are shown in Table 3.11. The time savings calculation for the transit option was based upon average transit and carpool wait times, and is thus a constant value for the entire morning peak period. The average time savings was approximately two-and-a-half minutes for the Kingsland and Addicks locations, and approximately one-and-a-half minutes for the Northwest Station location.

3.4 Summary

In this chapter, the data collection process was detailed along with some of the preliminary analyses performed using the data. Data were collected from three sources: the casual carpool survey conducted in November 2003 by TTI, speed data collected by Houston TranStar, and data collected manually at a park and ride location during a typical morning peak period. The data were used to analyze the time savings gained by casual carpool passengers as compared to driving alone on the general purpose lanes or using transit. The calculations showed that casual carpool passengers could save as much as 13 minutes over driving alone on the general purpose lanes and as much as two and a half minutes over transit during the peak hour on the Katy Freeway. Additionally, the number of casual carpool passengers was generally higher during times of larger time savings. However, travelers might have additional reasons for casual carpooling such as saving money, comfort or meeting people (*17*).

There are numerous other factors besides travel time savings that might influence the mode choice of a traveler. Monetary costs, such as transit fare and fuel, or trip purpose could affect a traveler's decision. Additionally, socio-economic characteristics could also have a major influence on the decision of whether a traveler will choose to casual carpool. Travelers may also value the reliability of travel times on the HOV lane. In the next chapter, the survey data is used to determine what, if any, trip and socio-economic characteristics are more likely to influence a traveler's decision to casual carpool.

CHAPTER IV

DATA ANALYSIS AND RESULTS

4.1 Introduction

In this chapter, the data analyses that were performed on the survey responses are described. First, descriptive statistics were calculated for the survey data, including questions that were asked exclusively of casual carpool passengers. Each variable was tested to determine if a significant difference existed between respondent groups based on their travel mode. Additionally, the data were used to estimate coefficients for two discrete choice models for the I-10 and US 290 corridors. The first discrete choice model was used to estimate the utility function of the choice between transit and casual carpooling. The second model was used to estimate the utility function of the choice between driving on the main lanes, forming a traditional carpool and using the HOV lane, casual carpooling, and transit.

4.2 Hypotheses

Based upon data from San Francisco and Washington D.C., logical reasoning, and the nature of casual carpooling, a number of hypotheses were made concerning the factors influencing casual carpooler passengers' travel behavior and traveler characteristics that might indicate an increased likelihood of choosing to casual carpool. It was hypothesized that casual carpool passengers were more likely to be making commute trips due to the time of day that casual carpooling occurred. Casual carpooling primarily

occurs during peak periods of travel and can potentially provide a travel time savings and reliability benefit from the use of the HOV lane. It was believed that casual carpooling was more likely to be used by travelers who have little choice about their time of travel and are forced to make their trips during peak hours (typical of commuters). Additionally, it was hypothesized that casual carpool passengers would likely be, on average, younger than other travelers. Younger people are typically more adventurous and would likely view the possible risks of casual carpooling in a more favorable light than older travelers. Casual carpool passengers were also hypothesized to have lower incomes than other travelers. It was believed that lower income people would gravitate toward casual carpooling because it offers a similar trip as transit, but without the associated fare. It was also thought that males may have been more likely to casual carpool than females. The results of Spielberg and Shapiro's analysis (*4*) indicated a two-thirds male majority among casual carpool passengers in Washington, D.C. Men may have been less influenced by the perceived risks of accepting rides with strangers. Travelers from smaller households were also hypothesized to be more likely to casual carpool because of an increased difficulty of forming a traditional carpool.

4.3 Descriptive Statistics

The survey data from the 2003 survey conducted by TTI were initially examined for significant differences among groups of travelers. The data were grouped by four mode choices: driving on the main lanes, using the HOV lane with a traditional carpool (non-

bodysnatchers), casual carpooling, and transit. The statistical package SPSS (*22*) was used to calculate the descriptive statistics and perform the statistical tests (see Table 4.1).

Table 4.1. Descriptive Statistics of Surveyed Travelers.

	Main Lanes (n=1032)	**HOV (n=331)**	**Casual Carpooling (n=149)**	**Transit (n=290)**
Trip Purpose				
Commute[AB]	85.0%	79.8%	96.0%	88.9%
Recreation[A]	1.9%	2.8%	0.0%	0.3%
Work (non-commute)	9.0%	5.8%	4.0%	7.3%
School[A]	2.3%	7.0%	0.0%	2.4%
Other[A]	1.9%	4.6%	0.0%	1.0%
Trips per Week	9.85	9.91	9.67	9.20
Age				
16-24	3.9%	2.2%	1.4%	4.9%
25-34[AB]	23.0%	17.9%	27.7%	18.4%
35-44	27.6%	33.3%	31.8%	25.8%
45-54	30.1%	31.5%	33.1%	38.2%
55-64[B]	12.5%	11.1%	5.4%	12.0%
65+[A]	2.8%	4.0%	0.7%	0.7%
Sex[A]				
Male	60.9%	49.7%	50.7%	45.8%
Female	39.1%	50.3%	49.3%	54.2%
Household Type				
Single Adult[A]	12.4%	5.3%	10.3%	15.3%
Unrelated Adults	2.6%	2.5%	3.4%	3.3%
Married w/o Child[A]	25.2%	24.0%	21.9%	16.7%
Married w/ Child(ren)	52.0%	59.5%	52.1%	54.9%
Single Parent Family	5.3%	4.0%	8.9%	7.3%
Other	2.5%	4.7%	3.4%	2.5%
Household Size[A]	3.02	3.32	3.01	3.06
Number of Vehicles[A]	2.42	2.39	2.22	2.19

[A] Significant when comparing all four modes
[B] Significant when comparing casual carpooling and transit

Table 4.1. Continued.

	Main Lanes (n=1032)	HOV (n=331)	Casual Carpooling (n=149)	Transit (n=290)
Occupation				
Professional/Managerial[B]	62.8%	57.9%	67.6%	56.9%
Technical	10.0%	9.6%	10.8%	12.5%
Sales[A]	7.4%	3.4%	0.7%	1.8%
Administrative/Clerical[A]	8.4%	10.8%	19.6%	23.5%
Manufacturing	0.6%	0.0%	0.0%	0.7%
Homemaker/Parent[A]	0.8%	4.0%	0.0%	0.0%
Student	1.9%	1.5%	0.0%	2.1%
Self Employed[A]	3.7%	5.0%	0.0%	0.4%
Unemployed	0.1%	0.0%	0.0%	0.0%
Retired[A]	1.4%	3.4%	0.0%	0.0%
Other	2.8%	4.3%	1.4%	2.1%
Education				
Less than High School	0.5%	0.3%	0.0%	0.4%
High School Graduate[A]	4.2%	6.5%	6.1%	8.7%
Some college/Vocational	23.5%	23.7%	22.4%	24.5%
College Graduate	46.9%	43.6%	51.7%	44.0%
Postgraduate Degree	24.9%	25.9%	19.7%	22.4%
Income				
Less than $10,000	0.5%	0.4%	0.0%	1.6%
$10,000 to $14,999	0.7%	0.4%	0.0%	1.2%
$15,000 to $24,999	1.1%	0.7%	0.7%	1.6%
$25,000 to $34,999[AB]	5.1%	4.2%	0.7%	7.6%
$35,000 to $49,999	9.7%	9.9%	14.5%	12.4%
$50,000 to $74,999[A]	19.6%	17.3%	27.5%	24.5%
$75,000 to $99,999	21.5%	17.3%	24.6%	19.7%
$100,000 to $199,999[A]	32.3%	42.4%	29.7%	28.5%
$200,000 or more[A]	9.4%	7.4%	2.2%	2.8%
Travel Time	57.00	54.24	55.30	55.46

[A] Significant when comparing all four modes
[B] Significant when comparing casual carpooling and transit

4.3.1 Tests for Significant Difference

First, statistical tests were performed to determine any significant differences in traveler characteristics among all four mode choices. A Chi-Square test was used to test for significant differences among the binary variables, and a one-way analysis of variance (ANOVA) was used to test the continuous variables. Additionally, a Kruskal-Wallis test was used to determine any significant difference for the ordinal variables of age, income, and education. The variables that were found to be significantly different at the 95 percent confidence level were marked with an "A" symbol in Table 4.1.

Next, tests were performed to test for significant differences between the mode choices of casual carpooling and transit in order to find potential characteristics that may affect the likelihood to casual carpool rather than use transit. The variables that were found to significantly different at the 95% confidence level were marked with a "B" symbol in Table 4.1.

4.3.2 Significant Differences Between Casual Carpooling and Transit

The results of the statistical tests revealed significant differences between casual carpooling and transit for a number of the data variables. Significant differences between the two modes were found for travelers making commute trips, as well as those between the ages of 25 and 34 and those between 55 and 64. Significantly more casual carpool passengers were on commute trips and between the ages of 25 and 34, while

significantly more transit users were between the ages of 55 and 64. There were also significantly more casual carpool passengers with professional/managerial occupations, while significantly more transit users had household incomes between $25,000 and $34,999.

4.3.3 Significant Differences Between All Four Modes

The results of the statistical tests also revealed a number of significant differences among the four primary morning travel modes. The percentage of respondents on commute, recreation, school and other trip types were significantly different among the four groups. The percentage of respondents 25 to 34 years old and 65 or more years old was significantly different among modes. This was also true for single adult households and married without children households. The average household size and number of vehicles were also significantly different among modes, with HOV users having significantly larger households. Additionally, a significant difference was found for those with occupations that were professional/managerial, sales, homemaker, self-employed, or retired. The income ranges of $25,000 to $35,000, $50,000 to $75,000, $100,000 to $200,000, and $200,000 or more were also significantly different among the four mode choices.

4.4 Casual Carpool Passenger Characteristics

The surveys that were distributed to casual carpool passengers contained a series of questions that were exclusive to that group of travelers. The questions inquired about

the nature of each traveler's casual carpooling trip and his or her previous experience using the mode (see Table 4.2). The results provided insight into the practice of casual carpooling in Houston, including what modes were commonly used for return trips and how frequently respondents joined a casual carpool.

Table 4.2. Casual Carpool Passenger Characteristics.

Familiarity With Carpool Companions	
Never traveled with before	65.3%
Traveled with once or twice before	28.1%
Travel with frequently	6.6%
Reasons That Would Cause a Choice NOT to Casual Carpool	
More than 5 persons waiting for carpool	14.0%
More than 10 persons waiting for carpool	47.8%
Bus arrives just as traveler arrives	3.9%
Unsafe feeling about the carpool	27.5%
No one in line waiting to form a casual carpool	2.2%
Bad weather	15.7%
More frequent bus service to destination	9.0%
Other	29.2%

Note: some percentages sum to over 100% as respondents could choose multiple answers for some questions

Table 4.2. Continued.

Frequency of Casual Carpool Use	
Everyday	52.0%
3 to 4 days per week	24.0%
1 to 2 days per week	19.9%
Less than once per week	4.1%
First time	0.0%
First Casual Carpool Use	
Within the last month	6.7%
Within the last year	40.5%
More than a year ago	52.8%
Reason For Using Casual Carpooling	
Congestion on the freeway	28.1%
Bus service too slow	52.6%
Cars more comfortable than the bus	34.2%
Save money	62.8%
Save time	79.1%
Meet new people	16.3%
Other	13.3%
Modes Used for Similar Trips	
Drive alone	26.2%
Regular carpool with family or friends	18.8%
Ride the bus	91.6%
Other	6.3%
Monetary Contribution to Driver?	
Yes	1.0%
No	99.0%
Mode Used for Evening Return Trip	
Casual carpool	12.8%
Bus	66.3%
regular carpool with family or friends	5.1%
Drive alone	0.0%
Other	15.8%

Note: some percentages sum to over 100% as respondents could choose multiple answers for some questions

The survey responses indicated that most casual carpool passengers (65.3 percent) had never met their travel companions before. However, almost one-third indicated that they had traveled with them once or twice, indicating that a relatively small number of people are using the mode consistently. The results also showed that over 75 percent of users casual carpooled at least three times per week. Casual carpool passengers also cited saving money (62.8 percent) and slow bus service (52.6 percent) as the two primary reasons for casual carpooling. They indicated that they often use the bus for similar trips and for the evening return trip. They also indicated that money is rarely given to the driver as compensation, which is consistent with casual carpooling practices elsewhere in the U.S.

4.5 Modeling the Choice Between Casual Carpooling and Transit

To better understand casual carpoolers and the factors that affect their mode choice, discrete choice model coefficients were estimated for two sets of choices. The choice between casual carpooling and transit was evaluated with the first model. Transit is often a back up mode for casual carpoolers and carpools typically form at or near transit stops. Also, casual carpoolers are often former transit users (*5*). The choice between all four primary modes was evaluated with the second model and is discussed in the next section.

4.5.1 Methodology

The choice between casual carpooling and transit was estimated using a discrete choice model. Discrete choice models assume that each traveler makes his or her decision based upon the utility of each mode (*23*). The utility to each traveler of each mode is described by the following equation:

$$U_{in} = \beta X_{in} + \beta S_{in} + \varepsilon_{in} \tag{4.1}$$

where:

U_{in} = the utility of mode i for traveler n

X_{in} = vector of the attributes of the mode alternative

S_{in} = vector of the attributes of the traveler

β = vector of the coefficients of X_{in} and S_{in}

$\beta X_{in} + \beta S_{in}$ = systematic utility

ε_{in} = random error term

The traveler's ultimate decision will be based upon both the systematic and random utility of each mode. Systematic utility is estimated by the model and is based upon measured variables. Random utility accounts for the affect of all unmeasured and unobservable variables that affect the traveler's decision. This random utility cannot be measured and must be accounted for by using probability functions. The model in this analysis was estimated using a logit model, which assumes that random utilities follow

an extreme value distribution (*12*). Thus, the probability that traveler *n* will choose mode *i* is described by the equation:

$$P_{in} = \frac{e^{\beta X_{in} + \beta S_{in}}}{\sum_j e^{\beta X_{jn} + \beta S_{in}}} \tag{4.2}$$

where:

P_{in} = probability of traveler *n* choosing mode *i*

j = number of mode alternatives

4.5.2 Model Coefficient Estimation and Results

Many variables were tested when estimating the model coefficients. The results of the statistical tests and the hypotheses in subheading 4.2 were used to help determine which variables to consider when estimating the model coefficients. Those that were thought to be influential were used in the initial models. The model coefficients were estimated first using all potentially influential variables. The one or two variables that were found to be the least significant were removed and the model coefficients were estimated again. This process was repeated until only significant variables remained. Only those variables that were significant at the 95 percent confidence level and were not correlated to other variables were left in the final model. Table 4.3 contains a description of the variables used in the model. Table 4.4 shows the results of the discrete choice model. For this model, the null choice was casual carpooling. The utility function derived in the model describes the utility of the transit mode relative to the casual carpooling mode

which has all coefficients equal to zero. For the purposes of calculating mode choice probability, the utility of casual carpooling is zero. Positive coefficients indicated a higher likelihood of using transit.

Table 4.3. Definitions of Variables Used in Logit Model (Casual Carpooling vs. Transit).

Variable	Measurement
Commute Trip	1, if trip purpose is commuting
	0, otherwise
Trips per Week	Total number of trips in last work week
Age	1, if age is 25 to 34
	0, otherwise
Income	1, if income is $25,000 to $34,999
	0, otherwise

Table 4.4. Model Coefficient Estimation Results (Casual Carpooling vs. Transit).[A]

Variable	Coefficient	Std. Error	t-stat	p-value
Mode Specific Coefficient	2.99	0.75	4.00	0.00*
Commute Trip	-1.09	0.51	-2.14	0.03*
Trips per Week	-0.15	0.06	-2.62	0.01*
Age	-0.53	0.26	-2.01	0.05*
Income	2.73	1.07	2.56	0.01*
Summary				
Number of Observations	362			
Log Likelihood	-225.71			
Restricted Log Likelihood	-240.12			
ρ^2	0.06			
Percent Estimated Correctly	64.1%			

[A]base alternative is casual carpooling with utility of zero
*significant at the 95% confidence level

The results of the model highlight some of the factors that describe selected types of travelers who choose to casual carpool rather than utilize transit. The constant coefficient is 2.99, indicating that with all else being equal, travelers were more likely to choose transit than casual carpooling. This is not surprising as many more travelers use transit than casual carpool. The results also indicate that having an income between $25,000 and $35,000 increased the traveler's likelihood to use transit rather than casual carpool. However, being on a commute trip, making a higher number of total trips per

week, and/or being between the ages of 25 and 34 increased the traveler's likelihood of forming casual carpools for their trips rather than taking transit.

4.6 Modeling the Choice Between Four Primary Modes

The second model used in the analysis compared the choices of driving on the main lanes, driving in the HOV lane, forming a casual carpool, and using transit. The purpose of this model was to better understand what factors influenced travelers to choose casual carpooling over the most common other available modes during the morning peak travel time.

4.6.1 Methodology

The choice among the four mode choices was again estimated using a discrete choice logit model. However, for this model, mode specific constants were used to better describe traveler behavior. Mode specific constants were applied to only specific mode choices rather than all choices. For each variable, the calculated coefficient was only applied to certain mode choices. For all others, the coefficient was zero.

4.6.2 Model Coefficient Estimation and Results

Several sets of variables were used for testing the model, using the main lanes option as the null choice. Only variables that were significant at the 95% confidence level remained in the final model. The variables used in the model as well as which mode

choice utility functions they were associated with is listed in Table 4.5. The model estimation results can be found in Table 4.6.

Table 4.5. Definitions of Variables Used in Logit Model (All Four Modes).

Variable	Measurement	Mode Choice Variable		
		HOV	Casual Carpool	Transit
Trip Purpose-Commute	1, if trip purpose is commuting		✓	
	0, otherwise		✓	
Age-60	1, if between 55 and 64		✓	
	0, otherwise		✓	
Single Adult	1, if single adult	✓		
	0, otherwise	✓		
Number of Vehicles	Total number of vehicles in household		✓	✓
Occupation-Prof./Mgr.	1, if professional or managerial		✓	
	0, otherwise		✓	
Occupation-Adm./Cler.	1, if administrative or clerical		✓	✓
	0, otherwise		✓	✓
Income-30K	1, if income is $25,000 to $34,999		✓	
	0, otherwise		✓	
Income-150K	1, if income is $100,000 to $199,999	✓		
	0, otherwise	✓		

Table 4.6. Model Coefficient Estimation Results (All Four Modes).[A]

Variable	Coefficient	Std. Error	t-stat	p-value
HOV Mode Specific Coefficient	-1.21	0.09	-13.24	0.00*
Casual Carpool Mode Specific Coefficient	-3.11	0.55	-5.68	0.00*
Transit Mode Specific Coefficient	-1.08	0.18	-6.03	0.00*
Trip Purpose-Commute	1.49	0.52	2.90	0.00*
Age-60	-0.87	0.40	-2.16	0.03*
Single Adult	-0.67	0.27	-2.50	0.01*
Number of Vehicles	-0.18	0.07	-2.63	0.01*
Occupation-Prof./Mgr.	0.41	0.21	1.98	0.05*
Occupation-Adm./Cler.	1.04	0.17	5.97	0.00*
Income-30K	-2.21	1.02	-2.17	0.03*
Income-150K	0.35	0.14	2.53	0.01*
Summary				
Number of Observations		1507		
Log Likelihood		-1702.93		
Restricted Log Likelihood		-2089.15		
ρ^2		0.185		
Percent Estimated Correctly		40.8%		

[A]base alternative is driving alone on main lanes with utility of zero
*significant at the 95% confidence level

The constants for the HOV, casual carpool, and transit modes were all negative which indicated that with all else being equal, travelers were most likely to choose to drive on the main lanes. The trip purpose, age, and occupation (professional) variables applied only to the casual carpooling utility function and indicated a number of factors influencing casual carpoolers' decisions. The coefficient for the trip purpose was positive indicating that being on a commute trip increased the likelihood that a traveler would choose casual carpooling over the other three modes, which duplicates the results of the previous model. Occupations that were professional/managerial or administrative/clerical also increased a traveler's likelihood to use casual carpooling over the other three modes. Additionally, the results indicated being between the ages of 55 and 64 and/or having incomes between $25,000 and $35,000 reduced a traveler's likelihood to casual carpool.

4.7 Summary

The results of the analyses show some of the factors that influence travelers' decisions whether or not to casual carpool, including income, age, and occupation. Some additional characteristics of casual carpool passengers were also evaluated. The results indicated that most casual carpool passengers often used transit for evening return trips and similar morning trips. About 63 percent used casual carpooling to save money and about 53 percent used casual carpooling because of slow bus service. Most casual carpoolers (76 percent) used this mode three or more times per week.

Of the proposed hypotheses, two were proven correct, while the others were proven incorrect. The results of the model coefficient estimations showed that casual carpool passengers were significantly more likely to be on commute trips, which verified one of the hypotheses. Additionally, the results showed that casual carpoolers were significantly more likely to be between the ages of 25 and 34 (younger) and less likely to be between the ages of 55 and 64 (older). This also confirmed one of the hypotheses.

However, the hypothesis that casual carpooling would attract low income travelers was not substantiated. The results showed that travelers with incomes between $25,000 and $35,000 were significantly less likely to use casual carpooling than other travelers. There were a few possible explanations for this result. One explanation was that these lower income persons already used transit for many of their other trips, and they choose to use transit during the times of casual carpooling as well. Another possible explanation is subsidized transit passes that are available to low income travelers. Travelers with subsidized transit passes would have no money-saving incentive to casual carpool. Also, the descriptive statistics indicated that travelers with incomes between $25,000 and $35,000 were less likely to be making commute trips. This would lead to less use of casual carpooling because commuting is a primary factor that influences casual carpool use. The hypotheses that males and those from smaller households were likely to casual carpool were also not substantiated. Although the gender and household size variables were significant when comparing all four modes, neither was found to significantly influence casual carpooling use in the models.

The results obtained in these analyses provide some information on the type of travelers that choose to casual carpool. This information can be used to better evaluate HOV/HOT lanes use in the future and it can be used in future lane development considerations. Casual carpooling has grown in popularity, and it must be considered when assessing potential corridor improvements. It has the potential to improve the operation efficiency HOV/HOT facilities by improving person movement. The primary goal of HOV facilities is to improve person throughput of a corridor, and casual carpooling promotes this goal. Although there are potential liability concerns, it may eventually become beneficial to promote casual carpooling as a viable mode alternative, and it will be important to know the type of travelers that will be more likely to use it.

CHAPTER V

FINDINGS AND RECOMMENDATIONS

5.1 Findings

Although casual carpooling only exists in three locations in the United States, it will likely become a more common form of transportation in the future. With the continued proliferation of HOV and HOT lanes in the U.S., there will be more opportunities for casual carpools to occur. It is important to better understand the casual carpooling mode, its impact on HOV and HOT lanes, and what factors influence people to casual carpool. Statistical methods and discrete choice models were used in this research to examine the characteristics of casual carpoolers and describe their travel behavior.

The travel time savings that were gained by casual carpool passengers were evaluated in this research. The results of the analyses showed that travelers saved as much as thirteen minutes during the peak hour by casual carpooling rather than driving alone on the freeway main lanes. Additionally, casual carpooling offered time savings of up to two-and-a-half minutes over transit.

The results of the analyses indicated that one of the primary factors driving the use of casual carpooling was trip purpose. In two different models, being on a commute trip was found to increase a traveler's likelihood to use casual carpooling. The results also indicated that making a large number of trips per week, being between the ages of 25

and 34, and/or having occupations that were either professional/managerial or administrative/clerical increased the likelihood that a traveler would choose to casual carpool. Additionally, having incomes between $25,000 and $35,000 and being between the ages of 55 and 64 were reduced a traveler's likelihood to use casual carpooling.

The results of these analyses provided insight into some of the factors that influence the decision to casual carpool. It is important to understand the types of travelers that use casual carpooling, and the information learned in these analyses can be used to better evaluate HOV and HOT lane use and optimize their performance. Casual carpool passengers can comprise a significant portion of HOV/HOT lane person movement and should be considered when considering HOV or HOT lane implementation. However, further research in this area is necessary to better understand these travelers.

5.2 Recommendations

This analysis was performed using data from Houston area casual carpool passengers. It is important to note that although there are only three current casual carpooling locations in the country, they each have very unique characteristics. A more comprehensive study that analyzes all three locations is recommended. This type of study would yield a much better overview of casual carpool behavior on a nationwide scale. Additionally, this research focused only on casual carpooling in the morning peak period. Casual carpooling is growing as a mode for return trips. It would be beneficial to evaluate the

factors influencing evening casual carpool trips, as they could be vastly different than those for the morning period.

Stated preference data should also be used to learn more about how casual carpool passengers value their time and what tradeoffs they make when choosing to casual carpool. This type of study would allow researchers to learn what casual carpool users would be willing to pay to avoid casual carpooling and drive alone on the HOT lane. In addition, a study of casual carpool drivers would also be beneficial as they likely have very different factors influencing their mode choice decisions that casual carpool passengers. Further research in the area of casual carpooling will expand the limited knowledge base on the subject and help professionals better understand what types of travelers are using this mode.

REFERENCES

1. Turnbull, K.F. *History of HOVs*. Committee on High Occupancy Vehicles Systems, Transportation Research Board. <http://www.hovworld.com> Accessed October 18, 2004.

2. LeBlanc, D.E. *Slugging: The Commuting Alternative for Washington, D.C.* Forel Publishing, East Point, Georgia, 1999.

3. Reno, A.T., Gellert W.A., and Verzosa, A. Evaluation of Springfield Instant Carpooling. *In Transportation Research Record 1212*, Transportation Research Board, Washington, D.C., 1989, pp. 53-62.

4. Spielberg, F. and Shapiro, P. Mating Habits of Slugs: Dynamic Carpool Formation in the I-95/I-395 Corridor of Northern Virginia. *In Transportation Research Record 1711*, Transportation Research Board, Washington, D.C., 2000, pp. 31-38.

5. Beroldo, S. Casual Carpooling in the San Francisco Bay Area. *Transportation Quarterly*, Vol. 44, No.1, January 1990, pp. 133-150.

6. RIDES for Bay Area Commuters, Inc. *Casual Carpooling 1998 Update*, January 1999. <http://rideshare.511.org/research/pdfs/casualcarpool.99.pdf> Accessed December 8, 2003.

7. Ojah, M. and Burris, M. *Quantification of Casual Carpooling in Houston*, Texas Transportation Institute, College Station, Texas, February 2004.

8. Sullivan, E. 2000. Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes: Final Report. Retrieved September 9, 2004, from the Department of Civil and Environmental Engineering, California Polytechnic State University at San Luis Obispo Web site: http://ceenve.calpoly.edu/sullivan/sr91/sr91.htm.

9. SR 91 Express Lanes Homepage. http://www.91expresslanes.com, Orange County Expressway Authority. Accessed September 22, 2003.

10. Supernak, J., D. Steffey, and C. Kaschade. Dynamic Value Pricing as Instrument for Better Utilization of High-Occupation Toll Lanes: San Diego I-15 Case. *In Transportation Research Record 1839*, National Academy Press, Washington, D.C., 2003, pp. 55-64.

11. I-15 FasTrak Online. http://argo.sandag.org/fastrak, San Diego Association of Governments. Accessed September 22, 2003.

12. Small, K.A. and C. Winston. The Demand for Transportation: Models and Applications. *In Essays in Transportation Economics and Policy*, Brookings Institute Press, Washington, D.C., 1999.

13. Calfee, J. and C. Winston. The Value of Automobile Travel Time: Implications for Congestion Policy. *Journal of Public Economics*, Vol. 69, No. 1, 1998, pp. 83-102.

14. Small, K.A. *Urban Transportation Economics*, Harwood Academic Publishers, Chur, Switzerland, 1992.

15. Bates, J., J. Polak., P. Jones., and A. Cook. The Valuation of Reliability for Personal Travel. *In Transport Research Part E 37*, Pergamon, New York, 2001, pp. 191-229.

16. Slug-lines.com: Slugging and Slug Lines Information for Washington, D.C. http://www.slug-lines.com, Forel Publishing Company. Accessed October 3, 2003.

17. Wall, L. In Search of Slugs: Impatient Houston-Area Commuters Form Impromptu Car Pools. *Houston Chronicle*, December 2, 2002.

18. Burris, M. and W. Stockton. HOT Lanes in Houston - Six Years of Experience. *Journal of Public Transportation*, Volume 7, No. 3, 2004, pp. 1-21.

19. Houston TranStar Real Time Traffic Information. http://traffic.tamu.edu, Houston TranStar. Accessed July 10, 2004.

20. Greenshields, B. and F. Weida. *Statistics with Application to Highway Traffic Analyses*. Eno Foundation for Transportation, Westport, Connecticut, 1978.

21. Meyer, D. and E. Miller. *Urban Transportation Planning*. McGraw-Hill, New York, New York, 2001.

22. SPSS for Windows Release 10.0.5. SPSS, Inc., Chicago, Illinois, 1999.

23. Ben-Akiva, M. and S. Lerman. *Discrete Choice Analysis: Theory and Application to Travel Demand*. MIT Press, Cambridge, Massachusetts, 1985.

APPENDIX A

CASUAL CARPOOL PASSENGER SURVEY

Part I: Please tell us about your current trip on the Katy Freeway (I-10) traveling towards downtown Houston.

1. What was the purpose of the trip?
   - ❑ Commuting (going to or from work)
   - ❑ Recreational / Social / Shopping / Entertainment / Personal errands
   - ❑ Work related (other than going to or from work)
   - ❑ School
   - ❑ Other (*specify*): _____

2. What time of day did your trip start (for example, when did you leave your driveway)?

   [ ] ***a.m. p.m.***
   (*circle one*)

3. Would it have been possible to start your trip earlier or later?

   - ❑ I could have easily made the trip [ ] minutes earlier/later.
   - ❑ I could have made the trip anytime the same day.
   - ❑ I could not take the trip at any other time.

4. Near what major cross streets did your trip start? *Example: Kingsland Blvd. and Mason Creek.*

   [ ] ***and*** [ ]

5. What time of day did your trip end (for example, when did you arrive at work)?

   [ ] ***a.m. p.m.***
   (*circle one*)

6. Near what major cross streets did your trip end? *Example: Main St. and Texas Ave.*

   [ ] ***and*** [ ]

7. How many people, including yourself, were in the vehicle?

   □ 2 □ 3 □ 4 □ 5 or more

8. How well do you know the people you traveled with?
- ❑ I have never traveled in a casual carpool with them before
- ❑ I have traveled in a casual carpool with them once or twice before
- ❑ I frequently travel in casual carpools with them

9. How long did you wait before a vehicle picked you up?

[ ] minutes

10. How much travel time do you think you **saved** on the HOV lane**,** compared to the main lanes?

[ ] minutes.

11. For today's trip, please indicate what would have caused you to NOT use a casual carpool. (check all that apply):
- ❑ More than 5 persons waiting for a carpool ride
- ❑ More than 10 persons waiting for a carpool ride
- ❑ The bus arrives just as you arrive
- ❑ Unsafe feeling about the carpool
- ❑ No one in line waiting to form a casual carpool
- ❑ Bad weather
- ❑ More frequent bus service to my destination
- ❑ Other (specify): _____

12. How many ***total trips*** did you make during the past full work week (Monday to Friday) on the Katy Freeway? (Count each direction of travel as one trip, include trips on the HOV or main lanes)

[ ] trips

13. Do you sometimes use a route other than the Katy Freeway to make trips with a similar purpose?

□Yes □No

14. How often do you travel by forming a casual carpool?
    - ❑ Everyday
    - ❑ 3 to 4 days per week
    - ❑ 1 to 2 days per week
    - ❑ Less than once per week
    - ❑ This is my first time

15. When did you first travel by casual carpool?
    - ❑ I started within the last month
    - ❑ I started within the last year
    - ❑ I have been casual carpooling for more than a year

16. Why did you first start using casual carpools to travel? (check all that apply):
    - ❑ Congestion on the freeway
    - ❑ Bus service too slow
    - ❑ I find cars more comfortable than the bus
    - ❑ To save money
    - ❑ To save time
    - ❑ To meet new people
    - ❑ Other (specify): _____

17. What other ways do you travel for a similar trip? (check all that apply):
    - ❑ Drive alone
    - ❑ Regular carpool with family or friends
    - ❑ Ride the bus
    - ❑ Other (specify): _____

18. Do you contribute money to the driver of the casual carpool to offset expenses?
    - ❑ No
    - ❑ Yes → If Yes, on average how much per trip? _____

19. How will you travel back to the park and ride facility later today?
    - ❑ Casual carpool
    - ❑ Bus
    - ❑ Regular carpool with family or friends
    - ❑ Drive alone
    - ❑ Other (specify): _____

Part II: Questions Regarding the QuickRide Program

During most of the time the HOV lane is open, vehicles with 2 or more occupants can use the HOV lane on the Katy Freeway (I-10), free of charge. However, during peak traffic periods (from 6:45 a.m. to 8:00 a.m. and 5:00 p.m. to 6:00 p.m.) toll-free use of the HOV lane is restricted to vehicles with 3 or more occupants.

Under a program called QuickRide, vehicles with only 2 occupants are permitted to travel on the HOV lane during peak traffic periods for a $2.00 toll per trip. Participants must set up a QuickRide account with their credit card before using the program. Enrollees are issued toll transponders that electronically charge the toll each time QuickRide is used. Additionally, a $2.50 monthly administration fee is charged to each account. For more information, please call 713-224-RIDE or 1-888-606-RIDE (toll free) or visit
http://www.hou-metro.harris.tx.us/services/quickride.asp

20. Prior to this survey, had you heard of the QuickRide program?
    - □ Yes → Go to Question 21
    - □ No → Go to Question 22

21. How did you hear about QuickRide? (*Check all that apply*)
    - ❑ TV
    - ❑ Radio
    - ❑ Mail
    - ❑ Newspaper
    - ❑ METRO website
    - ❑ Family / Friend
    - ❑ On the bus
    - ❑ I don't remember
    - ❑ Other (*specify*):_____

    → Go to Question 23

22. Now that you know about the QuickRide program would you be interested in using it?
    - □ Yes If Yes, what interests you **most** about QuickRide? (*check only one*)
        - ❑ Being able to carpool with just one other person and still use the HOV lane
        - ❑ Being able to use the HOV lane more often because it is much faster than the main freeway lanes
        - ❑ Being able to use the HOV lane more often because the travel times on the HOV lane are consistent
        - ❑ Being able to use the HOV lane more often because it is safer / less stressful than on driving main freeway lanes
        - ❑ Other (*specify*): _____

□ No If No – what are the primary reasons you would not use QuickRide? (*check all that apply*)

- ❑ I do not want to set up a QuickRide account
- ❑ I do not have a credit card needed to set up an account
- ❑ I do not want to pay the $2.50 monthly administration fee
- ❑ I do not want a toll transponder in my car
- ❑ Access to the HOV lane is not convenient for my trips
- ❑ The HOV lane does not offer me enough time savings
- ❑ The HOV lane is sometimes just as congested as the main freeway lanes
- ❑ The QuickRide program is complicated or confusing
- ❑ I have the flexibility to travel at less congested times
- ❑ I do not want to pay the $2.00 per trip cost of QuickRide
- ❑ Other (*specify*): _____

The questions in this part of the survey are to find out your views on an option for improving QuickRide. The option raised is only an example and does not represent local, state or federal policy.

23. How do you feel about allowing people who drive alone to use the HOV lane for a higher toll than carpoolers?

- ❑ Strongly favor
- ❑ Somewhat favor
- ❑ Indifferent
- ❑ Somewhat oppose
- ❑ Strongly oppose

24. If you could drive alone on the HOV lane for the toll listed below, how often would you drive alone on the HOV lane?

Toll	*Number of trips per week (count each direction of travel as one trip)*
$3.00	_____
$4.00	_____
$5.00	_____
$6.00	_____

Part III: Travel Scenarios

Each of the following questions asks you to choose between four potential travel choices on the Katy Freeway (I-10). For your most recent trip, please circle the one option that you would be most likely to choose if faced with these specific options. Remember that main lane traffic tends to be congested and could be slower than shown here if congestion is worse than usual. HOV lane traffic is fast moving. Peak hours are 6:45 a.m. to 8:00 a.m.

25. Circle the option you would choose:

A	B	C	D
Drive alone on the HOV lane during off-peak hours. Travel time is **13** minutes Toll for HOV lane: **$1**	Drive alone on the HOV lane during peak hours. Travel time is **12** minutes Toll for HOV lane: **$4**	Take a METRO Park & Ride bus during peak hours. Travel time is **17** minutes (this includes 5 minutes for waiting for the bus and walking from the bus stop) Bus Fare: **$3**	Casual Carpool on the HOV lane during peak hours. Travel Time is **21** minutes (this includes 5 minutes to wait for the carpool to form) Toll for HOV lane: **$0**

26. Circle the option you would choose:

A	B	C	D
Drive alone on the HOV lane during off-peak hours. Travel time is **15** minutes Toll for HOV lane: **$3**	Drive alone on the HOV lane during peak hours. Travel time is **16** minutes Toll for HOV lane: **$8**	Take a METRO Park & Ride bus during peak hours. Travel time is **17** minutes (this includes 5 minutes for waiting for the bus and walking from the bus stop) Bus Fare: **$3**	Casual Carpool on the HOV lane during peak hours. Travel Time is **16** minutes (this includes 5 minutes to wait for the carpool to form) Toll for HOV lane: **$0**

27. Circle the option you would choose:

A	B	C	D
Drive alone on the HOV lane during off-peak hours. Travel time is **13** minutes Toll for HOV lane: **$2**	Drive alone on the HOV lane during peak hours. Travel time is **12** minutes Toll for HOV lane: **$6**	Take a METRO Park & Ride bus during peak hours. Travel time is **17** minutes (this includes 5 minutes for waiting for the bus and walking from the bus stop) Bus Fare: **$2**	Casual Carpool on the HOV lane during peak hours. Travel Time is **16** minutes (this includes 5 minutes to wait for the carpool to form) Toll for HOV lane: **$0**

28. Circle the option you would choose:

A	B	C	D
Drive alone on the HOV lane during off-peak hours. Travel time is **15** minutes Toll for HOV lane: **$1**	Drive alone on the HOV lane during peak hours. Travel time is **16** minutes Toll for HOV lane: **$4**	Take a METRO Park & Ride bus during peak hours. Travel time is **20** minutes (this includes 5 minutes for waiting for the bus and walking from the bus stop) Bus Fare: **$3**	Casual Carpool on the HOV lane during peak hours. Travel Time is **16** minutes (this includes 5 minutes to wait for the carpool to form) Toll for HOV lane: **$0**

Part IV: User Information

The following questions will be used for statistical purposes only and answers will remain confidential. All of your answers are very important to us and in no way will they be used to identify you.

29. What is your age?
    - ❑ 16 to 24
    - ❑ 25 to 34
    - ❑ 35 to 44
    - ❑ 45 to 54
    - ❑ 55 to 64
    - ❑ 65 and over

30. What is your gender?
    - ❑ Male
    - ❑ Female

31. Please describe your household type.
    - ❑ Single adult
    - ❑ Unrelated adults (e.g. room-mates)
    - ❑ Married without child
    - ❑ Married with child(ren)
    - ❑ Single parent family
    - ❑ Other (*specify*): _____

32. Including yourself, how many people live in your household?

33. All together, how many motor vehicles (including cars, vans, trucks, and motorcycles) are available for use by members of your household?

34. What category best describes your occupation?
    - ❑ Professional / Managerial
    - ❑ Technical
    - ❑ Sales
    - ❑ Administrative / Clerical
    - ❑ Manufacturing
    - ❑ Stay-at-home homemaker / parent
    - ❑ Student
    - ❑ Self employed
    - ❑ Unemployed / Seeking work
    - ❑ Retired
    - ❑ Other *(specify)*: _____

35. What is the last year of school you have completed?
- ❑ Less than high school
- ❑ High school graduate
- ❑ Some college / Vocational
- ❑ College graduate
- ❑ Postgraduate degree

36. What was your annual household income before taxes in 2002?
- ❑ Less than $10,000
- ❑ $10,000 to $14,999
- ❑ $15,000 to $24,999
- ❑ $25,000 to $34,999
- ❑ $35,000 to $49,999
- ❑ $50,000 to $74,999
- ❑ $75,000 to $99,999
- ❑ $100,000 to $199,999
- ❑ $200,000 or more

37. Please list any comments or suggestions you have regarding travel in the Katy Freeway (I-10) corridor:

_____

_____

_____

Thank you for your participation.

VITA

Name:	Justin R. Winn
Address:	Wilbur Smith Associates 4925 Greenville Ave., Suite 915 Dallas, TX 75206
Email Address:	jwinn@wilbursmith.com

Education:	B.S., Civil Engineering, Texas A&M University, 2003. M.S., Civil Engineering, Texas A&M University, 2005.