Time-of-Day Choice Modeling for Long-Distance Trips

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ABSTRACT

During the last two decades increasing attention has been given to incorporating the temporal nature of trip making into the travel demand modeling process. The vast majority of prior studies have focused on daily urban trips. This study explores the timing/scheduling decision-making behavior for long, occasional and exceptional travel, rather than habitual, repetitive trips. A long-distance trip is defined for this study as 50 miles or longer in distance and 60 minutes or longer in travel time, one way. An intensive preference survey was conducted to help expose those salient factors that affect TOD choice, and help understand the prioritization among the variables and constraints. A multinomial logit model was then developed from the 2001 NHTS daily-trip survey data. Various trip activity, personal and household characteristics were examined. The TOD choice process for long-distance trips was found to be more complicated than that for daily short trips. Trip duration, activity duration, travel day type, whether traveling with other persons and the presence of young children all had strong implications on the departure time choice for long-distance trips.

INTRODUCTION

Time-of-day (TOD) models deal with the time at which travel occurs throughout the day, instead of treating a full day's demand at once. With increasing levels of traffic congestion and with recent emphasis on environmental and economic impacts of transportation projects and policies, there has been an increased interest in improving the capabilities of travel demand models to estimate travel conditions with detailed temporal resolution (*1*).

There has been a fair amount of research on TOD modeling during the past two decades, however almost all studies focused on urban trips. TOD analysis for long-distance trips has the potential to improve the forecasts of rural/intercity travel and could valuably supplement urban forecasts of vehicular emissions and traffic congestion.

Urban trips and long-distance trips differ from each other in terms of distance traveled, mode used, and motivations for travel. When travelers make decisions on when to travel for urban daily routine trips, the major concerns are usually traffic congestion or travel time or work schedules. TOD choice for long-distance trips involves many other important factors such as overnight stays, available transportation services, fares and travel cost, automobile availability, safety, presence of children, and interactions with traveling companions. All these factors suggest that the decision-making process for long trips is more complicated than that for urban trips. As many urban trips are made as part of daily routines, long-distance trips are most often occasional and exceptional. Long-distance trips and urban trips have similarities as well as differences. Urban experience could be borrowed to some extent when dealing with long-distance trips, but long-distance trips deserve a separate exploration on their own.

This paper presents a study of TOD choice making for long-distance trips for which very little is known. The major hypothesis tested in this study is that TOD choice for long distance trips is highly dependant upon the characteristics of the trip/activity, the circumstances of the traveler, and the level of service of the transportation system; and that it is possible to forecast the temporal distribution of demand with greater accuracy when these factors are incorporated into choice models.

BACKGROUND

Long-Distance Trips

With the rapid development of technologies and economies, people are increasingly engaging in activities at longer distances. The 1995 American Travel Survey (ATS) reports at that time Americans took about 1 billion long-distance (longer than 100 miles one way) person trips, consisting of nearly 827 billion miles, which accounted for about 25 percent of all trip miles made in the country (*2*). The 2001 National Household Travel Survey (NHTS) said Americans made about 2.6 billion long-distance trips annually (longer than 50 miles one way) involving over 1.3 trillion person miles in 2001 (*3*).

The 2001 NHTS helps characterize long distance travel. Women were less likely to make long trips than men as compared to urban trip making, while people aged between 55 and 64 were more likely to make long trips than urban trips as compared to other age groups. About 90 percent of the long-distance trips were made by personal vehicle, with 7 percent by air and 3 percent by bus and train. Nearly all trips (97 percent) less than 300 two-way miles were made within personal vehicles, while urban trips had relatively smaller mode share for personal vehicles (about 87%). A majority (55%) of long-distance trips was made for pleasure including vacation, visiting, and recreation. Commuting and business trips comprised 13 percent and 16 percent, respectively, with the remaining 13 percent taken for personal business such as shopping or health-related needs. In comparison, a large portion of daily trips were taken for family and personal reasons, such as shopping and running errands (45%). Social and recreation trips accounted for 27 percent of the daily trips.

There are two good reasons for TOD analysis for long-distance trips. First, such analysis will improve forecasts of rural and intercity travel demand, assessments of the adequacy of rural and intercity highway networks, and evaluations of the connectivity and efficiency of facilities between metropolitan areas. Moreover, a sizable portion of the overall person miles of travel (about one-third according to the 2001 NHTS) is rural or intercity long-distance trips. A complete vehicular emissions and air quality study would not be possible without TOD analysis for long-distance trips because of the portions of long distance trips that occur in urban areas and the amount of rural roads within non attainment areas. Congestion management programs would also benefit from long-distance trip TOD analysis since many long-distance trips either have one end within an urban area or must pass through an urban area. Besides all the benefits of long-distance trip TOD analysis to ground travel, TOD analysis for air travel is very important to air traffic service providers in terms of demands for seats, gates, runway space and air lane space at certain times of day.

TOD Modeling

Various approaches have been proposed for TOD modeling. Approaches include: simple TOD factors; peak spreading procedures; equilibrium-based models that account for interactions between network supply and demand; choice behavior modeling that examines the underlying causality of individual TOD choice; and activity-based micro-simulations that involves comprehensive daily travel activity scheduling.

Given the objective of modeling TOD choice for long-distance trips, and based on the review of urban experience, a choice modeling approach will likely produce the fastest and most informative results, at least initially. First, choice modeling provides the opportunity to examine the effects on long trip TOD choice of various factors and to better understand the underlying causality of revealed behaviors. Second, an equilibrium-based approach would not easily work for long-distance trips exclusively, because it must include urban trips that would tend to confound the analysis. Moreover, since most people take none or only one long-distance roundtrip a day, the comprehensive daily activity-travel pattern may not have as much influence on the TOD choice for long-distance trips as it does on daily repetitive trips. In future research long-distance trips may be incorporated into the daily pattern, but that must rest on a better understanding of the choice behavior for these long, occasional and exceptional trips.

This section briefly and selectively presents studies in TOD choice models to provide a framework for the analysis described later. All these studies relate to urban experiences, since there is minimal relevant research on long-distance trips. Small (*4*) investigated the TOD choice for automobile commuters. Based on reported preferred arrival time (PAT), actual arrival time (AAT) and official work start time, a multinomial logit (MNL) model was developed to predict the arrival time choice among 12, 5-minute interval time choices. The ratio of the coefficients indicates that one minute of early arrival equals to 0.61 minutes of travel time, one minute's late arrival equals to 2.4 minutes' travel time, and late arrival causes a 5.5 minute penalty of travel time. The model provided some insights on the willingness to reschedule in order to avoid congestion, but the information about PATs are often not available in revealed preference (RP) data. Furthermore, individual's preference on value of time and willingness to reschedule may vary.

Steed and Bhat (*5*) and Okola (*6*) examined the effect of many variables on departure time choice using MNL models. Steed and Bhat found that socio-demographic characteristics such as age, income, presence of young children, and employment status had strong impacts on departure time choice for home-based non-work trips, while level-of-service variables generally did not show strong effects. Okola found income and presence of young children to be insignificant to elderly when making recreational trips, but day of week, group or non-group activity had strong impacts.

Besides investigating the TOD choice behavior, some studies were interested in the interaction between mode choice and TOD choice. Bivariate probit models were developed by Tringides *et al*. (*7*) to investigate the relationship between departure time choice and mode choice for non-work trips. The models were simplified giving only SOV and non-SOV for mode choice and peak and non-peak for departure time choice. The results indicated that workers tended to make departure time choice before mode choice because of fixed work schedules, while non-workers were more constrained on mode choice than TOD choice. Hess *et al.* (*8*) also studied the relative sensitivity of mode and TOD choices to changes in network performance. Three related stated preference (SP) survey datasets from UK and the Netherlands were investigated. It was found that travelers generally had higher sensitivity to changes in departure time than to changes in participation time; commuters generally were less likely to shift to later departure times than early ones; and travelers were more constrained by mode than by TOD. That is, a large quantity of time shift (more than 90 minutes) was required to have the same effect as a mode shift.

In recognition of travel as the means to fulfill the needs of pursuing activities at various locations, researchers incorporated activity scheduling components into the utility functions for TOD choice. Hess *et al.* (*8*) considered penalties for departure time shifts and penalties for activity duration change at destinations. Ettema *et al.* (*9, 10*) suggested that an individual would choose a departure time that maximizes the total utility derived from the trips as well as the associated activities, as presented in the equation below:

Vovsha and Bradley (11) developed a hybrid model to predict discrete departure time choice and tour duration under the same framework. The TOD choice utility included departure time and arrival time components, duration components, and a mode choice log-sum. The model was applied to the Mid-Ohio Regional Planning Commission (MORPC) model system which provided the travel time and cost simulations by TOD periods. Zeid, Rossi, and Gardner developed a TOD model that can be applied to tour/activity based travel models (*12*). MNL models were developed to predict departure time and arrival time based on socio-demographic variables, TOD-dependent travel times, distance, cost, mode (drive-alone or share-ride), predetermined tour characteristics, and length of the time periods. The model was applied within the San Francisco County Transportation Authority (SFCTA) model with TOD specific travel times; and the model contained a feedback between traffic assignment and TOD choice.

In summary, discrete choice modeling provides an effective approach to studying the TOD choice behavior for urban trips. In the emerging activity- or tour-based models, choice modeling still serves as the basis for TOD analysis, with some scheduling constraints or conditional probabilities representing the interactions among tours or activities. Various structures of logit models were tested and compared against the MNL model. Some studies showed results in favor of the advanced structures, while others found no advantage of engaging complex structures over the MNL model. As for the research reported in this paper, the widely accepted MNL structure was employed, principally for the sake of efficiency. Once a better understanding of the TOD choice for long-distance trips has been established, the more advanced structures can be examined.

APPROACH AND DATA SOURCES

Preference Survey

Choice behavior research can often be enhanced with the use of intensive interviews of a small panel of consumers, either in a group setting or as individuals. For travel choices, such interviews can include stated preference questions or could explore the motivations for travel and the constraints that shaped the travel decision.

Because of the dearth of information on long-distance TOD choice, it was determined that a small scale preference survey would greatly help in gaining insights about the underlying causality of choices. Through individual interviews that expose the decision-making process of the travelers' TOD choice, the trade-offs between the departure time choice and the related factors, such as peak hour congestion, mode captivity and night driving, can be revealed. Moreover, a preference survey would also help understand how travelers prioritize such factors. These prioritizations surely vary among individuals according to their own experiences and preferences. One would suspect that the same traveler has a different choice process for trips with different purposes, for trips that go through different types of land uses, and for trips with different companions. All these issues will have implications on TOD choice.

Given the above goal, a preference survey was conducted by email or by face-to-face interviews. The major concerns of the interviews were how travelers make TOD choices for long-distance trips, in terms of:

a) schedule constraints—the need of being somewhere at a specific time (may include traveling companions);
b) mode captivities—whether travel mode is a determinant variable for TOD choice, or whether there is an order in making mode choices and TOD choices;

c) differences from urban trips—whether there are differences in the decision making process between long-distance trips and urban trips, and if any, in what manner and why; and
d) any other important issues that arise during the interviews.

Three types of information were collected through the interviews: 1) personal information (very limited because of privacy concerns) and habitual information regarding long-distance trip making; 2) trip information regarding the most recent one or two long trips; and 3) general preference, such as whether there is a tendency to avoid night driving. The respondents were also asked to rank the factors that affect their TOD choices.

MNL Modeling

After the preference survey, a MNL model was developed to further test the hypothesis. The procedure forecasts the probability of one TOD being chosen for each long-distance trip based on a set of taste parameters and the attributes of the alternatives and the decision-maker. The model used in this study is described in the equation below:

$$\Pr(TOD) = f(T, A, P, H)$$

where

TOD =	TOD period choice for the long trip,
T =	trip related factors such as purpose, mode, travel time, traveling companions,
A =	activity related factors such as activity duration,
P =	personal characteristics such as age, gender, education level,
H =	household characteristics such as income, size, auto-ownership, presence of young child.

Since arrival time is a random outcome of the departure time and given the uncertainty of travel time especially for long-distance trips, it is far more convenient to relate TOD choice to departure time than to arrival time. The entire day was aggregated into six departure time period choices including early morning (0:00 am-6:29 am), morning peak (6:30 am-8:59 am), morning off-peak (9:00 am-11:59 am), afternoon off-peak (12:00 pm-15:59 pm), afternoon peak (16:00 pm-18:29 pm), and evening (18:30 pm-23:59 pm). Of course, it would be possible to examine TOD choice at a finer level for certain time periods if warranted by the initial analysis.

The 2001 NHTS data were employed. For this study, a long-distance trip was defined as 50 miles or longer in distance **and** 60 minutes or longer in travel time for both air and land-based trips. Among the 106 air trips included in the data, the longest trip was 7000 miles and took 780 minutes; while the average trip length was about 1222 miles and the average travel time was about 228 minutes. Although no TOD information was collected in the NHTS for its special long-distance travel component, departure time and arrival time were recorded for daily trips, of which a small percentage were long trips. These trips were retrieved from the daily trip file and used as the data set for long-distance trips in this analysis. A wide range of independent variables were examined in the model to determine whether and to what extent these variables affect TOD choice for long-distance trips.

The NHTS data still had notable deficiencies. The NHTS data did not allow for a clean determination of level-of-service for trips. For example, the data could not differentiate a trip on moderate speed highways from a trip on high speed highways that included congested sections. In addition, it was not possible to develop a satisfying, independent measure of trip cost from the data. It should be noted that the usually-seen high correlation between trip duration and trip distance is further strengthened by the way trips had been selected from the full database (i.e., 50 miles and 60 minutes). Thus, trip duration was selected as the sole measure of trip length within the choice model.

RESULTS

Preference Survey

The survey was conducted between November 2006 and February 2007 via email and face-to-face interviews. Fourteen responses were collected and 20 long trips were recorded. The age of the respondents ranged from 25 to 66. On average the respondents took 2 or 3 long-distance tours per month (besides commuting). Except for one trip in the early morning and one in the evening the other trips were almost evenly distributed throughout the remaining four time periods. Most of the trips took place on weekends when the peak hour effects are moderate.

In terms of their TOD choice behavior, the findings are summarized from three perspectives: scheduling constraints, mode captivity, differences or unrevealed concerns from the experience of urban trips. These results by themselves should not be considered statistically significant; rather, they serve as guidance and justification for the statistical analysis presented in the next section.

1. Scheduling constraints were the predominant factor for all respondents; no matter whether they were on business trips or just on holiday get-aways.
    - One direct reflection of scheduling constraints is arrival time, which varies by trip purpose. For example, people tend to leave in the late afternoon or evening for parties, while they try to leave before noon for get-together lunches with friends. In this survey, all business trips took place in the morning peak period, while personal business trips either happened in the morning off-peak period or the afternoon off-peak period.
    - When traveling with children, household members or other persons, there are more constraints in scheduling, such as pick-up, drop-off, and sufficient rest time for children.
    - Scheduling constraints also have to deal with the trade-off between arrival time and peak hour congestion. All respondents reported that they would choose a departure time to avoid peak hours. Two respondents reported that their departure time choice would take into account whether they were traveling through the metropolitan area—because of the extended peak hours and congestion in the area.
    - The effects of night driving were mixed. Some reported a preference for driving at night because of less traffic. A majority of the respondents do not mind or do not think of night driving as a concern. Four out of 14

respondents said they would choose a departure time to avoid night driving.

2. In this survey, mode seemed not to be a determinant factor of TOD choice either because there was no alternative mode available or people prefer the convenience and flexibility provided by driving, regardless of the TOD.
    - When public services were used, TOD choice was determined by the service schedule only at a fine level (within 30 minutes); travelers decide when to leave still based on other factors such as trip purpose, activity duration, and scheduling; however, the travelers would be more constrained in terms of the return trip scheduling.
    - In this survey, 3 trips were made by airplanes (1 oversea travel for business); all took place in morning off-peak period. Departure times were determined based on flight schedules. Cost was not mentioned as an important factor in the TOD choices. Airfare has more influence on day of week and month of year choices rather than TOD choice.
    - In most cases, mode choice was chosen before TOD choice.
3. More factors were in effect in terms of the TOD choice for long-distance trips compared to urban daily trips.
    - Long trips had fewer mode choices than urban trips.
    - Long-distance trips were less reliable in travel times than urban trips; travelers would routinely plan for extra time when making TOD decisions.
    - Travelers would plan their departure time in consideration of the activity scheduling at the destination and intermediate stops for rest, eating, staying overnight, etc., based on their knowledge and comfort level of the traffic and roads in the arrival or through cities.
    - Some long-distance trips were relatively more flexible, so TOD choice would be made in accordance with weather conditions.

It worthwhile to point out that trip cost and trip convenience factors were not cited as important considerations in TOD choice.

Although the information collected from the preference survey does not necessarily represent the general population at a wider environment and it was not possible to do statistical analysis with the data, valuable knowledge was gleaned from the survey. TOD choice depended largely on the purpose at the destination. Mode was not found to have a strong effect on the departure time choice. Long trips were constrained in TOD choice because of the tour's long duration (which includes intermediate stops for rest, eating, and stays) especially with the presence of children and traveling companions.

MNL Analysis

Valid data from the NHTS consist of 3322 long-distance trip records made by 2439 adults from 1924 households. More than half (55%) took place during the mid-day periods from 9:00 am to 16:00 pm. About 18% of the trips were taken during the am peak period, a majority of which were work, school or related trips. The evening period has the smallest proportion of long-distance trips—only 5%, while the pm peak and early morning periods had about 12% and 11%, respectively. Figure 1 shows the distribution of long-distance trips across the day. This figure shall not be compared with the commonly seen diurnal distribution of daily trips, since this figure shows only long-distance trips which were accumulated from different days including both weekdays and weekends.

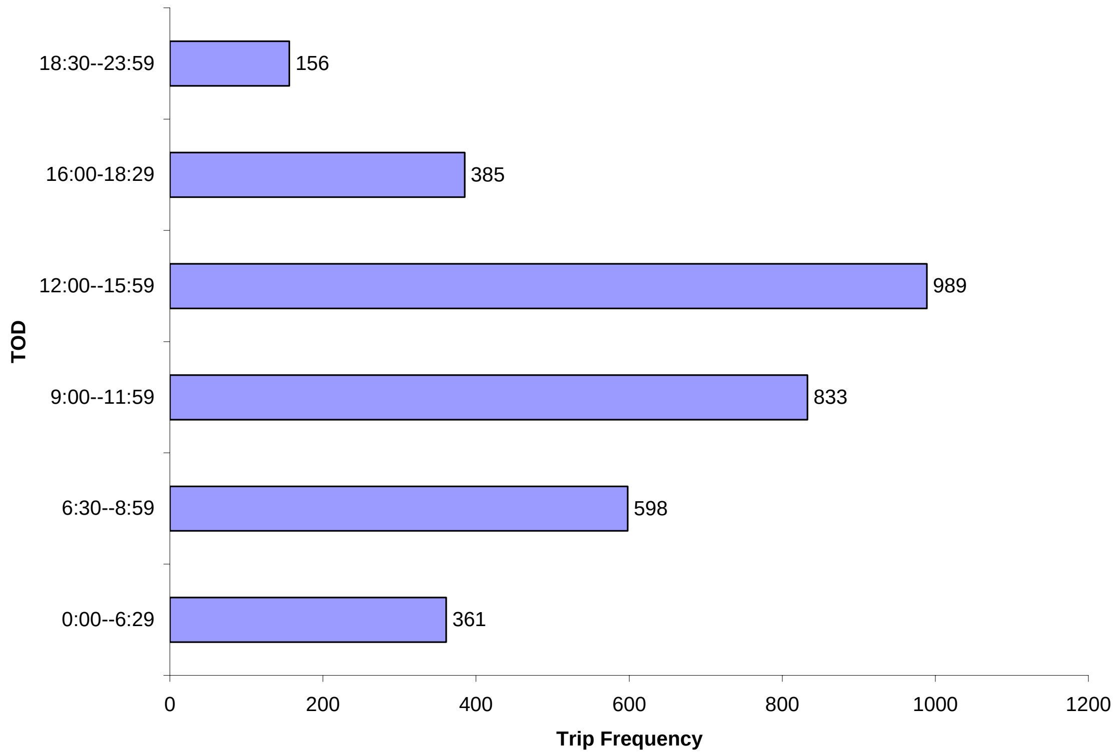


Figure 1 Distribution of Departure Time for NHTS Long-Distance Trips

The last time period (18:30-23:59) served as the reference category since long-distance trips were least likely to happen in this time period. The MNL process would estimate the probability of departing at each of the time periods as opposed to the evening period, separately. Similarly, for each categorical independent variable the last category served as the base category, the coefficients were calculated against the base category.

The discussion of the analysis uses the exponential, Exp(B), of the each model coefficient, rather than the raw coefficient itself, because the exponential is readily interpretable as odd ratios. The traditional form of the MNL model can be found in *(13)*.

Various types and combinations of explanatory variables were examined in MNL analysis before arriving at the model presented here. It was found that household size and household structure (*lifecycle*) both were significant when and only when included in the model separately. *Lifecycle* was chosen over size because of better model performance. Surprisingly, income and number of household vehicles did not show significant effects even when all other household and personal related variables were excluded. Of the three variables regarding traveling companions, only the number of non-household members (*num_nonhh*) significantly improved the model; number of household members and number of total people in the travel had no significant impact on the TOD choice. Mode (*mode07*) was not significant at 0.05 level (0.101), but it was included for interpretation purposes. Other factors proven to have very little influence on long trips TOD choice were whether the trip ended the next day, whether the housing unit was owned or rented, and whether the traveler lived in an urban or rural area. Table 1 summarizes the results of the MNL model. Blank cells are reference categories. Cells in gray indicate that the coefficients were not significant at 0.2 level.

Generally speaking, the number of non-household members participating in the trip had a negative impact on TOD other than the evening period (Exp(B)<1) holding other conditions constant. But this estimated difference is insignificant for the pm peak period. Comparing the Exp(B) across the time periods indicates that the more non-household persons in the travel, the later the travelers would start the long-distance trip. The number of non-household member in travel was associated with trip purpose, but the relationship was fairly weak (correlation coefficient of 0.063).

Trip duration and activity duration (in minutes) had positive impacts on the odds of traveling in the time periods other than the evening period. The longer the trip or the longer the time being spent at the destination of the trip, the earlier the trip would be taken.

Age of the traveler also had a positive impact on the probability of traveling long-distance in the day time periods rather than in the evening except for the pm peak period. Most likely, older people would start long-distance travel in the morning more often than other time periods.

Households with more workers (*hhworker*) tended to have long-distance travel most likely in the pm peak period, followed by the early morning period, compared to households with fewer workers. Logically, travelers with jobs (*worker*) were more likely to take long-distance trips in the evening period compared to non-workers. Workers were least likely to make long trips during the pm off-peak period.

The odds ratios for weekend trips compared to weekday trips were less than 1 for all time periods, indicating that weekend long trips were more likely to be taken in the evening than weekday trips. Compared to weekday trips, weekend trips were least likely to be taken in the morning periods (0.283), and relatively more likely during the mid-day periods (0.518 and 0.419) followed by the pm peak period (0.380).

Females were more likely to have long trips during the later time periods of a day compared to men, except for the pm peak period. The odds that a male takes a long trip in the early morning period (opposed to the evening period) was 1.38 times higher than for a female, while the odds for a female to depart for long trips during the am peak period was 1.4 times higher (1/0.709) than for a male given all other conditions the same.

Table 1 Model Parameter Coefficients--Exp(B) for Long Trips

Exp(B) TOD	Num_nonhh	Trip Dur.	Activity Dur.	Age	HHWorker	Mode: Car	Mode: Air	Mode: Others	Weekend: Yes	Weekend: No	Sex: Male	Sex: Female	Worker: Yes	Worker: No
0:00--6:29	0.945	1.015	1.018	1.011	1.146	1.104	0.332	.	0.284	.	1.380	.	0.798	.
6:30--8:59	0.919	1.011	1.016	1.014	0.987	1.294	0.328	.	0.283	.	0.709	.	0.655	.
9:00--11:59	0.948	1.008	1.013	1.018	1.006	2.570	1.024	.	0.518	.	0.737	.	0.637	.
12:00--15:59	0.948	1.005	1.011	1.001	0.897	1.223	0.602	.	0.419	.	0.810	.	0.567	.
16:00--18:29	0.987	1.001	1.008	0.994	1.162	2.303	1.346	.	0.380	.	1.014	.	0.875	.
18:30--23:59		.	.	.	.	.	.	.	.	.	.	.		

Exp(B) TOD	Purpose: Work/ School	Purpose: Return	Purpose: Persn Busin	Purpose: Social Rec.	Purpose: Others	Education: HS or less	Education: HS	Education: College	Education: Grad.	LifeCycle: No child	LifeCycle: Child 0-5	LifeCycle: Child 6-15	LifeCycle: Child 16-21	LifeCycle: Retired no child
0:00--6:29	3.841	0.036	1.346	0.498	.	2.792	1.644	2.362	.	0.489	0.507	0.540	0.277	.
6:30--8:59	2.796	0.168	1.981	0.998	.	1.487	1.084	1.823	.	0.721	0.464	0.563	0.495	.
9:00--11:59	1.411	0.657	1.617	1.382	.	1.207	0.996	1.609	.	0.756	0.721	0.887	0.558	.
12:00--15:59	1.043	1.773	1.191	1.295	.	0.877	0.940	1.647	.	0.915	0.682	1.068	0.643	.
16:00-18:29	0.550	1.239	0.779	0.782	.	0.876	0.943	1.154	.	0.945	0.477	0.748	0.600	.
18:30--23:59	.	.	.	.	.	.	.	.	.	.	.	.	.	.

N = 3322
-2LL = 9325.567 (intercept only--10943.245)
Pseudo R-Square = 0.400

Long-distance travelers using private vehicles were least likely to depart in the evening, while air travel was least likely to take place in the morning peak and early morning periods. Although these differences were substantial, they were not significant for all time periods. As shown in Figure 2, the odds ratio of choosing a TOD between 9:00 and 11:59 was estimated to be 2.57 times higher for private vehicle users than for travelers using other modes. Compared to air travelers, the relative odds for leaving in the morning peak period (opposed to the evening period) by other modes were 3 times higher (1/0.332).

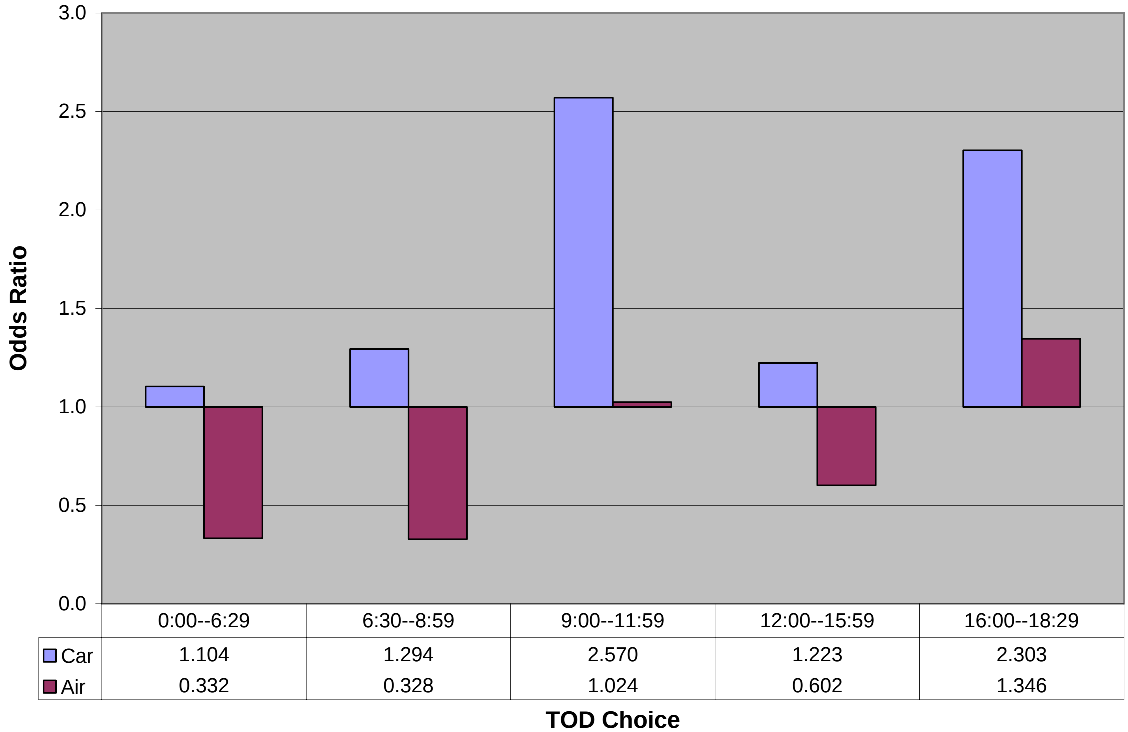
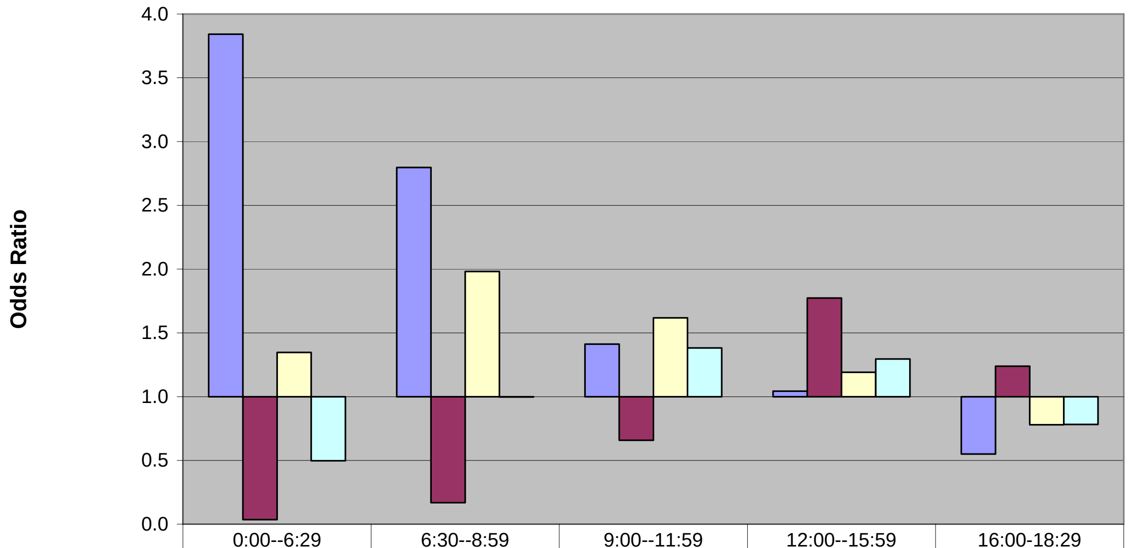


Figure 2 Comparative Odds of TOD Choice for Long Trips by Mode

The coefficients for education show some interesting results. Travelers with high school education or less would take long-distance trips most likely in the early morning period and least likely in the pm peak period; while travelers with graduate education or higher were least likely to make long trips in the am peak period compared to other travelers.

Household lifecycle or structure of households, including the existence of young children, is another way to measure the scheduling constraints from a household on the TOD choice for long trips. Households were classified according to the age of the youngest child in the household. The reference category was households with children older than 21 years old, or those did not live with their children anymore. Almost all the Exp (B) values were less than 1, indicating that households with children or young couples with no child were more likely to take long trips in the evening.

Figure 3 shows the odds of TOD choice for long-distance trips by trip purpose. Long trips for work or school purposes would take place in early time periods, most likely in the morning periods and least likely in the pm peak periods, compared to other types of trips. Return home trips mostly took place during the afternoon periods; personal business trips would most often be taken during the morning; while recreation trips took places more often in the morning and afternoon off-peak hours. The relative odds for taking work trips during the early morning period were 3 times higher (3.841-0.550) than during the pm peak hours. The odds for personal business travelers departing between 9:00 and 11:59 (against the evening) were 2.5 times higher (1.617/0.657) than for return home travelers.



	0:00--6:29	6:30--8:59	9:00--11:59	12:00--15:59	16:00-18:29
Work/ School	3.841	2.796	1.411	1.043	0.550
Return	0.036	0.168	0.657	1.773	1.239
Persn Busin	1.346	1.981	1.617	1.191	0.779
Social Rec.	0.498	0.998	1.382	1.295	0.782

TOD Choice

Figure 3 Comparative Odds of TOD Choice for Long Trips by Purpose.

Figure 4 shows the comparison of the impacts of various factors on choosing the am peak period (opposed to the evening period) as the departure time for long-distance trips. Only variables that were significant at 0.2 level are included in the figure. Besides trip duration, activity duration, and number of non-household members in the travel, the rest are dummy variables coded as 1 or 0 indicating trip-related or personal attributes. The further away the odds from 1.0, the greater impact the variable has on the TOD choice.

The number of non-household member in the travel had a negative impact on departing during the morning peak period. Traveler's age, trip duration and activity duration all had positive impacts on leaving in the am peak period for long-distance travel. Although the Exp(B) for trip duration and activity duration were very small compared to other variables, they could have substantial impacts on the TOD choice because the units for duration are minutes. Among the dummy variables, trip purpose was the most powerful factor affecting TOD choice. Taking a work or related trip would increase the probability of leaving during am peak hours substantially. Males showed less probability of departing in the am peak hours compared to females. The rest of the explanatory variables had similar influence on the TOD choice, in terms of both direction and magnitude. Traveling by air, traveling during weekends, or having young children would substantially reduce the probability of taking long trips during the am peak period.

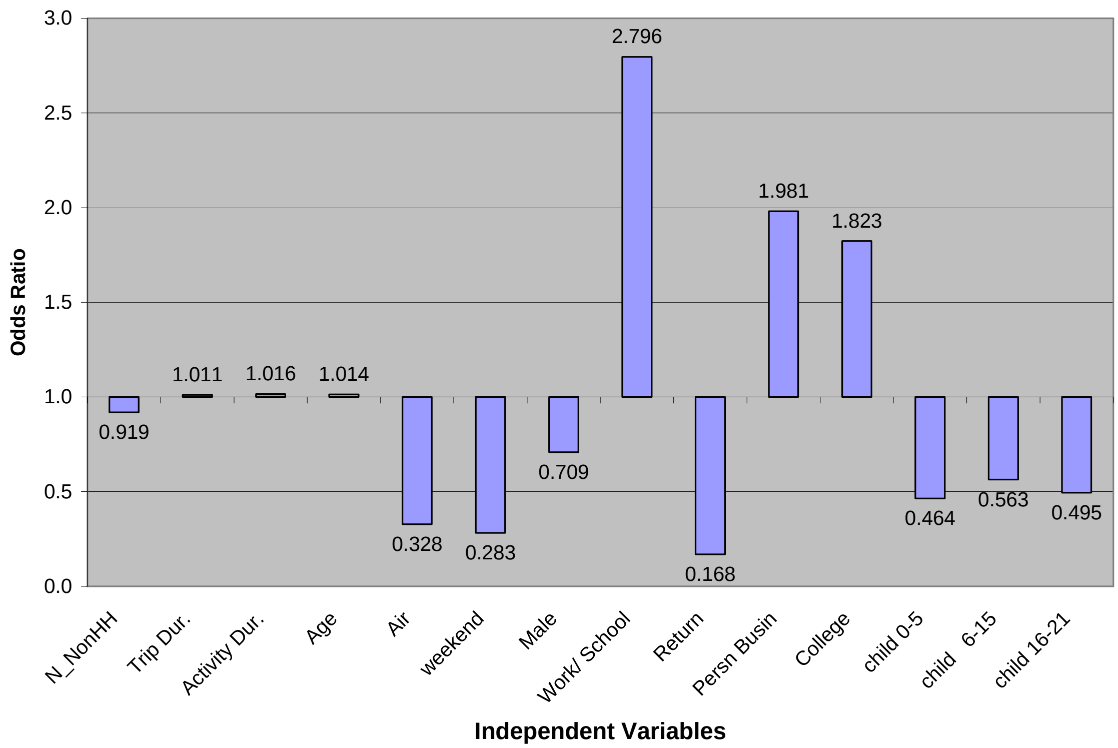


Figure 4 Comparative odds of departure at am peak period for long trips.

In summary, trip duration, activity duration, trip purpose, and whether the trip took place on weekend were the most powerful factors in determining the TOD choice for long-distance trips. The longer the trip itself or the longer the time to be spent at the destination, the earlier the trip would be taken. Weekend long-distance trips had a higher probability of happening in the evening period, followed by the mid-day periods compared to weekday long trips. Different types of long trips exhibited different preferences on the departure time. Work or related trips most often took place in the early morning and am peak periods; return home trips had the highest probability of occurring in the afternoon periods; travelers were more likely to depart in the morning for personal business trips, and in the afternoon for recreation trips.

Generally, traveling with companions would increase the probability of making long-distance trips in the evening. Travel mode, in general, was not a determinant factor to the TOD choice. However, for long trips made by automobiles, whether the traveler was a driver or passenger had significant impacts on departure time choice (*13*).

The traveler's age, gender, employment status, education level all presented significant impacts on the TOD choice for long-distance trips.

CONCLUSIONS

Since urban trips and long-distance trips differ in many ways, their TOD choice behavior also differs. Particularly, long-distance travel TOD choice encountered different constraints. Departure time choice for long trips was strongly affected by how long the trip would be, how much time would be spent at the destination, whether traveling on a weekday or weekend, whether traveling alone or with other companions, and whether traveling with young children.

There were some consistencies with the experience from urban trips. Trip purpose and socio-demographic characteristics had significant impacts on the TOD choice for long trips; although in many urban TOD models, the trip purpose was simply defined as work trips and non-work trips. Income and mode which were often found to be significant to the TOD for urban trips had no strong impact for long trips.

This paper recognizes the need to treat TOD choice behavior for long occasional trips separately from urban daily trips. A sizeable number of planning issues could benefit from detailed temporal resolution of long distance trip making. These may include but not limited to: forecasts of statewide or regional travel demand; evaluations of the adequacy of infrastructure network at certain times of day, especially between metropolitan areas; complete vehicular emissions and air quality studies including both urban trips and intercity travel; assessments of the effectiveness of TOD specific congestion management programs; and TOD sensitivity analysis for air travel demand.

The MNL model developed for this study also provides insights to the timing/scheduling decision-making behavior for long-distance trips that have implications on policy issues such as TOD pricing.

Because of the occasional and varied nature of long-distance travel, the TOD modeling for long trips is more complicated than that for urban short trips. Urban trips would more likely be scheduled around work and other daily routines, while long trips could have very high priority in the daily schedule and might be planned weeks even months ahead. Conversely, long trips could also be very flexible and random, and to some degree depend upon the travelers' mood and the weather conditions. These opposing features of long-distance travel suggest that the current modeling approaches to daily travel demand may not work well for long trips. In particular, long-distance trip making, especially for multi-day trips, does not fit well into the current activity-based framework, which does not have the appropriate link to incorporate high priority long-distance trips, nor can it appropriately represent the situations where the travel and the activity are pursued in different days given the current 24-hour time frame.

As an effort to predict the unpredictable, the mixed nature of long-distance trip making can be partly captured by defining the purpose and travel day type (weekday/weekend). Long-distance trips for different purposes have different needs on TOD, as indicated from the MNL model. Travelers on weekdays or on weekends also have distinct preferences to departure time choice, not only for workers, since non-workers also have to consider the network conditions by TOD, and/or the scheduling of other working household members. Future work should be done by separating weekday trips and weekend trips or by focusing on certain types of long trips. Further improvement can also be done considering level-of-service variables such as travel time and travel cost at different time periods.

As this research indicates the needs for incorporating TOD components into the statewide modeling process, the necessary prerequisites for implementation are not ready yet. Dynamic traffic assignment has good potential to link this work with statewide forecasting models.

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