MODELING ATTRACTION-END CHOICE FOR URBAN RECREATIONAL TRIPS: IMPLICATIONS FOR TRANSPORTATION, AIR QUALITY AND LAND-USE PLANNING

by

Michael A. Pozsgay

Chandra R. Bhat

Research Report SWUTC/01/167800

Southwest Regional University Transportation Center

Center for Transportation Research

The University of Texas at Austin

Austin, Texas 78712

December 2000

DISCLAIMER

ABSTRACT

Attraction-end choice studies have primarily focused on non-urban recreational trips or non-recreational urban trips. Relatively little attention has been focused in the literature on urban recreational trips. In contrast, urban recreational trips are contributing increasingly to overall urban travel. In this paper, we examine attraction-end choice models for home-based urban recreational trips. A non-linear-in-parameters multinomial logit model is estimated using the 1996 Dallas-Fort Worth household activity survey. The effects of level-of-service, zonal attributes, trip attributes, and socio-demographic variables on recreational attraction-end choice are examined, and the implications of the results for land-use, transportation planning, and air quality analysis are discussed.

ACKNOWLEDGEMENTS

This research was funded by the U.S. Department of Transportation through the Southwest Region University Transportation Center. The second author would also like to acknowledge funding support from the Texas Department of Transportation and the National Science Foundation grants DMS 9208758 and DMS 9313013 to the National Institute of Statistical Sciences (NISS). We are grateful to the North Central Texas Council of Governments Staff for providing the data and assisting with data-related issues.

December 2000

EXECUTIVE SUMMARY

Recreational travel contributes a significant and growing number of passenger vehicle miles traveled on urban streets (1995 Nationwide Personal Transportation Survey; U.S. Department of Commerce; and Steed and Bhat, 1999). Previous travel modeling research has generally focused on work trips, and lumped non-work trips into a single category. Yet, recent research has underscored the need to differentiate between types of non-work trips and to identify the behavioral differences underlying travel decisions for each type. The focus of this research is on modeling the attraction-end choice of urban recreational trips based on travel impedance characteristics, attraction-end attributes, trip characteristics and individual and household characteristics. This focus was selected because very little attention has been given to this dimension of choice in the context of recreational trips. Furthermore, the model is developed at a disaggregate (individual and household) level, as opposed to an aggregate level that is commonly assumed by metropolitan planning organization (MPO) models.

There are several potential benefits of improving our ability to predict recreational attraction-end choice. First, a disaggregate attraction-end recreational choice model facilitates improved policy evaluation of transportation control measures (TCMs) and better forecasting of travel conditions. Second, the improved attraction-end choice model would better estimate vehicle trip lengths, therefore improving estimates of vehicle miles traveled (VMT). This results in superior air quality modeling, since VMT is a critical input to mobile-source emissions forecasting. Third, the improved model could facilitate land-use planning that is directed towards locating recreational facilities.

The model structure chosen is a non-linear in parameters multinomial logit. This disaggregate level model is preferred because the aggregate level gravity model has been shown to be inadequate in numerous studies (Bhat, 1998; Sikdar, 1981; and Todes, 1981).

The data sources for this research were obtained from the North Central Council of Governments (NCTCOG) in the Dallas-Fort Worth area. They are the 1996 Dallas-Fort Worth metropolitan area household activity survey, level-of-service information for Dallas-Fort Worth and land use information. The Dallas-Fort Worth area is divided into 919 Transportation Analysis Process (TAP) zones, 858 of which were represented in the recreational trip data set. The household activity survey, which includes household data, individual data, and trip characteristics, contains the recreational trips selected for modeling. Variables from the level-of-service and land use data sets were appended to these recreational trips. Each recreational trip record, therefore, contains information about the origin and destination zones, as well as the level-of-service for the transportation network between the zones. For each recreational trip, a choice set was developed by adding nine alternative destination zones to the data set, in addition to the chosen destination zone. A variable was added to indicating which zone was the chosen zone.

Several results were found from the empirical analysis. The level-of-service between the origin and destination zone is an important determinant of whether the site will be chosen. Zonal size, characterized by retail and non-retail space influences the choice of zone for recreational activity. Zones with a better mix of recreational facilities are preferred over those with a higher percentage of water area. Zones clustered around other zones with a large parkland area are preferred to those that are relatively isolated. Older individuals, individuals in households with children, and single-individual households are likely to choose recreational destinations closer to home. These results have implications for transportation planning, transportation air-quality analysis, land-use planning and demographic modeling.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

BACKGROUND

Traffic congestion resulting from participation in recreational activities such as sporting events, concerts, and festivals are a frequent occurrence in many metropolitan areas. According to the 1995 Nationwide Personal Transportation Survey (NPTS), recreational trips constitute about 12% of all urban trips on weekdays (recreational trips include trips related to exercising activities and entertainment activities). This percentage rises to about 23% on weekends, when more recreational trips are pursued. The NPTS data also indicates that the average recreational trip length is around 23.3 miles, which is much larger than the overall average urban trip length of 14.3 miles. In addition, recreational trips are primarily pursued using the private automobile (Steed and Bhat, 1999). As a result of these factors, urban recreational travel contributes a significant number of passenger vehicle miles of travel on urban streets today. This contribution is only likely to grow in the future as leisure time and disposable income increase in the United States (U.S. Dept. of Commerce), and as the socio-demographic characteristics of the population change over time (Misra and Bhat, 2000).

In contrast to the significant (and projected) contributions of recreational travel to overall urban travel, relatively little attention has been focused on recreational activity participation in travel modeling practice. Most metropolitan areas still continue to use a trip purpose classification that groups all non-work trips into a single category for modeling purposes; in fact, the emphasis in many metropolitan areas continues to be on work trips. However, many recent studies (Handy, 1992; Hunt, 1996; Bhat, 1998) have underscored the need to model non-work trips more systematically and to recognize the behavioral differences underlying travel decisions for different types of non-work trips. Specifically, these studies have emphasized the relatively flexible nature of non-work trips compared to work trips, and the greater temporal flexibility for recreational travel compared to other non-work trips. The implication of the greater flexibility of non-work trips in general, and recreational trips in particular, is that changes in demographics of the population or implementation of land use or transportation control measures may have a larger effect on non-work trips than the more schedule-rigid work trips. Thus, it is important to examine the determinants of non-work travel choices carefully and systematically.

OBJECTIVE OF THESIS AND MOTIVATION FOR RESEARCH FOCUS

The broad objective of this thesis is to contribute toward the growing literature on urban non-work trip modeling, with an emphasis on home-based urban recreational trips. This thesis concentrates on the attraction-end (or, more loosely, destination) choice dimension of recreational travel. The term attraction-end choice is more technically appropriate since the objective is to predict the attraction-end of the trip, which is not necessarily the destination of the trip (for example, the attraction-end of a trip from a shopping location to home is the shopping location, while the destination is home).

The focus of this research is on attraction-end choice of urban recreational trips because other dimensions of choice in the context of recreational trips such as number of trips, mode choice, and departure time have been examined elsewhere (Steed and Bhat, 1999; Bhat, 1998; Hunt, 1996; Kumar and Levinson, 1995). Another reason for our focus on attraction-end choice modeling is that disaggregate analysis procedures (that is, methods that examine travel choices at the level of the decision-making unit such as the individual or the household) have yet to influence the fundamental specification of trip attraction and distribution models employed in practice; in particular, most MPOs still use aggregate-level cross-classification and gravity models, which do not adequately account for the characteristics of households and trip makers, and the way in which those characteristics interact with the attributes of alternative destinations (in an exhaustive review of travel demand modeling practice in several metropolitan planning organizations in the country, Deakin, Harvey, Skabardonis, Inc., 1993, indicated that "the aggregate gravity model remains deeply ingrained in practice despite its apparent disadvantages").

There are several potential benefits from improving our ability to predict recreational attraction-end choice of individuals as a function of their socio-demographic attributes, and the interaction of these attributes with level-of-service and destination characteristics. First, a disaggregate attraction-end recreational choice model would facilitate improved policy evaluation of transportation control measures (TCMs) as well as better forecasting of travel conditions because it can accommodate the effect of multiple level-of-service measures, and allow variations in sensitivity to level-of-service measures and attraction-end characteristics across different socio-demographic sub-groups. Second, improved attraction-end choice modeling of recreational trips would contribute to more accurate estimates of vehicle trip lengths and, therefore, better estimates of vehicle miles of travel (VMT). This, in turn, would facilitate improved air quality modeling, since VMT is a critical input to mobile-source emissions forecasting. Third, improved recreational attraction-end modeling could facilitate land-use planning that is directed toward locating recreational facilities to reduce VMT or to improve accessibility to recreational facilities for mobility-challenged sub-groups of the population (see Williams, 1995, for an extensive discussion of this issue).

THESIS STRUCTURE

The remainder of this thesis is organized as follows. The second chapter reviews previous literature on non-work trip modeling, with an emphasis on studies that focus on recreational travel modeling. The third chapter highlights the inadequacies of the commonly used gravity model formulation for attraction-end choice modeling and discusses the modeling formulation used in this thesis. The fourth chapter describes the data source used in the empirical analysis of the thesis and discusses the sample formation process. The fifth chapter presents the variables considered in the empirical analysis and interprets the modeling estimation results. The final chapter highlights the important contributions of the research, and discusses the implications of the research for land-use, transportation, and air quality planning.

CHAPTER 2: LITERATURE REVIEW

The literature on attraction-end choice of recreational travel is rather limited in the context of urban travel modeling. However, there are many studies that provide helpful background for the current work. The first section of this chapter highlights research in the general area of non-work travel behavior. The second section discusses non-work travel studies focusing specifically on the attraction-end choice of trips.

STUDIES OF GENERAL NON-WORK TRAVEL BEHAVIOR

For several decades now, researchers have recognized the value of modeling non-work travel. However, it has been only in the past decade that research studies have begun to examine the factors affecting non-work travel behavior in a systematic manner. Some of these non-work travel related studies are reviewed in this section.

Handy (1993) shows that there is a relationship between local and regional accessibility measures and shopping travel patterns. She used data from the San Francisco Bay Area to better characterize alternative forms of development in relation to accessibility. A significant finding of her work is that areas with poor accessibility to shopping facilities have roughly the same shopping trip frequency as areas with better accessibility. Consequently, areas with higher levels of accessibility have been shown to have up to 40% less shopping travel than areas with poor accessibility. The implication is that policies intended to improve accessibility of shopping facilities can reduce total vehicle miles traveled.

Williams (1995) underscores the importance of urban recreation in the context of the overall functionality of a city. He notes that an adequate range of recreational facilities should be available to meet the needs of the public. Because many recreational facilities are not driven by economic profitability, they are provided by the public sector. Consequently, city engineers and planners have to meet the demands generated by travel to these recreational facilities.

Steed and Bhat (1999) developed a departure time model for home-based social/recreational and home-based shopping trips. Two different modeling structures are used for comparison purposes. The first is the multi-nomial logit model (MNL) and the other is the ordered generalized extreme values (OGEV) model. Although the OGEV is a less restrictive model than the MNL, the authors found the MNL to be adequate for departure time choice modeling of both social/recreational and shopping trips. Their results showed that socio-demographic characteristics play an important role in departure time choice

Bhat (1998) emphasizes the need to capture unobserved attributes in multi-dimensional choice modeling, using choice of travel mode and departure time of social and recreational trips as an example. He develops a mixed multinomial logit (MMNL) structure that allows shared unobserved attributes along one or the other choice dimension. This work assumes that decisions of mode and departure time are made after the destination has already been chosen.

Several studies have emphasized the need to recognize and model the linkage between work and non-work travel. For example, Purvis, Iglesias and Eisen (1996) demonstrate that work trip accessibility is an important factor in non-work trip generation models. Individuals give priority to work travel over non-work travel because of its importance to economic well-being. It follows that a reduction in work travel time may lead to an increase in non-work trip generation. Their results show that "a 10 percent decrease in average work trip duration would yield a 1.2 percent increase in home-based shop trips and a 0.9 percent increase in home-based social / recreational trips. Strathman *et al.* (1994), Bhat (1997), and Hamed and Mannering (1993), also examine the linkage between work and non-work travel, and present empirical evidence demonstrating the influence of work duration, work schedules, and work travel time on non-work stop-making during the work commute.

STUDIES OF NON-WORK ATTRACTION-END CHOICE BEHAVIOR

There has been very little attention directed toward urban non-work attraction-end choice in the literature. Most of the non-work attraction-end studies focus on regional or inter-city travel rather than urban travel. In this section, we review attraction-end studies of both regional and urban travel.

Increasing weekend congestion prompted the Ministry of Construction in Japan to conduct a nationwide recreation travel survey in 1992. Yai, Yamada and Okamoto (1995) explored this data and developed trip generation and distribution models for recreational trips at a regional level. The authors emphasize the increasing contribution of recreation weekend recreation trips to traffic congestion at the fringes of urban areas.

Train (1992) developed a recreational demand model for the choice of fishing sites. As in the case of Yai *et al,* Train also focuses on regional long-distance trips rather than urban trips. The author allows for variation of sensitivities across individuals by using a random-parameters logit model. Train identifies several characteristics that are significant for choice of fishing site, such as aesthetics, number of campgrounds per area and number of restricted species. This research has the advantage of the availability of very specific variables about the attraction sites such as: fish stock, rating of aesthetics, and trip cost.

Timmermans (1996) explored the modeling of destination and mode choice for urban shopping trips using stated preference surveys. He examined the interactions in destination and mode choice dimensions of individual's demographics, and concluded from his empirical analysis that mode choice for shopping trips is independent from destination choice. The variables used as predictors of shopping destination choice in Timmerman's study included attributes of the shopping center (such as size, price of commodities, and parking) and travel distance to the destination.

Miller and O'Kelly (1983) also investigate shopping destination choice. They demonstrate the importance of collecting multi-day data in travel diary surveys. Most destination choice models, such as the current work, are estimated from single-day surveys. Miller and O'Kelly point out that many households may not have a "typical day" and that information about travel behavior over a span of days may be necessary to fully understand an individual's destination choice. They find that using multi-day travel diary data instead of single-day travel diary data yields significant improvement in destination choice modeling.

Bhat, Pulugurta and Govindarajan (1998) developed disaggregate attraction-end choice models for home-based work and shopping trips. This work provides an excellent basis for this thesis because their data and model structures are similar. Their model takes the form of a non-linear-in-parameters multinomial logit, which is also the structure used in the current research. Bhat *et al.* found that the disaggregate attraction-end choice model performed significantly better than a disaggregate equivalent of the traditional gravity model. This was due to the importance of including multiple size measures, zonal attractiveness and location measures, the location pattern of zones, and socio-demographic interactions with travel impedance in the model.

To summarize, non-work travel modeling has received little attention in transportation research. Only in recent years has there been an increasing emphasis on non-work travel. However, the destination choice dimension of non-work travel has received less attention than other choice dimensions. Within the context of urban recreational destination choice, the primary focus has been on inter-city or regional trips, rather than urban trips. This thesis is a contribution to the relatively small, but quickly expanding, research area of urban recreational destination choice modeling.

CHAPTER 3: MODEL DEVELOPMENT

AGGREGATE ZONAL LEVEL MODEL VERSUS DISAGGREGATE INDIVIDUAL LEVEL MODEL

Trip distribution is the second step of the four-step urban transportation model system. In the first trip generation step, the number of productions from each zone and the number of attractions to each zone are estimated. Traditionally, MPOs have subsequently used the aggregate-level gravity model in the trip distribution step to determine the zone-to-zone pairings of trips. The gravity model takes the form shown below:

$$V_{ij} = \frac{O_i D_j f(C_{ij})}{\sum_{j'} D_{j'} f(C_{ij'})} \qquad (1)$$

In this equation, Vij is the estimated number of trips produced in zone i that are attracted by zone j. Oi is the estimated number of productions in zone i, and Dj is the estimated number of attractions to zone j. The function $f(Cij)$ reflects the effect of travel impedance on trip interchanges between zones i and j.

The gravity model is appealing because of its simple structure. However, this model structure does not recognize the spatial interaction of traffic zones and does not capture the interaction of the characteristics of travelers with the attributes of alternative destinations. Thus, it is not surprising that the gravity model has been found inadequate in numerous studies (see, for example, Bhat, 1998; Sikdar, 1981; and Todes, 1981). These inadequacies can be overcome by estimating the choice of attraction-end at the disaggregate level of the individual decision-maker rather than at an aggregate zonal level. The next section discusses the model formulation for the disaggregate-level attraction-end choice model used in the current research.

MODEL FORMULATION

This section discusses the spatial unit used to define attraction-end and presents the procedure used to generate the attraction-end alternatives in each individual's choice set.

Definition of Attraction-End Choice Alternatives

The disaggregate attraction-end choice model predicts the individual choice of travel to aggregated zones (or spatial clusters) and not to specific recreational sites within the zones (or elemental alternatives). This approach is used for two reasons. First, the use of elemental alternatives would create a substantial number of alternatives in the individual's choice set. This would pose infeasible data processing requirements, and make the modeling process and definition of alternatives difficult. Second, for transportation planning, the desired end-result is the prediction of trip-interchanges between zonal pairs, not between elemental attraction alternatives. From this standpoint, an attraction-end choice model with zonal alternatives is easy to apply for forecasting.

Generation of Alternatives in the Choice Set

The actual choice set of a traveler is infinite. A destination choice model cannot consider every possible choice and a feasible choice set must be created. The methodology chosen for creating the feasible choice set is important because the assumptions made in this process can affect the results and validity of the model (Thill, 1992). The most straightforward approach is to assume that an individual is choosing from all possible destinations in the study area. (See, for instance Fotheringham, 1988; Thill and Horowitz, 1991 and Bhat, Pulugurta and Govindarajan, 1996). Burnett (1974) points out that it is unlikely that every individual has the same choice set. Clearly a person on the southern edge of the study area would have a different choice set than the person on the northern edge. The individual on the southern edge may actually travel to a zone that is not in the study area. Unfortunately, it is extremely difficult or impossible to consider each individual's choice set. In this work, the choice set is assumed to be all the zones in the study area.

Within the study area, the number of possible attraction-end alternatives for a trip remains very large, even after defining alternatives at the zonal level. To resolve this situation, a subset of alternatives is drawn from the universal choice set for each trip. Restricting the number of alternatives in this manner is acceptable as long as an identically and independently distributed (IID) structure is assumed for the random error terms across attraction-end alternatives (McFadden, 1978). This is the error structure we adopt in our model, as discussed in the next section.

There are several approaches to drawing the subset of alternatives from the universal choice set (see Ben-Akiva, *et al.*, 1984). The simplest approach is to select a subset of non-chosen alternatives randomly from the universal choice set, and then add the chosen alternative to this subset. This approach is used in this thesis to generate a choice set with ten alternatives for each trip, nine of which are randomly picked non-chosen alternatives and the tenth is the actual chosen alternative.

MODEL STRUCTURE

The alternatives in the attraction-end model are aggregated zones. Each zone j may contain several possible elemental attraction alternatives. Let the number of elemental attractions in j be Dj. Assume the following: a) Dj is large for each zone, b) utilities of the elemental alternatives within each zone are IID, and c) the quality of elemental attraction alternatives are relatively homogenous within each aggregate zone or the within-zone variance of the systematic utilities of the elemental alternatives are about equal across zones. With these assumptions, the utility *Uqij* accruing to an individual *q* in zone *i* from choosing attraction-end zone *j* may be written as (Daly, 1982):

$$U_{qij} = V_{qij} + \varepsilon_{qij} = \beta' x_{qij} + \gamma \log(D_j) + \varepsilon_{qij} \qquad (2)$$

where *xqij* is a vector of exogenous variables influencing the choice of zone *j* for an individual *q* in zone *i*, *Dj* is the number of elemental attractions in attraction-end zone *j*, and *εqij* is a random term distributed IID gumbel across zonal alternatives and individuals. *β* is a vector and *γ* is a scalar, both of which are to be estimated. The logarithm of *Dj*, the number of elemental attractions, reflects the diminishing effect of an additional elemental attraction as the number of attractions becomes large. The number of elemental attractions within a zone is not easily quantifiable. However, we can proxy *Dj* by a set of observable size variables of zone *j*, such as total area of the zone or areas in different types of land-uses. Let *dj* represent a vector of proxy size variables for zone *j* and let *δ* be a corresponding vector reflecting the contribution of the proxy size variables to the actual zone size *Dj*. Then, we re-write equation (2) as:

$$U_{qij} = V_{qij} + \varepsilon_{qij} = \beta' x_{qij} + \gamma \log(\delta' d_j) + \varepsilon_{qij} \qquad (3)$$

The magnitude of the "logsum" parameter *γ* represents the presence of common unobserved zonal attributes affecting the attractiveness of elemental alternatives in a zone. If there are no common unobserved factors influencing the attractiveness of elemental alternatives within a zone, the parameter equals one. On the other hand, if all unobserved factors affecting the attractiveness of elemental alternatives are unobserved zonal attributes, the parameter equals zero. In practice, we would expect the value of *γ* to fall between 0 and 1.

The probability that individual q will choose attraction-end j from the choice set Cq may be computed from equation (3) and the assumed IID distribution of the random components:

$$P_{qij} = \frac{e^{V_{qij}}}{\sum_{j' \in C_q} e^{V_{qij'}}} \qquad (4)$$

The model specified above is similar to the familiar multinomial logit model. However, it differs due to the presence of the component $\gamma \log(\delta' d_j)$ in equation (3), which implies a non-linear (in parameters) utility function. The model is estimated using a maximum likelihood procedure written in the GUASS matrix programming language.

CHAPTER 4: DATA SOURCE AND ASSEMBLY

DATA SOURCES

Three data sources are used in this research, all of which were obtained from the North Central Council of Governments (NCTCOG) in the Dallas-Fort Worth area. The first data source is the 1996 Dallas-Fort Worth metropolitan area household activity survey. The second data source provides level-of-service information for the Dallas-Fort Worth area. The final data source contains land use information. This section discusses these sources in detail.

The 1996 Dallas-Fort Worth Household Survey collected information about travel and non-travel activities undertaken during a weekday by members of 4839 households. Households were selected based on a random selection of all listed and unlisted telephone numbers. Each household was given a survey form with sections to be completed concerning the household in general and individual members. Each individual in the household was also handed an activity diary to be completed on a predetermined weekday. Tables 1 and 2 show the data collected in the household and activity surveys. (NCTCOG, 1999).

The second data source is a level-of-service (LOS) file that provides information on travel between each pair of the 919 Transportation Analysis Process (TAP) zones in the Dallas-Fort Worth area. The file contains information for both highway and transit modes during the peak and off-peak. For the highway mode, level-of-service information corresponding to the high occupancy vehicle (HOV) lane is also available. Level-of-service data for the highway mode between each zonal pair include in-vehicle travel time, out-of-vehicle time, toll costs and distance. The level-of-service available for transit modes includes travel fare, in-vehicle travel time, and measures associated with access characteristics to the transit stop. Table 3 summarizes the level-of-service information.

The third data source is a zonal-level land use characteristics file containing land use data at the level of the traffic survey zone (TSZ) within the Dallas-Fort Worth metropolitan planning area. Only 858 of the 919 TAP zones in the Dallas-Fort Worth area were represented in this land-use file. Further, none of the recreational trips were attracted to the 61 TAP zones with missing land-use data. Therefore, the study only included the 858 TAP zones for which land-use information was available. Table 4 shows the categories of land use available for consideration.

Table 1: Data Collected in the 1996 Dallas-Fort Worth Household Survey

Household Data	Total Annual Household Income (1995) Number of people living in the household Type of dwelling unit Type of ownership Total number of separate telephone numbers Number of telephone numbers used for fax or modem Vehicles available to the household Year that household moved into current residence Location of previous home, and duration of residence
Individual Data	Total annual personal income Relationship to others in household Age, sex, race Spanish / Hispanic origin (yes / no) Driver's license (yes / no) Physical limitations Highest level of schooling completed Student information • Name / location of school • Means of transportation to school in past seven days, personal cost to park) Worker / job information • Name and business of usual work address • Business or industry type • Occupation • Flexibility in work hours • Month and year started at usual work address • Total hours worked last week • Total hours worked on Saturday or Sunday last week • Means of transportation to workplace last week • Days worked at home last week (instead of usual workplace) • Personal cost to park • Employer subsidies for parking costs or bus fares • Is a personal vehicle needed at work for business purposes?

Table 2: Data Collected in the 1996 Dallas-Fort Worth Activity Diary

Time of Day	Start and end time for each event.
Location (for non-traveling activities)	Activity code Address of the place
For Traveling Activities	If car, van, truck or motorcycle: Were you driver or passenger Was a household vehicle used, and if so, which one? Total persons in vehicle Total persons in vehicle who are members of the household Personal payment for parking Walk time (if any) from the vehicle to the next activity If bus, school bus, trolley or taxi: • Total friends / relatives in vehicle • Total persons in vehicle who are members of the household • Personal payment for fare • Bus route number If other means of travel: • Identify (walk, bike, wheelchair or other) • How far traveled (feet, blocks, or miles)

Table 3: Transit and Highway LOS Data Available for Zonal Pairs

Highway	The following data are available for peak, off-peak and HOV lane: In-vehicle travel time Out-of-vehicle travel time Toll costs Distance
Transit	Method of access (Walk, drive or both) Fare In-vehicle travel time For accessing the station by walking: Walk access in vehicle miles Access and egress distance Access and egress time First wait time Number of transfers Transfer time

Table 4: Land Use Acreage Data Categories Available from NCTCOG

Commercial (sum of office, retail and hotel / motel)	Landfills, flood control and parks
Flood control structures	Group quarters (nursing homes, jails, etc.)
Hotel / motel	Industrial
Infrastructure	Institutions (churches, government, museums)
Landfills	Multi-family housing (3 or more)
Mobile / manufactured homes	Office
Other residential	Park space
Vacant	Parking structures (CBD only)
Retail	Roadways
Single family and duplex housing	Railroads
Land under construction	Utilities
Water area	

DATA ASSEMBLY

The objective of data assembly was to extract the home-based recreational trips from the activity survey and structure the data in a form suitable for multi-nomial logit estimation. The flowchart in figure 1 outlines the procedure.

The first step consolidated the raw data files to create one large activity file, comprising 119,863 records. Each record corresponds to an activity (travel or non-travel) undertaken by an individual. The travel records did not originally contain the origin and destination zone for that trip. Therefore, it was necessary to extract this information from the preceding and succeeding non-travel records. In a similar manner, the activity codes, and start and stop times of the adjacent non-travel activity records, were copied to the trip record. All non-travel entries were next deleted from the dataset, leaving a trip file with 28,830 records.

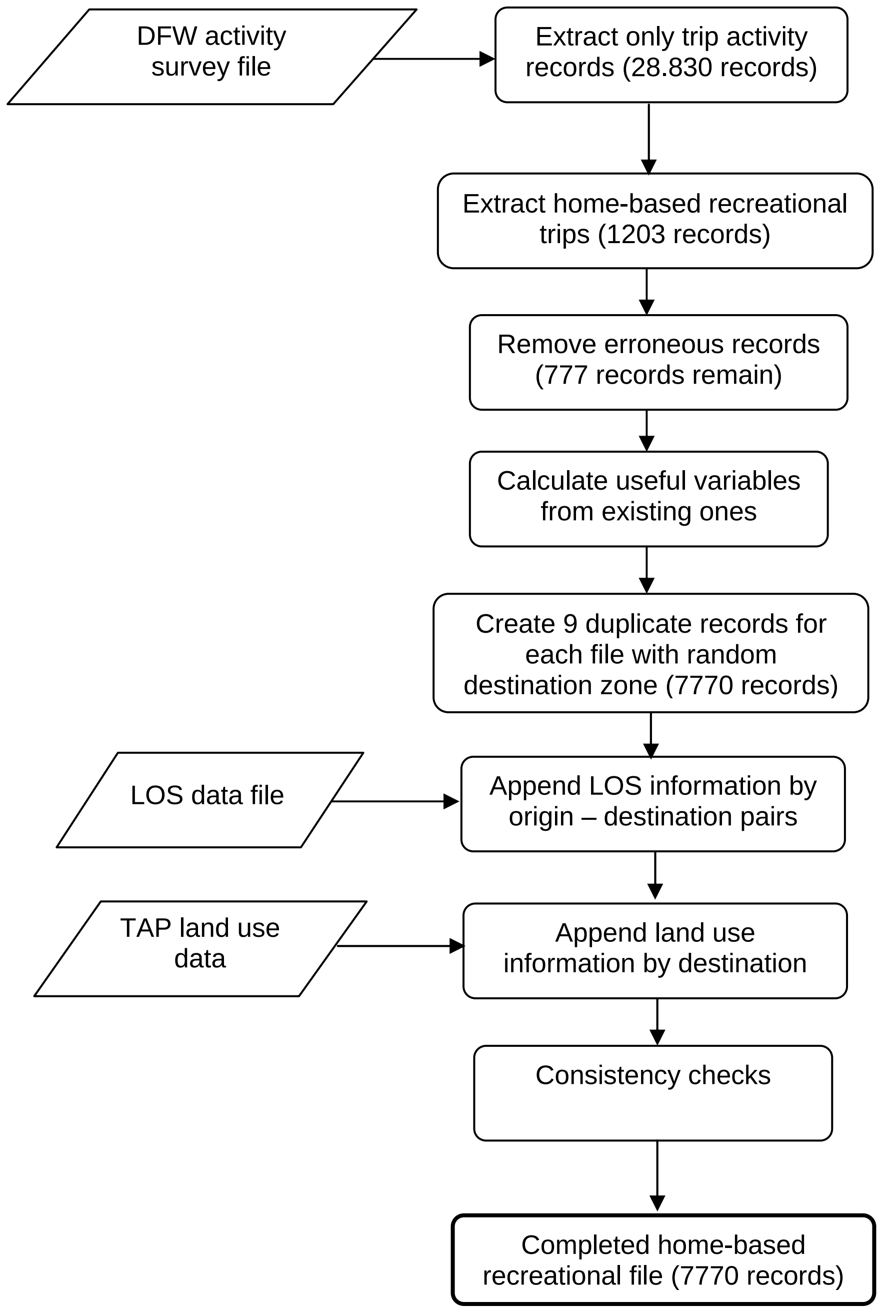

Figure 1: Flowchart of Steps Used in Data Assembly

The second step created a home-based recreational trip file. The original dataset included thirty-six codes for activity type. Three of these codes describe various types of recreational activities: health club, exercise / recreation, and entertainment. Records with these codes for the origin or destination purpose were flagged as recreation activities. Five activity codes in the survey represented home activities. A record containing any of these codes as their origin or destination purpose was flagged as a home-based trip. Finally, records that were flagged as both recreational and home-based were copied into a home-based recreation file. The home-based recreation file included 1203 records.

The third step removed inconsistent records; including those with incomplete information on age, household income, race, travel mode, number of passengers, departure time, origin zone and destination zone. This screening reduced the size of the home-based recreation file to 777 records. The reduction in the number of records from 1203 to 777 is primarily due to missing origin and destination TAP zone identifiers.

The fourth step converted variables in the activity survey to more useful representations for analysis. Specifically, dummy variables were created for variables that were recorded as categories in the original data. For instance, the race variable was available as a single variable, where "1" was defined as Caucasian, "2" as African-American, "3" as Asian, and so on. To model this information, a dummy variable was created for each race, taking the value "1" for individuals belonging to a particular race and "0" otherwise. This step also included extracting the age of each individual from the birth date and obtaining the number of children in the household in each of several age categories. Table 5 summarizes the variables created during this step.

The fifth step randomly selected nine alternative attraction TAP zones for each trip (not including the actual selected attraction zone) and then added the actual chosen attraction zone (for a total of ten attraction-end alternatives). It was ensured that the randomly selected zones were unique and that there was no replication of the same zone. Next, each recreational trip production was replicated ten times and each attraction-end alternative generated earlier was appended to one of the ten replicated records. A variable indicating the actual chosen attraction-end zone of the ten alternatives was created.

The sixth step appended the appropriate zone-to-zone level-of-service (LOS) values from the zonal LOS file to each of the ten records of each trip in the replicated file based on the production-end TAP zone and attraction-end TAP zone. The LOS variables in the zonal LOS file include distance, cost, in-vehicle travel time (IVTT) and out-of-vehicle travel time (OVTT); the values for these variables differ by time-of-day and travel mode. The LOS values appended to each record correspond to the time-of-day of the trip and the mode (drive alone or shared-ride) used for the trip.

The seventh step aggregated the TSZ-level land-use and demographic characteristics to the TAP-level, and appended this information to each trip record based on the TAP identifier of the attraction-end zone. Not all land- use variables from the original data source were appended. Variables were selected based on the hypotheses that were to be tested. Table 6 shows the types of land uses included in each file.

Table 5: Variables Converted to Format Useful for Modeling

Original Variable(s)	New Variable(s)
Birth date of each household member	Decimal age of each household member (including the trip maker)
Age of each individual in the household	Number of children in the household from each of the following age categories: less than 5, 5 to 11, 11 to 16 and 16 to 21 The number of adults in the household
Race variable of trip maker	Dummy variables for each of the following race groups: Caucasian, African-American, Hispanic and other
Household income	Dummy variables representing if the household is in each of the following income categories: less than $30,000 annually, $30,000 to $75,000 annually, and more than $75,000 annually
Category of education level completed by trip maker	Dummy variables for whether the trip maker has completed high school and college
Employment status of each individual in the household	Number of workers between 16 and 21 years of age and older than 21 Dummy variables for occupation of trip maker (student, employed, self-employed, volunteer, homemaker, retired)
Start time (in minutes) of the trip	Departure time variable with the following categories: early a.m. (midnight to 6:29 a.m.), a.m. peak (6:30 a.m. to 8:59 a.m.), a.m. off-peak (9:00 a.m. to 11:59 a.m.), p.m. off-peak (12:00 p.m. to 3:59 p.m.), p.m. peak (4:00 p.m. to 6:29 p.m.), and evening (6:30 p.m. to 11:59 p.m.)

Table 6: Land Use Acreages Included in the Recreational Trip File

Total Acres
Commercial
Flood control + parks
Group quarters
Hotel / Motel
Institutions
Multi-family residential
Mobile Homes
Park space
Retail
Single family residential
Water

The final step included several screening and consistency checks on the resulting data set from the previous steps. This checks that variables in each data set had the proper relation to one another. For instance, the number of children in each age category should add up to the total number of children.

The final home-based recreation sample for analysis includes 777 trip cases (777x10=7770 records). All of these trips are pursued using some form of motorized personal transportation (car, van, truck or motorcycle). No home-based recreation trips were pursued using transit. About 46.2% of recreation trips were pursued using the drive alone mode. Almost half of the trips began in the evening. This suggests that individuals tend to pursue routine activities during the day and recreational endeavors toward the end of the day.

CHAPTER 5: EMPIRICAL RESULTS

VARIABLE SPECIFICATION

Several types of variables were considered for the recreational and social attraction-end choice models. These include a) travel impedance characteristics, b) attraction-end zone attributes, c) an attraction-end zonal spatial structure measure, d) trip characteristics, and e) interactions of individual and household characteristics with the preceding four sets of variables. Each of these sets of variables is discussed next.

The travel impedance characteristics considered in our analysis included the cost, in-vehicle travel time (IVTT) and out-of-vehicle travel time (OVTT). The cost variable is a summation of per-mile travel costs, parking costs and toll costs of a trip. Due to substantial multi-collinearity among the impedance measures, we converted cost and OVTT into equivalent IVTT units using money values of time obtained from travel mode choice estimation. Thus, travel impedance is incorporated as a single comprehensive measure in effective IVTT units. We considered two functional forms for the effect of the composite impedance variable on utility; the linear form and the log-linear form (these are the two most widely used forms in the literature; see Fotheringham, 1983). The linear form implies that the marginal deterrence due to travel impedance is independent of the existing impedance level, while the log-linear form implies that the marginal deterrence decreases as the existing travel impedance level increases (that is, a constant increase in the composite impedance has a higher deterrence when the initial impedance level is low than when the initial impedance level is high). Between the linear and log-linear functional forms, we found the log-linear form to perform substantially better in the empirical analysis and, therefore, retained this functional form for the composite impedance variable.

The attraction-end zone attributes included size variables and non-size variables. Several size variables, representing acreages in different kinds of land uses (such as park space, retail space, water area, *etc.*), were considered in the analysis. As indicated in section 3, these land use acreages may be considered as substitute measures for the amount of recreational opportunity within a zone. Non-size variables associated with the zones were also considered in the analysis.

The zonal spatial measure was created to capture the impact of the location pattern of recreational attraction-end zones. Consider the following simple example drawn from Fotheringham. Let an individual in zone *i* have a choice of 5 alternative attraction-end zones for her/his recreational trip. The five alternatives are equivalent in all respects, including in size and impedance from zone *i*. Now, consider two alternative spatial arrangements of the zones as shown in figure 2.

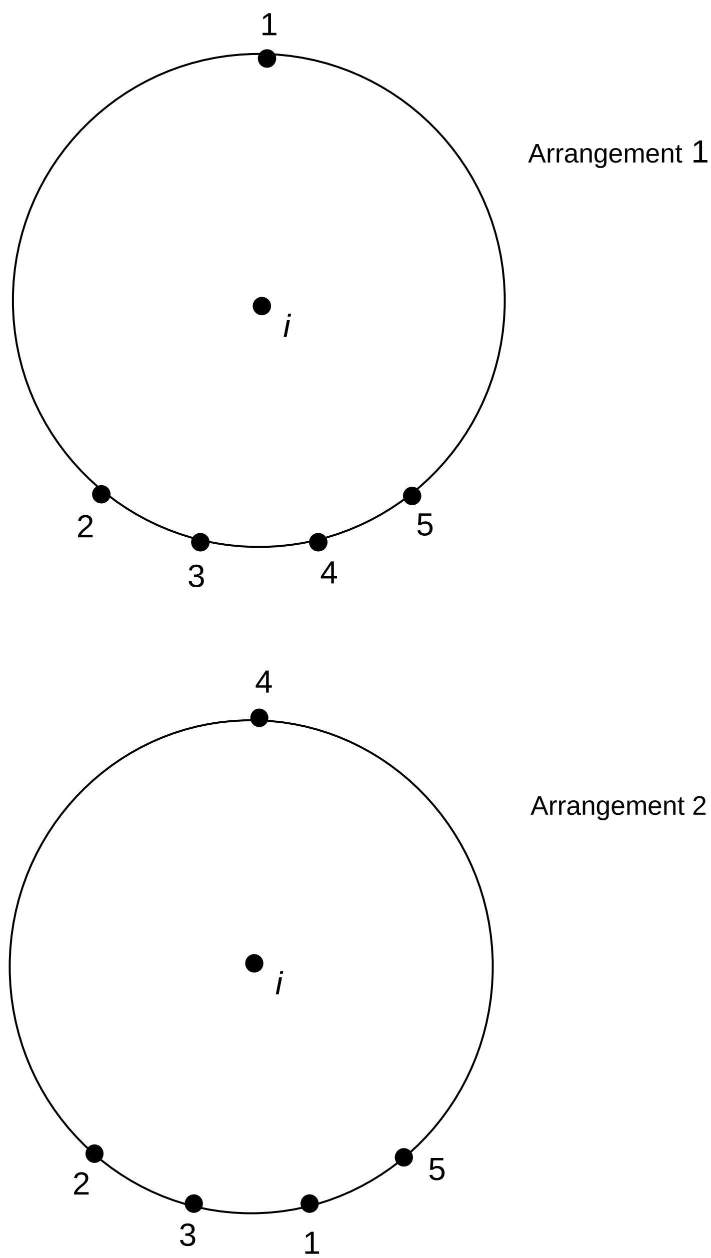

Figure 2: Example of Spatial Arrangement of Zones (Fotheringham, 1983)

It is possible that the individual's choice of zone 1 in the two spatial arrangements is different. One possibility is that zone 1 is more attractive in the first configuration than the second because of competition effects; that is, zone 1 may occupy a unique location in the spatial cognitive perception of the individual in zone *i* because it is isolated, while there is more competition among other potential attraction zones (zones 2 through 5). In addition, zone 1 may be preferred in arrangement 1 because of higher traffic congestion in and around a group of zones with several complementary recreational opportunities in close proximity. On the other hand, zone 1 may be more attractive in the second configuration than the first because of what Fotheringham labels as an agglomeration effect; that is, individuals in zone *i* may perceive a greater variety of recreational opportunities in zone 1 in the second configuration because of the clustered nature of recreational opportunities. We develop a zonal spatial measure to capture these spatial location pattern effects. Because several land use types are important in recreation attraction-end choice, we created spatial measures specific to three land use types: water, parkland and retail. These measures are created using the following formulation adopted by Bhat, *et al.* (1998):

$$M_j = \left[\frac{1}{L} \sum_{l=1}^{L} \left(\frac{\log R_l}{\log H_{lj}} \right) \right] \tag{5}$$

In the above equation, M_j is the spatial measure for attraction-end zone j, R_l is the acreage in a particular type of land use within zone l, H_{lj} is the travel impedance between zones l and j , and L is the total number of TAP zones in the Dallas-Fort Worth region. The spatial measure for an attraction-end zone is higher if there are a large number of recreational opportunities in the immediate vicinity of that zone, and is lower if the zone is spatially isolated from other recreational opportunities. Hence, a positive coefficient on the spatial structure measure in estimation would suggest that travelers prefer clustering of recreational opportunities (that is, agglomeration effects dominate and zone 1 is more attractive in the first spatial configuration than in the second in Figure 5.1); conversely, a negative coefficient would suggest that travelers prefer zones that are spatially isolated (that is, competition effects dominate and zone 1 is more attractive in the second arrangement than in the first in Figure 5.1).

The trip related attributes describe the excursion. Several trip-related variables (including number of individuals participating in the recreational or social pursuit, travel mode choice, and departure time of trip) were considered in the analysis.

The final set of variables comprises interaction effects of individual and household socio-demographics with other sets of variables. The motivation for considering such interaction effects is that the sensitivity to travel impedance, or to zonal size and non-size measures, or to the zonal spatial measure may vary across socio-demographic sub-groups. For example, older individuals may be more sensitive to travel impedance than younger individuals because of greater mobility challenges. Similarly, households with children may be more sensitive to travel impedance since they might want to invest in less travel time and more recreational time at the destination. Also, the sensitivity to travel impedance may vary based on the income of the household.

EMPIRICAL RESULTS

The final specification results of the home-based recreational attraction-end choice model are presented in table 7. The log-likelihood value at convergence is –876.70, the log-likelihood value with no variables in the model is –1789.00, and the log-likelihood value with only the impedance variable and the size variable is –935.61 (the size variable in this last model is represented as retail acreage+0.0458*other acreage; the coefficient of 0.0458 is borrowed from the convergent value in our attraction-end choice model). The latter log-likelihood value corresponds to a model that is the disaggregate equivalent of the traditional production-constrained gravity model with a parametric power function for the effect of travel impedance (see Deakin, Harvey, Skabardonis, Inc., 1993). The log-likelihood ratio test value for comparing the attraction-end choice model with the disaggregate form of the gravity model is 118. This value far exceeds the corresponding chi-squared value with 8 degrees of freedom at any reasonable level of significance. Thus, the test rejects the traditional gravity model in favor of an attraction-end choice model.

As can be observed from table 7, the variables in the final specification include the composite impedance variable, three zonal attributes (retail acreage, other acreage and percentage of water area), the zonal spatial structure measure specific to park area, and socio-demographic and other interaction variables. None of the trip-related attributes (number of individuals participating in the recreational pursuit, travel mode choice, departure time of trip, *etc.*) were statistically significant.

The parameter signs on the variables are in the expected direction. A larger impedance between the production zone and a candidate attraction-end zone makes it less likely that the candidate attraction-end zone will be chosen for the recreational trip.

Table 7: Home-Based Recreational Attraction-End Choice Model

Variable	Parameter	t-stat.
Log of composite impedance[1]	-1.965	-5.56
Zonal attributes		
Log of Composite zonal size measure	0.496	8.79
Retail acreage[2]	1.000	--
Non-retail acreage	0.045	2.13
Percentage of water area	-3.598	-3.19
Zonal spatial measure specific to Parkland	1.191	5.05
Socio-demographic and other interactions		
with log of composite impedance		
Age	-1.753	-3.21
Presence of children between 5-21 years in household	-0.689	-3.41
Participating alone in recreation	-0.391	-2.29
Number of cars in household	2.988	3.33
Low income household (< $30,000 per year)	0.399	1.71
with spatial measure specific to Parkland		
Worker	-0.727	-2.24
Number of observations	7770	
Log-likelihood at zero	-1789.0	
Log-likelihood at convergence	-876.7	

1 The unit of the composite impedance variable is equivalent highway in-vehicle travel time (in minutes).
2 The coefficient on this variable is constrained to one for identification purposes.

Among the zonal attributes, the coefficient on the composite size variable is significantly smaller than one, indicating that there are unobserved zonal attributes affecting the utility of elemental recreational destinations within the zone (see Daly, 1982). Between the retail acreage and non-retail acreage size variables characterizing the composite size measure, the parameter on the former is larger than that on the latter (the coefficient on retail acreage is constrained to one for identification). However, the average non-retail acreage is about 64 times the average retail acreage. After controlling for the magnitude difference, the results imply that 1 square mile of non-retail acreage (including park space and water area) is equivalent to about 3 square miles of retail acreage in terms of zonal size representation. Effectively, then, retail area contributes less to the attractiveness of a zone compared to non-retail area. The only non-size zonal variable found to influence zonal attractiveness is the water area in the zone as a percentage of total zonal area. The result implies that while water area increases attractiveness of a zone through the size measure (since water area is included within non-retail area), zones with a higher percentage of water area are less preferred to those with a better mix of recreational facilities.

The spatial structure measure specific to parkland is highly significant in its effect on attraction-end choice. The positive parameter on this measure reflects the presence of agglomeration forces; that is, zones in close proximity to other park-related recreational opportunities have a higher utility than zones in spatial isolation. This may be a reflection of the preference for large parks extending across several spatially contiguous zones, which manifests itself in the form of an agglomeration effect.

The empirical results indicate significant socio-demographic and other interactions, especially with the composite impedance variable. The sensitivity to impedance is higher for older individuals, for individuals with children in their households, and for individuals participating alone in recreational activities. These results are quite intuitive. Older individuals might prefer less travel because of physical challenges and constraints; individuals with children may prefer closer recreational destinations because of the children's impatience with longer car trips or the need to return home to care for other children; individuals traveling alone may have a higher sensitivity to level-of-service because travel time is likely to be more onerous compared to traveling with others. On the other hand, sensitivity to impedance is lower for individuals with many cars in the household and for lower income households (less than an annual income of \$30,000). The former effect might reflect a lack of car allocation-related constraints among individuals of a household, so that recreational pursuits of individual in households with several cars are not time-constrained. The explanation for the latter effect may be two-fold. First, individuals in low-income households may be willing to travel farther to explore inexpensive locations for recreational pursuits. Second, low-income households may be located in areas that are not near recreational facilities. The final socio-demographic variable represents the differential sensitivity of workers and non-workers to the spatial measure for parkland. Specifically, the positive sign on the interaction of employment status and the parks and spatial measure suggests that the agglomeration effect characterizing recreational attraction-end choice is tempered for workers compared to non-workers (note that the agglomeration effect still persists for workers, since the overall spatial effect for workers is the sum of the spatial measure for parkland and the interaction term). The smaller agglomeration effect for workers may reflect a time trade-off; workers may visit near-by, small, parks rather than large parks spanning multiple zones that may be farther away from their home.

A note regarding the specification of the socio-demographic variables is in order here. In addition to the linear interaction effect of age with level-of-service presented in table 5.1, we also explored non-linear spline effects of age; however, these non-linear effects did not improve data fit and were also difficult to interpret. An approach that assigned people to discrete categories based on age was also tested, but the linear interaction specification of age was superior in terms of data fit. For income, however, the best result was obtained by using a discrete categorization.

CHAPTER 6: CONCLUSIONS

This paper presents an attraction-end choice model for urban recreational trips. The focus on recreational trips is motivated by the growing number of such trips in urban areas, and also because such trips tend to be longer than trips for other purposes.

The model structure used in the analysis takes the form of a non-linear-in-parameters multinomial logit model to accommodate multiple size measures characterizing the number of elemental alternatives within each attraction-end zone. A random-sampling scheme that selects ten attraction-end zonal alternatives is implemented to address the large number of alternatives in any individual's attraction-end choice set for recreational trips. The model is estimated using data on home-based recreational trips from the 1996 Dallas-Fort Worth activity survey conducted by the North Central Texas Council of Governments (NCTCOG). Important results from our empirical analysis are as follows:

- The level-of-service from the home of the individual to a potential recreational site is an important determinant of whether or not the site will be chosen; individuals prefer locations which are easier to reach and less expensive to travel to.
- Zonal size, characterized by retail space and non-retail space (including park space, water area, and other area), influences the choice of zone for recreational activity; larger zones with more opportunities for recreation are preferred to smaller zones. One unit of non-retail area is about equivalent to three times a unit of retail area in the context of size representation for urban recreational trips.

- Zones with a higher percentage of water area are less preferred to those with a better land-mix of recreational facilities.
- Agglomeration effects dominate in recreational attraction-end choice; specifically, zones that are clustered around other zones with large parkland area are preferred over zones that are relatively isolated.
- Socio-demographics have a very important role to play in recreational attraction-end choice. In particular, older individuals, individuals in households with children, and single-individual households (who comprise a large fraction of individuals participating alone in recreational activities) are likely to choose recreational locations that are closer to home. On the other hand, individuals with several cars in their households and low-income individuals tend to travel farther away from home.

The foregoing results have implications for transportation planning, transportation air quality analysis, land-use planning, and demographic modeling, as we discuss next.

TRANSPORTATION PLANNING

The empirical analysis indicates significant differences in the decision process underlying recreational location choice based on the socio-demographics of the traveler and her/his household. Recognizing these socio-demographic effects is very important today because of the rapidly changing socio-demographic profile of the United States. For example, the age of the population is increasing, especially in the South and the Midwest United States (Texas State Data Center, 2000; U.S. Bureau of Census, 1996). Also, single-individual families are on the rise (a recent survey by the University of Chicago indicates that the percentage of traditional nuclear families decreased from 45% in 1972 to 26% in 1998; see Austin-American Statesman, 1999). The effect of these changes will be to reduce the length and duration of recreational trips, according to our empirical results. From this perspective, socio-demographic changes in the population might alleviate traffic congestion in the context of recreational travel. However, the shorter trips may also imply a displacement of trips from urban freeways to surface streets (such as arterial and collector roads). To the extent that the capacity of surface streets is much lower than freeways, the displacement might add traffic congestion within urban areas. Appropriate transportation planning to recognize the increased demands on urban non-freeway facilities due to recreational travel would, therefore, be important.

The empirical results also indicate the positive influence of number of cars in a household on the duration and length of recreational trips. Earlier studies have indicated that a higher number of cars in a household leads to increased trip-making, more drive alone travel, and the de-coupling of activities from activity chains, all of which contribute to increased traffic congestion in urban areas (see, for example, Agyemang-Duah and Hall, 1997, and Misra and Bhat, 2000). Our study suggests that car ownership also has an impact on the length of trips for recreational purposes. Thus, land-use and transportation policies (such as better land-use mixing, improved transit service, higher car purchase and gas taxes, *etc.*) which reduce car dependency and increase car costs, and eventually reduce car ownership, constitute one of the most fundamental ways to reduce vehicle miles of travel in urban areas.

The model of recreation choice behavior in this paper can also be used to assess the potential impact of transportation control measures (TCMs). For example, the model can be used to evaluate the impact of a congestion pricing strategy on the spatial re-distribution of trips. To be sure, the aggregate gravity model can also be used for this purpose as long as the impedance term in the gravity model includes time and cost components. However, the gravity model does not adequately capture the effect of socio-demographics on sensitivity to level-of-service. Thus, it assumes away the existence of demographic variations across different spatial units within a metropolitan region. This can lead to incorrect origin-destination interchanges and, consequently, inaccurate policy analysis. In addition, an advantage of the attraction-end choice formulation of this paper is that it is able to assess the impact of TCMs by socio-demographic group (for example, low income earners and the elderly). This is critical in the context of environmental justice considerations in transport policy analysis.

To summarize, a disaggregate recreational choice model integrated within the travel demand modeling framework of Metropolitan Planning Organizations can improve forecasting as well as policy analysis.

TRANSPORTATION AIR QUALITY ANALYSIS

The integration of transportation planning and air quality planning is important for mobile source emissions estimation and for establishing conformity of mobile source emissions to the emissions budgets in State Implementation Plans. The Environmental Protection Agency (EPA) requires the use of the MOBILE emissions factor model for such emissions estimation and conformity analysis for all areas except California, which uses the EMFAC7F model.

The emissions factor models (MOBILE or EMFAC7F) require several traffic-related inputs, some of which are obtained from travel demand models (for example, speed and vehicle miles of travel (VMT) on links in the network). To the extent that the current paper has formulated a recreational attraction-end choice model that can contribute to improved link speeds and VMT, improved mobile-source emissions forecasting can also be expected. In addition, the emissions models also require certain supplementary inputs, one of which is the vehicle trip duration distribution in the planning region. The emissions factor model uses this information to estimate running loss emissions. Running loss emissions are evaporative emissions that have escaped from a vehicle while the engine is operating (from spots where the vehicle's evaporative/purge system has become inoperative). Due to greater heating of the engine fuel and evaporative system on longer trips, running loss emissions continually increase as a function of trip duration until the emissions reach a plateau at a trip duration of about 50 to 60 minutes. The model in this paper can be used to forecast recreational site choices due to socio-demographic, land-use, and network level-of-service changes, which may then be translated to an effective trip time distribution for recreational travel using the level-of-service information.

It is clear from above that accommodating socio-demographic interactions with level-of-service and land-use patterns in recreational destination choice is important not only for transportation planning, but also for transportation-air quality modeling.

LAND-USE PLANNING

In the section on transportation planning above, we discussed the travel impacts of the rapidly changing socio-demographic characteristics of the U.S. population. However, one can also view the empirical results from the perspective of the mobility needs of socio-demographic groups; this will facilitate land-use planning that is consistent with the changing recreational needs of the population. For instance, older individuals are very sensitive to travel level-of-service. Thus, targeted investments to provide more opportunities for recreational pursuits, especially in retirement communities, should be a goal of land-use planning in the next decade.

The focus should be on pedestrian- and transit-friendly recreational developments that are inexpensive to travel to.

Similarly, the positive coefficient on the low-income interaction variable with level-of-service may suggest the absence of adequate recreational facilities in and around low-income neighborhoods. Targeting such neighborhoods for the construction of recreational facilities, or for information campaigns on currently available facilities in the neighborhood, would be useful for two reasons. First, low-income individuals may travel less for recreational pursuits, thereby reducing vehicle miles of travel. Second, building relatively inexpensive and mixed recreation/child care facilities might encourage more recreational activity participation, which may have far-reaching health and other societal benefits.

Another empirical finding from our analysis is that workers have less of a preference for large parks compared to near-by parks, even if these close-to-home parks are small. These results suggest that neighborhoods with a high percentage of workers, or a growing number of workers, should be designed to provide well-dispersed recreational opportunities. This is of particular relevance since the fraction of workers in the overall population is increasing.

Collectively, the results show a need for adequate distribution of recreational facilities in residential areas. Areas with a poor park system or substandard recreational facilities appear to be contributing to extra vehicle miles because people are traveling farther to reach better facilities. Also, the changing socio-demographic profile of the population requires careful land-use planning to locate recreational facilities. Finally, in an era of urban renewal and downtown restoration projects, recreation should not be overlooked as a trip attractor.

DEMOGRAPHIC MODELING

A clear finding from our empirical analysis is the effect of socio-demographics on recreational location choice. Of course, the application of the model in forecasting requires spatial-temporal forecasts of household structure, car ownership, and employment arrangements, in addition to the age and income forecasts that are commonly used by MPOs. This need for more extensive socio-demographic forecasting is sometimes inappropriately perceived as a "weakness" of disaggregate travel models such as the one estimated in the current paper. The more appropriate conclusion to be drawn from the results is that socio-demographic forecasting must be given substantially more attention today, both because of the changing face of the population as well as because of the substantial impacts that these changes will have on future travel patterns (see also Deakin, Harvey, Skabardonis, Inc., 1993, for the importance of including socio-demographic and lifestyle issues in forecasting travel behavior). In this regard, micro-simulation approaches, based on transition probabilities or underlying econometric models, have been receiving substantial attention in the past decade (see, for example, Goulias and Kitamura, 1992 ; Bhat and Koppelman, 1993; and Miller and Salvini, 2000).

REFERENCES

Agyemang-Duah, K. and F.L. Hall. Spatial Transferability of an Ordered-Response Model of Trip Generation. *Transportation Research*, Vol. 31A, 1997, pp. 389-402.

Austin-American Statesman. Poll: Only a quarter of families are 'traditional'. November 26th, 1999, p. A31.

Ben-Akiva, M., G.H. Gunn, and L. Silman. Disaggregate Trip Distribution Models. *Proceedings of the Japanese Society of Civil Engineers (JSCE)*, 1984.

Bhat, C.R. Work Travel Model Choice and Number of Non-Work Commute Stops. *Transportation Research, Part B*, Vol. 31B, No. 1, 1997, pp. 41-54.

Bhat, C. R. Accommodating Flexible Substitution Patterns in Multi-dimensional Choice Modeling: Formulation and Application to Travel Mode and Departure Time Choice. *Transportation Research*, Vol. 32B, No. 9, 1998, pp. 455-466.

Bhat, C.R., A. Govindarajan, and V. Pulugurta. Disaggregate Attraction-End Choice Modeling. *Transportation Research Record*, Vol. 1645, 1998, pp. 60-68.

Bhat, C.R. and F.S. Koppelman. An Endogenous Switching Simultaneous Equation System of Employment, Income and Car Ownership. *Transportation Research*, Vol. 27A, 1993, pp. 447-459.

Burnett, P. Disaggregate Behavioral Models of Travel Decisions Other Than Mode Choice: A Review and Contribution to Spatial Choice Theory. *Transportation Research Board Special Report*, Vol. 149, 1974, pp. 207-222.

Daly, A. Estimating Choice Models Containing Attraction Variables. *Transportation Research*, Vol. 16B, 1982, pp. 5-15.

Deakin, Harvey, Skabardonis, Inc. Manual of Regional Transportation Modeling Practice for Air Quality Analysis. The National Association of Regional Councils, Washington, D.C., 1993.

Fotheringham, A. Some Theoretical Aspects of Destination Choice and Their Relevance to Production-Constrained Gravity Models. *Environment and Planning*, Vol. 15A, 1983, pp. 1121-1132.

Fotheringham, A.S. Market Share Analysis Techniques: A Review and Illustration of Current U.S. Practice. *Store Choice, Store Location and Market Analysis*, Wrigley, N., ed. Routledge: London, 1988. pp. 120-159.

Goulias, K.G. and R. Kitamura. Travel Demand Forecasting with Dynamic Microsimulation. *Transportation Research Record*, Vol. 1357, 1992, pp. 8-17.

Hamed, M.M. and F.L. Mannering. Modeling Travelers' Postwork Activity Involvement: Toward a New Methodology. *Transportation Science*, Vol. 27, No. 4, 1993, pp. 381-394.

Handy, S.L. Regional Versus Local Accessibility: Neo-Traditional Development and its Implications for Non-Work Travel. *Built Environment*, Vol.18, No. 4, 1992, pp. 253-267.

Handy, S.L. Regional Versus Local Accessibility: Implications for Non-Work Travel. *Transportation Research Record,* Vol. 1400, 1993, pp. 58-66.

Hunt, J. D. A Stated Preference Examination of Time of Travel for a Recreational Trip. *Journal of Advanced Transportation*, 1996.

Kumar, A. and D. Levinson. Temporal Variations on Allocation of Time. *Transportation Research Record*, Vol. 1493, 1995, pp. 118-127.

McFadden, D. Modeling the Choice of Residential Location. *Spatial Interaction Theory and Planning Models*, Edited by Karlquist, A., Lundquist, L., Snickbars, F., and J.W. Weibull. North Holland, Amsterdam, 1978, pp. 75-96.

Miller, E. and M. O'Kelly. Estimating Shopping Destination Choice Models From Travel Diary Data. *Professional Geographer*, Vol. 35, No. 4, 1983, pp. 440-449.

Miller, E.J. and P.A. Salvini. Activity-Based Travel Behavior Modeling in a Microsimulation Framework. Invited resource paper, forthcoming in the proceedings of the Eighth Meeting of the International Association for Travel Behaviour Research, Austin, Texas, 2000.

Misra, R. and C.R. Bhat. A Descriptive Analysis of Non-Worker Daily Activity Travel Patterns. *Forthcoming, Transportation Research Record*, 2000.

North Central Texas Council of Governments. *Regional Mobility Initiatives,* Vol. 4, no. 1, 1999.

Purvis, C.L., M. Iglesias and V.A. Eisen. Incorporating Work Trip Accessibility in Non-Work Trip Generation Models in San Francisco Bay Area. *Transportation Research Record*, Vol. 1556, 1996, pp. 37-45.

Sikdar, P.K. Empirical Studies of Work Trip Distribution Models. *Transportation Research,* Vol. 15A, No. 3, 1981, pp. 233-243.

Steed, J., and C.R. Bhat. On Modeling Departure Time Choice for Home-Based Social/Recreational and Shopping Trips. *Forthcoming, Transportation Research Record*, 2000.

Strathman, J.G., K.J. Dueker, and J.S. Davis. Effects of Household Structure and Selected Travel Characteristics on Trip Chaining. *Transportation*, Vol. 21, 1994, pp. 23-45.

Texas State Data Center & The Center for Demographic and Socioeconomic Research and Education. *Projections of the Population of Texas and Counties in Texas by Age, Sex and Race/Ethnicity for 1990-2030*. College Station, Texas A&M, 2000. http://txsdc.tamu.edu/cgi-bin/prjctn2000.cgi

Thill, J.C. Choice Set Formation for Destination Choice Modeling. *Progress in Human Geography*, Vol. 16, No. 3, 1992, pp.361-382.

Thill, J.C. and J.L. Horowitz. Estimating a Destination Choice Model From a Choice-Based Sample With Limited Information. *Geographical Analysis*, Vol. 23, 1991, pp. 298-315.

Timmermans, H. J. P. A Stated Choice Model of Sequential Mode and Destination Choice Behavior for Shopping Trips. *Environment and Planning* Vol. 28A, 1996, pp.173-184.

Todes, M. The Inapplicability of the Gravity Model in Non-Gravity Situations. *Traffic Engineering and Control*, Vol. 22, No. 1, 1981, pp. 14-18.

Train, K. Recreation Demand Models with Taste Differences Over People. *Land Economics*, Vol. 74, No. 2, 1998, pp. 230-239.

U.S. Bureau of the Census. *Population Projections for States by Age, Sex, Race, and Hispanic Origin: 1995 to 2025*. Population Projections Branch, 1996. http://www.census.gov/population/www/projections/ppl47.html

U.S. Department of Commerce. Total Disposable Personal Income by State and Region, 1969-95. Bureau of Economic Analysis. http://www.bea.doc.gov/bea/regional/articles/1096rem/tab3-1.htm

Williams, S. *Outdoor Recreation and the Urban Environment*. Routledge, New York, 1995.

Yai, T., Yamada, H., and N. Okamoto. Nationwide Recreational Travel Survey in Japan: Outline and Modeling Applicability. *Transportation Research Record*, Vol. 1493, 1995, pp. 29-38.