Southwest Region University Transportation Center

Promoting the Sustainable Community: The Application of Geographic Information Systems in Ridesharing

SWUTC/96/467303-1

Center for Transportation Research
University of Texas at Austin
3208 Red River, Suite 200
Austin, Texas 78705-2650

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
SWUTC/96/467303-1		
4. Title and Subtitle Promoting the Sustainable Community: The Application of Geographic Information Systems in Ridesharing		5. Report Date August 1996 6. Performing Organization Code
7. Author(s) Gregory C. Han and C. Michael Walton		8. Performing Organization Report No. Research Report 467303-1
9. Performing Organization Name and Address Center for Transportation Research University of Texas at Austin 3208 Red River, Suite 200 Austin, Texas 78705-2650		10. Work Unit No. (TRAIS) 11. Contract or Grant No. 10727
12. Sponsoring Agency Name and Address Southwest Region University Transportation Center Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135		13. Type of Report and Period Covered 14. Sponsoring Agency Code

15. Supplementary Notes
Supported by general revenues from the State of Texas.

16. Abstract

The Clean Air Act of 1990 mandated that areas classified as "severe" non-attainment must impose commuting restrictions on major employment sites. The mandates were recently put on hold and states were given the option of implementing the mandates. The previously required mandates demanded that organizations employing over 100 employees survey their work sites to obtain information on commuter mode usage, develop plans to reduce vehicle occupancy (usually in the form of transportation demand management (TDM) techniques) to meet regional target occupancy rates, and maintain those occupancy rates the employer would be penalized financially and/or criminally.

Currently, there are only a handful of urban areas that fall under the "severe" non-attainment classification. However, because the classification of "severe" non-attainment brings considerable economic penalties with it, cities currently not classified as "sever" non-attainment are continuously trying to find ways to reduce air pollution. Voluntary trip reduction strategies for work sites have been adopted by these cities as a way to control vehicular ozone levels.

The specific problem that this study addresses is the problem of forecasting rideshare demand for the work trip to an employment site. A major employer in the Austin area of Travis County has expressed interest in developing ridesharing systems to curb demand for parking and therefore will be used as a case scenario for the application to innovative demand forecasting techniques.

17. Key Words		18. Distribution Statement	
Rideshare, Carpool, Vanpool, Commuter, Geographic Information Systems (GIS), Clean Air Act		No Restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161	
19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	106	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PROMOTING THE SUSTAINABLE COMMUNITY: THE APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS IN RIDESHARING

by

Gregory C. Han
and
C. Michael Walton

Research Report SWUTC/96/467303-1

Southwest Region University Transportation Center
Center for Transportation Research
The University of Texas
Austin, Texas 78712

AUGUST 1996

DISCLAIMER

ACKNOWLEDGMENT

Support for this report was provided by a grant from the U.S. Department of Transportation, University Transportation Centers Program to the Southwest Region University Transportation Center.

EXECUTIVE SUMMARY

The specific problem that this study addresses is the problem of forecasting rideshare demand for the work trip to an employment site. A major employer in the Austin area of Travis County expressed interest in developing ridesharing systems to curb demand for parking and therefore will be used as a case scenario for the application of innovative demand forecasting techniques.

Mode split analysis has been used frequently to estimate demand for alternative modes to the single occupant vehicle. The results of the mode split analysis are then used to predict demands for various kinds of transportation services. However, in the case of ridesharing, geographical and temporal considerations must be accounted for in order to develop a viable rideshare commuter system. Specifically, a commuter would not be able to rideshare to work if there are no compatible rideshare partners within his or her vicinity or with the same destination. Feasible rideshare partners are those who commute to the same destination, live within reasonable proximity, and have similar work schedules.

Because of the geographical and temporal considerations explained above, traditional forecasting methods cannot be employed alone. A more innovative way of predicting rideshare demand is needed. With the assistance of Geographic Information Systems (GIS), analysts have the capability of using the results of the mode split analysis to predict rideshare demand as well as perform spatial analysis. Therefore, instead of simply determining how many want to rideshare, those that want to rideshare and actually are capable of ridesharing can be determined.

The method of predicting rideshare demand described in this study consists of two major tasks. First, a mode split model is estimated from employee data obtained from a survey. Second, a GIS is used to apply the estimated model as well as to perform ridematching on the geographic database of employees.

ABSTRACT

The Clean Air Act of 1990 mandated that areas classified as "severe" non-attainment must impose commuting restrictions on major employment sites. The mandates were recently put on hold and states were given the option of implementing the mandates. The previously required mandates demanded that organizations employing over 100 employees survey their work sites to obtain information on commuter mode usage, develop plans to reduce vehicle occupancy (usually in the form of transportation demand management (TDM) techniques) to meet regional target occupancy rates, and maintain those occupancy rates. If an employment site failed to meet the target occupancy rates the employer would be penalized financially and/or criminally.

Currently, there are only a handful of urban areas that fall under the "severe" non-attainment classification. However, because the classification of "severe" non-attainment brings considerable economic penalties with it, cities currently not classified as "severe" non-attainment are continuously trying to find ways to reduce air pollution. Voluntary trip reduction strategies for work sites have been adopted by these cities as a way to control vehicular ozone levels.

The Austin area in Central Texas is a rapidly growing urban area that may someday fall into the "severe" non-attainment category if measures to reduce automobile related air pollution are not taken. Currently, Austin is near the non-attainment level for ozone. Thus, the metropolitan planning organization (MPO) for Austin, Austin Transportation Study (ATS), has begun a pilot program called the Voluntary Trip Reduction Program (V-Trip) that aims to reduce congestion and air pollution by encouraging employers to implement transportation demand management strategies.

Several of the organizations participating in the V-Trip program have successfully implemented measures such as vanpool programs, compressed work week schedules, etc. However, none of the organizations have attempted to predict employee responsiveness to such programs. Predicting travel behavior is an important issue because it would be wasteful for an organization to invest time and resources to develop programs which employees are not willing to use.

The specific problem that this study addresses is the problem of forecasting rideshare demand for the work trip to an employment site. A major employer in the Austin area of Travis County has expressed interest in developing ridesharing systems to curb demand for parking and therefore will be used as a case scenario for the application of innovative demand forecasting techniques.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

FIGURES

TABLES

INTRODUCTION

PROBLEM STATEMENT

The Clean Air Act of 1990 mandated that areas classified as "severe" non-attainment must impose commuting restrictions on major employment sites. The mandates were recently put on hold and states were given the option of implementing the mandates. The previously required mandates demanded that organizations employing over 100 employees survey their work sites to obtain information on commuter mode usage, develop plans to reduce vehicle occupancy (usually in the form of transportation demand management (TDM) techniques) to meet regional target occupancy rates, and maintain those occupancy rates. If an employment site failed to meet the target occupancy rates the employer would be penalized financially and/or criminally.

Currently, there are only a handful of urban areas that fall under the "severe" non-attainment classification. However, because the classification of "severe" non-attainment brings considerable economic penalties with it, cities currently not classified as "severe" non-attainment are continuously trying to find ways to reduce air pollution. Voluntary trip reduction strategies for work sites have been adopted by these cities as a way to control vehicular ozone levels.

The Austin area in Central Texas is a rapidly growing urban area that may someday fall into the "severe" non-attainment category if measures to reduce automobile related air pollution are not taken. Currently, Austin is near the non-attainment level for ozone. Thus, the metropolitan planning organization (MPO) for Austin, Austin Transportation Study (ATS), has begun a pilot program called the Voluntary Trip Reduction Program (V-Trip) that aims to reduce congestion and air pollution by encouraging employers to implement transportation demand management strategies.

Several of the organizations participating in the V-Trip program have successfully implemented measures such as vanpool programs, compressed work week schedules, etc. However, none of the organizations have attempted to predict employee responsiveness to such programs. Predicting travel behavior is an important issue because it would be wasteful for an organization to invest time and resources to develop programs that employees are not willing to use.

The specific problem this study addresses is the problem of forecasting rideshare demand for the work trip to an employment site. A major employer in the Austin area of Travis County has expressed interest in developing ridesharing systems to curb demand for parking and therefore will be used as a case scenario for the application of innovative demand forecasting techniques.

NEED FOR STUDY

Mode split analysis has been used frequently to estimate demand for alternative modes to the single occupant vehicle. The results of the mode split analysis are then used to predict demands for various kinds of transportation services. However, in the case of ridesharing, geographical and temporal considerations must be accounted for in order to develop a viable rideshare commuter system. Specifically, a commuter would not be able to rideshare to work if there are no compatible rideshare partners within his or her vicinity or with the same destination. Feasible rideshare partners are those who commute to the same destination, live within reasonable proximity, and have similar work schedules.

Because of the geographical and temporal considerations explained above, traditional forecasting methods cannot be employed alone. A more innovative way of predicting rideshare demand is needed. With the assistance of Geographic Information Systems (GIS), analysts have the capability of using the results of the mode split analysis to predict rideshare demand as well as perform spatial analysis. Therefore, instead of simply determining how many want to rideshare, those that want to rideshare and actually are capable of ridesharing can be determined.

The methodologies proposed in this study can be effectively adapted to similar situations throughout the country. Employment sites interested in reducing single occupant vehicle usage, whether they are affected by trip reduction ordinances or are interested voluntarily, could possibly benefit from considering these methodologies.

OBJECTIVES

Primary Objective

The primary objective of this study is to propose an efficient method for analyzing rideshare demand using a GIS for work commute trips to an employment site. The method consists of two major tasks. First, a mode split model must be estimated from employee data obtained from a survey. Second, a GIS is used to apply the estimated model as well as to perform ridematching on the geographic database of employees.

GIS is a tool that greatly enhances the management of spatial data. Because of the efficiency and the ability to graphically display data, the quality of urban transportation data can be greatly improved. Meanwhile, the cost of data acquisition and preparation can be decreased by the greater ease in data sharing among agencies.

The proposed method of analyzing rideshare demand using a GIS must have as a goal the capability to be applied to any work site interested in estimating and/or forecasting travel demand. The benefits of the method can be realized only when the method can be implemented efficiently. Through an integration of current demand forecasting techniques and the power of a GIS, this goal can be achieved.

Secondary Objectives

1) A secondary objective of this study is to demonstrate the proposed method on an employment site in the Austin area and evaluate its effectiveness. The proposed method will be applied to Travis County work sites and the results will be used to make recommendations to Travis County. Conclusions will be drawn from the results as to whether or not feasible solutions were found for the problems addressed.

2) Another secondary objective is to assess the practicality of the proposed method and suggest improvements. The innovation of the method is in the synthesis of current modeling techniques and the GIS. GIS is a rapidly developing technology. Information can be efficiently stored, edited, manipulated, and graphically displayed. The practicality of the proposed method depends on the technology available. However, it may be a reality that improvements to the technology would enable even greater analysis capabilities in the very near future. Improvements to the proposed method, both in the modeling and GIS aspects, which could potentially lead to further advancements will be suggested.

BACKGROUND

RIDESHARING

Ridesharing, in the form of carpooling or vanpooling, could produce such benefits as:

- Lower commuting costs and reduced automobile dependence
- Reduced parking demand
- Community and societal savings

Lower commuting costs refer to savings in fuel, maintenance, and the discomfort for the commuter. Reduced parking demand refers to savings to employers who would not have to build as much parking for their employees. Community and societal savings refer to savings in the environmental and congestion costs. Table 1 gives a more extensive view of the benefits of ridesharing.

Carpools

Carpooling refers to two or more people prearranging a trip in a private automobile. Carpooling has the potential of reducing vehicle miles traveled and other environmental costs by reducing the number of single occupant vehicles on the roads. However, because carpools are usually arranged casually, they are difficult to supervise and are often unstable since parties may stop carpooling at anytime for any reason. Carpools work best where there is a high concentration of activities such as jobs, schools, or special events. Some factors favoring carpooling include high parking costs, high occupancy lanes on freeways, congested freeways, lack of good transit or high fares, as well as other factors [University Transportation Research Center Region II].

Parking situations at employment sites have had impacts on people's decisions to carpool. A survey of Warner Plaza's employees in Southern California indicated that 22 percent would carpool if they had free and preferential parking privileges [TRB, 1981].

Vanpools

Vanpooling is the mode of transportation where members of a group are picked up at specific points and taken to a common employment site and then taken back to the pickup points at the end of the workday. Workers could either be picked up at their homes separately or all at once at a prearranged intermodal site such as a specified residence, parking lot of a mall, or a

Table 1: Benefits of Ridesharing

Commuter Benefits

1) Reduced stress and fatigue from driving, especially in congested traffic

2) Reduced commuting cost (fuel, maintenance, insurance, parking, and vehicle ownership costs)

3) Reduced vehicle maintenance difficulties and responsibilities

4) Reduced susceptibility to fuel shortages and associated difficulties such as waiting/delays and higher fuel costs

5) Increased reliability of commute, particularly in vanpools and buspools

6) Socializing opportunities with ridesharing acquaintances

7) Opportunity for riders to spend commuting time reading, sleeping, relaxing

8) Enjoyment of ridesharing incentives, e.g. preferential parking and freeway access

9) Reduced dependence on a personal automobile, and possible elimination of commute vehicle or availability for uses

10) Reduced need to find parking or anxiety about parking

11) Door-to-door service (compared with public transit)

Employer Benefits

12) Reduced parking demand, resulting in fewer parking spaces, more usable space, less capital expended for parking areas, and less need for local parking control

13) Alleviation of local traffic congestion

14) Reduced employee tardiness and fatigue, and improved morale

15) Improved safety in parking lots due to groups of employees leaving worksite simultaneously

16) Reduced need for traffic control

17) Lower taxes for road building, traffic management, public parking, etc.

18) Access to expanded labor pools (ridesharing's attractiveness to long distance commuters)

19) Public relations boost for reducing community traffic, energy use, air pollution, and noise pollution

20) Improved employee morale

21) Compliance with ridesharing laws

22) Fringe benefits for employees (such as better parking for pools)

Community, State, and National Benefits
23) Reduced peak period traffic congestion
24) Reduced energy use
25) Reduced air pollution
26) Reduced accident costs
27) Reduced parking demand
29) Reduced need for additional highway capacity

Source: TRB, 1981

park-and-ride lot. The van could be driven by a member of the vanpool who has responsibility for the van and use of the van during non work times or by a vanpool agency driver. With a third party vanpool service, an agency, which could be a ridesharing agency (RSA), provides the vanpool service for the employer.

Vanpooling is ideal for suburban areas and especially for those who commute from the suburb to the central city because it is most attractive to workers who live approximately twenty or more miles away from their work sites. Since larger distances between specific origins and destinations are characteristic of suburban areas due to lower population densities, vanpooling has the potential of being an attractive option for suburban residents. This is because the time spent picking up other passengers or gathering at an intermodal site becomes acceptable when the overall travel time is long. This has been supported by empirical evidence. According to the 1978 Commuter Computer Survey in Los Angeles, vanpoolers tended to travel farther to work than other commuters [TRB, 1981]. Vanpoolers averaged 72 miles round-trip; carpoolers, 45 miles; and 19 miles for all other commuters.

The Commuter Computer Survey also found other interesting facts about vanpooling. It found that about 72 percent of new carpoolers were solo drivers and that 37 percent of vanpoolers were former solo drivers. This indicates that new vanpoolers had more prior contact with ridesharing and/or mass transit than carpoolers.

The survey also found that 38 percent of new vanpoolers joined through a personal reference, 29 percent joined as a result of a company presentation, and 19 percent from advertising. There were a number of reasons for joining as summarized in Table 2.

Table 2: Reasons for Vanpooling

Reason	Riders (%)	Drivers (%)
Not having to drive	25	
Convenience	15	
Reduced cost	14	40
Save wear on car		36
Other	46	24

Source: TRB, 1981

This table indicates that, although there is a large percentage of participants that had reasons other than those given, it can be seen that the riders of vanpools chose to join because of their irritation with driving rather than the cost savings.

One important fact learned from the survey was that vanpoolers were extremely satisfied with the service, giving it a 90 percent approval rate. The reasons for liking the service ranged from comfort to developing new friends. Former carpoolers and transit users who joined a vanpool emphasized comfort, convenience, time savings, and new friendships. On the other hand, former solo drivers valued monetary benefits more highly.

Impediments to ridesharing

The availability of abundant free parking has been a major roadblock in implementing successful ridesharing programs. Limited parking, although not necessarily the absolute reason for a rideshare program's success, provides employees with an incentive to rideshare. Employers do not find limiting parking an attractive option for several reasons. First, developers find reducing parking to encourage ridesharing to be risky. This is especially true for suburban office complexes. Suburban office complexes are extremely expensive to build and abundant parking is needed to attract tenants. Second, parking is viewed as permanent whereas carpooling and vanpooling are not. In the case of employer sponsored vanpools, employers do not like the idea that such a program has to be constantly funded thus giving them the impression that there are no savings. In addition, ridesharing programs could fold at any moment for any number of reasons, leaving the employer in a predicament if parking were not available. Third, banks have been hesitant to finance projects with below standard parking due to the perception that it would detract from the project's marketability. Fourth, city ordinances may require a minimum level of parking to be provided for worksites.

Another negative aspect of ridesharing from the commuter perspective is that riders would not be able to tend to midday business if stuck at the office. This becomes inherent in situations where office settings are in outlying areas that would require a vehicle in order to make the necessary trips. Sparse on-site consumer services contributes to this problem. Workers who are not provided with banking and food services at the employment site certainly would rather drive to work so that a vehicle is available during the day for those purposes. There have been, however, attempts to partially rectify this problem by guaranteeing ridesharers a ride home in case of emergencies and providing a midday shuttle to transport employees to shopping areas so that midday personal business could be accomplished [Cervero, 1986].

There are many other impediments to ridesharing that are sometimes not obvious, but may be important. Employers may view vanpooling as unfavorable to morale because the service may seem to be a fringe benefit to a few workers: those that live far away from the site. Also, employers may not want to go through the trouble of setting up a ridesharing program and have it fail, thus embarrassing the company. Some employers believe that vanpooling would result in unnecessary pressure on employees. Even other employers fear that vanpooling may result in losing proprietary information to competing companies from the interaction and socialization during shared rides [Cervero, 1986].

Support strategies for ridesharing

Ridesharing programs require employers to provide support services in order for them to be successful. Some important support services, some of which were mentioned previously, pertinent to ridesharing are preferential parking, guaranteed ride home, supportive work policies, and on-site amenities [University Transportation Research Center Region II, 1994]. Preferential parking gives pooling parties an extra incentive to share rides over driving alone. Guaranteed ride home programs allow commuters who rideshare to get home in case of emergencies rather than being stranded at work. Supportive work policies, like not holding meetings in the late afternoon that may run over, would allow workers to catch their rides home more easily. Also, not penalizing ridesharers who choose not to work overtime can help poolers schedule their rides home.

On-site amenities play an important role in making ridesharing viable. They allow employees to be less dependent on a personal vehicle by providing services at the work site that usually require a mid-day trip, thereby increasing the likelihood that an employee will rideshare to work. The need for on-site amenities to encourage ridesharing varies from work site to work site. For instance, a suburban office complex located in a low density area would need more on-site amenities to keep workers from driving to mid-day destinations than a work site located in a bustling downtown area where mid-day destinations can be reached on foot.

Some important on-site amenities are a cafeteria, automatic teller machine (ATM), fitness center, postage stamps, travel agency, dry cleaning, day care, etc. [Davidson, 1995]. These amenities provide the employee with the option of taking care of mid-day activities at the work site rather than driving to another location. Commuters would be less likely to rideshare if they were left stranded at the work site when they needed to tend to mid-day business.

CLEAN AIR ACT AMENDMENTS

Non-attainment areas

The Clean Air Act Amendments of 1990 bring an environmental angle into the issue of ridesharing and employer trip reduction. Ozone pollution of the lower atmosphere is directly related to the vehicle miles traveled on our roads. This means that more automobile usage degrades air quality. The Clean Air Act defines non-attainment areas as:

> regions- metropolitan statistical areas or larger- within the country that fail to meet federal air quality standards applicable to a variety of pollutants, including ozone (smog), carbon monoxide, sulfur dioxide, nitrogen dioxides, lead, and particulates [Clean Air Act Law and Explanation].

These non-attainment areas have a financial incentive to improve their air quality. Federal subsidies may be lost if the non-attainment area does not take measures to improve air quality. Also, controls could be imposed on the city by the EPA through local laws. This could also cost the city financially in lost business.

Because nearly all US cities are declared non-attainment areas for one or more of the National Ambient Air Quality Standards (NAAQS), of which ozone is the most common, there should be great incentive all over the country to implement ridesharing [Clean Air Act Law and Explanation]. The Clean Air Act targets automobile emissions by stating that transportation control measures (TCMs) should be adopted to reduce ozone. A number of measures are cited such as public transit, high-occupancy vehicle lanes, employer based transportation management plans, trip reduction ordinances, etc. Ridesharing is an effective TCM because one vehicle could potentially remove from 2 to 14 vehicles from the road, thereby reducing automobile use and improving air quality. Ridesharing is even more effective if used in conjunction with other TCMs. High occupancy vehicle lanes complement ridesharing because they allow ridesharers to gain travel time advantages over single occupant vehicles, thereby giving solo drivers an added incentive to share a ride.

Employee Commute Options programs

A specific section of the Clean Air Act Amendments of 1990 targets employers in "severe" non-attainment areas. This section, known as the Employer Trip Reduction Program (ETRP) or Employee Commute Options (ECO), requires that certain employers comply with trip reduction targets within a specific time frame or suffer penalties. Currently, these mandates have been made optional for the states. If a state wishes, it could put the trip reduction requirements on hold. Trip reduction programs, however, remain an objective for urban areas suffering from ozone air pollution.

The Environmental Protection Agency has measured the levels of air pollution around the country and has classified those areas that exceed certain standards as non-attainment areas. A select few areas have been classified as "severe" non-attainment areas due to the severity of their air pollution problems. These areas are the ones affected by the ECO mandates. The cities that were affected by the ECO regulations include Houston/ Galveston, New York/ Long Island, Baltimore, Chicago/ Gary, Ind., San Diego, Philadelphia/ Wilmington/ Trenton, Milwaukee, and Los Angeles [Committee on Small Business, 1994].

An ECO program is a program that increases the employee's alternatives to driving alone, decreases the number of vehicles driven to and parked at company work sites, and helps reduce congestion and air pollution around the work site [University Transportation Research Center Region II, 1994]. The regulations were different from past legislation in that they delegated responsibility for clean air goals to employers. Past efforts to reduce automobile emissions had failed due to increases in the total amount that Americans drive. However, a previous Southern California law cut solo commuting by 5 to 10 percent since 1990 [Committee on Small Business, 1994].

METHODOLOGY

MODE SPLIT MODELING

As mentioned in the problem statement, a method for determining rideshare demand is needed in order to predict the effectiveness of trip reduction strategies. A common approach is the use of discrete choice models to model individual mode choice.

Discrete choice modeling

With discrete choice an individual selects an option from a finite set of alternatives. In the scenario of this report, the option is a mode of travel to work among the set of possible modes of travel. The probability of an individual choosing a mode is a function of the relative attractiveness of the mode and the individual's socioeconomic characteristics. A utility function expresses the relative attractiveness of each mode. The most appropriate discrete choice model for the choice scenario is the logit model. The general logit model form is where the probability of using a mode is equal to the exponential of the utility of that mode divided by the summation of the exponentials of the utilities of all modes considered.

The general logit model has the form of

$$Prob\,(A) = \frac{e^{U_A}}{\sum_i e^{U_i}}$$

where Prob(A) represents the probability that mode A is chosen over all modes, U_i is the respective utility of each mode i, and U_A is the utility of mode A.

The utility of a given mode is a numeric expression associated with the attributes of that mode as perceived by the commuter choosing between available modes. In the functional form of the utility, the emphasis of an attribute appears as a weighting factor, and characteristics of a particular commute and of the commuter appear as the independent variables. Random utility theory states that an individual's utility is separated into systematic and random utility. Systematic utility is the measurable part of utility whereas random utility represents the unmeasurable or unknown part of utility.

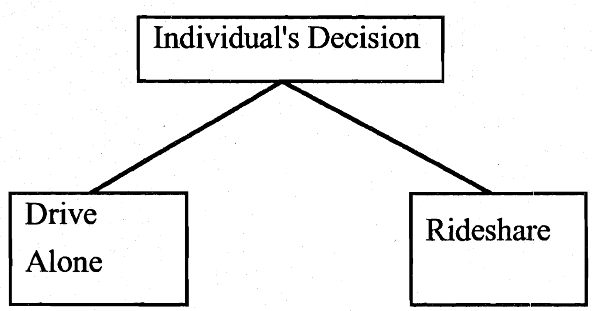
For modeling purposes a linear utility function is used. Given n attributes associated with mode A, its utility is:

$$U(A) = k_0 + k_1x_1 + k_2x_2 + \ldots + k_nx_n$$

where each attribute j appears with its weighting factor and respective trip value as k_j and x_j, and k_0 is the constant term.

The decision making process modeled involves the selection between two alternatives: rideshare or drive alone. Figure 1 illustrates the decision making process. As will be explained later, a survey, the Travis County Employee Survey, was conducted to obtain travel, demographic, and mode choice information. The survey results showed that the majority of Travis County employees drive alone to work. The remaining employees rideshare, bus, bike, etc.

Figure 1: Modeling framework



Because driving alone dominates the sample, driving alone and ridesharing are the two modes considered in the individual's choice set. There is no formal ridesharing program at Travis County and therefore it is a hypothetical mode even though some forms of ridesharing are being used. The hypothetical rideshare mode includes both carpooling and vanpooling. It is assumed that the employer will implement some sort of rideshare program in order to make employees aware that it is a viable alternative to driving alone as well as provide the ridematching or have Capital Metro perform the ridematching.

A binary logit model is used to model this decision between driving alone and ridesharing. Therefore, the general logit equation reduces to the following binary logit equation:

$$Prob(rideshare) = \frac{e^{U_{rideshare}}}{e^{U_{rideshare}} + e^{U_{drive\ alone}}}$$

where $U_{drive\ alone} = a_1X_1 + a_2X_2 + \ldots + a_nX_n$

and $U_{rideshare} = b_0 + b_1Y_1 + b_2Y_2 + \ldots + b_nY_n$

For each of the attributes X_i and Y_i, there is a corresponding coefficient: either a_i or b_i.

Due to the exponential form of the probability it may be simplified as:

$$\text{Prob(rideshare)} = \{1 + \exp[\text{U(drive alone)} - \text{U(rideshare)}]\}^{-1}.$$

This shows that for a binary model it is only the difference in the utilities that determines the probability that one mode will be chosen over another.

The following equation, the logarithm of the ratio of the probabilities of choosing a mode, is the difference of the utility functions and can be regressed using computer statistical packages to obtain the coefficients in the utility functions.

$$\log(\text{Prob of rideshare/ Prob of drive alone})$$
$$= -(U_{\text{rideshare}} - U_{\text{drive alone}})$$
$$= U_{\text{drive alone}} - U_{\text{rideshare}}$$

Once the coefficients of the mode choice model are estimated, the model can be applied to obtain mode shares for a given scenario. The characteristics of the system can be altered in order to predict the demand for each mode, and the sensitivity of the model to various attributes can be tested.

Stated preference surveys

Because the choice context used in this study is one where one mode is introduced to the individual (the rideshare mode), a stated preference survey is used to obtain the necessary information needed to calibrate the mode split model. In stated preference, respondents are asked to choose one option out of a set of options. The set of options could include all hypothetical options or both hypothetical and real options. Each option in the set has different assigned attributes. The respondent then selects options based on corresponding attributes' attractiveness.

In using stated preference for mode choice, the survey will present two options: the "current" option and a "rideshare" option. The "current" option is the respondent's current mode of transportation. The "rideshare" option is a hypothetical option whereby the respondent would either drive to a park and ride lot and share a ride to work with a co-worker or be picked up at his or her residence by a co-worker. The rideshare option encompasses both carpool and vanpool types of rideshare structures.

Many different scenarios are presented in the stated preference survey. The respondent, therefore, must select between the options several times. Each scenario differs by its attributes. For example, one scenario may have a rideshare cost of one dollar, a rideshare added travel time of 5 minutes, and no guaranteed ride home, preferential parking, or midday shuttle programs while another scenario may have the same rideshare cost and added travel time but with the guaranteed ride home, preferential parking, and midday shuttle programs. Attributes are varied such that no two identical scenarios are presented.

The survey captures variables representing the characteristics of the trip maker and characteristics of the system. Characteristics of the trip maker are obtained by asking demographical questions that are clear and concise. Units common to the everyday person are used to facilitate survey response. For instance, travel time was obtained in minutes and travel distance was obtained in miles.

Characteristics of the system do not exist for the hypothetical mode but do exist for the current mode. Characteristics of the current mode are obtained from questions about the respondent's daily work trip.

The survey has the capability of obtaining all the information necessary to calibrate a mode split model once it captures the individual's choice, the characteristics of the individual's current mode, and the individual's demographic information. Because the choice experiment presents the attributes of the hypothetical mode, the characteristics of the hypothetical mode are already known.

DESCRIPTION OF SURVEY

A stated preference survey, the Travis County Employee survey, was designed to obtain the necessary information to calibrate the binary logit model presented previously. The survey was distributed to all Travis County employees at all Travis County work sites enclosed in their paycheck envelopes. The survey was designed such that a respondent could fold the survey and mail it to a central location via inter-office mail. Making the act of responding to the survey as efficient as possible helped to maximize the response rate. In addition, only necessary questions were included in the survey to make it as brief as possible.

The survey instrument developed for this experiment is located in Appendix A. Table 3 summarizes the reasoning behind each question and section of the survey.

Table 3: Description of Survey Questions

Question number	Description/Reason
I. Travel Characteristics	
1	To get current mode of travel in order to target solo drivers
2	To get travel time for model
3	To get travel distance to calculate gas costs which is part of travel cost
4	To get walk time for model
5	To get parking cost component of travel cost
6	To get travel cost if bus were used
II. Socio-Economic Characteristics	
7	Approximate location of residence. Could be used in GIS databases
8	Another source of residential location. Zip codes link databases
9	To get income of respondent for model
10	To get age of respondent for model
11	To get gender of respondent for model
12	To get work schedule information
13	To obtain schedule flexibility for model
14	To get work schedule information
15	To get work schedule information
16	To get children variable for model
17	To calculate veh/#licenses per household
18	To calculate veh/#licenses per household
19	To obtain trip chain variable for model
20	To obtain mid-day business variable for model
21	To obtain vanpool benefits variables for model
III. Choice Experiment	To get choice observations to calibrate mode choice model

Cover page

The front page of the survey is a memo which informs the respondent about the purpose of the survey and gives instructions on returning surveys. Special care was made to mention the sponsors of the project: US Department of Transportation and Texas Department of Transportation. This was done in hopes that the prestige of the sponsors would encourage survey recipients to return the survey. In addition to mentioning the sponsors, it was arranged for the survey to be returned to a county commissioner's office through inter-office mail. It was hoped that having a commissioner's name on the survey would provide an incentive for a respondent to return the survey.

Section I: Travel Characteristics

Section I of the questionnaire obtains information on the respondent's travel characteristics. When applicable, questions were asked about the particular day's journey because those travel characteristics would be fresh in the respondent's mind. This prevents the respondent from taking the extra time to figure out average travel characteristics and therefore reduces respondent fatigue.

Question 1 asks the respondent which mode of travel was used to get to work on that particular day. This is an important question because this information will be necessary when modeling choice between rideshare and current mode.

Question 2 obtains the travel time to work for that particular day. The units specified are in minutes. This will be used later as the travel time variable. It is hypothesized that as travel time by driving alone increases, the probability of ridesharing increases. This is due to the discomfort of driving long distances.

Question 3 obtains the travel distance for the particular day. Travel distance is used to calculate part of the travel cost. The longer the travel distance, the more will be spent on gas. It is hypothesized that as travel cost for driving alone increases, the probability of ridesharing increases. This is due to the individual's desire to save money by finding cheaper modes.

Question 4 obtains the walk time from the respondent's parking spot to the work site. This variable reveals how far of a walk it is for an employee to get from the parking spot to the work site. Ridesharing is most effective when complemented with policies like preferential parking. With preferential parking the closest parking spots to the work site are assigned to ridesharing parties. It is hypothesized that as an individual's walk time increases, the probability that he or she will rideshare increases because of the desire to take advantage of preferential parking privileges and/or reduced anxiety about parking.

Question 5 obtains the daily parking cost of the individual if any. Parking cost is a component of travel cost. As explained above, there is a direct relationship between driving cost and the probability of ridesharing.

Question 6 obtains the daily bus fare of the individual if the individual took the bus. The purpose of this question was to be able to model the choice between bus and rideshare if there were significant numbers of bus riders in the sample.

Section II: Socioeconomic Characteristics

Section II obtains demographic as well as work schedule information. Work schedule and residential location information is necessary in order to compile the geographic database. The geographic database would serve as a tool in devising trip reduction strategies and would aid in matching potential rideshare partners.

Question 7 obtains the department within Travis County that the individual works for. This is a rather open ended question and is problematic in that respondents can provide a multitude of responses that may represent the same department. The purpose of this question is to determine the destination of the employee. Through the GIS, individuals with the same work destination could be matched into rideshare parties.

Question 8 obtains the closest major intersection to the respondent's residence. It was left up to the respondent to decide what is considered to be a major intersection. The purpose of this question is to obtain an accurate description of residential location without having the respondent provide his or her actual address. In more advanced applications of GIS, major intersections could be located on digitized city maps.

Residential location is important in matching ridesharing parties because it is most efficient for a commuter to rideshare with others who reside within close proximity. The added travel time needed to pick up partners would be minimized in this case.

Question 9 obtains the respondent's residential zip code. Zip code will be used to match ridesharing parties together. It is assumed that those residing in the same zip code live within close enough proximity to each other so that added travel time will be minimized. This, however, may not be true for large zip code areas where individuals living near the borders of the zip code may be better matched with those in adjacent zip codes. Zip codes are probably larger in the outskirts of the urban area where commutes are longer. This is a limitation of using zip codes as geographic analysis areas.

Question 10 obtains the gross annual income for the household. This question was made optional in case respondents considered the question to be too personal. It is hypothesized that people with high incomes are less likely to rideshare than those with low incomes because the monetary savings that ridesharing provides are less attractive when one earns a high income.

Question 11 obtains the age of the respondent. Age may or may not have a role in the probability of ridesharing. Older people may be less flexible and therefore less likely to rideshare.

The life cycle that older people are in may not permit them to rideshare due to added responsibilities for children, aging parents, etc.

Question 12 obtains the gender of the individual. Gender may influence the probability of ridesharing in that females may feel less secure ridesharing with new acquaintances; whereas males may not be as concerned about ridesharing with strangers.

Question 13 obtains starting and ending work times for the employee. This information is important because ridesharing parties should be matched based on a criteria of common work schedules, residential proximity, and common destination.

Question 14 obtains the flexibility in one's schedule. Schedules that are extremely rigid and do not allow any variation are not conducive to ridesharing. This is because the added travel time to the work trip from ridesharing may also vary; thus, making it difficult for commuters to get to work at the exact scheduled time. Flexible schedules are more conducive to ridesharing since they provide some security to the commuter in the case that he or she does not get to work at the exact scheduled time.

Question 15 obtains the days of the week that the respondent is scheduled to work. In addition to the criteria for matching ridesharers already mentioned, commuters should be matched based on common work days.

Question 16 obtains whether or not the respondent has children in day care. Children in day care bring added responsibilities to the household. Additional trips are needed and it is likely that these trips can only be made with a personal vehicle. Therefore, it is hypothesized that a person's probability of ridesharing greatly diminishes when he or she has children in day care.

Questions 17 and 18 share the same goal of obtaining the information necessary to calculate the vehicles per licensed drivers in the household. Question 17 obtains the number of vehicles in the household and question 18 obtains the number of licensed drivers in the household. It is hypothesized that as the number of vehicles per licensed drivers in the household increases, the probability of ridesharing decreases. This is because more vehicles per licensed drivers in the household increases the individual's accessibility to a vehicle. Greater accessibility to a vehicle increases the ease of driving; therefore, making ridesharing less attractive.

Question 19 asks for the number of trip chains per week a person usually makes. A trip chain is where an individual makes a journey for personal purposes while going to and/or from work. Trip chaining works against ridesharing. It is not practical for ridesharing parties to make stops on the way to work for personal purposes. This means that people who normally trip chain often are less likely to rideshare.

Question 20 obtains the number of midday work related trips that the respondent normally makes per week. Certain jobs require that the individual make trips during the day. Oftentimes, this means that the individual must have his or her own vehicle. Ridesharing is not an attractive option if the individual requires his or her own vehicle to commute to work.

Question 21 asks the individual to rate on a scale of 1 to 10, 10 being the highest and 1 being the lowest, the importance of a reason for ridesharing. Several reasons for ridesharing are listed. The purpose of this exercise is to capture the effects of the individual's attitude toward ridesharing. People with favorable attitudes towards ridesharing are more likely to rideshare than those who do not have favorable attitudes towards ridesharing. Higher ratings indicate that the individual regards the reasons as important reasons for ridesharing and therefore has a better attitude towards ridesharing.

Section III: Choice Experiment

Section III of the survey is the stated preference experiment. Five attributes of the hypothetical rideshare system have been identified as those attributes that can be realistically altered. These are rideshare cost, rideshare travel time, presence of a mid-day shuttle, existence of a guaranteed ride home program, and preferential parking. The mid-day shuttle attribute has two levels: yes, meaning it exists, and no, meaning it does not exist. The rideshare cost has three levels: high, medium, and low. These three levels represent different possible fares that could be charged to a passenger. The rideshare travel time attribute is presented as the added travel time of picking up passengers and waiting for the ride. There are three levels of rideshare travel time: faster, in-between, and slower. There are two levels for the guaranteed ride home attribute: yes (exists) and no (does not exist). Similarly, there are two attribute levels for preferential parking: yes (exists) and no (does not exist).

The number of possible combinations is calculated by taking the number of attributes, a, to the power of the number of levels, n. In this case, three attributes have two levels and two attributes have three levels. The number of combinations therefore is $3^2 2^3 = 72$.

Because it is too tedious for a survey respondent to compare 72 different situations with his or her current commuting situation in order to choose between the two alternatives, Section III of the survey is broken into four different sets of 18 scenarios. Each survey will have either choice experiment A, B, C, or D attached at the end of the same survey. This is justified because stated choice surveys are efficient in that many observations are obtained through one survey. Eventually all of the choice observations will be grouped together in order to calibrate a mode split model. Table A1 in Appendix A illustrates the attribute levels and the 72 different scenarios. The order of the 72 combinations was randomized so that each of the four different sets of 18 scenarios do not result in any systematic biases that may result from the respondent discontinuing the survey in the middle of the choice experiment due to fatigue.

Table A2 in Appendix A summarizes the variables captured by the survey and the variables' expected relation to the probability of ridesharing.

APPLYING THE MODE CHOICE MODEL

Conventional Methods

The conventional method of applying a mode split model in order to forecast demand requires obtaining the mean probability of ridesharing for the population. This is done after computing the probability of ridesharing for each individual. The product of the mean probability of ridesharing and the number of individuals in the population is the forecasted demand for ridesharing. However, the forecasted demand does not consider that in order for an individual to rideshare he or she must be matched with other potential ridesharers who reside in close proximity, have similar work schedules, and commute to a common destination. Because of this limitation, a new method of obtaining rideshare demand using the mode split model in conjunction with a GIS is proposed.

GIS/ Mode split modeling method

1. Link Travis County employee database with a digitized zip code map

The first step in performing analysis on the Travis County employee data set is to link the employee database to a digitized zip code map. The purpose of this step is to provide the capability of quick access to the database through a geographic reference. When the database is linked to the map, an analyst can use the mouse to point and click on a record in the database and not only will the record be highlighted but also the corresponding zip code area on the map or highlighting a zip code area automatically highlights the records in the database with that particular zip code.

Linking the employee database with the digitized zip code map is done by linking the employee dataset to the zip code attribute table that is linked to the digitized zip code map. Each zip code area on the digitized zip code map is linked to a record in the accompanying attribute table. The zip code attribute table is comprised of records for each zip code. This table includes extraneous data, like the perimeter and area of each zip code, which is not used in this study.

The zip code attribute table is linked to the Travis County employee data set through the zip code field. This is known as a "one to many" relationship. For example, all employees of one zip code are related to one record of the zip code table. The analyst can, therefore, click and highlight a zip code area on the map with the mouse and not only does the respective zip code table entry in the zip code attribute table become highlighted but also the respective employee database entries with the same zip code in the Travis County employee database table.

2. *Compute probabilities of ridesharing for each individual for a given set of system characteristics*

The best mode split mode estimated is one that is both conceptually and statistically valid. Using the best mode choice model found in the model estimation process, the probabilities of choosing the rideshare mode for each individual can be found. This is done by computing two new fields into the Travis County employee database. First, the difference in utilities is calculated, $U_{drive\ alone}$ - $U_{rideshare}$. The second field computed is the probability of ridesharing, which is computed from the logit equation, Pr(rideshare) = $1 / (1 + e^{Udrive\ alone\ -\ Urideshare})$.

The characteristics of the rideshare system must be specified so that the utilities can be calculated. That is, whether a guaranteed ride home program exists, whether a preferential parking policy is implemented, whether a midday shuttle for lunch and personal purposes is provided, and the travel cost and time of the rideshare mode must be inputted.

3. Generate random numbers

Another new field consisting of random numbers is created. These random numbers are integers from 1 to 100. Each record in the Travis County employee database will have a random number. The purpose of the random number is explained below.

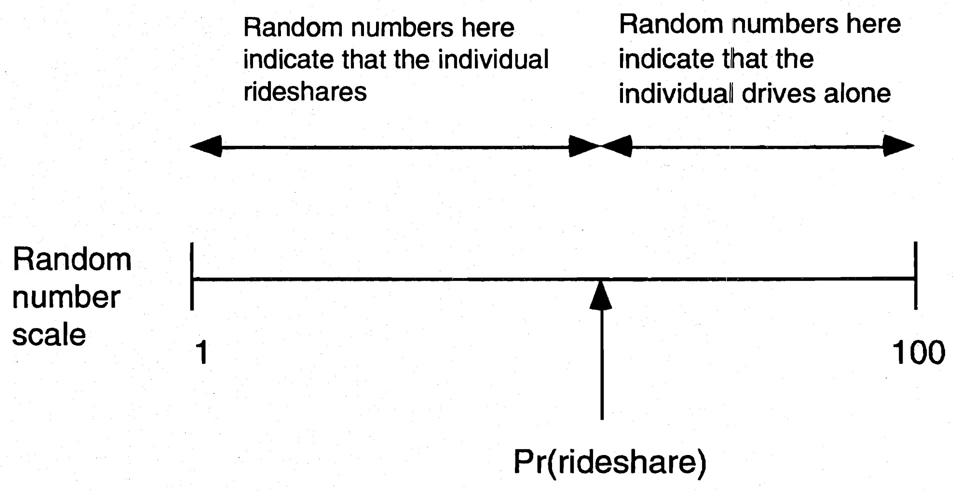
4. Compare random numbers with computed probability of ridesharing for each individual.

A method of predicting whether an individual chooses to rideshare is needed in order to estimate the demand for the rideshare mode. It would be short sighted to simply declare individuals with a computed probability of ridesharing above a certain threshold to be rideshare users. This is because there is a chance the individual does not rideshare. For instance, a person with a computed probability of ridesharing of 0.7 has a 70 percent chance of ridesharing or in other words 7 out of 10 times that person will rideshare. However, 3 out of 10 times that person will not rideshare. Therefore, a more realistic method is needed.

A more appropriate method of simulating the choice between ridesharing and driving alone is to compare the computed probability of ridesharing with the random number generated. If the probability of ridesharing (as a percentage) is greater than the generated random number, then the individual rideshares. If the probability of ridesharing is less than the random number generated, then the individual drives alone and does not rideshare. Figure 2 illustrates the simulation process.

A new field is added to the Travis County employee database that summarizes the results of the simulation process. A "1" is assigned to this new field if the individual rideshares and a "0" otherwise.

Figure 2: Assignment of Mode

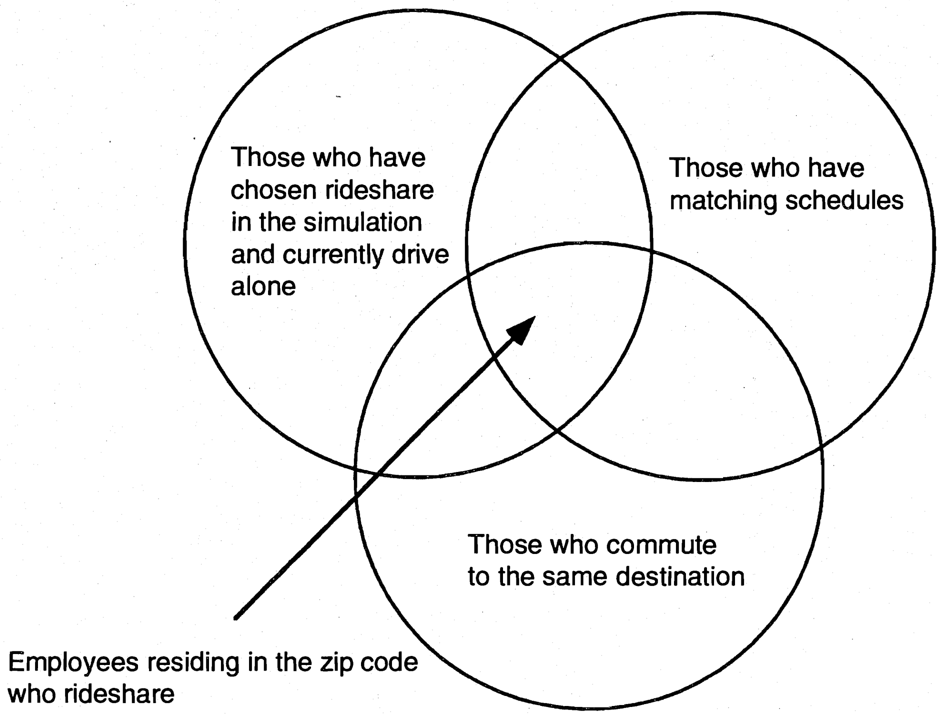


5. Perform query analysis to determine a more practical mode share.

Because there is a spatial and temporal aspect to ridesharing, querying must be performed to see if those individuals who chose to rideshare in the simulation process actually can rideshare. One can only rideshare if there are other individuals who live in close proximity, have similar work schedules, and work at the same location. If these criteria are not met, the individual cannot physically rideshare even though the individual was predicted to choose the rideshare mode.

Assuming that individuals residing in the same zip code area live close enough to each other such that ridesharing is feasible, the query can be performed on employees by zip code. The query analysis is performed on all employees who were simulated to rideshare in one step. The following figure, Figure 3, illustrates the set of employees who can feasibly rideshare in their particular zip code zone.

Figure 3: Set of Employees Who Rideshare

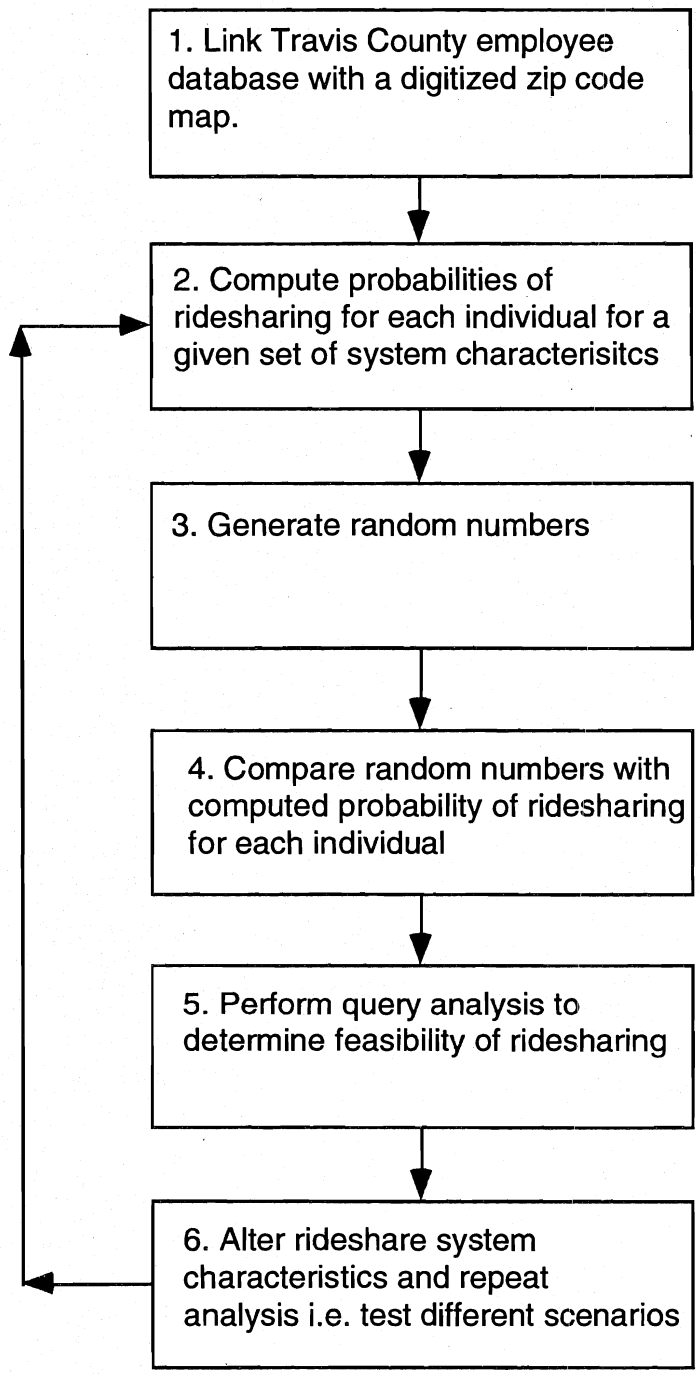


6. Alter system characteristics and repeat analysis

The power of using a mode split model is that characteristics of the rideshare system can be altered to analyze different scenarios. The user could specify whether a guaranteed ride home program, preferential parking, and a midday shuttle exists and alter travel time and cost to see how demand for ridesharing is affected. Different combinations of the attributes could be tested for its sensitivity to the resulting demand.

The following figure, Figure 4, shows the process of using the mode choice model with a GIS.

Figure 4: GIS/ Mode Split Method of Forecasting Rideshare Demand



RESULTS

SURVEY RESULTS

As mentioned before, the Travis County Employee Survey was distributed to all Travis County employees through paycheck distribution during August 1995. Approximately 3,400 surveys were distributed, and 756 surveys, roughly 22 percent of the total, were returned. The responses to each question were tallied. A previous Travis County parking survey conducted by Opinion Analysts, Inc. in 1993 provides results that compare quite well with the Travis County Employee Survey's results. Opinion Analysts' total response was higher than that of the present survey at a total number returned of 1,086. It is not known how many surveys were distributed by Opinion Analysts, therefore a response rate percentage for that survey is unavailable.

Table 4 summarizes the trip characteristics for the Travis County Employee Survey.

Table 4: Trip Characteristics of Travis County Employees

Average Travel Time	25.17 min
Average Travel Distance	14.08 miles
Average Walk Time	3.14 min
Average Parking Cost	$1.68
Average Bus Fare	$1.11

Opinion Analysts obtained an average one-way travel time of 25.44 minutes per one way trip [Travis County Parking]. The Travis County Employee Survey obtained a similar value: an average one-way travel time of 25.17 minutes per one-way trip as shown above.

Figure 5 and Table 5 show mode usage for Travis County employees. Approximately 82.8 percent drove alone and about 2.8 percent rode the bus. According to Opinion Analysts' results, 86 percent drove alone and 3 percent rode the bus. Due to differences in classifying modes, it is difficult to compare mode shares for rideshare, bicycle, and walk modes.

Figure 5: Mode Usage of Travis County Employees

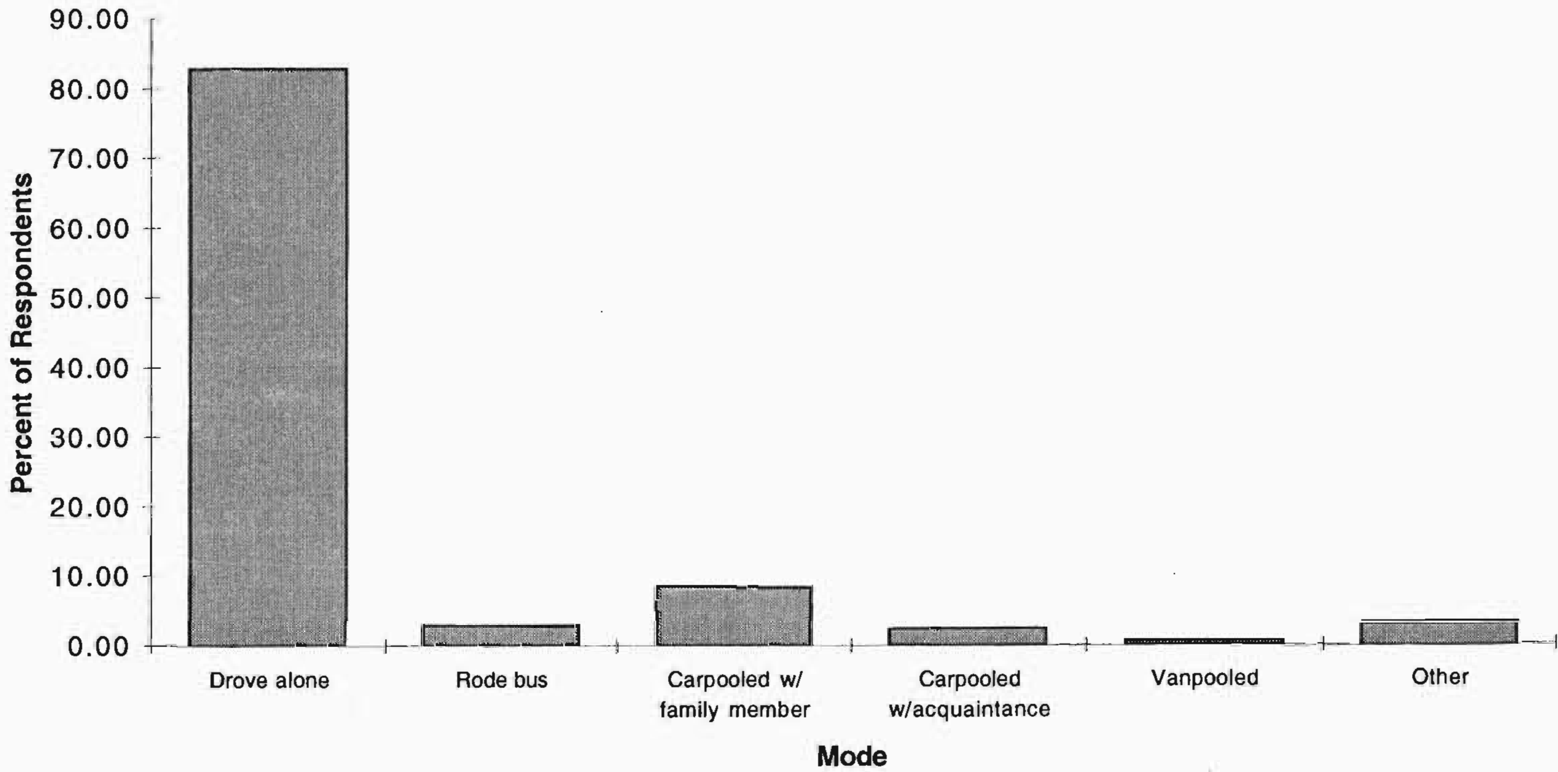


Table 5: Mode Usage Among Travis County Employees

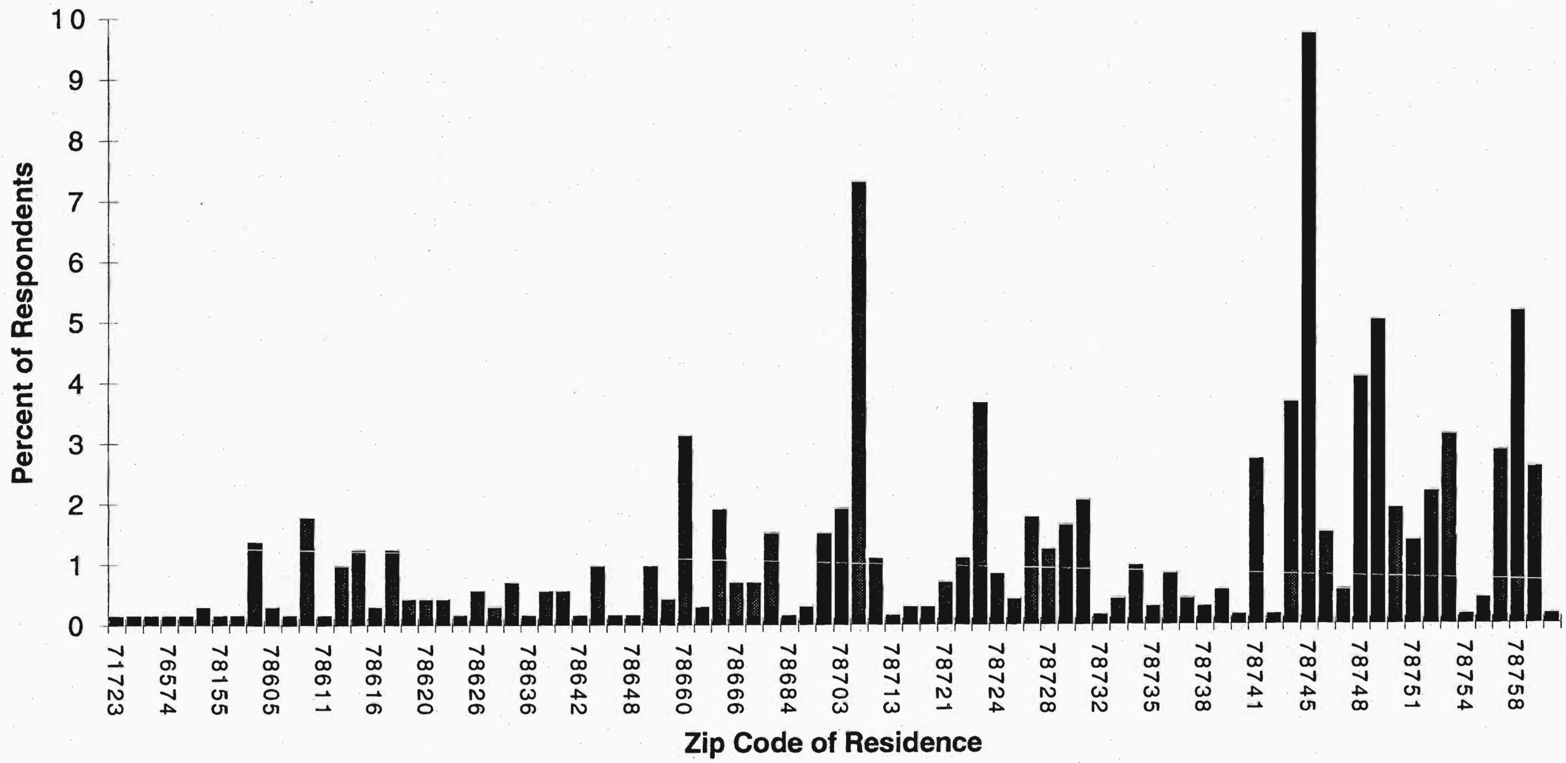
Mode	Number of Employees	Percent of Respondents
Drove alone	621	82.80
Rode bus	21	2.80
Carpooled w/ family member	63	8.40
Carpooled w/acquaintance	18	2.40
Vanpooled	4	0.53
Other	23	3.07

Figure 6 is a bar graph of residential zip code distribution among Travis County employees for the Travis County Employee Survey. Major concentrations of Travis County employees reside in 78704, 78745, and 78758. Opinion Analysts found that these zip codes had significant concentrations of employees also. Table B1 in Appendix B is the table that corresponds to Figure 6 and has specific tallies of employees per zip code.

Figures 7 through 10 show gender, income, age, and child care responsibility distribution among Travis County employees. It is not known whether these distributions are consistent with the actual demographical distributions of Travis County employees. Opinion Analysts did not obtain demographical information in their study, therefore a comparison cannot be made. Data on these characteristics were not available.

Table B2 in Appendix B is the response rate by Travis County department. The question that obtained this information was open ended and resulted in a wide variety of responses. Certain responses were departments within departments whereas others were too broad. Table B3 in Appendix B is a table of the distribution of employees by department provided by Travis County. As one can see, the departments with the most employees according to Table B3 had the most respondents in Table B2. For example, the Sheriff's department is the largest department with 1,117 employees as shown in Table B3. Table B2 indicates that the Sheriff's department had the highest response with 156 employees returning surveys.

Figure 6: Zip Code Distribution of Travis County Employees



To provide the reader with a general feeling for Travis County employees' opinions towards commuting issues, Table B4, which summarizes comments found on the survey, is included in Appendix B.

Table 6 summarizes the results for the attitude questions. Individuals were asked to rate each item based on importance to ridesharing. A ten means a very important reason for ridesharing and one means not an important reason for ridesharing. Averaging the responses gives a crude idea of which reasons for ridesharing are weighed as important to Travis County employees. It is believed that saving wear on personal automobiles and monetary savings are rated as very important reasons for ridesharing because they have an effect on the individual's monetary resources. However, it is believed that environmental conservation is also an important reason for ridesharing to survey respondents.

Figure 7:

Gender Distribution of Respondents

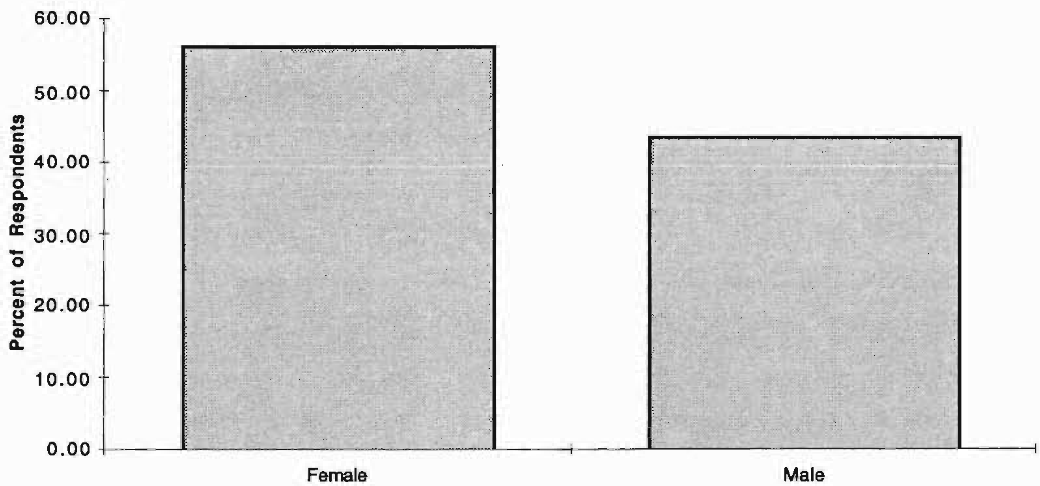


Figure 8: Income Distribution Among Survey Respondents

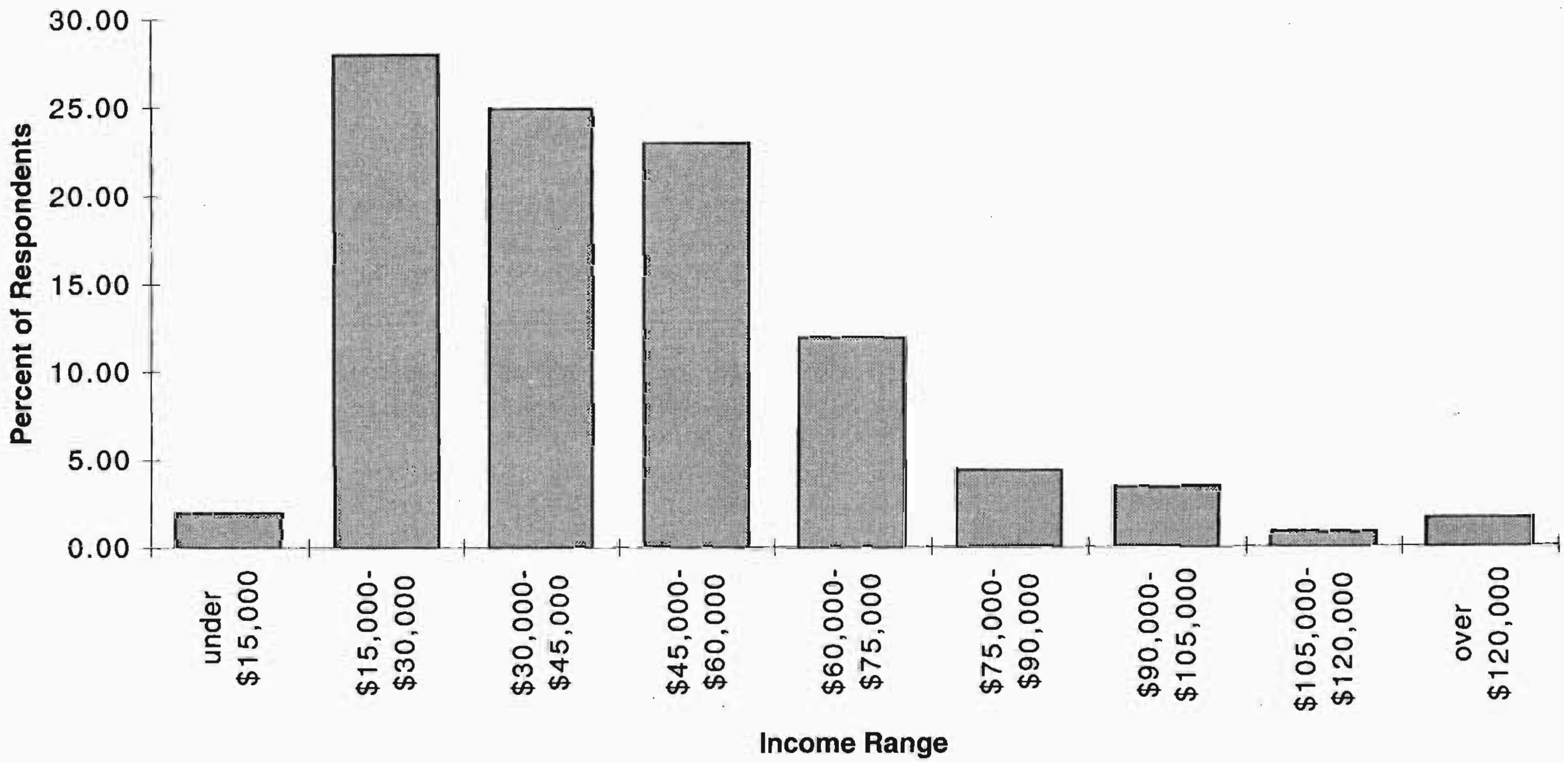


Figure 9: Age Distribution Among Survey Respondents

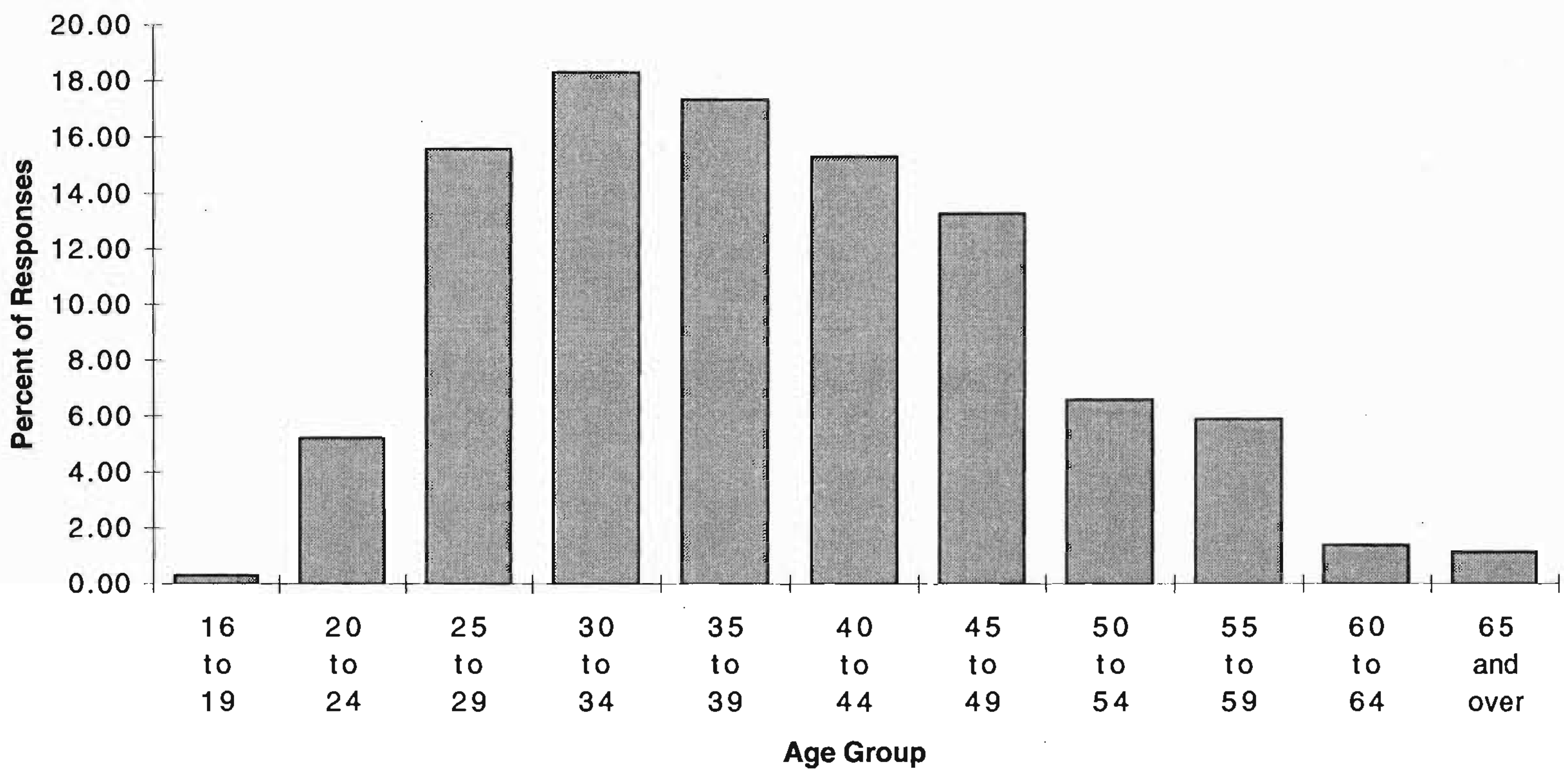


Figure 10:

Distribution of Child Care Responsibilities Among Respondents

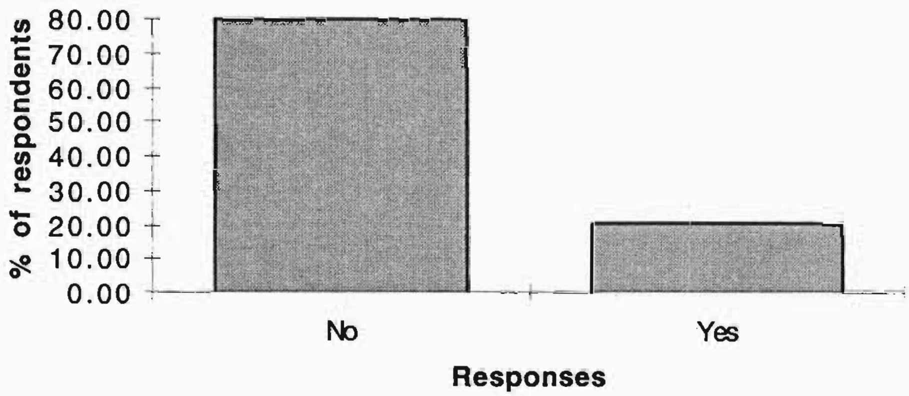


Table 6: Results of Attitude Questions

Reasons to Rideshare	Average Importance (10=highest,1=lowest)
Save wear	6.29
Environmental	5.86
Less need to drive	3.89
Increased safety/reliability	3.52
Socializing opportunities	2.45
Opportunity to spend time relaxing	3.2
Reduced Anxiety about parking	4.12
Insurance breaks	4.1
Employer encouragement	2.82
Monetary Savings	5.74

MODEL ESTIMATION

Because there are only two modes, the probability of using a mode is related to the difference in the two utilities. Parameters in one utility function can be placed in the other utility function as long as its sign is made opposite. SST, the statistical package used in this study, automatically places variables in the utility function of the dependent variable used. In this case, the dependent variable is the rideshare mode (1 if rideshare is chosen, 0 otherwise). This means that all estimated parameters should be interpreted with respect to the rideshare mode. Negative coefficients indicate inverse relationships. That is, as the parameter's value decreases, the probability of ridesharing increases. Coefficients of generic variables are estimated for the difference in the values for the two different modes. For instance, the coefficient of generic travel time is estimated for the travel time of driving alone minus travel time of ridesharing. This is equivalent to placing the travel time of driving alone variable in the driving alone utility function and the travel time of ridesharing variable in the ridesharing utility function.

The goal of calibrating a mode split model is to find the most practical predictive mode split model that can be defended statistically as well as conceptually. Many different model specifications will be tested. Models will first be evaluated by conceptual validity and statistical significance of variables to determine whether they are acceptable models or not. Then a more detailed analysis will be performed to select the best model out of those that are acceptable.

For simplification, four different groups of models are identified: models with cost and time as generic variables, models with cost and/or time as alternative specific, models with interaction terms, and market segmentation models.

Figure 11 illustrates each family of models and the respective models in each group that were tested.

Models with cost and time as generic variables

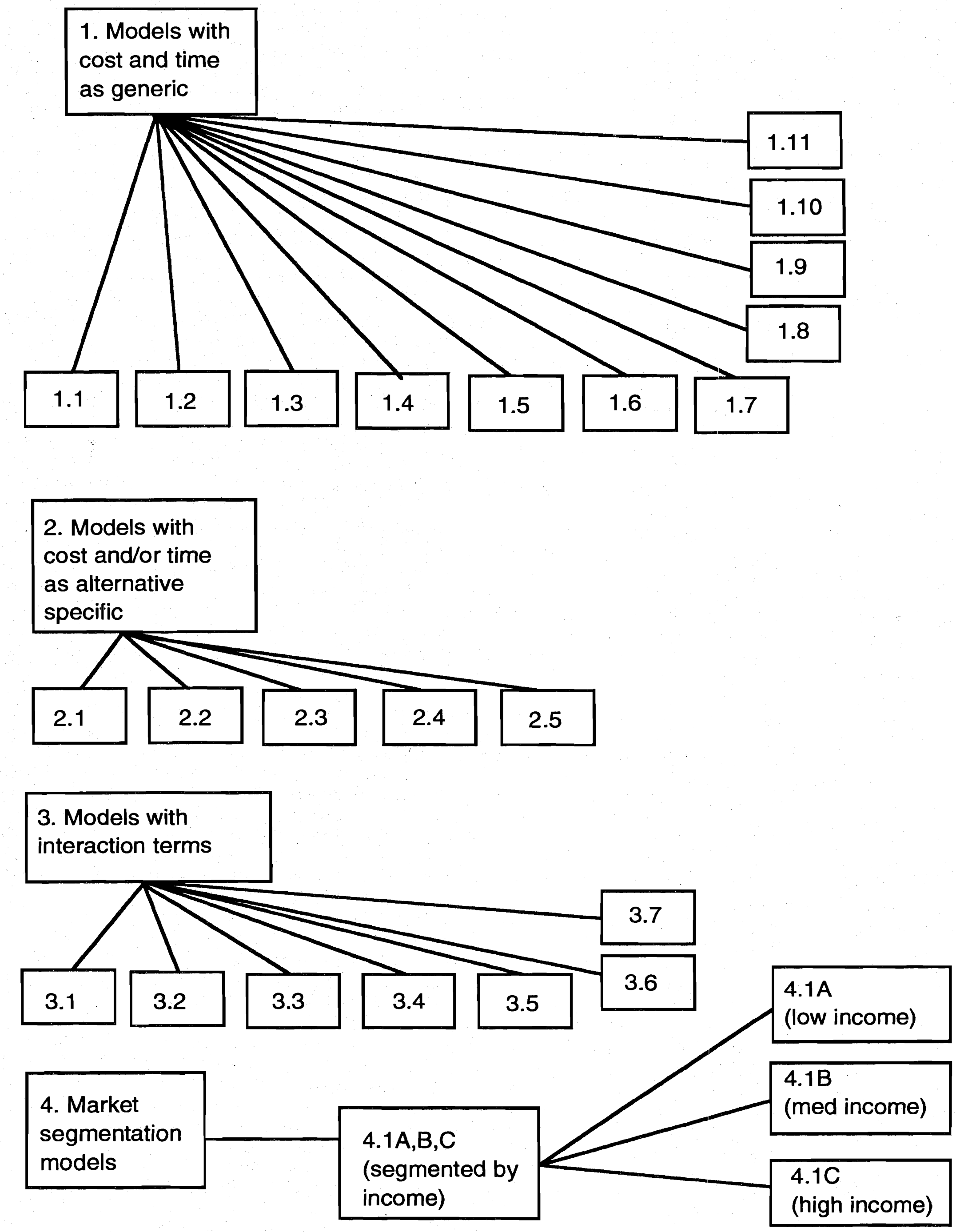
Having cost and time as generic variables means that coefficients for cost and time will be the same for either ridesharing or driving alone. The interpretation is that an individual weighs travel time and cost equally between modes. For example, generic cost and time would appear in the utility function of each mode with the same coefficient.

$$U(\text{rideshare}) = U' + a_1 \text{ Cost}_{rs} + a_2 \text{ Travel Time}_{rs}$$

$$U(\text{drive alone}) = U' + a_1 \text{ Cost}_{da} + a_2 \text{ Travel Time}_{da}$$

Where U' is the contribution to the utility by all other variables.

Figure 11: Groups of Models Tested



Models with cost and/or time as alternative specific variables

Alternative specific variables are those that have different coefficients for each mode. Alternative specific cost and time variables would indicate that the individual does not weigh cost and time equally between modes. That is, paying one dollar and traveling 15 minutes by ridesharing is different from paying one dollar and traveling 15 minutes by driving alone. For example, alternative specific cost and time would appear in the following way in the utility functions:

$$U(\text{rideshare}) = U' + a_1 \text{ Cost}_{rs} + a_2 \text{ Travel Time}_{rs}$$

$$U(\text{drive alone}) = U' + b_1 \text{ Cost}_{da} + b_2 \text{ Travel Time}_{da}$$

$$a_1 \neq b_1,\ a_2 \neq b_2$$

Where U' is the contribution to utility from all other variables.

It is hypothesized that ridesharing would be disadvantaged compared to solo driving. In other words, the disutility of paying one dollar and traveling 15 minutes by ridesharing is greater than that of solo driving.

Models with interaction terms

These are models where it has been hypothesized that certain estimated coefficients may differ for different sectors of the population. To test these hypotheses, dummy variables, which are qualitative in nature, are interacted with other variables.

Dummy variables may be interacted with nominal and ordinal variables by multiplying them together. For example, one can hypothesize that the effects of a continuous variable may differ between gender groups. In this case, a utility function may look like the following:

$$U = U' + a_1 \text{ Variable} + a_2 \text{ Gender} * \text{Variable}$$

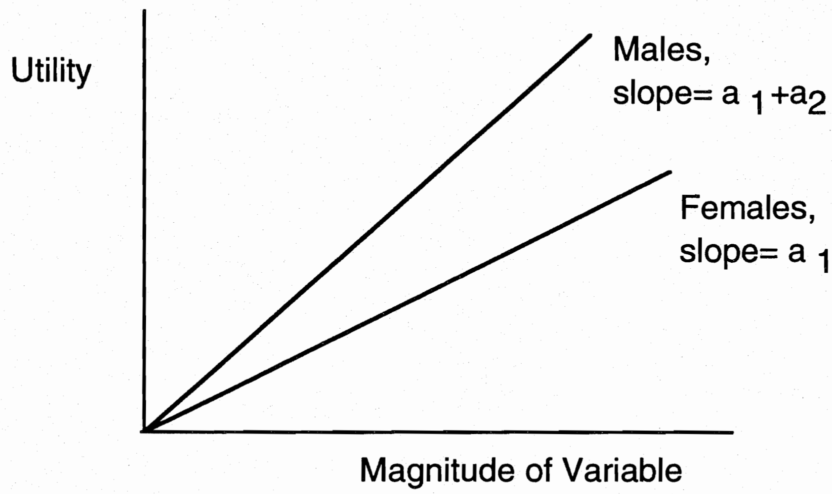
where gender is a dummy variable (1 for male, 0 for female) and Variable is a continuous variable. The utility functions for the model that would be estimated are the following:

$$U(\text{males}) = U' + a_1 * \text{Variable} + a_2 * 1 * \text{Variable} = U' + (a_1 + a_2) * \text{Variable}$$

$$U(\text{females}) = U' + a_1 * \text{Variable} + a_2 * 0 * \text{Variable} = U' + a_1 * \text{Variable}$$

This indicates that the coefficients for travel time for males and females are different. Figure 12 illustrates the difference in effects on the utility by the different coefficients for this example.

Figure 12: Effects of Different Coefficients for a Variable Interacted with a Dummy Variable



Analogously, a dummy variable can be interacted with another dummy variable. However, in the case of interacting dummy variables, the contribution of the interaction variable is not to the coefficient of a certain variable but is to the alternative specific constant.

Market segmentation models

Market segmentation is where models are calibrated for different segments of the population. This is done to see whether or not the estimated coefficients for the model differ across different segments of the population. Frequently, different models are calibrated for different income segments, age segments, or job classification. Tests can be performed to check whether different market segmented models are actually statistically different. Caution must be used when segmenting markets because the number of observations for each segment may be different and certain market segments may have too few observations to estimate valid models from.

PRELIMINARY SCREENING OF MODELS

As mentioned before, preliminary screening focuses on the conceptual validity and statistical significance of the variables in the models. Models with incorrect signs and/or low t-statistics for variables are rejected. The following table summarizes whether or not the above models were accepted or rejected in the preliminary screening.

Table 7: Preliminary Screening of Models

Model	Accepted?
1.1	No
1.2	Yes
1.3	Yes
1.4	No
1.5	No
1.6	Yes
1.7	Yes
1.8	No
1.9	No
1.10	No
1.11	Yes
2.1	No
2.2	No
2.3	No
2.4	Yes
2.5	No
3.1	Yes
3.2	No
3.3	Yes
3.4	No
3.5	Yes
3.6	No
3.7	Yes
4.1A	No
4.1B	No
4.1C	No

Models with cost and time as generic variables

Tables 8a, 8b, and 8c summarize the estimated coefficients and statistical information for these models.

Table 8a: Models with Cost and Time as Generic Variables

Models with cost and time as generic variables	Model 1.1		Model 1.2		Model 1.3		Model 1.4	
Description of Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
alternative specific constant	-4.25	-13	-4.31	-18	-2.51	-14	-4.45	-17
guaranteed ride home(1 if exists, 0 otherwise)	1.7	17.4	1.77	19.5	1.69	20	1.74	18.9
presence of midday shuttle(1 if exists, 0 otherwise)	0.52	5.98	0.52	6.58	0.48	6.65	0.53	6.61
preferential parking(1 if exists, 0 otherwise)	0.57	6.58	0.5	6.35	0.46	6.28	0.51	6.42
generic travel time variable (Ta-Trs)	0.058	5.56	0.058	6.04	0.056	6.28	0.056	5.71
generic travel cost variable (Ca-Crs)	0.106	6.68	0.1	7.36	0.11	9.04	0.11	7.98
vehicles per individuals in the household	-0.07	-0.5						
walk time (parking lot to worksite)	0.033	4.07	0.029	3.87	0.029	4.08	0.032	4.04
annual household income	0.014	0.48						
age	-0.09	-3.7	-0.07	-3.2	-0.12	-6.5	-0.07	-3.1
gender(1 if male, 0 otherwise)	0.32	3.44	0.23	2.81	0.39	5.37	0.19	2.34
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)	0.033	1.41					0.036	1.71
child care responsibility (1=yes, 0=no)	-0.02	-0.2						
trip chains (8=7 days a week, 1=no days a week)	0.028	0.95						
midday work related trips (8=7days aweek, 1=never)	-0.1	-3.9	-0.13	-5.6	-0.13	-5.9	-0.13	-5.4
importance to ridesharing (10=very important, 1=not important)								
saving wear on personal vehicle	0.04	2.15	0.062	3.97			0.056	3.57
environmentally safe transportation	0.046	2.81	0.047	3.25			0.056	3.74
less dependence on auto	0.053	2.94	0.041	2.92			0.054	3.58
reliable form of transporation	0.021	1.04						
socializing opportunities	-0.04	-1.8					-0.03	-1.3
ability to relax	0.11	6.66	0.094	6.54			0.099	6.53
reduced parking anxiety	0.053	3.71	0.054	4.46			0.064	4.89
insurance breaks	-0.02	-1.2						
employer encouragement	-0.03	-1.7					-0.03	-1.9
monetary savings	0.009	0.47						
alternative specific variable for cost(auto)								
alternative specific variable for travel time(auto)								
alternative specific variable for cost(rs)								
alternative specific variable for travel time(rs)								
generic cost divided by income variable								
age*gender								
gender*child care responsibility								
gender*trip chains								
child care responsibility*trip chains								
walktime from parking to worksite*gender								
downtown work location(1 if downtown, 0 otherwise)								
L(B)	-1854		-2218		-2579		-2136	
L(0)	-3808		-4634		-5355		-4472	
rhobarsquared	0.51		0.52		0.518		0.521	
number of observations	5493		6686		7726		6451	
number of estimated parameters (k)	25		15		10		18	
likelihood ratio test statistic	3908		4832		5552		4672	
X^2(k,0.05)	37.65		25		18.31		28.87	

Table 8b: Models with Cost and Time as Generic Variables (continued)

Models with cost and time as generic variables	Model 1.5		Model 1.6		Model 1.7	
Description of Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
alternative specific constant	-4.49	-17.4	-4.51	-17.5	-2.67	-15
guaranteed ride home(1 if exists, 0 otherwise)	1.74	18.9	1.75	19.06	1.68	19.6
presence of midday shuttle(1 if exists, 0 otherwise)	0.53	6.65	0.53	6.63	0.5	6.39
preferential parking(1 if exists, 0 otherwise)	0.52	6.47	0.52	6.47	0.47	6.36
generic travel time variable (Ta-Trs)	0.055	5.66	0.056	5.72	0.054	5.99
generic travel cost variable (Ca-Crs)	0.12	8.06	0.11	7.91	0.12	9.53
vehicles per individuals in the household						
walk time (parking lot to worksite)	0.03	3.87	0.029	3.8	0.029	4.09
annual household income						
age	-0.066	-3.03	-0.068	-3.16	-0.13	-6.5
gender(1 if male, 0 otherwise)	0.18	2.18	0.21	2.57	0.37	4.96
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)	0.039	1.83	0.043	2.02	0.052	2.67
child care responsibility (1=yes, 0=no)						
trip chains (8=7 days a week, 1=no days a week)						
midday work related trips (8=7days aweek, 1=never)	-0.13	-5.44	-0.13	-5.5	-0.13	-6
importance to ridesharing (10=very important, 1=not important)						
saving wear on personal vehicle	0.056	3.56	0.055	3.49		
environmentally safe transportation	0.056	3.76	0.051	3.45		
less dependence on auto	0.05	3.39	0.043	2.99		
reliable form of transporation						
socializing opportunities						
ability to relax	0.095	6.46	0.095	6.52		
reduced parking anxiety	0.065	4.95	0.058	4.64		
insurance breaks						
employer encouragement	-0.035	-2.08				
monetary savings						
alternative specific variable for cost(auto)						
alternative specific variable for travel time(auto)						
alternative specific variable for cost(rs)						
alternative specific variable for travel time(rs)						
generic cost divided by income variable						
age*gender						
gender*child care responsibility						
gender*trip chains						
child care responsibility*trip chains						
walktime from parking to worksite*gender						
downtown work location(1 if downtown, 0 otherwise)						
L(B)	-2137		-1147		-2504	
L(0)	-4472		-4497		-5206	
rhobarsquared	0.521		0.521		0.518	
number of observations	6452		6488		7510	
number of estimated parameters (k)	17		16		11	
likelihood ratio test statistic	4670		6700		6404	
X^2(k,0.05)	27.59		26.3		19.68	

Table 8c: Models with Cost and Time as Generic Variables (continued)

Models with cost and time as generic	Model 1.8		Model 1.9		Model 1.10		Model 1.11	
Description of Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
alternative specific constant	-4.14	-12	-4.13	-13.9	-3.99	-15.3	-2.53	-13.4
guaranteed ride home(1 if exists, 0 otherwise)	1.69	17.4	1.69	17.37	1.69	17.63	1.62	18.2
presence of midday shuttle(1 if exists, 0 otherwise)	0.51	5.95	0.51	5.93	0.5	5.94	0.46	5.93
preferential parking(1 if exists, 0 otherwise)	0.56	6.56	0.56	6.56	0.55	6.56	0.5	6.35
generic travel time variable (Ta-Trs)	0.059	5.64	0.059	5.66	0.06	5.86	0.056	5.92
generic travel cost variable (Ca-Crs)								
vehicles per individuals in the household	-0.01	-0.1						
walk time (parking lot to worksite)	0.035	4.32	0.035	4.36	0.037	4.7	0.027	3.73
annual household income								
age	-0.07	-3	-0.072	-3.14	-0.067	-2.97	-0.095	-4.68
gender(1 if male, 0 otherwise)	0.32	3.55	0.33	3.67	0.3	3.51	0.45	5.75
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)	0.031	1.31	0.03	1.28				
child care responsibility (1=yes, 0=no)	-0.01	-0.1						
trip chains (8=7 days a week, 1=no days a week)	0.016	0.55	0.015	0.5				
midday work related trips (8=7days aweek, 1=never)	-0.1	-3.8	-0.099	-3.81	-0.1	-4.07	-0.1	-4.52
importance to ridesharing (10=very important, 1=not important)								
saving wear on personal vehicle	0.043	2.31	0.044	2.4	0.053	3.2		
environmentally safe transportation	0.035	2.19	0.036	2.27	0.033	2.15		
less dependence on auto	0.055	3.07	0.06	3.69	0.063	3.96		
reliable form of transporation	0.016	0.77						
socializing opportunities	-0.05	-2	-0.043	-1.88	-0.048	-2.23		
ability to relax	0.11	6.85	0.12	6.99	0.12	7.49		
reduced parking anxiety	0.051	3.56	0.05	3.48	0.053	3.86		
insurance breaks	-0.02	-1.4	-0.022	-1.25				
employer encouragement	-0.04	-2.2	-0.04	-2.05	-0.05	-2.81		
monetary savings	0.023	1.28	0.021	1.18				
alternative specific variable for cost(auto)								
alternative specific variable for travel time(auto)								
alternative specific variable for cost(rs)								
alternative specific variable for travel time(rs)								
generic cost divided by income variable	0.16	3.98	0.17	4.09	0.16	4.01	0.2	5.8
age*gender								
gender*child care responsibility								
gender*trip chains								
child care responsibility*trip chains								
walktime from parking to worksite*gender								
downtown work location(1 if downtown, 0 otherwise)								
L(B)	-1868		-1870		-1939		-2255	
L(0)	-3808		-3820		-3995		-4529	
rhobarsquared	0.507		0.509		0.513		0.501	
number of observations	5493		5511		5763		6534	
number of estimated parameters (k)	24		21		17		10	
likelihood ratio test statistic	3880		3900		4112		4548	
X^2(k,0.05)	36.42		32.67		27.59		18.31	

Model 1.1

This model includes all variables that were originally in the data file. Some variables' estimated coefficients were not significantly different from zero. For this reason, this model is rejected.

Model 1.2

The variables in Model 1.1 that were not statistically significant and those that were borderline in significance were eliminated in this model. The remaining variables have high t-statistics as well as the correct signs. This model is therefore accepted.

Model 1.3

This model is the same as Model 1.2 but with the attitude variables eliminated. The attitude variables may be difficult to measure in future applications of the model and therefore practical models should not include them. The remaining variables are significant and have the correct signs. Therefore, this model is accepted.

Model 1.4

This model includes some of the variables that were borderline in significance and excluded from Model 1.2. The variables SCHEDULE FLEXIBILITY, SOCIALIZING OPPORTUNITIES, and EMPLOYER ENCOURAGEMENT remain borderline in significance. The problem with the estimated coefficients of SOCIALIZING OPPORTUNITIES and EMPLOYER ENCOURAGEMENT is that their signs are negative. This does not make sense because negative signs for these variables indicate that a higher importance to ridesharing a variable has the less likely he or she is to rideshare; thus, this model is rejected.

Model 1.5

This model is the same as Model 1.4 except that the variable SOCIALIZING OPPORTUNITIES is eliminated due to its t-statistic being too low. All other variables' estimated coefficients have t-statistics that are adequately high as well as the correct sign. However, the EMPLOYER ENCOURAGEMENT variable remained in this model and still has a negative sign. It does not make sense that as individuals weigh EMPLOYER ENCOURAGEMENT as an important reason to rideshare for the individual to be less likely to rideshare. Therefore, this model is rejected.

Model 1.6

This model is the same as Model 1.5 with the EMPLOYER ENCOURAGEMENT variable eliminated due to its incorrect sign. The remaining variables are acceptable so that the overall model is acceptable.

Model 1.7

This model is the same as Model 1.6 with the attitude variables eliminated. It is also the same model as Model 1.3 but with the variable for SCHEDULE FLEXIBILITY included. The t-statistics for each estimated coefficient is sufficiently high and has the correct sign. It is shown that the estimated coefficient for SCHEDULE FLEXIBILITY, which was originally interpreted as one that was borderline in significance, is actually adequately significant with a t-statistic of 2.67. All other estimated coefficients are significant and have the correct sign. Therefore, this model is accepted.

Model 1.8

This model includes all variables in the data file and a new variable, generic cost divided by income. Variables for VEHICLES PER INDIVIDUALS IN HOUSEHOLD, SCHEDULE FLEXIBILITY, CHILD CARE RESPONSIBILITY, TRIP CHAINS, and the importance to ridesharing variables, RELIABILITY, SOCIALIZING OPPORTUNITIES, INSURANCE BREAKS, EMPLOYER ENCOURAGEMENT, and MONETARY SAVINGS, were either insignificant or had the incorrect sign. This is reason enough to reject this model.

Model 1.9

This model is the same as Model 1.8 but with THE VEHICLES PER INDIVIDUAL IN THE HOUSEHOLD, CHILD CARE RESPONSIBILITY, and RELIABILITY excluded due to their coefficients' low t-statistics. Coefficients for schedule flexibility, trip chains, insurance breaks, and monetary savings are not significant. Therefore, this model is rejected.

Model 1.10

This model is the same as Model 1.9 with the variables SCHEDULE FLEXIBILITY, TRIP CHAINS, INSURANCE BREAKS, and MONETARY SAVINGS excluded due to their estimated coefficients' low t-statistics. The coefficients for EMPLOYER ENCOURAGEMENT and SOCIALIZING OPPORTUNITIES have the incorrect sign, and so this model is rejected.

Model 1.11

This model is the same as Model 1.10 but with the attitude variables eliminated. The remaining estimated coefficients are significant and have the correct sign. Therefore, this mode is accepted.

Models with cost and/or time as alternative specific variables

All models with cost and/or time as alternative specific are listed in Table 9.

Model 2.1

Model 2.1 is the same as Model 1.4 but with cost and time as alternative specific variables rather than generic variables. Variables that were significant and borderline in Model 1.4 were included in this model. As in Model 1.4, the estimated coefficients for SOCIALIZING OPPORTUNITIES and EMPLOYER ENCOURAGEMENT are both negative; meaning that the higher its importance the less likely a person is to rideshare. This is conceptually not valid and therefore the model is rejected.

Model 2.2

This model is the same as Model 2.1 except that only cost is made to be alternative specific. Time remains a generic variable in this model. The coefficients for SOCIALIZING OPPORTUNITIES and EMPLOYER ENCOURAGEMENT are still negative and so the model is rejected.

Model 2.3

This model is the same as Model 2.1 except that time is made to be alternative specific and cost is restricted to be generic. Again, coefficients for SOCIALIZING OPPORTUNITIES and EMPLOYER ENCOURAGEMENT are negative and so the model is rejected.

Model 2.4

This model has time and cost both as alternative specific and does not include the attitude variables. All variables are significant and have the correct sign. Therefore, this model is accepted.

Model 2.5

In the middle of the modeling process, a new variable was introduced: downtown work location. This variable is a result of the assistance of Travis County in interpreting the data from the question of the survey asking for the employee's department. The department was equated to a location that was either classified as a "downtown" location or not. A 1 was assigned if the work destination was in a downtown location and 0 otherwise. This model is the same as Model 2.4 but with the new downtown location variable. However, the coefficient of the downtown location variable is negative; thus, suggesting that an individual is less likely to rideshare if his or her destination is in a downtown area. This is conceptually not valid because it is expected that the disutility of dealing with downtown congestion would improve the probability of ridesharing and so the model is rejected.

Table 9: Models with Cost and/or Time as Alternative Specific

Models with cost and time as alt specific variables	Model 2.1		Model 2.2		Model 2.3		Model 2.4		Model 2.5	
Description of Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
alternative specific constant	-3.89	-14	-3.89	-15	-4.35	-16	-2.13	-11	-1.94	-8.5
guaranteed ride home(1 if exists, 0 otherwise)	1.76	18.9	1.77	19	1.73	19	1.69	20	1.69	20
otherwise)	0.57	7	0.55	6.8	0.55	6.8	0.53	7.1	0.53	7.1
preferential parking(1 if exists, 0 otherwise)	0.52	6.39	0.52	6.5	0.51	6.4	0.47	6.3	0.47	6.3
generic travel time variable (Ta-Trs)			0.06	5.8						
generic travel cost variable (Ca-Crs)					0.13	5.9				
vehicles per individuals in the household										
walk time (parking lot to worksite)	0.032	4	0.03	4.2	0.03	3.9	0.03	3.9	0.03	3.9
annual household income										
age	-0.08	-3.4	-0.06	-2.9	-0.07	-3.4	-0.13	-6.8	-0.13	-6.8
gender(1 if male, 0 otherwise)	0.25	2.88	0.23	2.7	0.18	2.2	0.42	5.4	0.41	5.3
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)	0.032	1.49	0.03	1.4	0.04	1.9	0.05	2.4	0.05	2.4
child care responsibility (1=yes, 0=no)										
trip chains (8=7 days a wk, 1=no days a wk)										
midday work related trips (8=7days/wk, 1=never)	-0.13	-5.1	-0.13	-5.2	-0.13	-5.3	-0.13	-5.9	-0.13	-5.8
importance to ridesharing (10=very important, 1=not important)										
saving wear on personal vehicle	0.062	3.87	0.06	3.8	0.06	3.7				
environmentally safe transportation	0.059	3.88	0.06	3.7	0.06	3.9				
less dependence on auto	0.056	3.69	0.05	3.6	0.06	3.7				
reliable form of transporation										
socializing opportunities	-0.03	-1.4	-0.03	-1.5	-0.03	-1.3				
ability to relax	0.1	6.59	0.1	6.8	0.1	6.6				
reduced parking anxiety	0.061	4.55	0.07	5	0.06	4.3				
insurance breaks										
employer encouragement	-0.03	-1.8	-0.03	-2	-0.03	-1.6				
monetary savings										
alternative specific variable for cost(auto)	0.063	2.57	0.09	6			0.06	2.7	0.06	2.6
alternative specific variable for travel time(auto)	0.065	5.82			0.05	4.6	0.07	6.5	0.07	6.5
alternative specific variable for cost(rs)	-0.83	-10	-0.81	-9.9			-0.79	-10	-0.79	-10
alternative specific variable for travel time(rs)	-0.06	-6			-0.06	-5.7	-0.06	-6.2	-0.06	-6.2
generic cost divided by income variable										
age*gender										
gender*child care responsibility										
gender*trip chains										
child care responsibility*trip chains										
walktime from parking to worksite*gender										
otherwise)									-0.2	-1.6
L(B)	-2077		-2096		-2118		-2441		-2437	
L(0)	-4447		-4472		-4447		-5181		-5156	
rhobarsquared	0.531		0.53		0.52		0.53		0.53	
number of observations	6415		6451		6415		7474		7438	
number of estimated parameters (k)	20		19		19		13		14	
likelihood ratio test statistic	4740		4752		4658		5480		5437	
X^2(k,0.05)	31.41		30.1		30.1		22.4		23.7	

Models with interaction terms

All models with interaction terms are located in Table 10. The purpose of interaction terms is to test hypothesis whether or not the effects of certain variables differ across segments of the population. A specific discussion of interaction terms follows the preliminary screening of models.

Model 3.1

This model is the same as Model 2.4 but with the additional variable AGE multiplied by GENDER. All variables' coefficients have the correct sign and are significant. Therefore, this model is accepted.

Model 3.2

This model is the same as Model 2.4 but with the variable CHILD CARE RESPONSIBILITY and the interaction term, CHILD CARE RESPONSIBILITY multiplied by GENDER. Both the coefficient for CHILD CARE RESPONSIBILITY and the interaction term CHILD CARE RESPONSIBILITY multiplied by GENDER have insignificant coefficients. Therefore, this model is rejected.

Model 3.3

This model is the same as Model 2.4 but with the variables TRIP CHAINS and the interaction term GENDER multiplied by TRIP CHAINS substituting for the variable GENDER. All estimated coefficients appear to have the correct signs and are statistically significant. Further analysis on the coefficient of the interaction term will determine whether it is conceptually valid. For now, this model is accepted.

Model 3.4

This model is the same as Model 2.4 but with the variable CHILD CARE RESPONSIBILITY multiplied by TRIP CHAINS and including the variable TRIP CHAINS. The estimated coefficients for these two additional variables have low t-statistics and so the model is rejected.

Model 3.5

This model is the same as Model 2.4 but with WALK TIME multiplied by GENDER replacing GENDER. The estimated coefficients are significant and therefore the model is accepted. The specific sign of the interaction term will be analyzed in the secondary analysis. For now, the model is accepted.

Model 3.6

Model 3.6 is a synthesis of Models 3.1 and 3.5. Both interaction terms, AGE multiplied by GENDER and WALK TIME multiplied by GENDER, are included in this model to see what kind of an effect including two interaction terms would have on the model. Since the t-statistic of WALK TIME multiplied by GENDER is a low -1.5, this model is rejected.

Table 10: Models with Interaction Terms

Models with interaction terms	Model 3.2.1		Model 3.2.2		Model 3.2.3		Model 3.2.4		Model 3.2.5	
Description of Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
alternative specific constant	-1.88	-9.5	-2.09	-10	-1.87	-8.6	-2.07	-9.5	-2.03	-10
guaranteed ride home(1 if exists, 0 otherwise)	1.686	19.6	1.68	19.5	1.69	20	1.69	19.6	1.68	19.5
presence of midday shuttle(1 if exists, 0 otherwise)	0.529	7.04	0.53	7.08	0.526	7	0.53	7	0.53	7.11
preferential parking(1 if exists, 0 otherwise)	0.469	6.26	0.474	6.32	0.466	6.2	0.47	6.23	0.48	6.38
generic travel time variable (Ta-Trs)										
generic travel cost variable (Ca-Crs)										
vehicles per individuals in the household										
walk time (parking lot to worksite)	0.028	3.79	0.028	3.85	0.029	4	0.029	3.89	0.018	1.75
annual household income										
age	-0.17	-8	-0.14	-6.9	-0.13	-6.8	-0.14	-6.8	-0.13	-6.5
gender(1 if male, 0 otherwise)			0.409	4.87			0.395	5.06		
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)	0.049	2.52	0.046	2.33	0.051	2.6	0.05	2.5	0.058	2.97
child care responsibility (1=yes, 0=no)			-0.1	-0.8						
trip chains (8=7 days/wk, 1=no days/wk)					-0.08	-3	-0.01	-0.5		
midday work related trips (8=7days aweek, 1=never)	-0.14	-6.1	-0.13	-5.8	-0.12	-5.4	-0.12	-5.4	-0.12	-5.4
importance to ridesharing (10=very important, 1=not important)										
saving wear on personal vehicle										
environmentally safe transportation										
less dependence on auto										
reliable form of transporation										
socializing opportunities										
ability to relax										
reduced parking anxiety										
insurance breaks										
employer encouragement										
monetary savings										
alternative specific variable for cost(auto)	0.07	2.85	0.061	2.76	0.055	2.5	0.059	2.65	0.077	3.59
time(auto)	0.067	6.51	0.066	6.42	0.068	6.5	0.066	6.42	0.062	6.11
alternative specific variable for cost(rs)	-0.8	-10	-0.8	-10	-0.8	-10	-0.79	-10	-0.79	-10
alternative specific variable for travel time(rs)	-0.06	-6.3	-0.06	-6.1	-0.06	-6.2	-0.06	-6.2	-0.06	-6.1
generic cost divided by income variable										
age*gender	0.07	5.67								
gender*child care responsibility			0.025	0.13						
gender*trip chains					0.119	5.9				
child care responsibility*trip chains							-0.02	-0.7		
walktime from parking to worksite*gender									0.022	1.85
downtown work location(1 if downtown, 0 otherwise)										
L(B)	-2439		-2440		-2423		-2427		-2454	
L(0)	-5181		-5181		-5118		-5118		-5181	
rhobarsquared	0.528		0.528		0.526		0.525		0.526	
number of observations	7474		7474		7384		7384		7474	
number of estimated parameters (k)	13		15		14		15		13	
likelihood ratio test statistic	5484		5482		5390		5382		5454	
X^2(k,0.05)	22.36		25		23.68		25		22.36	

Model 3.7

Model 3.7 is actually Model 3.1 but with the most significant attitude variables included. The variables SAVE WEAR, ENVIRONMENT, LESS DEPENDENCE ON AUTO, ABILITY TO RELAX, and REDUCED PARKING ANXIETY were included and remain statistically significant. Since all estimated coefficients in this model are statistically significant and have the correct sign, this model is accepted.

Market segmentation models

The market segmentation models are located in Table 11.

Model 4.1A, B, C

These models are specifically calibrated for different income levels of employees. Model 4.1A is for low income employees, Model 4.1B is for middle income employees, and Model 4.1C is for high income employees. Several variables in each model are not statistically significant and/or have incorrect signs. This means that all three models must be rejected.

Market segmentation models are not explored further because of the problem of the lack of robustness in the data of small market segments. As was seen from segmenting by income, certain segments had significantly fewer observations than others. Because each survey resulted in 18 observations, the demographic data for each set of 18 observations remained constant. This causes problems in estimating coefficients for segments with few observations.

FINAL MODEL SELECTION

All remaining models are shown in Table 12.

The goal of final model selection is to select the single best model of those that have passed the preliminary analysis screening. Analytical and practicality criteria are used to eliminate models until the best model is identified.

The chosen model is meant to be a tool that an analyst can use to predict demand for ridesharing. Practical models must have variables that can be measured.

Practicality in measuring variables

Models with variables that can be measured are desired. Due to the impracticality of measuring the attitudinal variables, all remaining models with attitude variables are eliminated. In order to obtain these variables, surveys must be conducted. The use of these variables requires the survey to obtain them in the same manner used in this study. The methods of obtaining this information are not necessarily reliable since, oftentimes, the survey questions are too confusing to the respondent.

Models 1.2, 1.6, and 3.7 are therefore eliminated because of this criteria.

Cost and time as alternative specific variables

The likelihood ratio test showed that both time and cost should be treated as alternative specific variables. When the likelihood ratio test was performed using time as alternative specific and using Model 1.4 as the restricted model (where both cost and time are generic) the likelihood ratio value was 35.2. This is greater than the chi-squared value of 3.84 for 1 degree of freedom at the 0.05 level; thus, indicating that the coefficients for travel time by driving alone and travel time by ridesharing are significantly different. One can therefore conclude that travel time should be specified as alternative specific rather than generic.

Similarly, the likelihood ratio test was performed with cost as alternative specific. The result is a likelihood ratio value of 79.4, which is greater than the chi-squared value of 3.84 for 1 degree of freedom at the 0.05 level. This indicates that the coefficients for cost of driving alone and cost of ridesharing are significantly different at the 0.05 level. Therefore, cost should be an alternative specific variable rather than a generic variable. The result of this test indicates that individuals weigh travel cost and travel time differently depending on the mode. Because generic cost and time variables are not acceptable, Models 1.3, 1.7, and 3.4 can therefore be eliminated.

Table 11: Market Segmentation Models

Market segmentation models	Model 4.1A (low income)		Model 4.1B (mid income)		Model 4.1C (high income)	
Description of Variable	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
alternative specific constant	-2.53	-8.55	-1.95	-5.7	-0.9	-0.6
otherwise)	1.88	14.32	1.6	11.3	0.19	0.4
presence of midday shuttle(1 if exists, 0 otherwise)	0.41	3.71	0.75	5.85	0.44	0.95
preferential parking(1 if exists, 0 otherwise)	0.69	6.21	0.42	3.3	-0.11	-0.2
generic travel time variable (Ta-Trs)						
generic travel cost variable (Ca-Crs)						
vehicles per individuals in the household						
walk time (parking lot to worksite)	0.029	2.8	-0.015	-0.9	0.27	2.23
annual household income						
age	-0.08	-2.77	-0.16	-4.4	0.27	0.97
gender(1 if male, 0 otherwise)	0.1	0.9	0.74	5.43	2.72	2.98
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)	0.036	1.22	0.0028	0.08	-0.18	-0.8
child care responsibility (1=yes, 0=no)						
trip chains (8=7 days a week, 1=no days a week)						
(8=7days/wk,1=never)	-0.079	-2.18	-0.082	-2.3	-0.76	-3.1
importance to ridesharing (10=very important, 1=not important)						
saving wear on personal vehicle						
environmentally safe transportation						
less dependence on auto						
reliable form of transporation						
socializing opportunities						
ability to relax						
reduced parking anxiety						
insurance breaks						
employer encouragement						
monetary savings						
alternative specific variable for cost(auto)	-0.033	-0.88	0.12	3.02	-0.1	-0.5
time(auto)	0.084	5.43	0.043	2.42	0.04	0.6
alternative specific variable for cost(rs)	-0.77	-6.72	-0.78	-6.1	-0.94	-2
alternative specific variable for travel time(rs)	-0.06	-4.38	-0.05	-3.3	-0.089	-1.6
generic cost divided by income variable						
age*gender						
gender*child care responsibility						
gender*trip chains						
child care responsibility*trip chains						
walktime from parking to worksite*gender						
downtown work location(1 if downtown, 0 otherwise)						
L(B)	-1102.6		-867.2		-73.48	
L(0)	-2220.2		-1847.9		-311.22	
rhobarsquared	0.5013		0.5281		0.7418	
number of observations	3203		2666		449	
number of estimated parameters (k)	13		13		13	
likelihood ratio test statistic	2235.2		1961.4		475.48	
X^2(k,0.05)	22.36		22.36		22.36	

Table 12a: Models Passing the Preliminary Screening

Final Models	Model 1.2		Model 1.3		Model 1.6		Model 1.7		Model 1.11		Model 2.4	
Description of Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
alternative specific constant	-4.31	-17.5	-2.51	-14	-4.51	-17.5	-2.67	-15	-2.53	-13.4	-2.13	-10.8
guaranteed ride home(1 if exists, 0 otherwise)	1.77	19.5	1.69	20	1.75	19.1	1.68	19.6	1.62	18.2	1.69	19.6
presence of midday shuttle(1 if exists, 0 otherwise)	0.52	6.58	0.48	6.65	0.53	6.63	0.5	6.39	0.46	5.93	0.53	7.08
preferential parking(1 if exists, 0 otherwise)	0.5	6.35	0.46	6.28	0.52	6.47	0.47	6.36	0.5	6.35	0.47	6.33
generic travel time variable (Ta-Trs)	0.058	6.04	0.056	6.28	0.056	5.72	0.054	5.99	0.056	5.92		
generic travel cost variable (Ca-Crs)	0.1	7.36	0.11	9.04	0.11	7.91	0.12	9.53				
vehicles per individuals in the household												
walk time (parking lot to worksite)	0.029	3.87	0.029	4.08	0.029	3.8	0.029	4.09	0.027	3.73	0.029	3.89
annual household income												
age	-0.067	-3.21	-0.12	-6.5	-0.07	-3.16	-0.13	-6.5	-0.095	-4.68	-0.13	-6.81
gender(1 if male, 0 otherwise)	0.23	2.81	0.39	5.37	0.21	2.57	0.37	4.96	0.45	5.75	0.42	5.4
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)					0.043	2.02	0.052	2.67			0.047	2.41
child care responsibility (1=yes, 0=no)												
trip chains (8=7 days a week, 1=no days a week)												
midday work related trips (8=7days aweek, 1=never)	-0.13	-5.6	-0.13	-5.9	-0.13	-5.5	-0.13	-6	-0.1	-4.52	-0.13	-5.93
importance to ridesharing (10=very important, 1=not important)												
saving wear on personal vehicle	0.062	3.97			0.055	3.49						
environmentally safe transportation	0.047	3.25			0.051	3.45						
less dependence on auto	0.041	2.92			0.043	2.99						
reliable form of transporation												
socializing opportunities												
ability to relax	0.094	6.54			0.095	6.52						
reduced parking anxiety	0.054	4.46			0.058	4.64						
insurance breaks												
employer encouragement												
monetary savings												
alternative specific variable for cost(auto)											0.06	2.71
alternative specific variable for travel time(auto)											0.067	6.5
alternative specific variable for cost(rs)											-0.79	-10.4
alternative specific variable for travel time(rs)											-0.057	-6.24
generic cost divided by income variable									0.2	5.8		
age*gender												
gender*child care responsibility												
gender*trip chains												
child care responsibility*trip chains												
walktime from parking to worksite*gender												
downtown work location(1 if downtown, 0 otherwise)												
L(B)	-2218		-2579		-1147		-2504		-2255		-2441	
L(0)	-4634		-5355		-4497		-5206		-4529		-5181	
rhobarsquared	0.52		0.518		0.521		0.518		0.501		0.528	
number of observations	6686		7726		6488		7510		6534		7474	
number of estimated parameters (k)	15		10		16		11		10		13	
likelihood ratio test statistic	4832		5552		6700		6404		4548		5480	
X^2(k,0.05)	25		18.31		26.3		19.68		18.31		22.36	

Table 12b: Models Passing the Preliminary Screening (continued)

Final Models continued	Model 3.1		Model 3.3		Model 3.5		Model 3.6		Model 3.7	
Description of Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
alternative specific constant	-1.88	-9.5	-1.87	-8.6	-2.03	-10	-1.87	-9.4	-3.81	-14
guaranteed ride home(1 if exists, 0 otherwise)	1.686	19.6	1.69	19.6	1.68	19.5	1.686	20	1.77	19.1
presence of midday shuttle(1 if exists, 0 otherwise)	0.529	7.04	0.526	6.98	0.53	7.11	0.529	7	0.569	7.02
preferential parking(1 if exists, 0 otherwise)	0.469	6.26	0.466	6.19	0.48	6.38	0.469	6.3	0.518	6.4
generic travel time variable (Ta-Trs)										
generic travel cost variable (Ca-Crs)										
vehicles per individuals in the household										
walk time (parking lot to worksite)	0.028	3.79	0.029	3.97	0.018	1.75	0.038	3.7	0.028	3.64
annual household income										
age	-0.17	-8	-0.13	-6.8	-0.13	-6.5	-0.18	-8.1	-0.1	-4.2
gender(1 if male, 0 otherwise)										
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)	0.049	2.52	0.051	2.58	0.058	2.97	0.05	2.6	0.04	1.88
child care responsibility (1=yes, 0=no)										
trip chains (8=7 days/wk, 1=no days/wk)			-0.08	-3						
midday work related trips (8=7days/wk, 1=never)	-0.14	-6.1	-0.12	-5.4	-0.12	-5.4	-0.14	-6.2	-0.13	-5.4
importance to ridesharing (10=very important, 1=not important)										
saving wear on personal vehicle									0.06	3.74
environmentally safe transportation									0.056	3.73
less dependence on auto									0.046	3.17
reliable form of transporation										
socializing opportunities										
ability to relax									0.096	6.47
reduced parking anxiety									0.054	4.23
insurance breaks										
employer encouragement										
monetary savings										
alternative specific variable for cost(auto)	0.07	2.85	0.055	2.49	0.077	3.59	0.061	2.8	0.061	2.49
alternative specific var for travel time(auto)	0.067	6.51	0.068	6.53	0.062	6.11	0.067	6.5	0.066	5.89
alternative specific variable for cost(rs)	-0.8	-10	-0.8	-10	-0.79	-10	-0.8	-10	-0.84	-10
alternative specific variable for travel time(rs)	-0.06	-6.3	-0.06	-6.2	-0.06	-6.1	-0.06	-6.3	-0.06	-6
generic cost divided by income variable										
age*gender	0.07	5.67					0.081	5.6	0.043	3.12
gender*child care responsibility										
gender*trip chains			0.119	5.86						
child care responsibility*trip chains										
walktime from parking to worksite*gender					0.022	1.85	-0.02	-1.5		
downtown work location(1 if downtown, 0 otherwise)										
L(B)	-2439		-2423		-2454		-2438		-2086	
L(0)	-5181		-5118		-5181		-5181		-4472	
rhobarsquared	0.528		0.526		0.526		0.528		0.532	
number of observations	7474		7384		7474		7474		6452	
number of estimated parameters (k)	13		14		13		14		18	
likelihood ratio test statistic	5484		5390		5454		5486		4472	
X^2(k,0.05)	22.36		23.68		22.36		23.68		28.87	

Interpretation of interaction terms

Model 3.1

The following table interprets the estimated coefficients for AGE and for the interaction term, age multiplied by gender.

Table 13: Coefficients for Age by Gender

Coefficient for age	Gender
-0.17	Female
-0.17 + 0.07 = -0.10	Male

These coefficients are the expected coefficients. Both are negative and therefore indicate that as age increases, the likelihood of ridesharing decreases. The coefficient for females is more negative than that of males. This indicates that older females are less likely to rideshare than older males. Conceptually, this is consistent with a priori expectations. As a result, Model 3.1 is not eliminated.

Model 3.3

The following table interprets the estimated coefficients for the interaction term in this model.

Table 14: Coefficients for Trip Chains by Gender

Coefficient for trip chains	Gender
-0.08	Female
-0.08 + 0.119 = 0.039	Male

The coefficient of -0.08 for trip chains for females makes sense. It means that the more trip chains a person makes, the less likely she is to rideshare. However, the coefficient for trip chains for males cannot be interpreted in the same way. The coefficient of 0.039 indicates that the more a male trip chains, the more likely he is to rideshare. This does not make sense and so Model 3.3 is eliminated.

Model 3.5

The following table interprets the estimated coefficients for the interaction term, walk time from parking to work site multiplied by gender.

Table 15: Coefficients for Walk Time by Gender

Coefficient for walk time	Gender
0.018	Female
0.018 + 0.022 = 0.04	Male

Both coefficients are positive and indicate that as walk time increases, the probability of ridesharing increases. The magnitude of the coefficient for males is greater than that for females. This indicates that males are more likely to rideshare than females at higher walk times from the parking area to the work site. Since there were no a priori expectations about the relative magnitudes of these two coefficients, this model is not eliminated.

Comparison of remaining models

The remaining models are Models 2.4, 3.1, and 3.5. Each model has similar characteristics. The rho-bar squared statistic, which is a goodness of fit indicator, is similar for all three models. Each mode has coefficients that have the correct sign. However, Model 3.5 has borderline t-statistics for the variables WALK TIME and WALK TIME multiplied by GENDER. On the other hand, Models 2.4 and 3.1 have high t-statistics for all of their variables' estimated coefficients. For this reason, Model 3.5 is eliminated.

Comparing Models 2.4 and 3.1 indicates that these two models are actually the same model except that Model 3.1 has the interaction term AGE multiplied by GENDER. This interaction term captures the effects of age on the probability of ridesharing for each gender group. Because this is a more detailed description of the effects of age on the probability of ridesharing than simply capturing the effects of age on the probability of ridesharing regardless of gender, as Model 2.4 does, Model 3.1 should be chosen over Model 2.4. Model 3.1 is the best model since the two models have similar alternative specific constants, have estimated coefficients with the correct signs, have high t-statistics for the estimated coefficients, and have similar rho-bar squared statistics.

If one were to choose the best "descriptive" model, a model which describes travel behavior, either Model 1.2, 1.3, or 3.7 should be chosen. This is because these models include the attitude variables. A model that describes the choice between ridesharing and driving alone from home to work should have all variables that may be pertinent to the mode choice decision. A person's opinion of ridesharing and the benefits of ridesharing is likely to play a role in his or her decision to rideshare. Therefore, attitudinal variables, which were shown to be significant, should be considered. Of the three models, Mode 3.7 should be chosen because it has travel time and travel cost as alternative specific variables. Mode 3.7 is actually the same as Model 3.1, which was the best "predictive" model chosen, but with the significant attitude variables. These variables are SAVING WEAR, ENVIRONMENTAL, LESS DEPENDENCE ON AUTO, ABILITY TO RELAX, and REDUCED PARKING ANXIETY.

Table 16 recommends a model for predicting ridesharing demand and a model for describing mode choice behavior.

GIS ANALYSIS

The GIS used in this study is ArcView. ArcView , made by Environmental Systems Research Institute, Inc. (ESRI) gives the analyst "the power to visualize, explore, query and analyze data spatially [Environmental Systems Research Institute, Inc., 1994]." To demonstrate how ArcView can be used to perform analysis on demand for ridesharing, two scenarios will be considered. First, the most optimistic scenario will be analyzed. This is where the organization has implemented a guaranteed ride home program, preferential parking, midday shuttle, and where rideshare cost per day is 25 cents and where additional travel time to rideshare is 5 minutes. This is a fairly ambitious scenario because much employer participation is needed to implement such support strategies. In addition, the 5 minute added rideshare time is unrealistic for Austin in most cases at the present time. A 5 minute added rideshare time, however, may be realistic where high occupancy vehicle (HOV) lanes exist, for instance, in large cities like Houston where a trip to work may be longer and may be offset by the travel time savings obtained from the right to use the HOV lane. This offset may be large enough such that the net added travel time due to ridesharing is only 5 minutes.

The second scenario is a more realistic one, but is also a hypothetical one. It is where a guaranteed ride home program and preferential parking exists but a midday shuttle does not. A concern from the comments written on some of the returned surveys stated that the lunch break may be too short for a midday shuttle to be successful. In addition, the logistics of implementing a midday shuttle may be too burdensome for it to become a reality; especially for Travis County offices in downtown where it would have to be coordinated with individuals working in different buildings. The rideshare cost in this scenario is 50 cents per day. This would equate to 10 dollars a month if a person commutes 5 days per week and 4 weeks per month. Capitol Metro charges a 10 dollars per month fare for their vanpool services and so this rideshare cost is a realistic one. The added travel time for this scenario is 15 minutes. It is not known whether this is realistic or not for most cases; however, 15 minutes may be more reasonable than 5 minutes for Austin since HOV lanes are not yet available. Table 15 summarizes the characteristics of the two scenarios.

ArcView was used to perform query analysis subsequent to the simulation. This was done in two steps. First, simulation using the estimated logit model determined who, among the database, will choose to rideshare. Second, query analysis answers the question, who, among those that chose to rideshare in the simulation, actually can rideshare. The GIS was used to perform the query analysis. The following criteria were used to determine if an individual is able to rideshare for those individuals who currently drive alone.

1) Start time is between 8:00 am and 9:00 am inclusive.

2) The work week is Monday through Friday.

3) The destination is Travis County's downtown campus.

These criteria were based on the most common responses obtained from the survey. Obviously, the number of ridesharing employees will change depending on how the criteria are defined. Starting work times and days worked could be altered, departure time could be included, other Travis County work destinations could be analyzed, etc.

All employees that did choose to rideshare in the simulation and did pass the above criteria were queried and summed by zip code. Table 18 summarizes the results for Scenario 1 and Table 19 summarizes the results for Scenario 2.

Table 16: Recommended Models

Best Models	Best predictive model		Best descriptive model	
	Model 3.1		Model 3.7	
Description of Variable	Coeff	t-stat	Coeff	t-stat
alternative specific constant	-1.87889	-9.46	-3.81	-14
guaranteed ride home(1 if exists, 0 otherwise)	1.686	19.56	1.77	19.1
presence of midday shuttle(1 if exists, 0 otherwise)	0.529	7.04	0.569	7.02
preferential parking(1 if exists, 0 otherwise)	0.469	6.26	0.518	6.4
generic travel time variable (Ta-Trs)				
generic travel cost variable (Ca-Crs)				
vehicles per individuals in the household				
walk time (parking lot to worksite)	0.0277	3.79	0.028	3.64
annual household income				
age	-0.1748	-7.98	-0.1	-4.2
gender(1 if male, 0 otherwise)				
schedule flexibility (6=daily hours can vary more than 1 hr, 1=daily hours cannot vary at all)	0.049	2.518	0.0402	1.88
child care responsibility (1=yes, 0=no)				
trip chains (8=7 days a week, 1=no days a week)				
midday work related trips (8=7days aweek, 1=never)	-0.137	-6.08	-0.132	-5.4
importance to ridesharing (10=very important, 1=not important)				
saving wear on personal vehicle			0.0598	3.74
environmentally safe transportation			0.056	3.73
less dependence on auto			0.0461	3.17
reliable form of transporation				
socializing opportunities				
ability to relax			0.096	6.47
reduced parking anxiety			0.0538	4.23
insurance breaks				
employer encouragement				
monetary savings				
alternative specific variable for cost(auto)	0.0696	2.846	0.0606	2.49
alternative specific variable for travel time(auto)	0.0671	6.51	0.0658	5.89
alternative specific variable for cost(rs)	-0.797	-10.4	-0.837	-10
alternative specific variable for travel time(rs)	-0.0576	-6.29	-0.0592	-6
generic cost divided by income variable				
age*gender	0.0696	5.666	0.0426	3.12
gender*child care responsibility				
gender*trip chains				
child care responsibility*trip chains				
walktime from parking to worksite*gender				
downtown work location(1 if downtown, 0 otherwise)				
L(B)	-2438.9		-2086	
L(0)	-5180.6		-4472.2	
rhobarsquared	0.5283		0.532	
number of observations	7474		6452	
number of estimated parameters (k)	13		18	
likelihood ratio test statistic	5484		4472	
X^2(k,0.05)	22.36		28.87	

Table 17: Two Hypothetical Scenarios Analyzed

Variable	Scenario 1	Scenario 2
Guaranteed ride home	Yes	Yes
Preferential parking	Yes	Yes
Midday shuttle	Yes	No
Rideshare cost	$0.25	$0.50
Rideshare added travel time	5 minutes	15 minutes

Table 18: Choice Simulation Results for Scenario 1

Zip Code	Number of Ridesharers	Zip Code	Number of Ridesharers
78602	1	78729	1
78612	1	78731	4
78617	1	78733	1
78620	1	78734	1
78621	1	78735	1
78622	1	78736	1
78626	1	78738	1
78634	1	78739	1
78641	1	78744	2
78652	2	78745	6
78660	4	78746	3
78664	1	78747	2
78666	1	78748	4
78681	2	78749	5
78702	1	78750	1
78703	4	78752	1
78704	6	78753	2
78705	2	78757	4
78722	1	78758	3
78727	2	78759	6
78728	2	78957	1
		total	88

Table 19: Choice Simulation Results for Scenario 2

Zip Code	Number of Ridesharers	Zip Code	Number of Ridesharers
78626	1	78744	1
78660	2	78745	1
78666	1	78746	3
78703	2	78747	1
78704	2	78748	3
78722	1	78749	2
78727	2	78750	1
78728	2	78752	1
78729	1	78753	1
78731	1	78759	2
78733	1	78957	1
78734	1	total	34

As expected, there are more ridesharers for Scenario 1 than there are for Scenario 2 since Scenario 1's attributes favor ridesharing.

A comparison of the mode share obtained from the simulation itself and the mode share obtained from the query demonstrates that there is a great disparity between those who want to rideshare and those who want to rideshare and actually can. Of course, because the analysis was performed on a sample of Travis County employees (those who returned the survey), the true forecasted mode share is not known. Table 20 compares the mode share from simulation and the mode share after querying is performed for both scenarios. Also included in Table 20 is the mode share obtained from the query analysis with all of the zip codes with just one ridesharer eliminated. This is because ridesharing can only be feasible when there are at least two employees queried for a given zip code.

Table 20: Mode Share Results for Scenarios 1 and 2

	Scenario 1	Scenario 2
1) Mode share resulting from simulation	44%	17%
2) Mode share obtained from query by work schedule and destination of simulated ridesharers	17%	6%
3) "Practical" mode share obtained from query with single ridesharers eliminated	12%	4%

MAPS PRODUCED FROM GIS

The cliché "a picture is worth a thousand words" applies to transportation data. ArcView has the capability to produce thematic maps from the employee database. A spatial representation of the ridesharing employees for both scenario 1 and scenario 2 may provide insight into their differences in demand levels. First, however, it would be helpful to examine a map of the residential distribution of Travis County employees. Figure 13 is a map of zip codes with different shadings for different ranges of employee totals for those employees commuting to Travis County's downtown campus. Figure 14 is the same map of employee residential distribution but focuses on the core Austin area rather than the broader central Texas area.

As one can see, the downtown Travis County employee commutershed area is rather large, spanning the corridor between Georgetown and New Braunfels. However, a closer look indicates that high concentrations of employees reside in zip codes within the core Austin area. The highest concentrations of downtown employees reside south of Town Lake and in north Austin. Round Rock, Pflugerville, and Buda, satellite cities of Austin, also have concentrations of downtown commuting employees. It should be noted that the map only includes employees who returned the survey.

Figure 15 is a map of the residential locations of ridesharing downtown commuters for scenario 1.

Figure 13: Employee Residential Distribution- View of Central Texas

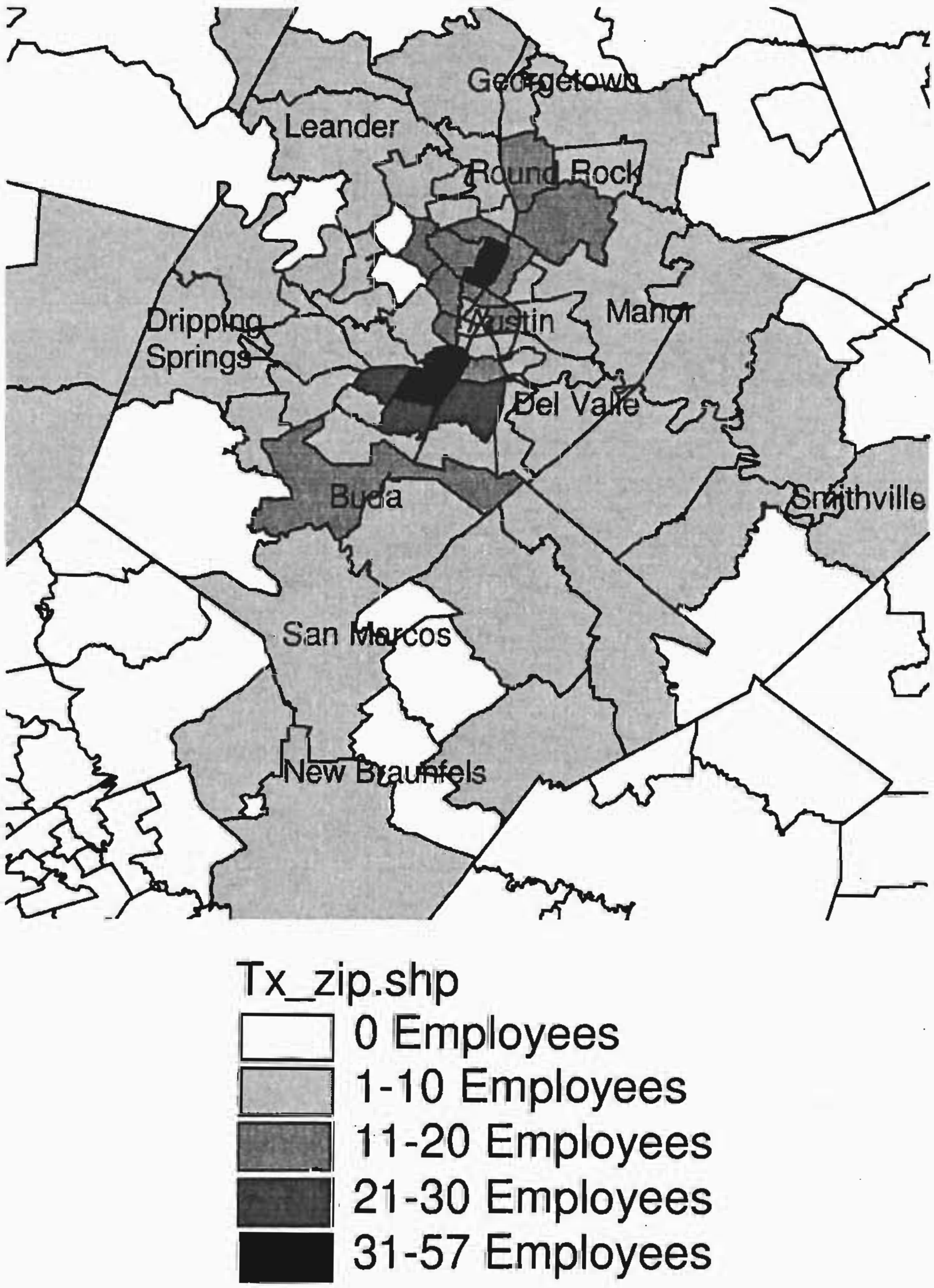
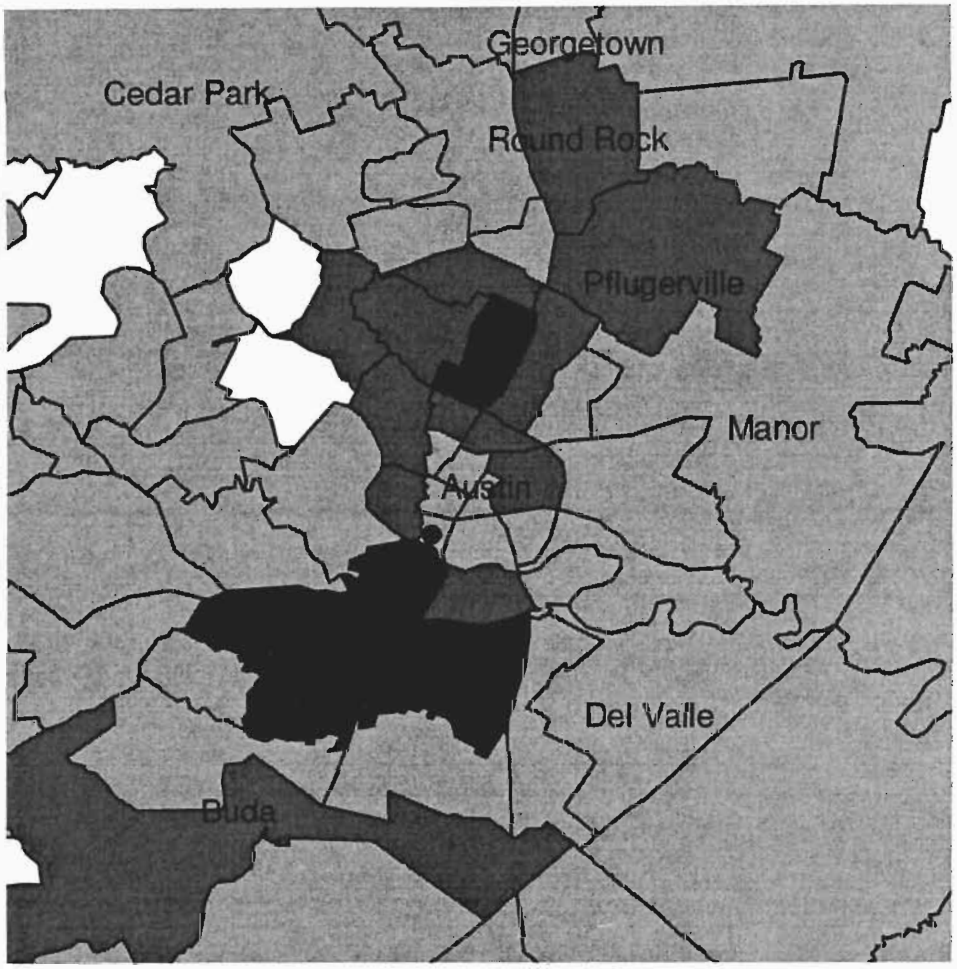


Figure 14: Employee Residential Distribution- View of Austin



Tx_zip.shp

0 Employees

1-10 Employees

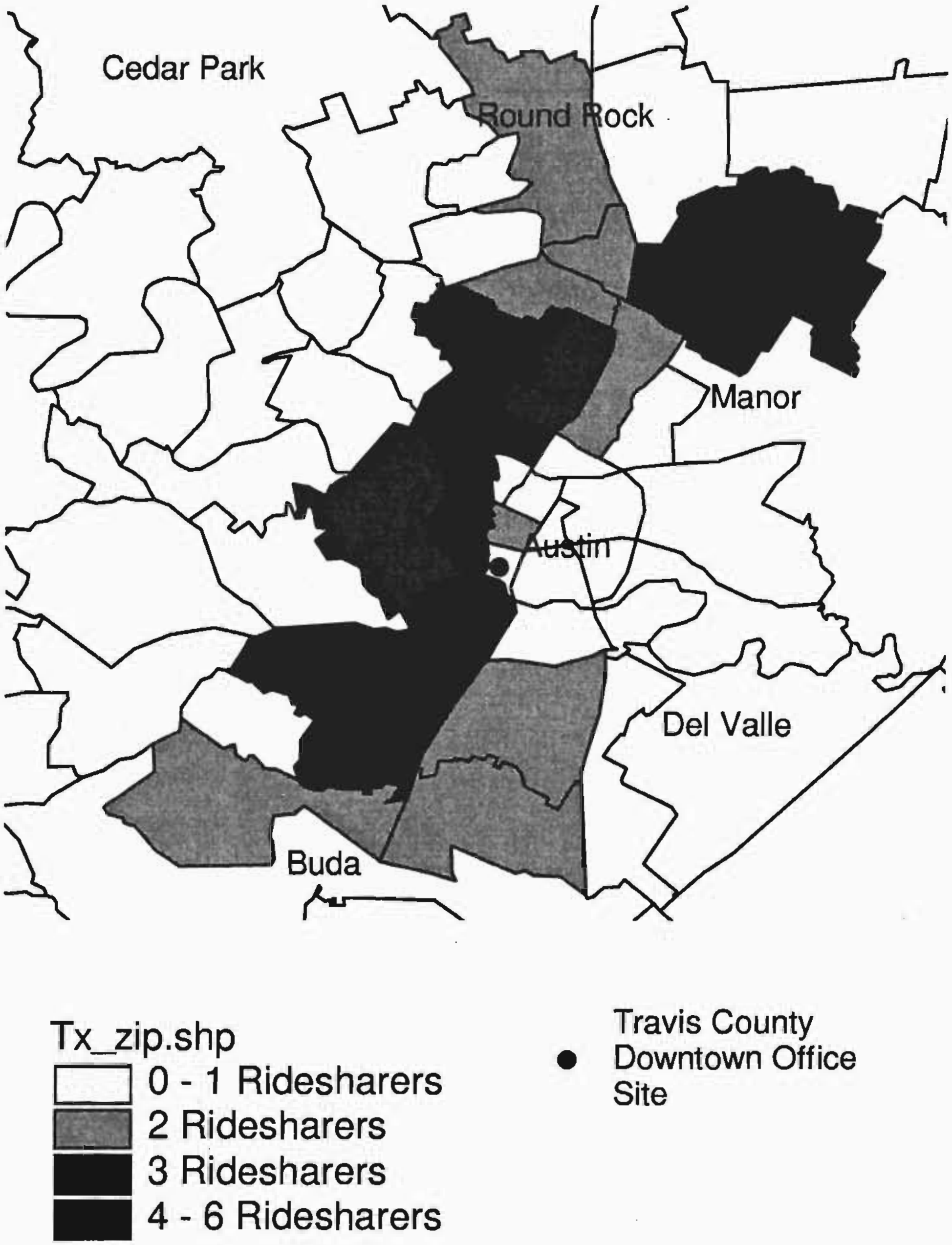
11-20 Employees

21-30 Employees

31-57 Employees

● Travis County Downtown Office Site

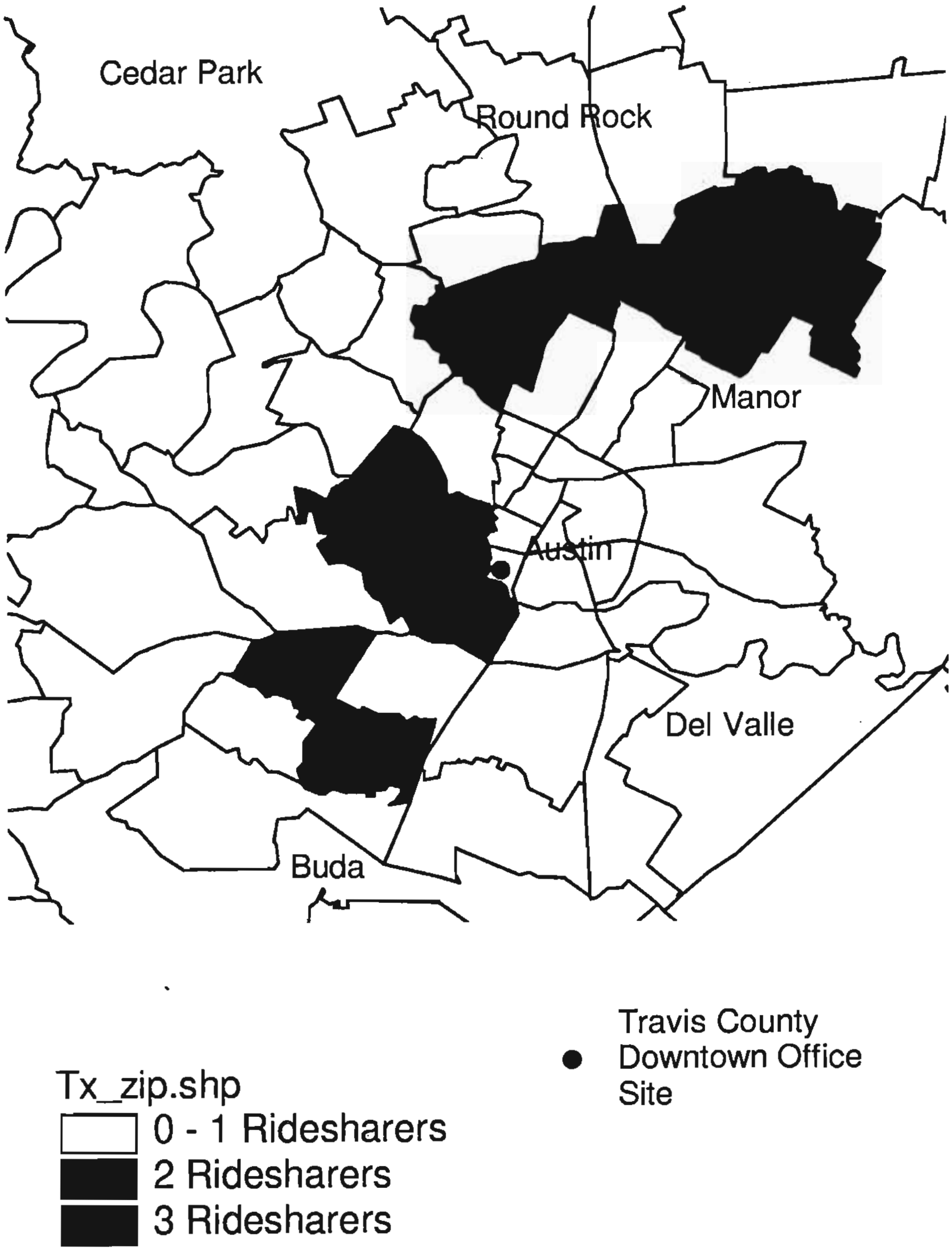
Figure 15: Residential Distribution of Ridesharers in Scenario 1



The highest concentrations of ridesharers commute from those zip codes with the highest concentrations of employees. This is because ridematching is facilitated when there are concentrations of employees who have common origins and destinations. Although zip codes with high concentrations of employees that are close to the downtown location have larger numbers of ridesharers, there do exist some zip codes that have relatively large numbers of ridesharers that are on the fringes of the Austin area. This is expected since the travel times for those locations to downtown may be great enough such that the disutility of driving may shift individuals to ridesharing. Overall, the numbers of ridesharers per zip code did not exceed 6. A vanpool may be an appropriate option for these zip codes since the vans typically can hold up to 12 passengers. The remaining zip codes do not have significant numbers of ridesharers especially since having a single ridesharer in a zip code is essentially the same as no ridesharers. An individual cannot rideshare if there are no other compatible rideshare partners.

As shown in Figure 16, in scenario 2 the numbers of ridesharers diminishes significantly. The greatest concentration of ridesharers reside in certain zip codes south, west, and north of downtown. The highest number of ridesharers that any zip code has is 3.

Figure 16: Residential Distribution of Ridesharers in Scenario 2



CONCLUSIONS

RECOMMENDATIONS FOR TRAVIS COUNTY

Because of the 22 percent response rate for the Travis County employee survey, the results of the mode split analysis were inconclusive for practical purposes. It is impossible to predict accurate forecasts of rideshare demand because the method utilizes a simulation procedure to determine whether an individual chooses to rideshare or not. This means that it is imperative that a complete dataset be obtained so that the resulting mode share is for the entire Travis County work force rather than a sample. The results do indicate that the most favorable set of feasible support strategies should be adopted in order to make ridesharing a viable option. The results also show which zip codes will most likely have the highest rideshare patronage.

A follow up survey is recommended for Travis County in order to obtain a more accurate forecast of mode share. Special care must be taken to obtain a high rate of return for the survey. The follow up survey need not include a stated preference section since the mode split model has been estimated. However, it is important to obtain the information for the variables in the model, destination, origin, and work schedule.

If it is desired, a stated preference section could be included in the follow up survey. Then a new mode split model could be estimated. A comparison between the new and current models would indicate whether the non-response of this study was in fact a significant factor.

If the current model is used, only simulating mode choice and performing ridematching for a given set of system characteristics using the complete employee dataset would have to be performed. The optimum set of support strategies and rideshare characteristics can therefore be implemented. It should be noted that the one support strategy that was implied throughout the study is ridematching. The stated preference section of the survey indicated to the respondent that ridematching would be performed by either the employer or by Capital Metro. The respondent performed the choice experiment believing that this support strategy would be a given. Ridematching is necessary in order to make the ridesharing program as attractive as possible.

EFFECTIVENESS OF METHODS

Not only does the GIS bring a spatial dimension to mode split modeling, but also combines the ridematching procedure to the process of demand forecasting. The resulting mode share is therefore a more practical one. Simply applying the mode split model to the population for predicting choice involving a rideshare mode is short sighted because of its neglect for spatial and temporal considerations. Individuals can only rideshare if there are compatible rideshare partners residing within close proximity.

Although GIS provides a powerful way of modeling mode choice and graphically displaying results for different rideshare schemes, it is not free of limitations. The results of the GIS analysis are only as good as the inputted data. Data that is faulty and inaccurate would cause the results to be skewed as well.

A more complete survey sample would improve the methodology in the following ways. First, estimation of the mode split model would be facilitated by a larger survey sample. This would minimize non-response bias. A response rate of 22 percent is fairly high for a survey that did not provide great incentives for the individual to return. However, since 78 percent of Travis County's employees did not return the survey, non-response bias could be a significant factor. Second, a greater response rate would facilitate the ridematching procedure of the methodology. The resulting modeled ridesharers would be more accurate since querying would be performed on a larger sample. Having the remaining 78 percent of Travis County employees' data would allow for more ridesharers to be matched.

Once larger, more complete datasets are acquired, more confident analysis could be performed. For the employer, different combinations of support strategies and pricing schemes could be tested to find the solution with the highest rideshare rate with the most realistic set of support strategies.

For the transportation analyst, different combinations of support strategies, pricing schemes, and levels of service could be tested to find the most appropriate system improvements. For instance, the GIS could provide a transit agency with information on where most ridesharers are commuting from in order to locate the best park-and-ride facility. Or, officials can analyze which corridors will be serving the most carpoolers and vanpoolers so that high occupancy vehicle lanes could be implemented.

Another obvious application of the rideshare prediction methods is for employers to predict trip reduction rates for possible Employee Commute Options (ECO) mandates or similar trip reduction ordinances. The methodology of this study was performed on an employer in Austin, a city that does not fall into the "severe" non-attainment category. This means that the methodology may face barriers in its implementation without active involvement in voluntary trip reduction programs by related agencies and employers.

Austin is a rapidly growing community and may someday fall into the "severe" non-attainment category as ozone pollution increases. However, Austin currently does not have a required trip reduction ordinance. There is a Voluntary Trip Reduction Program (V-Trip Program) where certain employers have volunteered to implement trip reduction programs. Because there does not exist a dire need to obtain vehicle occupancy rates, the employee data needed for analysis may be difficult to acquire.

Since organizations interested in reducing commute trips commonly conduct surveys of their employee commute characteristics, the survey could easily be designed to obtain the necessary data for predicting rideshare demand. A stated preference section would be needed to obtain information on the individual's choice behavior in addition to all other trip and employee information that is normally acquired from these surveys to develop a customized mode split model. It may be more efficient for the employer to conduct two surveys: one that obtains information on the complete population of commuters and one that obtains the choice behavior information. The one that obtains the choice behavior information need only be distributed to a large enough sample to estimate the models.

Information from several surveys of different employment sites could be compiled into one database. A mode split model could be estimated for the entire group of employers. The results could then be extrapolated to other employment sites. This would eventually streamline the methodologies by not requiring all employers to conduct stated preference surveys. Instead, the same model could be used to predict rideshare demand for any interested employment site.

Once a mode split model is estimated, the organization could use the GIS/ Mode split method to predict demand for ridesharing as well as future APO. Different support strategies could be tested with the GIS to determine if the target APO could be reached. Accurate forecasts could benefit companies by providing them with an effective management tool. The employer could save by only expending the necessary resources on achieving or maintaining the regional target vehicle occupancy rates.

FUTURE IMPROVEMENTS TO GIS/MODE SPLIT TECHNIQUES

Streamlining the GIS Analysis

An improvement for the near future is to streamline the analysis process by tailoring ArcView to perform the simulation and ridematching automatically. A script, which is like a macro, can be written to prompt the analyst for the attributes of the rideshare system and then compute the probabilities, simulate mode choice, and then perform the ridematching. Scripts in ArcView are written in a language called "Avenue." A working knowledge of this language is needed to program scripts.

Address matching of employee residential locations

The Travis County employee survey not only obtained the zip code of the origin but also the closest major intersection. This information, along with the Topologically Integrated Geographic Encoding and Referencing (TIGER) files for Austin, could be used to plot residential locations on the Austin road network. A TIGER file is a digitized street network of a city with the street names and addresses embedded into the file. Each road link has address information associated with it. ArcView has the ability to geocode the locations of employees as major intersections into the Austin network. This would provide for a greater range of analysis.

Network applications

A network with employees geocoded by major intersection could be used to perform network related analysis. First, impedances must be assigned to each link in the network. This describes either the speed traveled on the link or the travel time required to travel a link. A wide array of analyses could be performed subsequent to calibrating the network for impedance.

Ridematching could now be done by shortest travel time rather than by zip code. A query could be performed by travel time. For example, the query could identify all employees living within 10 minutes of another employee. This would provide a more detailed and more accurate way of matching ridesharers.

Another application that could be performed with the geocoded Austin network is to find the shortest routes for ridesharing parties. These routes could be recommended in real life to the actual ridesharing parties or they could be used for modeling demand for transportation corridors. The travel times associated with the chosen routes could be inputted as the travel time variable for the mode split model to obtain more accurate probabilities of ridesharing.

In more ambitious applications with large datasets of the population, network loadings could be computed for future planning purposes. These methods could accompany the four step urban transportation planning system (UTPS) where the four steps are trip generation, trip distribution, mode split, and route assignment.

An application in fixed route transit demand analysis could be to find all employees that live within a certain buffer zone around a transit route or transit station and then simulate mode choice for those individuals to forecast transit patronage. A digitized transit network would be needed for this kind of analysis. However, the ease of predicting demand for a transit corridor for varying scenarios and the power of displaying results graphically would make the digitization of the transit network well worth it.

APPENDIX A
TRAVIS COUNTY SURVEY

Figure A1: Travis County Employee Survey

COLLEGE OF ENGINEERING
THE UNIVERSITY OF TEXAS AT AUSTIN

Center for Transportation Research • Suite 200
3208 Red River • Austin, Texas 78705-2650 • (512) 472-8875 • FAX (512) 480-0235

To: Travis County Employee
From: Gregory Han, Graduate Research Assistant
Subject: Transportation Study
Date: August 15, 1995

The Center for Transportation Research at the University of Texas at Austin is presently engaged in a collaborative research program with the U.S. Department of Transportation and the Texas Department of Transportation through the Southwest Region University Transportation Center. One of the current research projects has as its objective the development of commuter rideshare systems for employees working in the Austin area. Part of the workplan consists of surveying a major employer in order to obtain the necessary information. Travis county has been invited to participate in this study.

It would be greatly appreciated if you could take a few minutes to complete the attached survey and return it to County Commissioner Karen Sonleitner at 5th floor, Travis County Administration Building within one week (by August 22). The return address is printed in bold at the bottom of this page. Simply fold and staple this survey so that it is showing and send through interoffice mail. Thank you for your cooperation.

County Commissioner Karen Sonleitner
5th Floor
Travis County Administration Building

I. Travel Characteristics

1. How did you get to work today?

a.	☐ Drove alone	d.	☐ Carpooled with acquaintance
b.	☐ Rode the bus	e.	☐ Vanpooled
c.	☐ Carpooled with family member	f.	☐ Other ____________

2. What was your travel time to work this morning? ________________(in minutes)

3. How far did you travel to get to work today? _________________(in miles)

4. How much time did it take for you to get from your parking spot to the work site today? ________________(in minutes)

5. What was your parking cost today (if any)?______________(in dollars)

6. How much was your bus fare today (if any)?________________(in dollars)

II. Socio-Economic Characteristics

7. What department of Travis County do you work for? ____________________________

8. What is the closest major intersection to your residence?: ______________________ and_________________________

9. What is your home zip code ____________

10. [Optional Question] What is the gross annual income of your household?

a.	☐ under $15,000	d.	☐ $45,000 - $60,000	g.	☐ $90,000 - $105,000
b.	☐ $15,000 - $30,000	e.	☐ $60,000 - $75,000	h.	☐ $105,000 -$120,000
c.	☐ $30,000 - $45,000	f.	☐ $75,000 - $90,000	i.	☐ over $120,000

11. What is your age?

a.	☐ under 16	d.	☐ 25 to 29	g.	☐ 40 to 44	j.	☐ 55 to 59
b.	☐ 16 to 19	e.	☐ 30 to 34	h.	☐ 45 to 49	k.	☐ 60 to 64
c.	☐ 20 to 24	f.	☐ 35 to 39	i.	☐ 50 to 54	l.	☐ 65 and over

12. What is your gender? ☐ Male ☐ Female

13. What are your normal work hours? ___:___ (AM or PM?) to ___:___ (AM or PM?)
Start time Leave time

14. Which describes your schedule?
   a. ☐ my daily hours cannot vary at all
   b. ☐ my daily hours can vary up to 15 minutes
   c. ☐ my daily hours can vary up to 30 minutes
   d. ☐ my daily hours can vary up to 45 minutes
   e. ☐ my daily hours can vary up to 1 hour
   f. ☐ my daily hours can vary more than 1 hour up to _____hours and _____minutes

15. What days do you commute?
   a. ☐Monday through Friday, or
   b. Check all days that apply:
   ☐Sun (U) ☐Mon (M) ☐Tue (T) ☐Wed (W) ☐Thu (R) ☐Fri (F) ☐Sat (S)

16. Do you have any children in day care? ☐ Yes ☐ No

17. How many motor vehicles (motorcycles, cars, trucks) does your household have?____________

18. How many individuals in your household are licensed to drive?____________

19. While going to or from work, how many days per week do you make trips for personal purposes (for shopping, bank, dry cleaners, etc)?

a. ☐ None	c. ☐ 2 days a week	e. ☐ 4 days a week	g. ☐ 6 days a week
b. ☐ 1 day a week	d. ☐ 3 days a week	f. ☐ 5 days a week	h. ☐ 7 days a week

20. How often do you travel for work related purposes during the day?

a. ☐ Never	c. ☐ 2 days a week	e. ☐ 4 days a week	g. ☐ 6 days a week
b. ☐ 1 day a week	d. ☐ 3 days a week	f. ☐ 5 days a week	h. ☐ 7 days a week

21. Which are important reasons for ridesharing (carpooling or vanpooling)? Use a scale of 1 to 10 (10=very important, 1=not important) to **rate** each reason.

a. ____Save wear on personal vehicle
b. ____Environmentally friendly form of transportation
c. ____Less of a need to drive
d. ____Increased reliability/safety of commute (in the case of vanpooling)
e. ____Socializing opportunities with ridesharing acquaintances
f. ____Opportunity to spend commuting time reading, sleeping, or relaxing
g. ____Reduced need to find parking or anxiety about parking
h. ____Some insurers will lower rates on personal vehicles for vanpool riders
i. ____Employer encourages ridesharing to reduce need for parking
j. ____Monetary savings

III. Choice Experiment

The following is a choice experiment for those who do not currently vanpool or carpool with acquaintances. You will be asked to choose between two commuting modes: either to continue your current mode of travel or to rideshare (carpool or vanpool). Ridesharing is where you would carpool or vanpool either by getting picked up at your residence or by driving to a pickup point. Ridesharing groups are matched for free either by Capital Metro or by your employer. Each scenario has a different set of attributes. The following list of definitions explains each attribute in case there is any confusion. Check off the mode that you would realistically choose for each of the eighteen hypothetical situations.

Mid-day shuttle: a service during the lunch hour that transports ridesharers to eating establishments, shopping, and other mid-day destinations.

Rideshare cost per day: the expense that a ridesharer pays to get to work every day. It includes all fares and gas expenses.

Rideshare added traveltime: the additional one way travel time to get to the worksite caused by the need to wait for rides and travel time to pick up other riders.

Guaranteed ride home: a service for ridesharers where a taxi will be provided in case of emergencies causing the need for the employee to leave work.

Preferential parking: where the closest parking spaces to the worksite are designated as carpool/vanpool spots.

Section III-B	Midday Shuttle	Rideshare cost per day	Rideshare added one-way travel time (min)	Guaranteed Ride Home	Preferential Parking	I choose to use my current mode	I choose to rideshare
Example							
1	Yes	$0.25	5	Yes	No		X
2	No	$1.50	5	No	Yes	X	
Scenario							
1	No	$0.75	5	No	No		
2	Yes	$1.50	10	No	No		
3	Yes	$0.75	5	Yes	No		
4	No	$0.25	5	No	Yes		
5	No	$0.75	5	Yes	Yes		
6	Yes	$0.25	5	Yes	No		
7	No	$0.75	10	Yes	Yes		
8	Yes	$0.25	10	No	No		
9	No	$0.25	5	No	No		
10	No	$0.75	5	Yes	No		
11	Yes	$0.75	10	Yes	No		
12	No	$0.25	5	Yes	No		
13	Yes	$0.25	15	No	No		
14	No	$1.50	10	No	Yes		
15	Yes	$1.50	5	No	Yes		
16	Yes	$0.25	5	No	No		
17	No	$0.25	10	Yes	No		
18	No	$0.25	15	Yes	Yes		

Table A1: Stated Preference Choice Scenarios

Stated Choice Preference Survey Design

Variables	Midday Shuttle	Rideshare cost	Rideshare added travel time	Guaranteed Ride Home	Preferential Parking
Outcome1	Yes	High	Faster	Yes	Yes
Outcome2	No	Med	In-Between	No	No
Outcome3		Low	Slower		
Options					
1	Yes	High	Faster	Yes	Yes
2	Yes	High	Faster	Yes	No
3	Yes	High	Faster	No	Yes
4	Yes	High	Faster	No	No
5	Yes	High	In-Between	Yes	Yes
6	Yes	High	In-Between	Yes	No
7	Yes	High	In-Between	No	Yes
8	Yes	High	In-Between	No	No
9	Yes	High	Slower	Yes	Yes
10	Yes	High	Slower	Yes	No
11	Yes	High	Slower	No	Yes
12	Yes	High	Slower	No	No
13	Yes	Med	Faster	Yes	Yes
14	Yes	Med	Faster	Yes	No
15	Yes	Med	Faster	No	Yes
16	Yes	Med	Faster	No	Yes
17	Yes	Med	In-Between	Yes	No
18	Yes	Med	In-Between	Yes	Yes
19	Yes	Med	In-Between	No	No
20	Yes	Med	In-Between	No	Yes
21	Yes	Med	Slower	Yes	No
22	Yes	Med	Slower	Yes	Yes
23	Yes	Med	Slower	No	No

24	Yes	Med	Slower	No	Yes
25	Yes	Low	Faster	Yes	No
26	Yes	Low	Faster	Yes	Yes
27	Yes	Low	Faster	No	No
28	Yes	Low	Faster	No	Yes
29	Yes	Low	In-Between	Yes	No
30	Yes	Low	In-Between	Yes	Yes
31	Yes	Low	In-Between	No	Yes
32	Yes	Low	In-Between	No	No
33	Yes	Low	Slower	Yes	Yes
34	Yes	Low	Slower	Yes	No
35	Yes	Low	Slower	No	Yes
36	Yes	Low	Slower	No	No
37	No	High	Faster	Yes	Yes
38	No	High	Faster	Yes	No
39	No	High	Faster	No	Yes
40	No	High	Faster	No	No
41	No	High	In-Between	Yes	Yes
42	No	High	In-Between	Yes	No
43	No	High	In-Between	No	Yes
44	No	High	In-Between	No	No
45	No	High	Slower	Yes	Yes
46	No	High	Slower	Yes	Yes
47	No	High	Slower	No	No
48	No	High	Slower	No	Yes
49	No	Med	Faster	Yes	No
50	No	Med	Faster	Yes	Yes
51	No	Med	Faster	No	No
52	No	Med	Faster	No	Yes
53	No	Med	In-Between	Yes	No
54	No	Med	In-Between	Yes	Yes
55	No	Med	In-Between	No	No
56	No	Med	In-Between	No	Yes
57	No	Med	Slower	Yes	No

58	No	Med	Slower	Yes	Yes
59	No	Med	Slower	No	No
60	No	Med	Slower	No	Yes
61	No	Low	Faster	Yes	Yes
62	No	Low	Faster	Yes	No
63	No	Low	Faster	No	Yes
64	No	Low	Faster	No	No
65	No	Low	In-Between	Yes	Yes
66	No	Low	In-Between	Yes	No
67	No	Low	In-Between	No	Yes
68	No	Low	In-Between	No	No
69	No	Low	Slower	Yes	Yes
70	No	Low	Slower	Yes	No
71	No	Low	Slower	No	Yes
72	No	Low	Slower	No	No

Table A2: Variables Captured By Travis County Employee Survey

Variables	Type of Variable	Relationship to Prob of Ridesharing	Description	Survey Quest/ Section(s)
Travel time	system	+	One way travel time to work	2,III
Travel cost	Char of system	+	One way cost of travel to work	3,5,6,III
Children	Char of trip maker	-	1: have children in day care, 0:otherwise	16
Guaranteed ride home	Char of system	+	1: GRH exists, 0:otherwise	III
Preferential parking	Char of system	+	1:P.P. exists, 0:otherwise	III
Vehicles/# drivers' licenses in H.H.	Char of trip maker	-		17,18
Gender	Char of trip maker	+	1:Male, 0:Female	12
Income	Char of trip maker	-	Combined household income	10
worksite	system	+	in minutes	4
Age	Char of trip maker	-		11
Flexibility in schedule	Char of trip maker	+	time which start time may vary	14
Large #of trip chains per week	Char of trip maker	-		19
Need for midday business travel	Char of trip maker	-	in days per week	20
Environmental consciousness	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21b
Mid-day shuttle	Char of system	+	1: Shuttle exists, 0:otherwise	III
Save wear on car	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21a
Not having to drive	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21c
Increased reliability/safety of commute	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21d
Socializing opportunities with ridesharing acquaintances	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21e
Opportunity for riders to spend commuting time reading, sleeping, relaxing	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21f
Reduced anxiety about parking or need to find parking	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21g
Possible reduction in insurance rates on personal vehicles for vanpoolers	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21h
Employer encourages ridesharing to reduce need for parking	Char of trip maker	+	Benefit of rs with importance scale from 1 to 10	21i
Importance of monetary savings	Char of trip maker	+	Benefit of rs with importance scale from 1 to 11	21j

APPENDIX B
SURVEY RESULTS

Table B1: Zip Code Distribution of Travis County Employees

Zip Code	Employees	Zip Code	Employees
71723	1	78704	54
75617	1	78705	8
76502	1	78713	1
76574	1	78717	2
76758	1	78719	2
78130	2	78721	5
78155	1	78722	8
78420	1	78723	27
78602	10	78724	6
78605	2	78725	3
78606	1	78727	13
78610	13	78728	9
78611	1	78729	12
78612	7	78731	15
78613	9	78732	1
78616	2	78733	3
78617	9	78734	7
78619	3	78735	2
78620	3	78736	6
78621	3	78737	3
78622	1	78738	2
78626	4	78739	4
78628	2	78740	1
78634	5	78741	20
78636	1	78742	1
78640	4	78744	27
78641	4	78745	72
78642	1	78746	11
78644	7	78747	4
78645	1	78748	30
78648	1	78749	37
78652	7	78750	14
78653	3	78751	10

78660	23	78752	16
78662	2	78753	23
78664	14	78754	1
78666	5	78756	3
78669	5	78757	21
78681	11	78758	38
78684	1	78759	19
78701	2	78957	1
78702	11		
78703	14		

Table B2: Response Rate by Travis County Department

Department	# of responses	Department	# of responses
Administrative Oper	1	Housing Services	2
Adult Probation	17	HRMD	2
Adult Probation-CSCD	1	Human Resources	1
Ag Extension	1	Human Services	32
Agri Extension Service	1	Human Services-CPS	1
Auditor	13	IA	1
Auditors	1	Info Sys	1
Bailiff	1	Information Systems	1
Budget Office	1	Internal Audit	3
CB	1	ISD-Corrections	1
Central Booking	2	ISM	12
Central Booking-CDI	1	Jail	1
Central Records	1	Jail Administration	1
Central Warrants	2	JP Court-Courthouse	1
Children Protective Services	3	JP Court-Pct 1	1
City of Austin Health Dept	1	JP Pct3	1
Civil District Court	1	JP#3	1
Classifications,Del Valle	1	JP1	1
Comissioner Pct2	1	Judges	1
Commisioner Pct3	1	Juvenile Court	32
Commissioner	1	Juvenile Probation	1
Commissioner Bristol	1	Juvenile Public Defender	1
Commissioner Pct 2	1	Library	1
Commissioner Pct4	1	Mail Services	1
Commissioners Court	1	Maintenance-Sheriff Dept	1
Commissioner Pct2	1	ME	1
Constable	3	Medical Examiner	1
Constable Pct1	1	Medical Examiners Office	1
Constable Pct2	1	Parks	1
Constable Pct4	1	PITD	2

Constable Pct5	4	Planning & Engineering SVCS	1
Construction/Inspection	1	Planning and Budget	2
Corrections	14	Planning&Budget	1
Corrections-Del Valle	1	Planning&Budget Office	1
Corrections-TCCC Del Valle	1	Pretrial	2
Counseling Center	2	Pretrial Services	7
County Agriculture/Extension	1	Probate Court	2
County Attorney	19	Probate Off	1
County Auditor	3	Probation	11
County Clerk	18	Purchasing	5
County Clerk Administration	1	Records Management	7
County Commissioner	2	Residential Services	1
County Court	1	SACA	7
County Court #6	1	Sheriff	1
County Court #7	1	Sheriff	155
County Courts	7	Sheriff/Corrections	1
County Judge	1	Sheriff-Corrections	2
County Treasurer	1	Sheriff-crime scene unit	1
Court1	1	Sheriff-Del Valle	1
Courthouse	2	Sheriff-Del Valle Complex	1
Courts	2	Sheriff-Medical	1
Criminal	1	Sheriff-TCCC	1
Criminal County Clerks	1	Sheriff	1
Criminal Court	1	Sign Shop	1
Criminal Courts Administration	1	Smart Program	1
Criminal District	1	Star Flight	1
Criminal Justice	1	Supervision +Correction	1
Criminal Justice Planning	4	Supervision&Corrections	1
Corrections	1	Tax	5
CSCD	52	Tax Assessor	1

Deaf Services	1	Tax Assessor Collector	1
Del Valle	1	Tax Collector	1
Detention	1	Tax Office	15
DHS	1	TC Counseling Crt	1
District Attorney	38	TCCB	1
District Clerk	12	TCCB-Sheriff	1
District Clerk Criminal	1	TCCC	3
District Court	4	TCCC Records	1
District Courts	4	TCCC-Maintenance Bld	1
District Criminal Courts	1	TCJ	1
District Judge	5	TCNR	1
District Judges	2	TCSO	10
Domestic Relations	7	TCSO-Corrections	1
DRO	7	TCSO-TCCC(Del Valle)	1
EMS	2	TNR	57
Extension Service	1	TNR-Satellite#4	1
Extension Services	1	Transportation	1
Facilities	1	Travis County Jail	1
Gen Svcs	1	TSCO	1
General Services	4	Vehicle Maintenance	1
Health/Human Services	1	Veteran Service	1
Housing	1	Veteran Services	1
Housing Repair	1	Veteran's Service	1

Table B3: Departmental Distribution of Travis County Employees

Travis County Department	# of emp	Travis County Department	# of emp
Auditor	46	EMS	14
Budget	10	Extension Agent	12
Case/Inv. Manager	2	Facilities Engineer	4
Chemical Justice Planning	7	General Services	130
Child Prot. Services	8	Health	15
Comm. Supervision & Corr.	280	Human Resource Management	18
Commissioner #1	4	Human Services	128
Commissioner #2	4	Information Systems	49
Commissioner #3	4	JP#1	6
Commissioner #4	4	JP#2	8
Constable #1	9	JP#3	8
Constable #2	11	JP#4	8
Constable #3	18	JP#5	10
Constable #4	6	Juvenile Court Dept.	291
Constable #5	51	Juvenile Public Defender	7
Counseling Center	4	Medical Examiner	14
County Attorney	108	PITD	349
County Clerk	66	Pretrial Services	37
County Judge	5	Probate Court	8
County Treasurer's	7	Purchasing	17
Courts At Law	19	Records Management-ISM	18
District Attorney	148	Sheriff	1117
District Clerk	80	Substance Abuse Coun(SACA)	39
District Judges-Annex	20	Tax Collector	91
District Judges-Courthouse	66	Veterans Service	7
		Total Employees	987

Table B4: Comments Written on Travis County Employee Survey

Comments
1) I use my personal vehicle for field work. I could never not drive to work unless the county provided a vehicle for field work
2) Note attached explaining single parent situation and inability to use transit
3) Because I travel frequently to Del Valle Jail, Rideshare is not an alternative for me
4) Need my car for job
5) I could not do any of these. I have children at 2 diff schools that I take to school and I must be available at all times to leave when they call for whatever reason
6) Would not work because I am a police officer
7) I make it a point to live close enough so that I can commute by bike at least part of the time
8)..on bus route, which I sometimes ride. I bicycle to work sometimes. I use Dillo services.
9) I believe carpooling is important, personally I would continue my 3 options. Thanks for your interest
10) Fortunately I live approx one block from work at this time. I would consider carpooling if I moved
11) (in reference to mid-day shuttle)Impossible, 30 minute lunch break
12) I live where I live in order to avoid the time,expense,and hassle of a long drive to and from work and will keep my present form of transportation
13) 150 Probation officers cannot carpool because 1)must do field visits,2)must go to court3)must do jail visits-Del Valle, Downtown4)take paper work to other agencies +meetings
14) I have to have my vehicle available in case the need arises to transport juveniles. My job evaluation specifically has a section on availability of your personal vehicle
15) Riding the bus is not practical if the person has to make numerous stops from point A to point B. The use of taxpayers money to have big empty buses is deplorable. The bus system is a big joke the way it is currently run
16) (in reference to mid-day shuttle) Great idea
17) Need car for work purposes during day
18) I need my car for work 2-3 times per week
19) I need to have emergency access to a ride b/c I have a small child that could get sick or hurt at the daycare. I also need an inexpensive ride

20) After dealing with a difficult public all day, I do not desire to spend any extra time in traveling. Especially with disgruntled co-workers.My time off work is my treasure and I am selfish with it.

21) My question is-what is the commissioners court thinking by building more and more Co buildings in an area with no parking?How many commissioners will be spending their time on park and ride. If the answer is 0,I would think they should not want it for me.

22) I sometimes ride the bus, and therefore I would more likely use bus service than rideshare.I may switch to bus service some day if it runs more frequently and later into the night(more than once every 30 minutes or so)

23) I have a mother in law w/cancer and a mother in a wheelchair so I will always bring my car in case I have to get to either one of them.

24) No one I work with lives within 10 miles of me. If I have to take my son to child care, I go 20 miles in the opposite direction

25) I work to make money to have a nice car so I can use it not to have it sit in the garage. Not to mention the inability to go and come as I please

26) I live out of town-no bus stop until you get to Austin

27) There are many court cases that go past 4 pm Particularly when we have juries;sometimes we may have to stay as late as 8:30 pm before jury bring in a verdict

28) Having a car at my disposal during work hours is a condition of employment

29) I am a part time student three days a week I go directly to class after work.One,or maybe both pf the other days I run errands after work.

30) I would generally choose my current mode of transportation because quite often I work late and come in early.It is difficult to share when my time is not fixed

31) None of these scenarios is acceptable.Not being able to guarantee a ride home is grounds to scrub this whole proposal

32) Choice of rideshare is not an option in my position

33) I use my vehicle for job related tasks such as client contacts at schools. No rideshare program would be appropriate for me.

34) This survey like all the others,misses the point. When you work 40 hrs a week and have children in school,you have to run errands at lunch and have a car available for doctor,dentist,orthodontist appts;classes after work/school;

35) Unexpected calls from your children requiring transportation/

36) I leave for meetings sometimes 2x a day and normally at least 3x a week depending

on time of year. None of the ridesharing options would work

37) Do not handicap those of us who need second income jobs to survive.I am unable to rideshare or take a job that I have to park far a way from my car as I have a second job I must be at by 5:30 each evening which gives me 30 min travel from downtown to far north Austin. That job accounts for 1/4 of my income.I must have it! I repeat I need my car for a second evening job.I work for 1/4 of my income.Don't you people understand there are some of us who want a better quality of life so don't penalize us.

38) I am sure elected officials don't rideshare or have parking difficulties!!!

39) How many of the commissioners court are going to carpool?Having a taxi pick someone up and take them home or to the place of the emergency could get very expensive for the county in just one day,you could get 5 or 6 emergencies or more in one office in one day.It has happened in our office many times.Add this to the other offices.Big bucks.Is all of this the reason you all want to take our longevity pay and cost of living raises away from us to pay for this?

40) I would not choose any rideshare.I drop off 2 kids at 2 different locations and then pick up in the evenings.Ridesharing would mean I'd add even more time to my schedule to allow me to meet a rideshare and get to work in time

41)..in order for me to be able(to rideshare)other transportation needs would have to be met

42) I am unable to rideshare because I have to travel to different job sites during the day and I work late almost every night.

43) Because of nature of my job I must use my personal vehicle everyday for co. business.I cannot rideshare or carpool

44) I choose ,y current mode and no other due to the nature of my job and needing my car frequently throughout the day for evening and weekend meetings and projects

45) I choose to use my current mode.I want to keep my free parking space after waiting for it for 3 years.I have been here 8yrs with very few perks-I want to keep this one.

46) There is no way to carpool at this time

47) I live so close and am in/out of office so much and parking is easy-I want my car available

48) Move county Commissioners back to their precincts so they can watch bridges,ditches,roads and machinery as they were elected to do.Why downtown they are county commissioners

49) Due to work that I do in evenings,which schedules me in various places at various time,ridesharing is unfeasible

50) Due to the nature of my position as Guardian, ridesharing/vanpooling is not a consistent option as I schedule home visits at various times during the day into the evening, including after 5 pm.Also,sometimes district court requires attendance after 5 pm

51) I frequently stay 30-60 minutes after 5 in order to avoid traffic

52) I would not give up my freedom to operate my own mode of transportation for any reason whatsoever.I pay all required fees,registration,and licensing in order to have this right.

53) I have to continue my present mode of travel due to my two jobs

54) I currently commute by bike 1-2 times a week.If the county would provide good,convenient facilities for showering,etc.I may be willing to increase my bike commuting(like in the new court bldg)

55) I currently use Capital Metro Vanpool with no midday shuttle,slightly increased travel time,guaranteed ride home,and the vanpool vehicle has guaranteed parking in the Stokes building.The metro "Armadillo" provides free shuttle for excursions

56) I use my own vehicle everyday attending meetings,conferences,staffings,training in the course of my job.I need my vehicle available at all times

57) This survey doesn't address the needs of parents(especially single parents)who must criss-cross the city dropping off children at various schools and/or daycare.I would imagine that that is why so many parents choose not to share-a-ride.They have a genuine need to drive in order to get their families situated at the start of the day.

58) I think many people are interested in carpooling. However, Austin is so spread out. I can bank,eat and run errands in my own car during an hour.This may not be possible with the mid-day shuttle.Perhaps if carpooling is implemented on a wide scale basis, employees who choose that option should be given one day a week to drive in to take care of business,doctor's appts,etc.

59) I have to take a child to day care before coming to work and have only 30 min after work to pick up

60) I need to drive my personal vehicle for security resons.Otherwise I'd be happy to consider some for of ridesharing

61) No we do not want a mandatory light rail system -without a vote

REFERENCES

Aronoff, Stan. Geographic Information Systems: A Management Perspective. Ottowa, Canada: WDL Publications 1993.

Beaton, Patrick, H. Meghdir, and J. Carragher. "A Stated Choice Performance Evaluation of Selected Transportation Control Measures and their Transfer Across Sites." Transportation Research Board, 74th Annual Meeting, Washington, D.C. 22-28 Jan 1995

Ben- Akiva, Moshe, and Steven R. Lerman. Discrete Choice Analysis.: Cambridge, Massachusetts: The MIT Press, 1993.

Capital Metro. Vanpool Drivers Guide

Cervero, Robert. Suburban Gridlock. New Brunswick, New Jersey, 1986.

Clean Air Act Law and Explanation. Chicago: Commerce Clearing House, Inc., 1990

Committee on Small Business, House of Representatives, 103rd Congress, second session, Environmental Benefits and Impact on Moderate-Sized Businesses of Employee Commute Options Required by the Clean Air Act Amendments of 1990. US. Government Printing Office, Washington: 1994.

Davidson, Diane. "The Role of Site Amenities as Transportation Demand Management Measures." Transportation Research Board, 74th Annual Meeting, Washington, D.C. 22-28 Jan 1995.

Environmental Systems Research Institute, Inc. Introducing ArcView 1994

Gujarati, Damodar N. Basic Econometrics. Third Edition. New York: McGraw-Hill, Inc. 1995.

Ortuzar, J. de D. and L.G. Willumsen Modelling Transport. Second Edition. West Sussex, England: Wiley 1990.

Transportation Research Board. Guidelines for Using Vanpools and Carpools as a TSM Technique. National Cooperative Highway Research Program Report 241 (December 1981).

University Transportation Research Center Region II. Employee Commute Options Guidebook. New York: May 1994.

Vonderohe, A.P., L. Travis, R.L. Smith, and V. Tsai. Adaptation of Geographic Information Systems for Transportation. University of Wisconsin, Madison. NCHRP Report 359, 1993.