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16. Abstract <p>Research on travel-demand modeling has predominantly focused on weekday activity-travel patterns, with the study of the effects of commute travel on peak period traffic congestion as a major objective. In contrast, there have been few studies examining the weekend activity-travel behavior of individuals. However, weekend travel volume has been increasing over time and is comparable to weekday travel volumes. Hence, weekend activity-travel patterns warrant careful attention in transportation planning.</p> <p>The focus of this report is to present a comprehensive exploratory analysis of weekend activity-travel patterns and to contrast weekday and weekend activity participation characteristics. Data from the 2000 San Francisco Bay Area Travel Survey are used in the analysis. A comparative analysis of several aggregate activity-travel characteristics indicates that, while the weekday and weekend travel volumes are comparable, there are several key differences in activity-travel characteristics. Specifically, weekend activity-travel is found to be predominantly leisure oriented and undertaken during the mid-day period. The average trip distances are longer during the weekends. The transit shares are lower but the occupancy levels in personal automobiles are higher during the weekends. The weekend activity sequencing and trip-chaining characteristics explored in this study provide further insights into individuals' activity organization patterns on weekend days.</p> <p>In the overall, this report highlights the importance of studying weekend activity-travel behavior for transportation planning and air-quality modeling. Insights from this exploratory analysis can form the basis for comprehensive weekend activity-travel modeling efforts.</p>			
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**An Exploratory Analysis of Weekend Activity Patterns
in the San Francisco Bay Area**

by

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ABSTRACT

Research on travel-demand modeling has predominantly focused on weekday activity-travel patterns, with the study of the effects of commute travel on peak period traffic congestion as a major objective. In contrast, there have been few studies examining the weekend activity-travel behavior of individuals. However, weekend travel volume has been increasing over time and is comparable to weekday travel volumes. Hence, weekend activity-travel patterns warrant careful attention in transportation planning.

The focus of this report is to present a comprehensive exploratory analysis of weekend activity-travel patterns and to contrast weekday and weekend activity participation characteristics. Data from the 2000 San Francisco Bay Area Travel Survey are used in the analysis. A comparative analysis of several aggregate activity-travel characteristics indicates that, while the weekday and weekend travel volumes are comparable, there are several key differences in activity-travel characteristics. Specifically, weekend activity-travel is found to be predominantly leisure oriented and undertaken during the mid-day period. The average trip distances are longer during the weekends. The transit shares are lower but the occupancy levels in personal automobiles are higher during the weekends. The weekend activity sequencing and trip-chaining characteristics explored in this study provide further insights into individuals' activity organization patterns on weekend days.

In the overall, this report highlights the importance of studying weekend activity-travel behavior for transportation planning and air-quality modeling. Insights from this exploratory analysis can form the basis for comprehensive weekend activity-travel modeling efforts.

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EXECUTIVE SUMMARY

Research on travel-demand modeling has predominantly focused on weekday activity-travel patterns, with the study of the effects of commute travel on peak-period traffic-congestion as a major objective. In contrast, there have been few studies examining the weekend activity-travel behavior of individuals. However, weekend travel volume has been increasing over time and is comparable to weekday travel volumes. Further, the unique characteristics of weekend travel patterns may have substantial implications for air quality modeling. Finally, realistic evaluation of the effects of policy actions aimed at regulating weekday traffic should accommodate the possibility that such strategies could transfer traffic to weekends. Hence, weekend activity-travel patterns warrant careful attention in transportation planning.

The objective of this study is to undertake a comprehensive exploratory analysis of weekend activity-travel patterns and to contrast weekday and weekend activity participation characteristics. We envision this exploratory analysis as a first step toward developing comprehensive models of activity-travel behavior that encompass both weekdays and weekend days. Data from the 2000 San Francisco Bay Area Travel Survey are used in the analysis.

The exploratory analysis indicates several key differences in the characteristics of the activity-travel across weekdays and weekend days. First, weekend activity-travel is found to be predominantly leisure-oriented, in contrast to weekday travel, which is largely undertaken for work/school purposes. Second, a substantial portion of the weekend travel is undertaken during the mid-day period, which corresponds to the off-peak period during the weekdays. Third, the average trip-distances are longer during the weekends, especially for social/recreational trips. Fourth, the transit shares are lower but the occupancy levels in personal automobiles are higher during the weekends. Finally, in addition to the above differences in the activity-travel characteristics across weekdays and weekend days, the overall weekday- and weekend- travel-volumes are found to be comparable (the average person miles of travel is found to be 22.85 miles on weekdays, 21.97 miles on Saturdays, and 20.4 miles on Sundays).

Subsequent to the comparative analysis of weekday and weekend activity-travel patterns in terms of several aggregate characteristics, we examine the individuals' activity episode organization patterns on weekend days. The overall sequencing of weekend episodes by activity type is examined in terms of the state dependence effects between consecutive activity episodes

using an activity transition matrix. Episodes of all out-of-home activity types, except personal business, are found to be more likely to be succeeded by an in-home activity episode than an out-of-home activity episode. This suggests that people, in general, prefer to return home immediately after undertaking out-of-home episodes. Next, an examination of trip-chaining characteristics indicates that 38% of all home-based tours during Saturdays are chained (*i.e.* involve multiple activity episodes) while 36% of all tours during Sundays are chained. Work/school, physically active social/recreation, and community/religious activity episodes are more likely to be undertaken alone than being chained, whereas personal business and serve passenger episodes are the most likely to be chained. Finally, we also find that work/school, physically active social/recreation, and community/religious activity episodes undertaken during Sundays are very likely to be undertaken as the first episode during the day. Physically inactive social/recreation episodes, meals, and maintenance shopping are relatively less likely to occur as the first episode of the day and more likely to occur as the last episode of the day.

In the overall, this report highlights the importance of studying weekend activity-travel behavior for transportation planning and air-quality modeling. The total person miles-of-travel (PMT) is about the same on a typical weekday and on weekend days while the total vehicle miles-of-travel (VMT) on a weekend day is about 80% of weekday VMT. Clearly, these results indicate that weekend activities and travel cannot be treated as “second class episodes” or “non existing episodes” in travel-demand modeling. The descriptive analysis undertaken in this study provides empirical evidence in support of the hypothesis that weekend activity-travel patterns are different from weekday patterns. Thus, simply transferring weekday models to weekend days may not be appropriate from a travel forecasting perspective. Further, the differences between weekdays and weekend days, especially in the temporal profiles of the travel patterns, also have substantial implications for air quality modeling. Insights from this exploratory analysis can form the basis for comprehensive weekend activity-travel modeling efforts.

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CHAPTER 1. INTRODUCTION

Almost all existing research studies in the travel behavior and travel-demand modeling field have examined weekday individual activity-travel patterns. One of the major motivations for this focus is the significant effect of commute travel on peak period traffic congestion and mobile source emissions. In contrast to the substantial literature on weekday activity-travel analysis, there have been only a handful of studies examining the activity-travel behavior of individuals over the weekend [see Parsons Brinckerhoff Quade and Douglas (PBQD) (2000); Bhat and Gossen (2004); Bhat and Srinivasan (2004), and Bhat and Lockwood (2004)]. There are many reasons why the study of weekend activity travel behavior is important:

1. The person trip rates during the weekend day are only marginally lower than those during the weekday. For example, a study using data from the New York metropolitan area indicates that the number of person trips per household is 8.02 on weekend days compared to 8.87 on weekdays (PBQD, 2000).
2. While the magnitudes of weekday and weekend travel volumes are comparable, their characteristics are likely to be quite different. For instance, one may expect weekend activity-travel participation to be largely non-work oriented in contrast to weekday activity participation, which is centered on work or other mandatory activities. Thus, weekend travel is not likely to follow the same peaking characteristics as weekday travel. Also, there could be unique traffic generators (such as sporting events and concerts) during weekends resulting in traffic characteristics that are very different from that of the typical workday traffic.
3. The study of weekend activity-travel behavior is also important from an air quality standpoint. The PBQD study observed that about half of all weekend trips are undertaken during the midday period between 10 a.m. and 4 p.m., compared to only about a third of all weekday trips undertaken during the same period. This higher occurrence of trips during the hotter part of the day can contribute to more ozone formation per vehicle mile traveled on weekends when compared to weekdays (since sunlight and temperature serve as catalysts for ozone formation). In fact, of the three days exceeding the 125 parts per billion (ppb) ozone level non-attainment standard in the Dallas-Fort Worth area in 2003, two were weekend days (North Central Texas Council of Governments, 2003). Thus, it is

important to consider the very different patterns of vehicle trips over the weekend day for a comprehensive analysis of mobile source emissions.

4. It is possible that transportation control measures intended to regulate traffic flows on weekdays might transfer traffic to weekends. For example, a study by Bhat and Misra (1999) suggests that policy actions such as a compressed workweek scheme may decrease weekday trips but also increase trips during the expanded weekend.
5. It is also important to examine weekend activity participation from the general social consideration of promoting physically-active recreational pursuits [see Sallis *et al.* (2004)].

The above discussion indicates that weekend activities and their associated travel warrant careful attention (in addition to weekday activity-travel analysis) for comprehensive travel demand modeling, as well as for evaluating policy actions aimed at alleviating congestion, improving air quality, and enhancing the overall quality of life of the people. The current report is directed toward this end. Specifically, the focus of this report is on undertaking a comprehensive exploratory analysis of activity and travel participation behavior during weekends. We envision this exploratory analysis as a first step toward developing comprehensive models of activity-travel behavior that encompass both weekdays and weekend days.

The rest of this report is structured as follows. The next section describes the data used in the analysis. Section 3 examines aggregate characteristics of weekend activity-travel patterns and presents a comparison of these characteristics with corresponding weekday aggregate characteristics. Section 4 analyzes weekend episode sequencing characteristics, including activity-type transitioning, activity chaining, and an analysis of the first and last out-of-home activity episodes during the weekend day. Finally, Section 5 summarizes the important findings from this research and their implications.

CHAPTER 2. DATA FOR ANALYSIS

The primary data source used for this analysis is the San Francisco Bay Area Travel Survey (BATS) conducted in 2000. This survey was designed and administered by MORPACE International Inc. for the Bay Area Metropolitan Transportation Commission. The survey collected information on all activity and travel episodes undertaken by individuals from over 15,000 households in the Bay Area for a two-day period [see MORPACE International Inc. (2002) for details on survey, sampling, and administration procedures]. However, each individual provided information on only one weekend day in the survey (*i.e.*, individuals were surveyed on Friday and Saturday or Sunday and Monday, but not Saturday and Sunday). The information collected on activity episodes included the type of activity (based on a 17-category classification system), the name of the activity participation location (for example, Jewish community center, Riverpark plaza, *etc.*), the type of participation location (such as religious place, or shopping mall), start and end times of activity participation, and the geographic location of activity participation. Travel episodes were characterized by the mode used, and the start and end times of travel. Furthermore, data on individual and household sociodemographics, individual employment-related characteristics, household auto ownership, and Internet access and usage were also obtained.

A secondary data source obtained from the Metropolitan Transportation Commission provided zonal-level network skim information that was appropriately appended to the activity-travel survey file to compute trip distance information.

The data were subjected to substantial cleaning and consistency checks and converted into an activity-episodes file with the information about travel-episodes appropriately retained in the activity-episodes file. The final sample used in the current analysis has information on 348122 activity episodes for 50,892 person-days. Of these, 304393 (87.4%) episodes for 44382 (87.2%) person days correspond to weekdays, 23698 (6.8%) episodes for 3551 (7%) person-days correspond to Saturdays, and 20031 (5.8%) episodes for 2959 (5.8%) person days correspond to Sundays.

CHAPTER 3. AGGREGATE CHARACTERISTICS

The cleaned sample has detailed characteristics on each in-home and out-of-home activity episode undertaken by individuals during the day. In this study, we focus only on out-of-home activity episodes and the associated travel to limit the scope of the analysis (see Lockwood *et al.* (2004) for an analysis that also includes in-home activity episodes].

In the rest of this section, we first undertake a comparative analysis of the activity participation characteristics across weekdays and weekend days (Section 3.1) and then compare the weekday and weekend travel characteristics along several dimensions (Section 3.2).

3.1 Activity Participation Characteristics

The out-of-home activity episodes were classified into the following nine purposes: (1) work/school, (2) physically active social/recreation (such as playing soccer, working out at a gym, *etc.*), (3) physically inactive social/recreation (such as going out to the movies), (4) meals, (5) maintenance shopping, (6) non-maintenance shopping, (7) personal business, (8) serve-passenger, and (9) community/ religious.

The average frequency and duration (in minutes) of activity episodes by purpose are presented in Table 1 (the average frequency for each activity purpose is computed across all individuals in the sample; the average episode duration for each activity purpose in Table 1 represents the mean duration across all episodes of the corresponding purpose in the sample). The results indicate that, in the overall, individuals undertake more out-of-home episodes during weekdays than during weekend days. Also, the average episode duration of weekday out-of-home activities is longer than weekend out-of-home activities (See the first row of Table 1). Further, the weekday activity participation behavior is clearly dominated by the work/school activity purpose (See the second row of Table 1). Almost 39% (0.82/2.11) of weekday activity episodes are work/school-related in contrast to only about 12% of the weekend activity episodes. The average duration of weekday work/school episodes is also found to be greater than that of the duration of weekend work/school episodes.

TABLE 1 Average Frequency and Duration (in Minutes) of Activity Episodes by Purpose

Activity Purpose	Weekday		Saturday		Sunday	
	Freq.	Duration	Freq.	Duration	Freq.	Duration
Overall (All Purposes)	2.11	202.71	1.91	171.58	1.71	175.12
Work/School	0.82	352.50	0.23	333.37	0.20	329.52
All Non-Work/School Purposes	1.29	155.12	1.68	159.09	1.51	163.53
Physically Active Social/Recreation	0.07	95.80	0.09	146.68	0.06	108.49
Physically Inactive Social/Recreation	0.18	130.65	0.39	158.11	0.29	145.74
Meals	0.23	83.45	0.31	92.41	0.26	89.48
Maintenance Shopping	0.12	28.98	0.16	33.23	0.17	33.52
Non-Maintenance Shopping	0.19	44.11	0.38	64.39	0.30	57.20
Personal Business	0.20	41.78	0.15	39.68	0.09	33.63
Serve Passenger	0.27	10.27	0.15	13.95	0.12	13.77
Community/Religious	0.05	119.45	0.05	151.45	0.20	131.54

In contrast to work/school purposes, the weekend time investment in non-work/school activity purposes is greater than that during the weekdays as indicated by higher frequency and longer episode durations during weekends when compared to weekdays (see the third row of Table 1). On further examining these non-work/school activities by purpose, we observe several interesting and intuitive results:

1. The average duration of physically active social/recreation episodes undertaken on Saturdays is found to be much greater than the duration of similar episodes undertaken during weekdays and Sundays. This could be reflective of the time-pressures during weekdays, which may prevent individuals from undertaking very long physically active recreational episodes. On the other hand, Sundays may be regarded as an overall rest and relaxation day and therefore individuals may not prefer to undertake physical activities for long durations.
2. Examining the rows for physically inactive social/recreation, meals, maintenance shopping, and non-maintenance shopping purposes, we find that individuals undertake more episodes of these purposes on weekend days than weekdays and that the average

duration of these episodes during weekend days is also longer than during the weekdays. Further, for all these four activity purposes with the exception of maintenance shopping, the frequency and duration is greater on Saturdays than it is on Sundays.

3. A comparison of the personal business purpose statistics across the different days indicates a higher frequency and duration on weekdays relative to weekend days. This is perhaps because businesses offering personal services are closed or are open only for reduced hours during weekend days.
4. A trend of higher frequency of participation during weekdays compared to weekend days is also observed for the serve-passenger activities. This could be indicative of the greater need to undertake pick-up and drop-off activities during the weekdays to transport children to and from school.
5. The frequency of participation in community/religious activities is the maximum during Sundays, a reflection of the greater number of religious services during Sundays.

In summary, individuals undertake more out-of-home episodes during weekdays than during weekend days. Further, the out-of-home activity participation is largely oriented toward mandatory (work/school) and maintenance (serve-passenger, meals, personal business) activities during the weekdays, and towards leisure/discretionary activities (physically inactive social/recreation, meals, non-maintenance shopping) during the weekend days.

3.2 Travel Characteristics

This section of the report compares weekday and weekend travel characteristics. The frequency of person trips undertaken for each activity purpose can be inferred from Table 1 as each activity episode is preceded by a trip. In addition to travel to these activity episodes, individuals on an average make 1.29 return-home trips during weekdays, 1.23 return-home trips during Saturdays and 1.14 return-home trips during Sundays. Therefore, the average number of daily person trips (across all trip purposes) per individual is 3.40 for the weekdays, 3.14 for Saturdays and 2.85 for Sundays. The PBQD study reports 8.87 person trips per household during weekdays and 8.02 person trips per household during weekend days. The two sets of numbers are reasonably consistent if we assume an average household size of about 2.5.

In the next few sections, we further examine the following travel-related characteristics: the time of day of travel (Section 3.2.1), the mode of travel (Section 3.2.2), the trip distance (Section 3.2.3) statistics, and the total volume of travel (Section 3.2.4).

3.2.1 Time of Day of Travel

Figure 1 presents the number of travel episodes in person-trips per 100 individuals ending during each one-hour period of the day. Several interesting observations can be made. First, an examination of the weekday profile in Figure 1 shows a distinct peaking of trips corresponding to the typical work start and end times. In other words, a large fraction of the weekday trips are concentrated during a few hours referred to as the morning and evening “peak” periods of the day. No such peaking is observed in the case of the weekend profiles. This could be the consequence of a greater temporal flexibility in undertaking weekend trips, which are often for non-work activity purposes. Second, the profiles indicate fewer trips during the early part of the day (up to 10 AM) on weekends when compared to weekdays. In contrast, the volume of weekend trips during the mid-day period (10 AM – 3 PM) is higher than the corresponding volume during the weekdays. Third, the profiles also reveal interesting differences in the characteristics of travel undertaken during the late evening period across weekdays and weekend days. The number of late evening (8 PM or later) trips is greatest on Saturdays, indicating a greater propensity to participate in out-of-home activities late into the evening on this day. In contrast, the number of such trips is the least for Sundays perhaps reflecting the desire to return home and rest prior to the start of another work week.

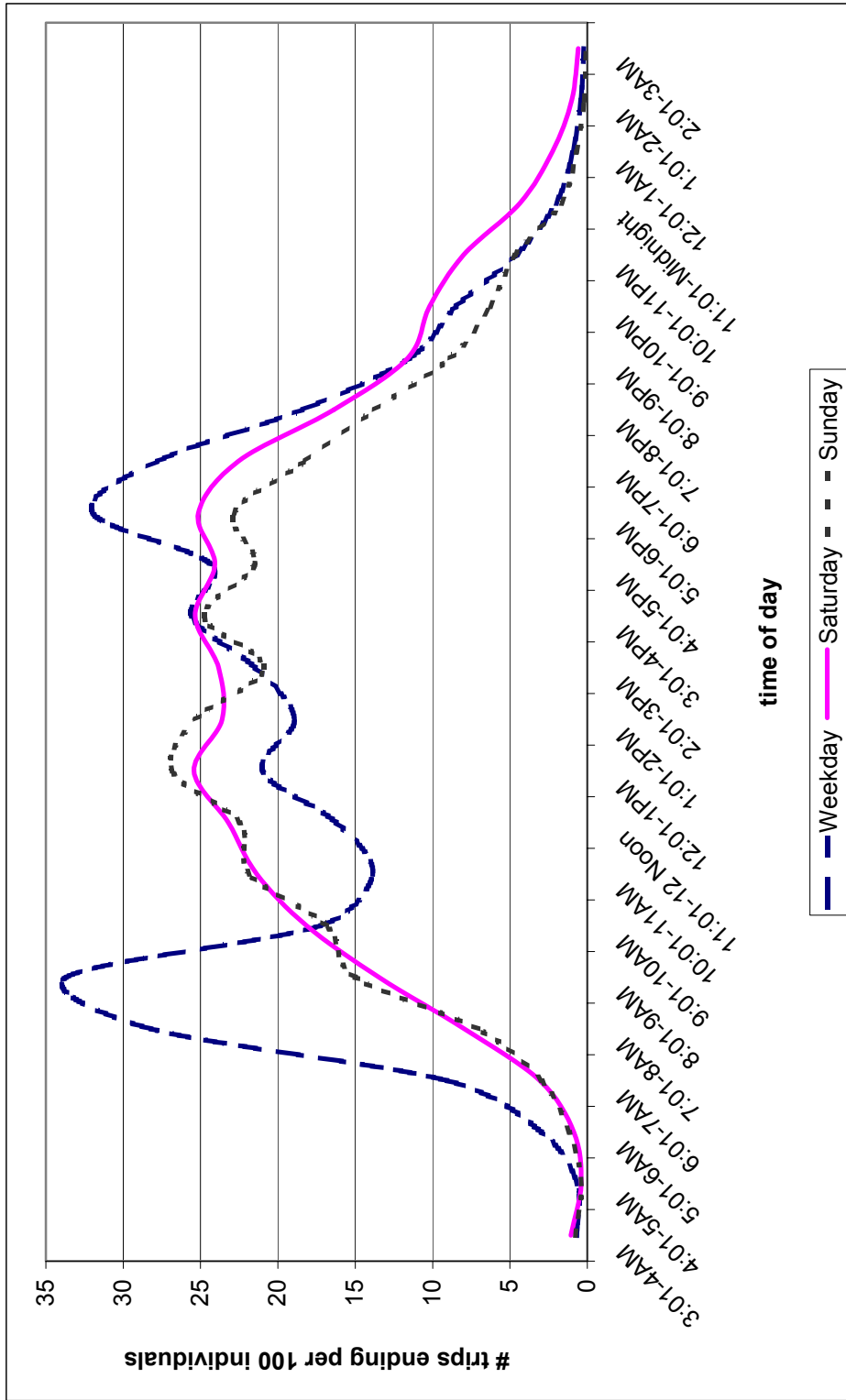


FIGURE 1 Time of day of travel.

3.2.2 Mode of Travel by Trip Purpose

Table 2 presents the percentage of trips undertaken by each of the following seven different travel modes: drive-alone, shared-ride with 2 individuals, shared-ride with 3 or more individuals, transit, bicycle, walk, and other modes. The results are presented for each trip purpose and in the overall. The shares for the auto modes (drive-alone, shared-ride with 2 people and shared-ride with three or more people) are examined first. For the aggregate category of all trip purposes (see the first row of Table 2), about 85% of trips are undertaken using one of the auto modes for both weekdays and weekend days. However, the share of the drive-alone mode is higher on weekdays compared to the weekend days and the converse is true for the shared ride modes. This could be due to the non-work nature of weekend activities. Since these activities are of a more relaxed and social nature, people are more likely to travel together with friends or family members. A further examination of the share of the auto modes by trip purpose reveals that trips to work/school, maintenance shopping, and personal business are more likely to be pursued by drive-alone relative to other purposes on weekdays (see the higher numbers for the drive-alone shares for these purposes on weekdays under the column labeled “drive alone” in Table 2). On weekend days, the drive alone share is the greatest for the work/school purpose. In contrast, the total share of the shared ride modes is higher than the drive alone share on weekend days for the physically inactive social recreation, meals, and non-maintenance shopping purposes. These are purposes for which there is likely to be a natural tendency to travel together with friends and family members.

TABLE 2 Travel Mode Shares (in Percentage) by Trip Purpose

Trip Purpose		Drive Alone	Shared Ride (2 people)	Shared Ride (>=3 people)	Transit	Bicycle	Walk	Other
Overall (All Purposes)	Weekday	54.45	17.77	14.46	1.87	1.40	9.28	0.78
	Saturday	40.58	24.13	24.46	0.87	0.83	8.06	1.05
	Sunday	38.88	25.17	23.60	0.96	1.62	9.04	0.72
Work/School	Weekday	61.66	11.14	10.01	3.62	1.59	10.60	1.37
	Saturday	63.70	11.51	7.88	2.88	0.75	9.26	4.01
	Sunday	62.14	11.88	8.32	3.74	1.36	9.85	2.72
Physically Active Social/Recreation	Weekday	48.63	17.62	19.02	0.79	1.95	11.48	0.51
	Saturday	30.87	19.94	31.51	0.96	2.89	12.86	0.96
	Sunday	41.21	15.93	26.37	0.55	3.85	11.54	0.55
Physically Inactive Social/Recreation	Weekday	38.97	23.78	22.47	1.87	1.45	10.38	1.08
	Saturday	27.42	26.76	33.45	1.24	0.65	8.73	1.75
	Sunday	30.53	29.82	25.15	1.17	1.99	9.71	1.64
Meals	Weekday	41.52	23.10	18.64	1.11	0.90	14.27	0.45
	Saturday	24.26	30.01	33.15	0.45	0.63	11.14	0.36
	Sunday	26.44	28.22	30.14	1.02	1.40	11.88	0.89
Maintenance Shopping	Weekday	63.20	18.29	10.18	0.58	1.12	6.27	0.36
	Saturday	50.34	19.18	21.58	0.34	0.51	6.85	1.20
	Sunday	49.30	24.85	16.30	0.20	1.39	7.95	0.00
Non-Maintenance Shopping	Weekday	55.97	23.37	12.54	0.89	0.67	6.27	0.30
	Saturday	40.43	31.08	23.20	0.74	0.52	3.90	0.15
	Sunday	37.18	32.19	24.20	1.00	0.67	4.66	0.11
Personal Business	Weekday	63.07	19.09	9.60	0.94	0.95	5.74	0.61
	Saturday	49.52	25.62	16.25	0.00	0.38	6.50	1.72
	Sunday	43.91	19.56	25.83	1.11	2.95	6.27	0.37
Serve Passenger	Weekday	30.71	33.39	32.82	0.27	0.33	2.38	0.10
	Saturday	25.27	32.23	39.74	0.18	0.18	2.38	0.00
	Sunday	27.20	30.49	38.74	0.27	0.00	3.02	0.27
Community/Religious	Weekday	57.85	19.19	14.55	1.24	0.81	5.98	0.38
	Saturday	46.88	20.00	25.63	0.00	0.00	6.25	1.25
	Sunday	26.50	32.50	33.17	0.33	1.00	6.50	0.00
Return Home	Weekday	56.97	15.90	12.83	1.71	1.77	10.10	0.71
	Saturday	44.70	21.88	21.77	0.82	1.12	8.93	0.78
	Sunday	41.65	22.85	21.64	0.71	1.98	10.60	0.59

Next, we examine the shares of the transit mode. In the overall (see first row under column labeled “Transit”), the share of transit decreases during the weekends. This may again be attributed to the non-work nature of weekend trips, which increases the reliance on using a personal vehicle because of joint activity participation or traveling to activities that begin or end at flexible times. The transit share is highest for the work/school trip purpose.

Finally, we examine the shares of the non-motorized modes (*i.e.*, bicycle and walk). In the overall (See first row of Table 2), the shares of these two modes are the least on Saturdays. On further examining the shares of these modes for different trip purposes, we find that there is a higher share of bicycle trips for physically active recreation during the weekend days, with the highest bicycle share occurring on Sundays. In the case of the walk mode, it is interesting to note that the share of this mode for the physically inactive social recreation, meals, and non-maintenance shopping during weekdays is higher than that during the weekends, a finding that deserves more attention in future research.

3.2.3 Trip Distances by Purpose

The average travel distances (in miles) by trip purpose are presented in Table 3. Overall, the weekend trips are longer than weekday trips, with the longest trips occurring on Sundays (see the first row of Table 3). Among the specific trip purposes, it can be observed that the average distances for social/recreation trips (both physically active and inactive), meals, and non-maintenance shopping are substantially longer during the weekends compared to weekdays. The implication here is that since there are relatively less work-related constraints during the weekends, individuals travel longer distances to reach their preferred activity venues. In addition, average trip distances for serve passenger type activities are considerably longer during the weekends, perhaps because of children being driven to sports activities and cultural events that are distant from home.

TABLE 3 Average Travel Distances (in Miles) by Trip Purpose

Trip Purpose	Weekday	Saturday	Sunday
Overall (All Purposes)	6.72	7.00	7.16
Work/School	9.02	8.77	9.93
Physically Active Social/Recreation	4.67	5.76	7.24
Physically Inactive Social/Recreation	6.80	10.20	11.14
Meals	5.31	7.14	7.44
Maintenance Shopping	4.91	4.61	4.33
Non-Maintenance Shopping	5.35	6.27	6.31
Personal Business	5.60	5.13	6.97
Serve Passenger	5.16	7.26	8.12
Community/Religious	5.06	6.43	5.14
Return home	6.52	6.48	6.51

3.2.4 Total Volume of Travel by Trip Purpose: PMT and VMT

Table 4 presents results on the total volume of travel undertaken by individuals for each activity purpose and in the overall. This travel volume is presented in terms of two measures, the person-miles of travel (PMT) per capita and the vehicle miles of travel (VMT) by personal automobiles per capita. The PMT was computed as the product of activity frequency and the average trip distance by purpose. The person trip frequencies were converted into vehicle trip frequencies using the modal shares and multiplied with the average trip distances to obtain VMT.

The results show that the overall PMT for weekdays and weekend days are comparable, implying that there is almost as much personal travel on weekends as there is during weekdays (see the first row of Table 4). The weekday VMT (by personal auto) is, however, larger than the weekend VMT (despite comparable PMTs) as a consequence of higher vehicle occupancy during the weekends. Among the weekend days, Saturdays exhibit greater overall PMT and VMT than Sundays. Also, the PMT and VMT are almost without exception greater on weekends than on weekdays for the non-work/school and non-return-home purposes, with the differences being particularly striking for physically inactive social/recreation, meals, and non-maintenance shopping trips. The reverse is true for work activities, whose PMT and VMT dominate weekday travel but are relatively small during the weekends.

TABLE 4 Total Volume of Daily Travel (PMT and VMT) by Trip Purpose

Trip Purpose	PMT per capita			VMT by personal auto per capita		
	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday
Overall (All Purposes)	22.85	21.97	20.40	15.57	13.36	12.10
Work/School	7.40	1.97	1.98	5.22	1.42	1.40
All Non Work/School and Non Return-Home Purposes	7.04	12.01	10.97	4.60	6.78	6.17
Physically Active Social/Recreation	0.31	0.50	0.45	0.20	0.26	0.26
Physically Inactive Social/Recreation	1.22	3.95	3.22	0.71	2.05	1.73
Meals	1.20	2.24	1.97	0.71	1.13	1.00
Maintenance Shopping	0.61	0.76	0.74	0.46	0.51	0.49
Non-Maintenance Shopping	0.99	2.40	1.92	0.71	1.53	1.18
Personal Business	1.10	0.76	0.64	0.83	0.51	0.40
Serve Passenger	1.37	1.12	1.00	0.80	0.61	0.55
Community/Religious	0.24	0.29	1.04	0.17	0.19	0.56
Return Home	8.40	7.99	7.45	5.81	5.03	4.49

CHAPTER 4. DETAILED EPISODE SEQUENCING CHARACTERISTICS

This section is focused on examining how individuals organize their weekend days; *i.e.*, how individuals sequence the various activities they desire to undertake into an overall activity-travel pattern for the day. The overall sequencing of out-of-home and in-home activity episodes is first examined in terms of an activity-transition matrix. Next, the sequencing of out-of-home activity episodes is examined in further detail in terms of activity chaining propensities and the choice of first and last stops of the day. The reader will note that this section, unlike section 3, does not provide a comparative analysis of weekday versus weekend characteristics. Rather, the intent is primarily to describe weekend activity-sequencing behavior. The reader is referred to research by Bhat and Singh (2000) and Misra and Bhat (2000) for studies on activity sequencing behavior in the context of weekdays.

4.1 Overall Sequencing of Activity Episodes

In this section, the overall sequencing of episodes by activity type is examined in terms of the state dependence effects between consecutive activity episodes (in-home episodes are included in this sequencing analysis). A transition matrix of activity episodes is designed to represent the likelihood that a subsequent episode of a certain type will occur given an episode of a current type. This transition matrix is presented in Table 5 for Saturdays (the transition matrices were not particularly different for Saturdays and Sundays, and so we discuss the matrix for Saturdays only for presentation simplicity). The columns in Table 5 represent the type of the current activity episode, while the rows indicate the type of the subsequent activity episode. The entries in each cell indicate the percentage of occurrence of an activity episode of type “z” (*i.e.*, the activity type of the row) subsequent to activity episode of type “y” (*i.e.*, the activity type of the column). For example, the value of 5.41 in the first cell of Table 5 implies that, of 10,000 occurrences of work/school activity episodes on Saturdays, 541 are followed by another work/school episode. Note that the percentages sum to 100 in each column.

TABLE 5 Activity Episode Transitions (in Percentage) Matrix for Saturdays

	Current activity episode										
	Work/ School	Phy. Active Soc./Rec.	Phy. Inactive Soc./Rec.	Meals	Maint. Shopping	Non-Maint. Shopping	Personal Business	Serve Passenger	Community/ Religious	In-Home	
Subsequent activity episode	5.41	0.97	0.96	3.90	2.40	1.70	3.07	6.43	1.89	4.51	
Work/School	0.77	1.94	0.44	1.00	1.37	0.74	1.72	2.94	0.00	1.85	
Phy. Active Soc./Rec.	4.25	7.12	11.19	10.07	4.45	6.13	7.28	9.38	5.03	6.52	
Phy. Inactive Soc./Rec.	7.08	9.71	10.08	3.18	6.85	8.43	8.43	8.46	8.81	4.62	
Meals	3.09	1.29	2.59	2.72	5.31	6.13	7.47	4.23	4.40	2.38	
Maint. Shopping	5.53	8.74	6.82	9.53	5.99	14.86	16.09	6.80	3.77	5.61	
Non-Maint. Shopping	2.45	4.21	1.11	2.18	2.91	2.37	7.66	1.65	2.52	2.69	
Personal Business	3.47	3.56	3.26	3.36	1.88	2.07	1.15	7.17	4.40	2.59	
Serve Passenger	0.26	0.00	0.67	0.64	0.34	0.52	0.57	1.29	0.00	0.95	
Community/ Religious	32.30	37.54	37.14	36.57	31.51	42.94	53.45	48.35	30.82	31.72	
All Out-of-Home Types	67.70	62.46	62.86	63.43	68.49	57.06	46.55	51.65	69.18	68.28	
In-Home											

There are many interesting findings from the transition matrix. Episodes of all out-of-home activity types, except personal business, are more likely to be succeeded by an in-home activity episode than an out-of-home activity episode as can be observed by comparing the last two rows in Table 5 for the columns corresponding to each current out-of-home activity purpose. This suggests that people, in general, prefer to return home immediately after undertaking out-of-home episodes. This desire could be motivated by different factors. For example, an in-home episode immediately after a maintenance-shopping episode might be motivated by the need to transport the perishable foods back home and refrigerate them. In the case of physically active social/recreation episodes, the desire to rest and clean up might motivate returning home. Personal business is found to be the activity that is most likely (among all out-of-home activity episodes) to be followed by another out-of-home activity episode indicating that personal business activity episodes (such as banking) tend to be chained with other out-of-home activity episodes. Serve passenger episodes are almost equally likely to be followed by either an in-home or out-of-home activity episode.

For each type of the current activity episode, detailed characteristics of the succeeding activity types are now discussed. The numbers in the column labeled “work/school” in Table 5 indicates that the out-of-home activity types that are most likely to be undertaken immediately after a work/school episode are meals, another work/school episode, non-maintenance shopping and physically inactive social/recreation. In contrast, physically active social/recreation and community/religious activity episodes are very less likely to be undertaken immediately after work.

The out-of-home activity types that are very likely to be undertaken immediately after a social/recreation episode (both physically active and inactive types) are meals, non-maintenance shopping, and physically inactive social/recreation (see second and third columns of Table 5). As one would expect, it is more likely for a physically inactive social/recreation episode to be followed by another episode of the same type than it is for a physically active social/recreation episode to be followed by another episode of the same type.

The out-of-home activity types that are most likely to be undertaken immediately after a “meals” episode (see column labeled “meals” in Table 5) are physically inactive social/recreation (perhaps this is a case of dinner before a movie), non-maintenance shopping, and work (this could be lunch between work episodes; note that out-of-home meals is an activity that is also

likely to follow a work episode). As we would expect, physically active social/recreation episodes are less likely to follow meals episodes.

Maintenance shopping episodes are very likely to be succeeded by an in-home activity episode rather than an out-of-home episode. As already discussed, this could be motivated by the desire to transport the purchased food items back home and store them. The most common out-of-home activity types to immediately follow a maintenance-shopping episode are maintenance and non-maintenance shopping.

The out-of-home activity episode type most likely to follow a non-maintenance shopping episode is another non-maintenance shopping episode, indicating travel between stores for either browsing or purchasing items. The other out-of-home activities that are most likely to follow a non-maintenance shopping episode are meals, physically inactive social/recreation and maintenance shopping.

As already discussed, personal business activities are the most likely (among all out-of-home activity types) to be followed by another out-of-home activity episode (see column labeled “personal business” in Table 5). In fact, it is found that personal-business episodes are more likely to be followed by an out-of-home episode than an in-home episode. The most common out-of-home activity types that are undertaken immediately after a personal business episode are non-maintenance shopping, meals, maintenance shopping, and physically inactive social/recreation.

Serve passenger episodes are almost equally likely to be succeeded by either an in-home episode or an out-of-home episode while community/religious episodes are the most likely to be followed by an in-home episode of all activity types. This last finding for Saturdays, however does not extend to Sundays where participation in out-of-home activities is much more prevalent after community activities. This is perhaps because community/religious episodes on Saturdays tend to be volunteer work, while episodes of this type on Sundays tend to be religious in nature with out-of-home social events and meals following the religious service.

Finally, the out-of-home activity episodes that are most likely to be undertaken as the first episode of a home-based tour (*i.e.*, immediately following an in-home episode) are physically inactive social/recreation, non-maintenance shopping, meals, and work/school (see the last column of Table 5).

4.2 Activity Episode Chaining

This section of the report further examines the sequencing of out-of-home activity episodes in terms of the organization of out-of-home activity episodes into tours. Specifically, we examine the chaining of out-of-home activity episodes, *i.e.*, the behavior of people to undertake multiple out-of-home activity episodes (or stops) as a part of the same sojourn or home-based tour. The activity episode chaining for each activity purpose, T , is described in terms of the *chaining propensity*, which is defined as the ratio of the number of multiple-stop tours containing activity type T to the total number of tours containing activity type T . For example, if out of 1000 home-based tours each comprising at least one shopping activity episode, 700 tours comprise only the shopping episode and the remaining 300 comprise one or more other stops in addition to shopping, then the chaining propensity for shopping is $300/1000 = 0.3$. Thus, for activity type T , a chaining propensity of 1 would indicate that all episodes of this type are chained with other out-of-home activity episodes (*i.e.*, they are undertaken in tours with multiple stops), whereas a chaining propensity of 0 would imply that episodes of type T are never chained with other out-of-home activity episodes (*i.e.*, they are undertaken in single-stop tours).

The chaining propensities for the different activity types and for each day of the weekend are presented in Table 6. In the overall, 38% of all out-of-home tours during Saturdays are chained (*i.e.* involve multiple activity episodes) while 36% of all tours during Sundays are chained (see first row of Table 6). This marginally higher chaining propensity during Saturdays when compared to Sundays might be a consequence of the greater frequency of out-of-home activity episodes during Saturdays when compared to Sundays (See Table 1) leading to a “more purposeful organization pattern” (Misra and Bhat, 2000). A further examination of the chaining propensity by activity purpose reveals several interesting results. Work/school, physically active social/recreation, and community/religious activity episodes are more likely to be undertaken alone than being chained. The work/school activity episodes are the least likely (among all activity purposes) to be chained. Perhaps the relatively strict spatial and temporal constraints within which the work/school activity is undertaken and the long durations invested in episodes of this purpose make it undesirable for persons to chain this activity with other out-of-home activity episodes.

TABLE 6 Chaining of Activity Episodes by Purpose

Activity Purpose	Saturday	Sunday
Overall (All Activity Purposes)	0.38	0.36
Work/School	0.40	0.41
Physically Active Social/Recreation	0.48	0.45
Physically Inactive Social/Recreation	0.53	0.53
Meals	0.62	0.65
Maintenance Shopping	0.63	0.61
Non-Maintenance Shopping	0.62	0.58
Personal Business	0.69	0.63
Serve Passenger	0.66	0.71
Community/Religious	0.41	0.43

In contrast to work/school, physically active social/recreation, and community religious purposes, the chaining propensities for other out-of-home activity purposes (*i.e.*, physically inactive social/recreation, meals, maintenance shopping, non maintenance shopping, personal business, and serve passenger) are greater than 0.5 and hence episodes of these activity types are more likely to be undertaken as a part of a chained tour than as part of a single-stop tour. Among the episodes of these activity purposes, personal business and serve passenger episodes are the most likely to be chained. Personal business activity episodes may often be used as a way to facilitate participation in other activity episodes. For example, an individual could make a trip to the bank to withdraw money in order to go shopping or to participate in a recreational activity. Similarly, the desire to participate in activities with friends and family may involve pick-ups prior to undertaking the desired activity and drop-offs after participating in the activity, leading to chained tours involving serve-passenger activity episodes.

4.3 Activity Purpose of the First and Last Out-of-Home Episode of the Day

This section examines the sequencing of out-of-home activity episodes in the context of the entire day by examining the likelihood that episodes of each activity purpose are undertaken as the first and last out-of-home episode for the day, conditional on participation in that activity purpose (Table 7). This analysis is restricted to only persons undertaking two or more out-of-home activity episodes during the day.

TABLE 7 The First and Last Out-of-Home Activity Episodes of the Day

Activity Purpose	Saturday		Sunday	
	% as the First Episode	% as the Last Episode	% as the First Episode	% as the Last Episode
Work/School	46.5	19.4	41.2	25.5
Physically Active Social/Recreation	50.8	20.1	36.6	28.9
Physically Inactive Social/Recreation	26.8	37.5	24.2	40.5
Meals	20.8	41.7	22.7	37.9
Maintenance Shopping	24.1	36.6	26.3	44.7
Non-Maintenance Shopping	25.6	25.7	26.1	30.9
Personal Business	45.8	13.8	36.3	23.5
Serve Passenger	29.1	26.5	30.1	31.8
Community/Religious	38.9	29.8	69.8	13.4

The numbers in Table 7 are interpreted as follows. For the work/school purpose, 46.5% of the episodes occur as the first episode of the day and 19.4% of the episodes occur as the last episode of the day. Thus, the results indicate that work/school activity episodes have a high likelihood of appearing first in the day (for both Saturdays and Sundays) and a low likelihood of being undertaken as the last stop. This is intuitive given that work and school activities often entail early morning start times. Further, individuals might desire to complete these mandatory activities before engaging in discretionary non-work activities. Physically active social/recreation episodes are also highly likely to be undertaken as the first activity of the day (especially on Saturdays) and less likely as the last episode of the day. The physical nature of these activities may motivate the individuals to undertake it earlier in the day when they are fresh and active rather than during the later part of the day. Physically inactive social/recreation episodes, meals, and maintenance shopping are relatively less likely to occur as the first episode of the day and more likely to occur as the last episode of the day. Most activities involving time constraints would already be participated in by this point, allowing for leisurely meals or recreation activities to occur in the evenings.

Non-maintenance shopping and serve passenger episodes are found to have a low likelihood of occurring as either the first or the last stop of the day. Rather, these activities are more likely to be undertaken as an intermediate activity during the day. Personal business episodes are more likely to be undertaken as the first episode on Saturdays when compared to

Sundays. In contrast, these are more likely to be undertaken as the last episode during Sundays when compared to Saturdays. Finally, community/religious activity episodes undertaken during Sundays are very highly likely to be undertaken as the first episode of the day. These activities are for religious services that occur on Sunday mornings.

CHAPTER 5. SUMMARY AND CONCLUSIONS

Weekend activities and travel constitute a significant component of the overall weekly activity-travel participations of individuals. Consequently, weekend activity-travel participation behavior and its implications on traffic patterns and mobile source emissions cannot be ignored. Further, reliable evaluation of the effect of transportation control measures requires explicit consideration of substitution between weekday and weekend activity participation. Motivated by these reasons, this report presents a comprehensive exploratory analysis of weekend activity-travel participation behavior data from the 2000 Bay Area Travel Survey (BATS) were used for the analysis.

A comparative analysis of the weekday and weekend activity-travel participation behavior indicates that the total volume of travel undertaken during weekdays and weekend days are comparable. The total person miles of travel (PMT) is about the same on a typical weekday and on weekend days while the total vehicle miles of travel (VMT) on a weekend day is about 80% of weekday VMT. Clearly, these results indicate that weekend activities and travel cannot be treated as “second class episodes” or “non existing episodes” in travel-demand modeling. In addition, our results highlight the many differences among the characteristics of the activity-travel patterns undertaken on weekdays, Saturdays and Sundays:

1. Activity participation during weekends is oriented toward discretionary/leisure activities in contrast to weekday activity participation behavior, which is oriented towards work/school and maintenance activities.
2. The weekend travel patterns do not exhibit the peaking characteristics associated with weekday patterns; the peak weekend travel occurs during the mid-day period, which corresponds to the weekday off-peak period
3. Transit shares are lower during the weekends whereas the occupancy levels in personal automobiles are higher during the weekends
4. The average trip distances are longer during the weekend days.

The above results indicate that simply transferring weekday models to weekend days may not be appropriate from a travel forecasting perspective. Further, the differences between weekdays and weekend days, especially in the temporal profiles of the travel patterns, also have substantial implications for air quality modeling. Specifically, the sustained high volume of weekend trips

during the hotter (*i.e.*, mid-day) period of the day amplifies the severity of the impact of emissions on air quality. Further, the longer soak times of vehicles prior to first use during weekends (as a consequence of departure from home much later in the day) compared to weekdays could also augment air pollution from emissions.

An examination of the sequencing of the activity episodes by purpose on weekend days indicates that episodes of all out-of-home activity types, with the exception of personal business, are found to be more likely to be succeeded by an in-home activity episode than an out-of-home activity episode. In particular, maintenance-shopping and community/religious episodes are found to be most likely to be succeeded by an in-home episode. In contrast, personal business episodes were found to be the most likely to be immediately followed by an out-of-home episode rather than an in-home episode.

The analysis of the propensity to chain episodes shows that serve passenger activities, personal business, meals, and maintenance shopping are the activity types most likely to be chained with other episodes. In contrast, work/school, physically active social/recreation and community/religious activities are least likely to be chained.

Finally, our results reveal that work/school, physically active social/recreation, and community/religious (on Sundays) are most likely to be undertaken as the first out-of-home episode. Physically inactive social/recreation episodes, meals, and maintenance shopping are more likely to occur as the last episode of the day.

In summary, the descriptive analysis undertaken in this report provides empirical evidence in support of the hypothesis that weekend activity-travel patterns are different from weekday patterns. Thus, this research is envisioned as a first step toward developing comprehensive travel-demand models that encompass both weekday and weekend travel behavior. Such travel demand models should (1) recognize critical differences between the weekday and weekend activity-travel desires (for example, the leisure orientation of the weekends in contrast to the mandatory and maintenance activity orientation of weekdays), (2) the relative lack of spatial and temporally constrained activities on weekend days compared to the weekdays, (3) strong inter-personal interactions on weekend days due to joint activity participation and travel, and (4) differences in the activity travel environment across weekdays and weekend days (for example, differences in facility operation hours, lower transit level-of-service, *etc.*).

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