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A METHOD FOR IMPROVING THE USEFULNESS OF HIGHWAY TRAFFIC DATA IN TOURISM STUDIES: A MICHIGAN CASE STUDY

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ABSTRACT

A METHOD FOR IMPROVING THE USEFULNESS OF HIGHWAY TRAFFIC DATA IN TOURISM STUDIES: A MICHIGAN CASE STUDY

By

Sinji Yang

Although the highway traffic data collected by the Department of Transportation is a set of comprehensive recordings of highway travel activities, the inherent problems in the data have deterred tourism researchers from using the data up to their full potential for many tourism studies and planning purposes. In addition, using untreated data, which contain tourism and non-tourism traffic, in tourism reports can produce misleading results.

This exploratory study was launched to examine the characteristics of highway traffic data, to enhance connections between highway traffic data and tourism studies, and to demonstrate that valuable tourism information can be derived from underutilized highway traffic data. These goals were achieved by the development of a new data processing method called the Removal of Routine Traffic Method. The method is designed to mitigate the problem of separating tourism traffic from non-tourism traffic thereby facilitating greater and more meaningful use of highway traffic data in the field of tourism.

Based on the patterned behavior of highway travelers, a conceptual model was developed to link highway traffic data to tourism studies. Traveler behavior theory

suggests that removing routine traffic from total traffic can improve data relevancy for tourism studies.

As a measurement of tourism traffic, the Removal of Routine Traffic Method provides face and construct validity in estimating tourism traffic. In a nutshell, the method functions as a filter screening out non-tourism traffic from total traffic and leaving the residual as an improved estimate of tourism traffic. Although the concept is relatively straightforward, it has been proved to be powerful. Using 1998 Michigan highway traffic data as an example, the method improved the overall data relevancy to tourism by 364%. Even simply performing the removal of truck traffic (i.e., non-recreational type vehicle traffic) can improve the overall data relevancy to tourism by 12%.

With the Removal of Routine Traffic Method, researchers not only can better understand the behavior of highway travelers and tourism traffic flows but also know how to utilize the extensive highway traffic data with the confidence that the estimates they derive are closer to their true values. Regional tourism planners or business operators can promptly estimate tourism traffic flow on a specific day or period of time if traffic counters are installed on vicinity highways. With only a small amount of initial investment in data storage and database programming, the removal of routine traffic operation can be highly automated. That is, the method is efficient and economical compared to other methods used in tourism studies. Hopefully, this study will encourage more researchers to use highway traffic data for regional tourism studies and planning, and to build upon this research to further improve tourism traffic volume estimates.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Highway System and Tourism

In the early 1980s, Francis B. Francois, Executive Director of the American Association of State Highway and Transportation Officials, considered the U.S. highway systems to be "the most awesome highway networks anywhere" in the world (Transportation Research Board, 1982). In 1996, the total length of public roads was 3.9 million miles. On each square mile of land, there was 1.05 miles of public road (FHWA, 1997). Although air travel has become an increasingly popular means of transportation, U.S. highway systems remain intensively used in the United States. According to the U.S. Travel Data Center (1996), the trend in use of personal vehicles and highways in the United States remains stable. This is because the need for personal vehicles has become indispensable for most travel activities, especially outdoor recreation, in the United States. Furthermore, for almost all air travelers, air carrier services are simply a part of their total travel services itinerary. Ground vehicles are almost always needed for air travelers to move from point to point within both origin and destination areas.

In the United States, 2,423 billion vehicle miles were registered in 1995. There are about 128 million registered automobiles in the United States, about 0.48 automobiles per capita (U.S. Bureau of Census, 2000).

About 83% of person-trips were taken by auto (including light trucks, RVs) and buses. Pleasure and business travelers accounted for 63% and 22% of auto person-trips during 1995, respectively. An inclusive definition of tourism recommended by the World

Tourism Organization (1991) counts both pleasure and business trips as tourism. (The WTO's definition of tourism will be discussed in the section of "Definitions of Terms.") If this definition of tourism is used, 85% of auto person-trips can be considered tourism related. According to the U.S. Bureau of Census, air travel only accounted for 16% of person-trips in the United States in 1995. The rest of person-trips (i.e., 84%) were almost all taken on highways (U.S. Bureau of Census, 2000). Since, as stated before, most air-trips also involve some kind of ground transportation, the actual percentage of auto person-trips would be much higher than that estimated by the U.S. Bureau of Census.

As one can see, almost every tourism activity involves using ground vehicles and highway systems. Therefore, highway traffic data are potentially an important source of information for those who engage in regional tourism studies.

1.1.1 Highway Traffic Data Collection

In the 1930s, statewide highway planning surveys were established to collect highway traffic characteristic information (FHWA, 1995). Since then, highway traffic data have been continuously collected by the Departments of Transportation of both state and local governments under the guidance of the Federal Highway Administration (FHWA) of the U.S. Department of Transportation (DOT). For example, the Michigan Department of Transportation (MDOT) is responsible for collecting and preparing highway traffic data in Michigan and making them available to the general public.

To increase reliability of data collection and efficiency of highway monitoring, the Federal Highway Administration has continuously made efforts to improve the methodologies applied in highway performance monitoring. According to the FHWA

(1995), its current highway performance monitoring procedures emphasize the use of a stratified random sampling method to produce reliable estimates, and integrated data collection processes to minimize data collection efforts, so that duplications in data collection can be reduced.

The integrated Highway Performance Monitoring System is designed to collect highway traffic volume, vehicle classifications, and truck weight data in a sequential format. Specifically, traffic volumes are sampled from the existing Highway Performance Monitoring System, vehicle classification information is derived from the traffic volume samples, and truck weight data are derived from the vehicle classification samples. When traffic volume data are collected, vehicle classification and truck weight data are also collected. Recently vehicle speed has been experimentally added to the data collected by the integrated Highway Performance Monitoring System, and, as new monitoring equipment is installed across the system, vehicle speed data will become more widely available.

Since highway traffic monitoring demands a significant amount of financial and human resources, the locations of traffic monitoring stations are generally determined by: (1) available funding to state and local governments, (2) perceived highway traffic characteristic information needs, and (3) previous efforts and commitment to data collection (FHWA, 1995). Thus, traffic data are usually collected in more populated areas where traffic volumes are relatively high. Regional tourism development may not be a major factor that influences the locations of permanent traffic monitoring stations.

1.1.2 Current Uses of Highway Data

Information about highway traffic can be used in a variety of ways by both public and private sector planners. The public sector uses traffic data in highway construction and re-construction planning, routing and detour design, economic benefit studies, transportation growth forecasting, and highway traffic control policies and regulations. The private sector uses traffic data to select business service areas and store locations, to plan parking and shuttle connections, and to develop marketing strategies (FHWA, 1995; U.S. Bureau of Census, 1999).

All levels of governments which spend a great amount of effort and money in collecting highway traffic data naturally remain the major users of these data. In the private sector, oil companies, restaurants, banks, real estate developers, and outdoor advertisers are the major users of highway traffic data (Cuyahoga County Engineer's Office, 1999). Although highway traffic data are readily available to the general public, the private sector has made less use of them than the public sector; moreover, the data are usually used in the forms that they are obtained.

1.2 Problem Statement

Chadwick (1994) points out that, because of the special nature of the tourism industry, it lacks distinct products and services. Therefore, economists generally don't consider travel and tourism to be an industry. Thus, any attempt to account for tourism in the gross national product (GNP) (i.e., the National Account) is liable to lead to double counting because economic activities of all travel and tourism establishments are already allocated to existing industries according to the Standard Industrial Classification system in use. A great amount of research effort has been focused on distinguishing tourism from non-tourism to avoid the double counting problem. For example, a Satellite Account, which uses a more sophisticated approach to distinguish tourism from other industries, can measure tourism more precisely than a National Account (Chadwick, 1994; Statistics Canada, 1991a). However, there is a continuing need to search for better methods to separate tourism form non-tourism. A similar problem is faced by tourism researchers using highway traffic data as a source of information for tourism studies.

As previously mentioned, a great portion of tourism trips are taken on highways in personal vehicles. Thus, highway traffic data have the potential for becoming a central source of information that researchers can utilize in tourism studies. Examining highway traffic data by can help tourism researchers better understand the tourism phenomenon, namely, its directional flow over periods of time, peaking tendencies, spatial distribution, and so on. Furthermore, estimates of tourism volume from highway traffic data can be used independently or in combination with other tourism data.

Although highway traffic data could be a valuable source of information for tourism studies, they are sometimes ignored and rarely, if ever, used to their full potential. Even governments, which recognize the important contributions of tourism to local economies, have failed to facilitate the use of these data fully in regional tourism planning studies. Even though a great number of tourism studies have been conducted, there has been little effort expanded to make highway traffic data more useful in the field of tourism. Reviewing published travel and tourism research in journals, one can rarely find articles or reports focusing on highway traffic and tourism. In the few instances where highway traffic data have been used, they are presented in their raw formats (e.g., the Average Daily Traffic) prepared by the Department of Transportation. Taking the Michigan Travel Indicators Reports (Yang and Holecek, 1996-99) as an example, Average Daily Traffic (ADT) volumes from a set of traffic counters over a year were aggregated and compared to their levels in the previous year. The derived percent changes were used as indicators of increase or decrease in tourism trips during the year. This method of estimating tourism growth is correct only when the growth of tourism traffic is in the same proportion as growth of total traffic. The fact is that the relation between tourism traffic and total traffic is generally unknown, and that reported traffic data include both tourism and non-tourism traffic. Thus, using them in tourism studies is always problematic.

To date, little scientific attention has focused on increasing understanding of the relationship between highway traffic and tourism trips. Traffic data in raw form have utility in some applications, but even in these cases, only insubstantial conclusions can be drawn. Given the costs and complexities of generating reliable tourism data, it seems worthwhile to explore ways by which readily available traffic data can be modified to improve their usefulness.

1.2.1 Problems in Using Highway Traffic Data

Researchers may fail to fully utilize highway traffic data in tourism studies due to the following problems with the data:

1. Traffic data are collected for non-tourism purposes. The main purpose for collecting highway traffic data is not for tourism studies but for general

purposes such as highway planning and re-constructions. Useful information for tourism and private business is neglected in the government traffic data reports. While more and more state and local governments have started to publish Average Daily Traffic data on the Internet for public access, it is still not easy for the private sector to analyze the data and sort out meaningful information.

2. Untreated traffic data are imperfect indicators of tourism. To private business operators, traffic flow is considered a business opportunity passing through a region or a site. Whatever deters traffic flow going through a region may generate opportunities to do business with those traveling through the region. For example, traffic flows may be deterred by severe weather conditions. Travelers may stop in a region for special scenery, events, stores, or restaurants on the way to their primary destination if the special attractions generate sufficient interest. While highway traffic data implicitly contain information on the size of potential tourism business opportunities, the size of vehicle count includes people traveling for a wide range of purposes. The inherent problem in using untreated highway traffic data in tourism studies is that traffic counting devices indiscriminately count all vehicles without recording whether a passing vehicle is driven by a pleasure traveler, a commuting worker, or a business traveler. Despite significant advances in traffic monitoring technology that allows separating car traffic from truck traffic, it is still very difficult to capture the trip purposes of highway travelers using

remote counting devices. There are ways to develop trip purpose information. For example, vehicles can be randomly stopped and their occupants surveyed. However, this method is rarely used today because it is costly. It also disrupts traffic and no longer is legal. Information on trip purposes, however, is what tourism researchers use to distinguish tourism from other forms of travel. Without knowing the trip purposes of travelers, it is theoretically impossible to separate tourism traffic from non-tourism traffic. Although highway traffic data are a set of comprehensive recordings of highway travel activities, using untreated highway traffic data in tourism studies may yield misleading results.

1.2.2 Need for a New Method to Resolve Problems

The Department of Transportation's current data processing method, which is not designed for tourism studies and unable to distinguish tourism from non-tourism traffic in highway traffic data, has limited use in the field of tourism. If highway traffic data can be separated into tourism and non-tourism related traffic, they will be much more valuable to tourism researchers as well as to business operators. Information on the potential size of tourism traffic on highways is also valuable to regional tourism planners, such as local Conventions and Visitors Bureaus (CVBs). To date, however, very little effort has been expanded in developing an appropriate data processing method to make traffic data more useful for tourism researchers, planners, and business operators. Thus, there is a need for new highway traffic data processing methods to mitigate the inherent problems in highway traffic data and to make them more useful for tourism studies.

1.3 Purposes and Objectives of the Study

The purposes of this study are: (1) to improve the relevancy of remotely sensed highway traffic data to tourism studies, and (2) to develop sound procedures for removing non-tourism elements from highway traffic data sets in order to enhance their applicability. Hopefully, this effort will stimulate greater use of these data as well as research that will further improve the utility of these data in tourism research applications.

The main objective of this study is to develop a methodology for refining highway traffic data for tourism research applications. It is designed to mitigate the inherent problem of distinguishing tourism from non-tourism traffic in remotely sensed highway traffic data. Using this new method, researchers will be able to estimate tourism from total traffic flow.

The purposes of this study will be facilitated and achieved by accomplishing the following objectives:

1. Identify the essential characteristics of highway traffic data and tourism related information that help link highway traffic data to tourism.
2. Construct a theoretical (conceptual) model to guide the development of a data processing method toward achieving the main objective described above and in the next step.
3. Develop a data processing method that mitigates the problem of separating tourism traffic from non-tourism traffic and which facilitates the use of highway traffic in the field of tourism.

4. Demonstrate how to estimate tourism traffic from total traffic flow by using the new method and determine the tourism relatedness of different highway routes.
5. Assess the validity of the method based on estimated tourism traffic and theoretical criteria.
6. Measure the degree to which the newly proposed method improves the relevancy of traffic data to tourism.

1.4 Definitions of Terms

The following definitions of terms are provided to avoid misunderstanding and confusion and will be used throughout this report.

Tourism—While there are different definitions of tourism, the term generally means pleasure travel in its daily usage. In 1991, the World Tourism Organization (WTO) recommended the following inclusive definition:

> Tourism: The activities of a person traveling outside his or her usual environment for less than a specified period of time and whose main purpose of travel is other than exercise of an activity remunerated from the place visited, where:
>
> 1. "usual environment" is intended to exclude trips within the area of usual residence and also frequent and regular trips between the domicile and workplace and other community trips of a routine character;
>
> 2. "less than a specified period of time" is intended to exclude long-term migration; and
>
> 3. "exercise of an activity remunerated from the place visited" is intended to exclude only migration for temporary work. (WTO, 1991)

In accordance with WTO's definition, Chadwick (1994) suggests the term "travel and tourism" used in combination to describe human and business activities associated with the aspects of temporary movement of people away from their home and work environments for pleasure, business, and personal reasons. In this study, the WTO's definition of tourism is used. Further, the term "tourism" is used as an equivalent to "travel and tourism" as suggested by Chadwick (1994).

Tourism Traffic—In this study, the term "tourism traffic" means traffic generated by persons who travel for pleasure, visiting friends or relatives, staying in seasonal homes, attending business conferences, or for other reasons related to/or associated with leisure. These trips can be either long or short distance day trips as well as overnight trips. There are many kinds of tourism trips. The most common tourism trips are listed below:

- Multipurpose vacation trips
- Business trips that include some leisure opportunities and associations
- Weekend trips to a recreation destination or to visit friends or relatives
- Trips to a second home or time-share
- Day trips to recreation destinations, visit friends or relatives, or leisure shopping
- Day trips primarily for driving itself (Kelly, 1996)

The main characteristic of these tourism trips is that they are not routinely taken by most people.

Non-Tourism Traffic—Although it may not be possible to distinguish clearly tourism from non-tourism traffic, generally non-tourism traffic includes: 1) truck traffic generated by cargo deliverers who use large size trucks to accomplish these tasks, and 2) routine traffic generated by commuters and local residents whose purposes of trips do not fit into the WTO's definition of tourism. For example, routine trips would include going to and from work, school, grocery shopping, seeing a doctor, etc.

Traffic Volume—Traffic volume is a count of passing vehicles at a specific site on a highway over a period of time. While mathematically highway segments are one-dimensional lines on a surface, traffic volumes are point data with no dimension. The Department of Transportation's concept of highway performance monitoring is basically using point data to infer traffic flow on a line and then possibly in an area.

Directional and Non-Directional Traffic Data—Most highway routes are bi-directional. Thus, traffic volumes are collected according to the directions of traffic flows. Usually, the traffic volume in one direction does not equal that in the other direction. Non-directional traffic data are derived by aggregating directional traffic data from both directions.

Tourism Dominance—Tourism dominance is determined by the percentage of tourism traffic on a route. There are two kinds of tourism dominance—absolute and relative. A highway route is "absolutely" tourism dominant if tourism traffic is proportionally greater than non-tourism traffic on the route. A highway route is "relatively" tourism dominant if tourism traffic on the route is proportionally greater than that on other routes. The tourism relatedness of highway routes can be determined by their tourism dominance. A highway route is more tourism related if it is more tourism dominant.

Tourism Relevancy--Tourism relevancy of traffic data can be determined by the percentage of tourism traffic in total traffic. A higher percentage of tourism traffic in data sets implies that their relevancy to tourism is also higher.

Rural- and Urban-Type Tourism--The term rural-type tourism is used to describe trips whose destinations are in rural areas. Urban-type tourism is used to describe trips whose destinations are in urban areas.

Average Daily Traffic (ADT)—According to DOT, Average Daily Traffic is the weighted averages of traffic volume occurring on weekdays, Saturdays, and Sundays within a given period of time. The following formula is used by DOT to calculate ADT:

$$ADT_i = \frac{(average\ weekday_i \times 5) + average\ Saturday_i + average\ Sunday_i}{7}$$

where i is a period of time such as a month or a year. ADTs negate disparities in the number of weekdays and weekend days in a month or a year and thus facilitate comparing traffic volumes over different time periods.

Weekday—The term "weekday" means any day from Monday through Friday. Although, Friday evening may be included as a part of weekend in some research, in this study all of Friday is considered a weekday.

Weekend day—The term "weekend day" is used to describe a day being either a Saturday or a Sunday. While a weekend includes both Saturday and Sunday, a weekend day is only one of the two days.

Four Seasons—The Travel Industry Association (TIA), Travel Michigan (previously known as the Michigan Travel Bureau), and the Michigan Travel, Tourism and Recreation Resource Center at Michigan State University have been using the following definition of the four seasons. Winter is from December to February, spring is from March to May, summer is from June to August, and fall is from September to November. This definition of the four seasons is also used in this study.

1.5 Organization of the Study

A review of literature pertaining to the subject of this study is presented in Chapter 2. Chapter 3, the core of this study, contains relevant theory development and methodological details. Specifically, the first section of Chapter 3 contains descriptions of data collection and types of data used in this study. The second section of Chapter 3 contains the results of some initial data analyses and findings used in identifying the characteristics of highway traffic data. The conceptual model and theory development in the third section is based on the initial analyses and findings in the second section. The detailed layout of a new highway data processing method is presented in the fourth section of Chapter 3. The fifth section contains a discussion on how to assess the validity of the newly proposed method. Finally, the chapter concludes with a discussion on how to measure the degree to which the method improves the relevancy of traffic data to tourism (i.e., a measurement for data improvement).

Chapter 4 presents a variety of descriptive and inferential statistical test results from data preparation and a demonstration of the new method. Results of method validation and data improvement evaluation are also included in Chapter 4.

Chapter 5 includes summaries, major findings, and implications of the study. The applications and limitations of the new method are also discussed. Finally, the study concludes with recommendations to the Department of Transportation for future data collection and to tourism researchers for further studies on using highway traffic data.

CHAPTER 2

REVIEW OF LITERATURE

The first section of this chapter reviews tourism literature pertaining to the geographical area of this study--its tourism activities, seasons, and characteristics. While little literature focuses on highway tourism traffic, the second section of this chapter includes a review of literature that inspired the author's thoughts on the subject of the study that highway traffic data can and should be more effectively used in tourism studies.

2.1 Study Area--Michigan

Michigan's highway traffic data were used as an example in this study because in Michigan nearly 90% of tourism involves the use of personal vehicles (cars, RVs, etc). In Spotts' (1991) study of Michigan's tourist attractions, he pointed out that visiting tourist attractions is one of the major reasons for pleasure travel in Michigan. The Upper and Northern Lower Peninsula are important natural resource-based tourism areas in Michigan and are heavily visited by tourists.

Most of Michigan's population resides in the Southern Lower Peninsula. In 1983-84, about 90% of trips to or through Michigan originated from either large or small metropolitan areas in Michigan and other states (Holecek, 1991). Attendance at attractions in Michigan's Upper Peninsula and Northern Lower Peninsula areas is mostly generated from residents of Michigan's Southern Lower Peninsula and neighboring states. Since Michigan has a relatively long snow season, many outdoor recreation and tourism activities take place during warmer periods in late spring, summer, and early fall. On the other hand, winter sports lovers generate a substantial amount of tourism traffic during the long snow season. In addition, since a large number of second homes (seasonal homes) are located in Michigan's Upper and Northern Lower Peninsulas, a significant amount of north-southbound traffic is generated by second home owners during weekends and holidays.

2.2 Related Literature

Reviewing published travel and tourism research, one can hardly find any articles or reports focusing on highway traffic and tourism. Among the few examples of existing published research associating tourism measurement with highway traffic, the Michigan Travel, Tourism and Recreation Resource Center's Michigan Travel Indicators serial reports, are the most continuous one in using highway traffic data. Another example is Yang and Holecek's (1997) investigation of the effectiveness of using Average Daily Traffic (ADT) in monitoring travel activity in Michigan.

Although very few tourism studies using highway traffic data were found, there are some intriguing published research articles that can be considered highway and tourism related. Langer (1996) examined the relationship between traffic noise and profits of hotels that are located close to highways. Steward et al. (1993) used a high-speed-shutter camcorder to capture license plate numbers of vehicles on Texas highways. Based on license plate information, Steward et al. then retrieved vehicle registration information to study the differences in trip characteristics between those who stop at highway welcome centers and those who don't.

While Gunn (1979) stressed the importance of attractions, services, infrastructure, and information in tourism development and planning, Roehl, Fesenmaier, and Fesenmaier (1993) investigated the relationship between highway accessibility (infrastructure) and tourism expenditures.

Roehl, Fesenmaier, and Fesenmaier (1993) used cluster, factor, and path analyses to examine the contribution of highway infrastructure to regional economic impact of tourism. In their study, the accessibility of a region was measured by the miles of highways in the region. They discovered that, when natural and man-made resources were held constant, regions with more miles of highways received more tourist expenditures. Further analysis of rural area highway infrastructure showed that the highway system alone explained a significant proportion of spatial variation in tourist expenditures. Spotts (1997) used factor analysis to examine tourism resources of each county in Michigan. In his study, tourist spending was regressed on the factor scores of tourism resources in a multiple regression analysis to determine the extent to which factor scores relate to tourism spending. His study results indicate that the factor scores of tourism resource common factors explained 64% of spatial variation in aggregate tourist spending in Michigan.

Other tourism infrastructure research shows that counties with interstate highways have a distinct advantage over other counties, which results in employment and population growth (Briggs, 1981; Lichter and Fuguitt, 1980; Kuehn and West, 1971). Further, highway development has different influences in rural and urban areas. An improved highway infrastructure has no identifiable effects on growth for places more than 25 or 30 miles from a metropolitan area (Stephanedes and Eagle, 1986; Humphrey and Sell, 1975; Kuehn and West, 1971). Nevertheless, Huddleston and Pangotra (1990) point to a consensus among scholars that a good highway infrastructure system is a necessary while not a sufficient condition for regional economic growth. Tourists businesses especially benefit from the increased volume of travelers due to improved highway accessibility.

In the reviewed regional analyses of tourism resources by the author, researchers have all taken a supply-side point of view to the study of tourism. While highway infrastructure represents accessibility in a passive, static, and supply-side sense, highway traffic, which takes place on highway infrastructure, represents accessibility of a region in an active, dynamic, and demand-side sense. Although tourism business operators may passively benefit from improved highway infrastructure, they are more interested in knowing the potential size of business opportunities due to the improvement in highway accessibility. Based on the potential size of business opportunities, tourism business operators can plan their marketing strategies. While mileage of highway will not provide them this information, highway traffic data have the potential of making available to them this kind of information.

Cross-sectional supply-side studies of tourism, such as Roehl, Fesenmaier, and Fesenmaier's (1993) and Spotts' (1997), often encounter the problem of using relatively static tourism resource inventory data to explain a dynamic tourism phenomenon. While tourism resources and highway infrastructure often remain unchanged overtime, tourism demand and the trend of participation in tourism activities fluctuate constantly. Analogous to inflation-adjusted price index, researchers can adjust tourist expenditures according to regional price differences. Generally speaking, the same bundle of tourism goods and services costs more in urban than in rural areas. However, regional (spatial) price differences in tourism goods and services often are not accounted for in regional (cross-sectional) analysis of tourism. The finding of a strong relationship between highway infrastructure (or tourism resources) and tourist expenditures often becomes less significant if researchers regress regional price difference adjusted tourist expenditures on highway infrastructure (or tourism resources).

The results of previous regional tourism and tourism infrastructure studies, which established a relationship between highway infrastructure and tourism, did not include traffic volume on highways as a potential explanatory variable. However, they shed light on the idea that highway traffic volume like highway infrastructure and tourism resources data should have explanatory power in regional tourist expenditures. The following chapters explore the possible utility of highway traffic data in tourism studies.

CHAPTER 3

METHODS

The study design and objectives are discussed in this chapter. The first section describes the types of data used in the study. The second section identifies the useful characteristics of highway traffic data for tourism studies (Objective # 1). The third section presents a theoretical model for linking highway traffic data to tourism studies (Objective # 2). The fourth section details the proposed new traffic data processing method to mitigate the problem of separating tourism from non-tourism traffic described in Chapter 1. Examples of data processing procedures are also provided (Objective # 3 and 4). The fifth section provides a proposed design to assess the validity of the new method (Objective # 5). The sixth section discusses how to measure the degree to which the newly proposed method improves the tourism relevancy of original traffic data. A measurement formula is also derived for this evaluation (Objective # 6).

A basic understanding of the concept of database is important for readers to follow subsequent discussions. Therefore, a short summary of the concept is presented here. A database is a collection of tables. Each table contains rows and columns. At the intersection of a row and a column is a data point. Usually a row is referred to as a piece of record which contains a number of related data points. A data point is referred to as a cell in a table or a row. A column is a collection of data points whose attributes (or characteristics) are the same across rows. A table can be referred to as a record set. The above database terminology should be sufficient to limit subsequent confusion.

3.1 Data Collection

This study is a secondary research design using highway traffic data collected by the Michigan Department of Transportation (MDOT). The acquired highway traffic data were recorded by a set of so-called "Permanent Traffic Recorders" (PTR). While there are temporary counters set up to record traffic information for a short period of time, this study uses data from Permanent Traffic Recorders only. Also, the Permanent Traffic Recorders are not truly permanent. The continuing existence of a counter depends on the needs for traffic information around its location; therefore, the exact number of permanent traffic recorders changes slightly from year to year. Between 1995 and 1998, there were 179 permanent traffic recorders distributed in nine MDOT highway monitoring regions in Michigan (Figure 3-1).

Approximately 47% of counter stations are located in the Southeastern and Southwestern Lower Peninsula and urban areas (i.e., Region 7, 8, and 9). A detailed regional distribution of these counter stations is presented in Table 3-1. Of the 179 counter stations in operation during the study period, not all remained operational continuously. According to the Michigan Department of Transportation, most non-operating counters are due to equipment failures and the difficulties in repairing the devices without closing highways. Thus, when there are serious equipment failures of traffic recorders, traffic data from failed counters will not be available for months or years until the next scheduled highway re-construction is completed.

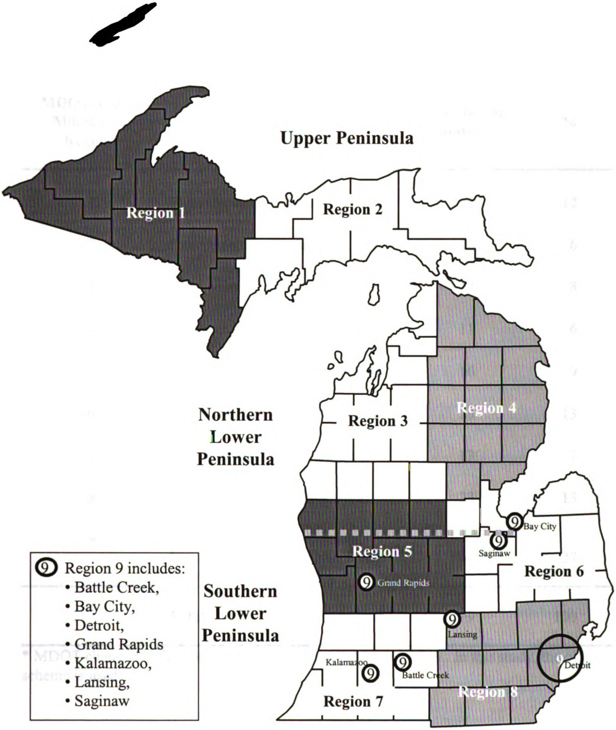


Figure 3-1. Michigan Department of Transportation Highway Monitoring Regions.

Table 3-1. Regional Distribution of Michigan Permanent Traffic Recorders.

MDOT Traffic Monitoring Region*	Region Description	Number of Stations	%
1	West Upper Peninsula	21	12
2	East Upper Peninsula	10	6
3	Northwestern Lower Peninsula	14	8
4	Northeastern Lower Peninsula	11	6
5	Middle-western Lower Peninsula	16	9
6	Middle-eastern Lower Peninsula	23	13
7	Southwestern Lower Peninsula	13	7
8	Southeastern Lower Peninsula	23	13
9	City Areas—Detroit, Lansing, Grand Rapids, Kalamazoo, Battle Creek, Saginaw, Bay City	48	27
	Total:	179	100

* MDOT changed its highway monitoring region scheme in 1999. In this study, the old scheme is used.

In 1998, 41 out of 179 counters were installed with the capacity to provide vehicle type information for the purpose of traffic classification. Counters with this capacity collect two sets of traffic data. One is Permanent Traffic Recorder (PTR) data, and the other is Classified Permanent Traffic Recorder (CPRT) data. Older counters without vehicle classification function record only PTR data.

The daily total traffic from PTR and CPTR usually do not equal each other. In most cases, the daily traffic volumes from PTR are greater than from CPTR. This is caused by the counters' wheel axle sensors failing to identify correctly the types of approaching vehicles under the following conditions:

1) extremely high vehicle speed,
2) sudden lane or speed change, and
3) unclassifiable vehicle types.

Traffic data are recorded according to traffic direction in hourly intervals. The daily recording period is from 00:00 to 23:59. It is an all year round, 24 hours a day, and 7 days a week recording system. Each day at midnight, data are downloaded through phone lines from traffic counters and then converted into database files. When a whole month's data are collected, they are sent to MDOT for highway performance monitoring.

Upon receiving raw traffic data, MDOT performs some basic data cleaning on the data sets. The criteria that MDOT uses in preparing the data are as follows. Abnormal traffic data points, which might have been subjected to problems such as partial equipment failure, highway construction, car accidents, and other unknown events, are identified. If more than five data points are missing in a given record, an indicator variable of a problematic record in the day's record will be labeled "TRUE" (The name of this variable is "DEL_FLAG" which means problems exist in this record and the record can be deleted. See Appendix A.); otherwise, the variable is labeled "FALSE" (which means there is no problem with the record). If fewer than five consecutively missing values are recorded, those missing values will be filled in by the average value of traffic volumes at the same hour interval and the same day of week within the month. For example, if the traffic volume of first Monday 9 AM in January is missing, then the missing value will be filled in by the average value of the second, third, and fourth Monday 9 AM traffic volumes in January. If some data points in a record are dubious (e.g., outliers), MDOT will try to check the data and determine their acceptability. If not acceptable, MDOT will replace the dubious data points with appropriate average values. If estimating a missing value or accepting a dubious data point is deemed problematic, the whole record will be discarded (i.e., the indicator of a problematic record is labeled as "TRUE").

3.1.1 Permanent Traffic Recorder Data

Most counters record data from both traffic directions. If a counter functions properly, the counter will record 24 data points for each traffic direction daily or 17,520 data points a year (i.e., 24 data points x 2 directions x 365 days). The PTR data used in this study were collected during January 1, 1995 through December 31, 1998. The MDOT Permanent Traffic Recorder (PTR) data sets come in both directional and non-directional format. The non-directional highway traffic data are not suitable for this study; therefore, non-directional traffic data were not used. Instead of being recorded hourly, bridge crossing data are only available in daily total volume. Not being compatible with other PTR data, the bridge crossing data were also excluded from this study.

Since MDOT has already performed basic data cleaning on the PTR data sets, they are ready for data analysis. Missing records in the data set were left alone without further treatment. Records with the problematic record indicator coded "TRUE" were excluded from this study. After removing problematic, non-directional, and bridge crossing traffic records, the acquired PTR data set comprised 242,979 usable directional records or 5,831,496 traffic data points. The successful rate of data recording is about 60%, which is considered adequate in sampling studies (Babbie, 1994).

In addition to traffic volumes, each record also contains information on its counter ID number, traveled lane, direction of traffic flow, year, month, date, day of week of the recording, total traffic volume of the day, indicator of problematic record, and a note about the problem. In the acquired PTR data sets, "Traveled lane" is always equal to zero. This means that the value is a summation of traffic volumes from all of the same direction lanes on a highway. Although the traffic volume on each lane is not provided, this information is not needed for this study. A typical example of PTR data format is displayed in Appendix A for the readers' reference.

Most major highway corridors in Michigan are either north-south or east-west oriented. Fifty-percent of counters are located on north-southbound highways and 43% are located on east-westbound highways. Counters located on northeast-southwest bound and northwest-southeast bound highways only account for 7% of all counters (Table 3-2).

Table 3-2. Directional Distribution of Michigan Permanent Traffic Recorders.

Highway Direction	Count	%
North-South Bound	88	49.16
Northeast-Southwest Bound	5	2.79
East-West Bound	74	41.34
Southeast-Northwest Bound	6	3.35
North Bound only	1	0.56
South Bound only	1	0.56
East Bound only	2	1.12
West Bound only	2	1.12
Total	179	100.00

There were 136 operating Permanent Traffic Recorders during the 1995 through 1998 time period. Their ID numbers, associated highways and locations, directions of traffic, and available number of records are listed in Table 3-3. Note that the first digit of a counter ID represents the MDOT highway monitoring region (See Table 3-1 for region descriptions).

Table 3-3. Locations of Michigan Permanent Traffic Recorders and Number of Available Records from 1995 through 1998.

Station ID	Location	County	Number of Records*
1019	US-141 Covington, N-S Bound	Baraga	898
1029	M-28 Bruce Crossing, E-W Bound	Ontonagon	1391
1039	US-2 Wakefield/Bessmer, E-W Bound	Gogebic	998
1049	US-2 Iron River, E-W Bound	Iron	2500
1069	US-41 Carney, N-S Bound	Menominee	2695
1089	US-41 Skandia, NW-SE Bound	Marquette	2624
1109	US-41, M-28 Champion, E-W Bound, W. of Jct. M-95	Marquette	2545
1149	US-41, M-28 Champion, E-W Bound, E. of Jct. M-95	Marquette	1960
1189	M-95 Champion, N-S Bound, S. of Jct. US-41, M-28	Marquette	2139
1309	US-45 Land O' Lakes, N-S Bound	Gogebic	2361
1449	US-2 Powers, E-W Bound, E of County Road 557	Menominee	2061
1529	US-2 Norway, E-W Bound	Dickinson	1357
2029	US-2 Brevort, E-W Bound	Mackinac	2054
2049	I-75 St. Ignace, N-S Bound	Mackinac	2466
2089	I-75 Mackinac Bridge, N-S Bound	Mackinac	2922
2109	I-75 International Bridge, N-S Bound	Chippewa	2922
2189	M-28 Raco Corners, E-W Bound	Chippewa	2344
2209	M-28 Deerton, E-W Bound	Alger	2448
3029	M-115 Farwell, NW-SE Bound	Clare	2360
3049	M-61 Harrison, E-W Bound	Clare	1656
3069	US-131, M-66 Kalkaska, N-S Bound	Kalaska	2121
3079	M-72 Kalkaska, E-W Bound	Kalaska	60
3089	M-66 Sears, N-S Bound, S. of US-10	Osceola	2706
3109	M-37 Baldwin, N-S Bound	Lake	2146
3129	M-37 Traverse City, N-S Bound, S of US-31	Grand Traverse	2715
3149	US- 10 Sears, E-W Bound, W. of M-66	Osceola	2704
3189	US-10 Sears, E-W Bound, E. of M-66	Osceola	2263
3229	M-66 Sears, N-S Bound, N. of US-10	Osceola	2674
3249	US-10, US-27 Clare, N-S Bound at Travel Info. Center	Clare	2558
3269	US-10 Branch, E-W Bound	Mason	2362
3289	US-10 Farwell, W Bound	Clare	755
4029	US-23 Alpena, N-S Bound	Alpena	2742
4049	I-75 Vanderbilt, N-S Bound	Otsego	1531
4069	Old M-76 Sterling, NW-SE Bound	Arenac	2610
4089	M-33 Rose City, N-S Bound	Ogemaw	2788
4129	US-27 Houghton Lake, N-S Bound	Roscommon	2252
4149	I-75 Prudenville, N-S Bound, at Maple Valley	Roscommon	2442
4229	US-23 Au Gres, E-W Bound	Arenac	2558
5029	US-27 St. Johns, N-S Bound	Clinton	1142
5039	US-27 By-Pass, St. Johns, S Bound	Clinton	581
5049	I-69 Dewitt, E-W Bound	Clinton	1990
5059	I-196 Hudsonville, NE-SW Bound	Ottawa	1516
5069	US-131 Wyoming, N-S Bound	Kent	2166
5109	Washington Road, Ithaca, E-W Bound	Gratiot	2778
5169	M-57 Perrinton, E-W Bound	Gratiot	2677

Table 3-3. (cont'd)

Station ID	Location	County	Number of Records*
5189	Jordan Lake Road, Lake Odessa, N-S Bound	Ionia	2474
5229	I-96 Grand. Rapids, E-W Bound	Kent	2243
5249	US-131 Morley, N-S Bound	Mecosta	1524
5269	US-3 I Pentwater, N-S Bound	Oceana	2512
5289	US-3 I Muskegon, N-S Bound	Muskegon	2368
5299	I-96 Ionia, W Bound	Ionia	500
5309	US-131 Big Rapids, N-S Bound	Mecosta	654
6049	M-25 Port Sanilac, N-S Bound	Sanilac	2610
6069	I-69 Lansing, NE-SW Bound	Shiawassee	2531
6109	I-94 Blue Water Bridge, E-W Bound	St. Clair	2922
6129	I-75, US-10, US-23 Birch Run, N-S Bound	Saginaw	2674
6149	I-75, US-10, US-23 Carrollion, NW-SE Bound, SE of I-675	Saginaw	611
6169	M-53 Hemans, N-S Bound, N of Jct. M-46	Sanilac	1966
6189	I-675 Carrollton N-S Bound, S of I-75	Saginaw	183
6209	M-46 Hemans, E-W Bound, E of Jct. M-53	Sanilac	641
6229	I-75 Carrollion NW-SE Bound, NW of I-675	Saginaw	222
6249	M-53 Hemans, N-S Bound, S of Jct. M-46	Sanilac	1848
6269	I-475 Mt. Morris, E-W Bound	Genesee	2555
6289	M-46 Hemans, E-W Bound, W of Jct. M-53	Sanilac	1925
6309	M-57 Clio, E-W Bound	Genesee	1846
6319	M-83 Frankenmuth at Cass River Bridge, N-S Bound	Saginaw	1383
6369	I-69 Capac, E Bound	St. Clair	648
6389	I-69 Capac, E-W Bound, E of Capac Road	St. Clair	2463
6429	I-75 Kawkawlin, N-S Bound	Bay	2526
6449	I-69 Swartz Creek, E-W Bound	Genesee	2293
6469	I-94 Port Huron, E-W Bound	St. Clair	2169
6479	US-10, Bay City, E-W Bound	Bay	792
7029	I-94 Grass Lake, at The Truck	Jackson	1791
7069	M-60 Homer, E-W Bound	Calhoun	2342
7109	US-131 Schoolcraft, N-S Bound	Kalamazoo	2006
7129	Niles-Buchanan Road, Buchanan, E-W Bound	Berrien	2642
7159	I-94 Battle Creek, E-W Bound	Calhoun	158
7169	I-94 Marshall, E-W Bound	Calhoun	2098
7179	I-94 Coloma, E-W Bound	Berrien	196
7189	I-94 New Buffalo, N-S Bound	Berrien	1639
7269	I-69 Coldwater, N-S Bound	Branch	2050
7289	M-43 Bangor, E-W Bound	Van Buren	2257
7309	I-196 Glenn, N-S Bound at the 114th St.	Allegan	2764
7329	US-12 White Pigeon, E-W Bound	St. Joseph	1340
8029	US-127 Mason, N-S Bound	Ingham	2219
8049	I-96 Fowlerville, E-W Bound at The Truck	Livingston	2214
8129	US-12 Jonesville, E-W Bound	Hillsdale	1822
8169	US-24 Erie, N-S Bound, N of Lakewood Road	Monroe	2262
8209	I-96 New Hudson, E-W Bound	Oakland	1961
8219	I-96 Howell, E-W Bound	Livingston	92

Table 3-3. (cont'd)

Station ID	Location	County	Number of Records*
8229	US-23 Brighton, N-S Bound, S of M-59	Livingston	2053
8249	I-75 Luna Pier, N-S Bound, S of Luna Pier Rd.	Monroe	2174
8269	I-75 Luna Pier, N-S Bound, N of Luna Pier Rd.	Monroe	296
8409	M-59 Troy, E-W Bound at John Road	Oakland	2554
8629	I-75 Clarkston, N-S Bound, S. of M-15	Oakland	1893
8649	I-75 Clarkston, N-S Bound, N. of M-15	Oakland	409
8669	M-15 Clarkston, N-S Bound, Over I-75	Oakland	2583
8689	US-23 Dundee, N-S Bound at the Travel Info. Center	Monroe	1612
8709	US-223 Dundee, E-W Bound, W. of US-23	Monroe	2705
8729	US-23 Lambertville, N-S Bound	Monroe	1659
9029	I-496 Lansing, E-W Bound at Clemens	Ingham	1969
9049	US-127 Lansing, N-S Bound, N. of Grand	Ingham	2112
9069	I-496 Lansing, E-W Bound at Everett	Ingham	1914
9089	Clemens St Lansing, N-S Bound at	Ingham	2430
9109	M-10 Detroit, N-S Bound at Milwaukee	Wayne	1126
9189	I-275 Romulus, N-S Bound	Wayne	280
9199	I-275 Canton Twp., N-S Bound	Wayne	1931
9209	I-275 N-S Bound at Cherry Hill Road	Wayne	45
9219	I-675 Saginaw, N-S Bound at Saginaw River	Saginaw	744
9369	I-94 Kalamazoo, E-W Bound	Kalamazoo	1191
9419	I-94 Detroit, E-W Bound at Brush St.	Wayne	1390
9449	I-75 Detroit, N-S Bound at 12th St.	Wayne	250
9489	I-94 Detroit, E-W Bound at Central St.	Wayne	219
9499	I-94, E-W Bound at Trumbull	Wayne	855
9529	I-94 (Dickman) Battle Creek, E-W Bound	Calhoun	2782
9629	Liberty Bridge Bay City, E-W Bound	Bay	2408
9649	Independence Bridge Bay City, N-S Bound	Bay	2748
9669	M-25 (Vet. Bridge) Bay City, E-W Bound	Bay	2205
9689	M-13/M-84 Bridge, Bay City, E-W Bound	Bay	2766
9709	I-75 Taylor, N-S Bound	Wayne	1464
9729	I-196 Grand Rapids, E-W Bound	Kent	2053
9749	M-11 (28th St) Gd. Rapids, E-W Bound	Kent	2643
9769	US-131 Grand Rapids, N-S Bound	Kent	2168
9789	M-39 Dearborn, N-S Bound	Wayne	805
9809	M-39 Detroit, N-S Bound	Wayne	1117
9829	I-696 Southfield E-W Bound, E of Southfield Road	Oakland	727
9839	I-696, E-W Bound at Schoenheer	Macomb	928
9849	M-10, Detroit, N-SW Bound at 8 Mile Road	Wayne	412
9869	M-10 Detroit, N-S Bound Between 7 Mile	Wayne	162
9889	I-75 Detroit, N-S Bound On Rouge River	Wayne	1165
9939	M-8 Davison, NE-SW Bound at John Road	Wayne	439
9959	I-75 N-S Bound at Mack Ave.	Wayne	990
9969	I-94 Detroit, E-W Bound at Dickerson St.	Wayne	2382
9979	I-75, N-S Bound at Wattles Road	Oakland	703
9989	I-75 Royal Oak, N-S Bound	Oakland	1429
9999	M-8 Davison, NE-SW Bound at 2nd St.	Wayne	688

*A complete data set should contain 2,920 records for each counter during the 4-year period.

3.1.2 Classified Permanent Traffic Recorder Data

The same traffic counters that provide PTR data can also detect vehicle types if they were installed with a wheel-axle sensor "loop" under the highway surface. Vehicles are classified according to the FHWA's classification method. FHWA classifies vehicles into the following 13 classes.

"Type Name and Description

1. Motorcycles (Optional)--All two-or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handle bars rather than [by steering] wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheel motorcycles. This vehicle type may be reported at the option of the State.

2. Passenger Car--All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers.

3. Other Two-Axle, Four-tire Single Unit Vehicles--All two-axle, four tire vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, carryalls, and minibuses. Other two-axle, four-tire single unit vehicles pulling recreational or other light trailers are included in this classification. Because automatic vehicle classifiers have difficulty distinguishing class 3 from class 2, these two classes may be combined into class 2.

4. Buses--All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. Modified buses should be considered to be a truck and be appropriately classified.

NOTE: In reporting information on trucks the following criteria should be used:

a. Truck tractor units traveling without a trailer will be considered single unit trucks.

b. A truck tractor unit pulling other such units in a "saddle mount" configuration will be considered as one single unit truck and will be defined only by the axles on the pulling unit.

c. Vehicles shall be defined by the number of axles in contact with the roadway. Therefore, "floating" axles are counted only when in the down position.

d. The term "trailer" includes both semi- and full trailers.

5. Two-Axle, Six-Tire, Single Unit Trucks--All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having two axles and dual rear wheels.

6. Three-Axle Single Unit Trucks--All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having three axles.

7. Four or More Axle Single Unit Trucks--All trucks on a single frame with four or more axles.

8. Four or Less Axle Single Trailer Trucks--All vehicles with four or less axles consisting of two units, one of which is a tractor or straight truck power unit.

9. Five-Axle Single Trailer Trucks--All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.

10. Six or More Axle Single Trailer Trucks--All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.

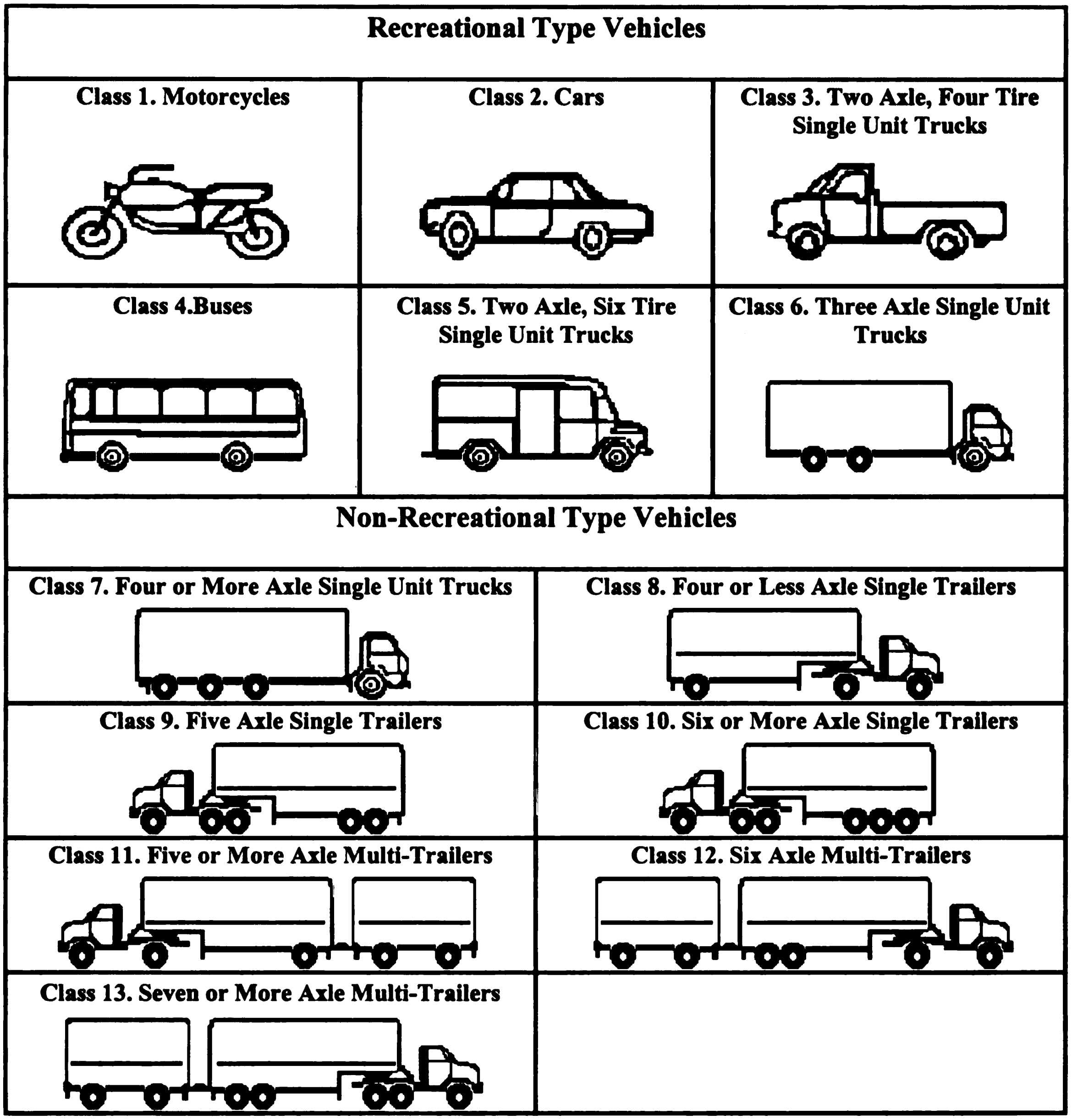
11. Five or Less Axle Multi-Trailer Trucks--All vehicles with five or less axles consisting of three or more units, one of which is a tractor or straight truck power unit.

12. Six-Axle Multi-Trailer Trucks--All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.

13. Seven or More Axle Multi-Trailer Trucks--All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit." (FHWA, 1995)

Among the 13 vehicle classes, Classes 1 (motorcycle), 2 (passenger car), and 3 (pickup) are generally used for multiple purposes which include leisure and recreation. Although Class 3 is labeled as pickup in Classified Permanent Traffic Recorder data (see Appendix B), sport utility vehicles (SUVs) and mini vans are also included in Class 3 according to the FHWA's classification. (Note that a pickup pulling a recreational trailer is classified as Class 3.) Class 4 (bus) is used for tourist group transportation. Most of the large-size recreational vehicles (RV in its common usage) are classified into one of the Classes in 4, 5, or 6.

Since Classes 1, 2, 3, 4, 5, and 6 are more likely used for leisure and recreation purposes, they are considered "recreational type vehicles" (RV in the usage of this study) in this discussion. And Classes 7-13 will be categorized into "non-recreational type vehicles" (NRV) because these are large trucks for delivering cargo and not likely to be used for leisure purposes. The typical vehicle silhouettes of these 13 vehicle classes are exhibited in Figure 3-2. (Note that a silhouette in Figure 3-2 does not imply that all vehicles classified into the class would look like the silhouette provided in the Figure.) The FHWA's vehicle classification is based on the number and distance of wheel axles that are non-floating (i.e., wheels have to touch ground). It is not based on the shape of vehicles.



Source: FHWA

Note: The FHWA's vehicle classification is based on the number and distance of wheel axles that are non-floating (i.e., wheels have to touch ground). Separation of recreational type from non-recreational type vehicles is based on the possible recreational use of vehicles.

Figure 3-2. Vehicle Classifications--Typical Vehicle Silhouettes.

Installing new equipment and retiring the old is a gradual process. To date, not all traffic counters are installed with the capacity to provide vehicle type information. Also, Classified Permanent Traffic Recorder (CPTR) data are currently available only for 1998. In 1998, only 41 Permanent Traffic Recorders had the capacity to provide classified traffic data. Among these 41 recorders, only 24 stations have the hourly CPTR data available. The 17 stations that have only daily CPTR data available are less suitable for the purposes of this study.

CPTR data are recorded hourly. Instead of generating one data point (i.e., one traffic volume from all vehicle types) per hour as PTR, CPTR generate 13 data points (i.e., 13 traffic volumes from 13 vehicle types) per hour. Thus, if it functions properly, a CPTR can generate 624 data points per day (i.e., 13 classes x 24 hours x 2 directions) and 227,760 data points per year (i.e., 624 data points per day x 365 days). Expressed in terms of a record set, a CPTR counter produces 48 records per day (i.e., 24 hours x 2 directions) and 17,520 records per year (i.e., 48 records per day x 365 days). The acquired hourly CPTR data from MDOT contain 214,319 useful records, which is about 51% of a complete data set derived from 24 CPTR stations (i.e., 24 stations x 17,520 records per year = 420,480 records).

Along with the 13 classified traffic data points, each CPTR record also includes information about its classification code, state code, county code, station number, direction of traffic flow, traveled lane, year, month, date, and hour of the recording, and total traffic volume of the day. A typical example of CPTR data format is provided in Appendix B for the reader's reference.

Stations that provide hourly CPTR data are listed in Table 3-4 with information on the number of available records. Their geographical locations are displayed in Figure 3-3. Note that there were no CPTR devices installed in the Upper Peninsula of Michigan during 1998. Since the acquired hourly CPTR data were not cleaned by MDOT, data cleaning was preformed according to the criteria and procedures used by MDOT described in the previous section of this chapter. Despite the fact that the acquired CPTR data are relatively incomplete in terms of available numbers of counter stations compared to PTR data, hourly CPTR data provide more detailed and valuable information for tourism studies than PTR data. This is because using hourly CPTR data allows researchers to remove traffic generated by non-recreational type vehicles (NRV) from total traffic within each hour interval. Thus, developing of new data processing method will be based on the assumption that hourly CPTR data are available. In this study, only the 24 sets of hourly CPTR data were used to demonstrate how highway traffic data are connected to tourism studies. PTR data were primarily used in the following section which concerns theory development.

Table 3-4. Michigan Permanent Traffic Recorders which Provided Vehicle Classification Information in 1998.

Station Number	Direction	Location	Number of Records*
3069	N-S	US-131, M-66 Kalkaska	13,441
4049	N-S	I-75 Vanderbilt	10,170
4129	N-S	US-27 Houghton Lake	3,768
5029	N-S	US-27 St. Johns	7,083
5039	S	US-27 By-Pass, St. Johns	6,452
5059	NE-SW	I-196 Hudsonville	15,362
5249	N-S	US-131 Morley	14,320
5299	W	I-96 Ionia	4,417
5309	N-S	US-131 Big Rapids	10,710
6369	E	I-69 Capac	4,705
7029	E	I-94 Grass Lake	2,522
7109	N-S	US-131 Schoolcraft	9,263
7159	E-W	I-94 Battle Creek	3,824
7179	E-W	I-94 Coloma	4,176
8219	E-W	I-96 Howell	2,186
8229	N-S	US-23 Brighton, S of M-59	8,248
8249	N-S	I-75 Luna Pier, S of Luna Pier Road	12,353
8689	N-S	US-23 Dundee	15,454
8729	N-S	US-23 Lambertville	11,136
9049	N-S	US-127 Lansing, N. of Grand River Ave.	15,730
9369	E-W	I-94 Kalamazoo	8,197
9829	E-W	I-696, E of Southfield Road	8,121
9959	N-S	I-75, at Mack Avenue	11,585
9979	N-S	I-75, at Wattles Road	11,096
Total			**214,319**

* A complete CPTR data set should contain 17,520 records in 1998.

Figure 3-3. Geographical Locations of Permanent Traffic Recorders which Provided Vehicle Classification Information in 1998.

3.2 Identifying Characteristics of Highway Traffic Data

As an exploratory step toward understanding highway traffic and creating a connection to tourism studies, this study begins with identification of highway traffic data characteristics. This is the first step toward generating basic information about highway traffic data and discovering its possible uses in tourism studies. Once this basic information on highway traffic characteristics is explained, the author will use these characteristics to develop a conceptual model that links highway traffic data to tourism. The model will become one of the supports for the author's postulation that highway traffic data is valuable for tourism studies, because traffic data can provide time series information about traffic volumes with characteristics that implicitly reflect the collective behavior of travelers.

Both PTR and CPTR data were used in identifying traffic data characteristics. The major analysis technique involved in these initial examinations of highway traffic data characteristics was time series analysis, which includes series data plotting, classical decomposition (i.e., separating time series data into trend, seasonal, and random components), the method of moving average, and analyzing the autocorrelation function of the random components. In addition to time series analysis, univariate analysis, bivariate analysis, pattern recognition, and tests of significance (such as one-way analysis of variances and two-sample *t* tests) were also applied in the initial analyses.

After carefully examining the traffic data, the author identified the following special characteristics of highway traffic data that are useful for tourism studies and worthy of being studied and documented.

(1) The random process of highway traffic time series--Taking a micro-view of the data, the author examined the autocorrelation functions and random processes of traffic data.

(2) Daily traffic distributions--Taking a 24-hour view of the data, the author examined the daily variations in traffic flows and their patterns.

(3) Seasonality--Taking a macro-view of the data, the author examined the seasonal variations of traffic flows.

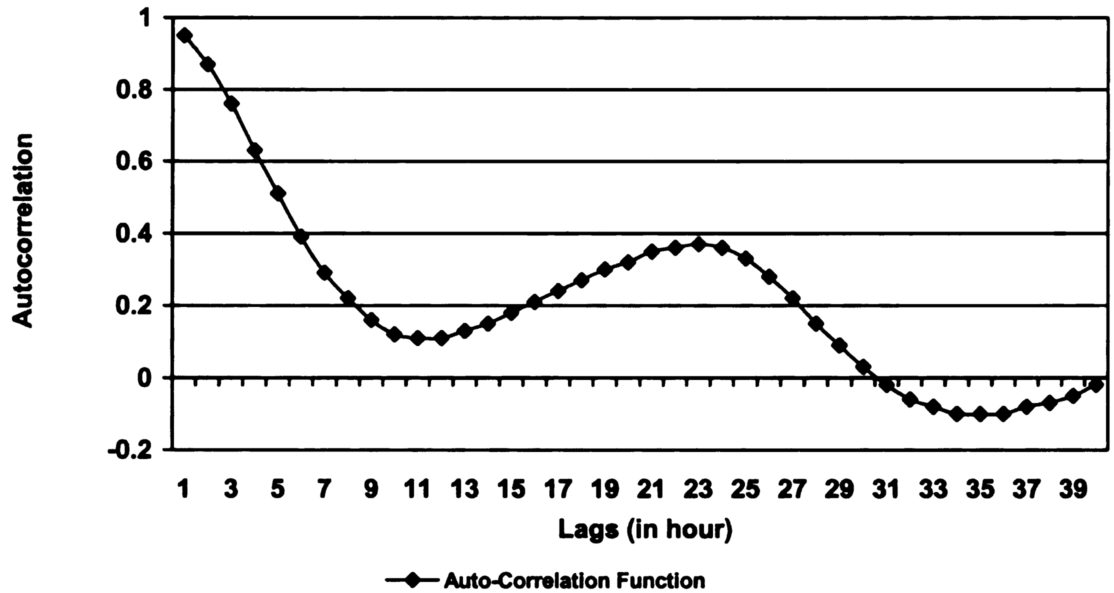
(4) Vehicle type distributions--Using CPTR data, the author examined the distribution of vehicle types in traffic flows.

(5) Geographical locations of traffic counters--Locations of traffic counters largely determine what will be recorded since the characteristics of traffic vary widely across a highway system.

3.2.1 The Random Process of Traffic Time Series

Highway traffic data are a set of discrete time series. Each highway traffic data point is recorded at a specified time interval, and each recorded data point is a realization of the random process that generates the traffic time series. As previously mentioned, time series usually can be decomposed into trend, seasonal, and random components. Here, the author focuses on examining the random component of the traffic time series. It is a micro-view of the data after removing the trend and seasonal components from the series.

After performing classical decomposition on some randomly selected sets of PTR time series, the sampled autocorrelation functions (ACFs) of these randomly selected highway traffic time series display a clear pattern of cyclical fluctuation, which reflects a periodic behavior in the "random" components. The cyclical period measured from one peak to the next peak is an exact 24-hour period (see Figure 3-4 for an example). As most people would expect, the cyclical pattern of highway traffic is influenced by the alternation of day and night. However, contrary to what one might expect, the random components are not as random as the ones spawned primarily by random forces. The cyclical pattern of autocorrelation functions indicates that the random components are not individually independently distributed white noises. A series of individually independently distributed white noises should yield a total randomness of ups and downs without any identifiable patterns, which means each data point has no relationship with any other data points. However, the ACFs of PTR data demonstrate that highway traffic data points are highly autocorrelated, and the strength of autocorrelation slowly subsides after a period of long lags (Figure 3-4). Thus, the ACFs of the random components of highway traffic data imply that highway travelers' behavior is not totally random as in a chaotic situation but closely follows distinct patterns. It follows that travel behavior is quite predictable as suggested by the observed autocorrelation functions. Travelers are likely to repeat the same travel behavior over any given periods of 24 hours, because 24-hour defines a cyclical period for traffic flow. Having made this observation about ACFs, the author looked further into daily traffic flow distributions in the traffic data to identify travel behavior for each cyclical period.



Note: A set of time series $\{ X_t, t = 1,2,... \}$, the autocorrelation function of X_t is defined as: $\rho(h) = \frac{Covariance(X_t, X_{t+h})}{Variance(X_t)}$, $h = 1$ to n. Here, $\{ X_t, t = 1,2,... \}$ represents the random component of traffic data; h is the lag period. For example, $\rho(1)$ means the correlation of 1AM with 2AM, and $\rho(2)$ is the correlation of 1AM and 3AM, and so on.

Figure 3-4. An Example of Autocorrelation Function of Traffic Time Series (4049 North).

3.2.2 Daily Traffic Distributions

The hourly directional PTR data from each counter station can be plotted to reveal traffic volume distribution over a 24-hour interval. In this section, the author examines the daily traffic distributions, and plots them for various periods of time (e.g., a month).

Daily traffic distributions reveal the patterns of travelers' collective travel behaviors during a period of 24 hours. Different patterns between daily traffic distributions on certain days of week indicate that travelers demonstrate different travel behaviors across the days of the week. Thus, differences in daily traffic distributions may help to separate non-discretionary types of travel (e.g., commuting to work) from discretionary types of travel (e.g., leisure). The results of the plotting indicate that the patterns of weekday daily traffic distributions are very different from weekends. Also, counters on tourism routes exhibit significant differences in traffic distribution patterns between Friday and other weekday afternoon hours. This may indicate that a substantial amount of tourism trips takes place during Friday afternoon and evening hours. For example, in Figure 3-5, Friday afternoon northbound traffic on highway I-75, a major highway linking the populated Southeast Michigan area to popular northern Michigan tourist destinations, increased significantly compared to other weekdays.

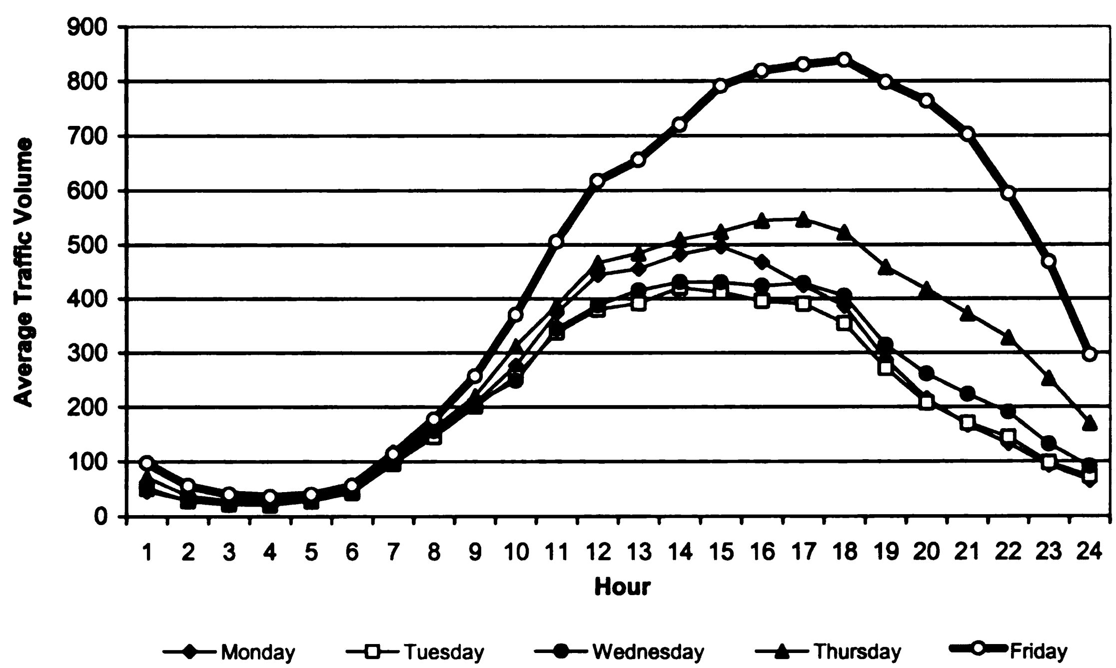


Figure 3-5. An Example of Weekday Daily Traffic Distributions in a Rural Area (4049 North).

The results from comparing daily traffic distributions of different counters indicate that the patterns of these distributions differ significantly between counters along tourism dominant and less tourism dominant routes (see Figure 3-5 and 3-6 for example).

Daily traffic distributions of counters on more populated areas frequently exhibit bimodal patterns on regular weekdays. The two peak points of the bimodal type distributions appear during morning and afternoon rush hours. Also for counters located in urban areas, the pattern of distributions indicates that the daily traffic distributions during weekdays are very similar to each other, and the curves cluster closely such that weekdays' distribution curves are almost identical to one another (see Figure 3-6).

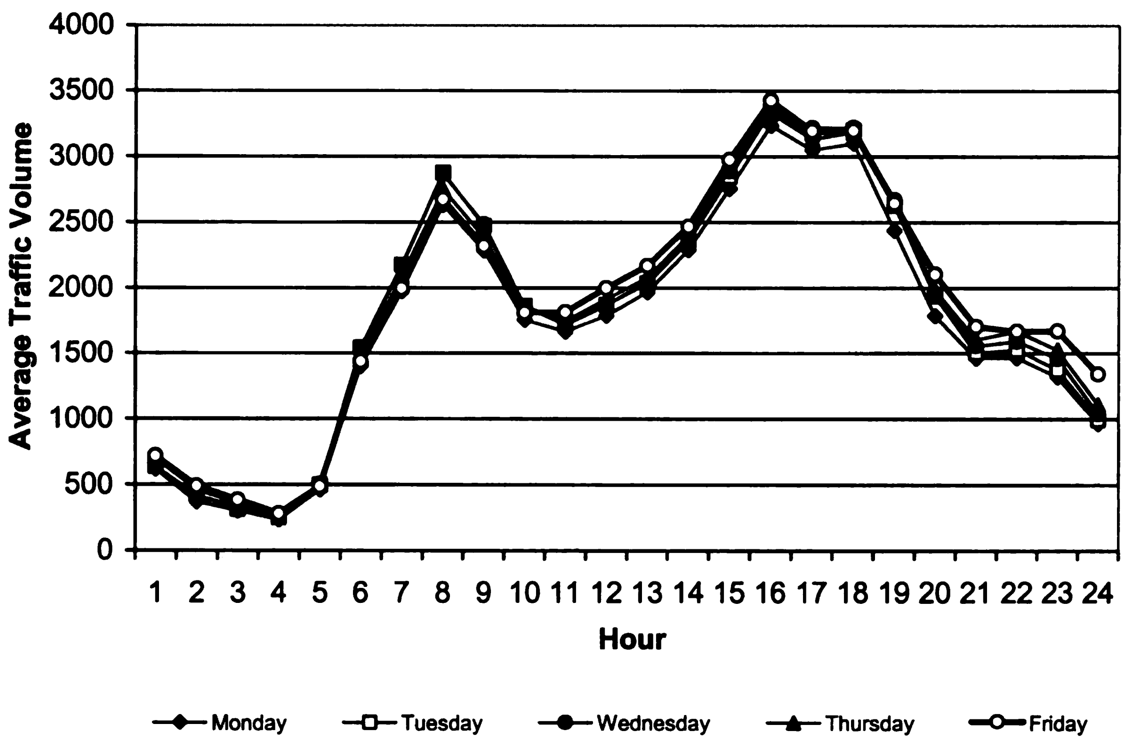


Figure 3-6. An Example of Weekday Daily Traffic Distributions in an Urban Area (9999 Northeast).

Monthly compilations of daily traffic distributions often reveal that there are three or four distinct clusters of daily traffic distributions. Usually, these clusters are Friday, Saturday, Sunday, and the other weekdays. Sometimes, Saturday and Sunday distributions are similar, but frequently the plots indicate that they do not cluster into a single group. Similar observations also occur on Friday and the other weekday clusters.

Moreover, for northbound traffic, the daily traffic distributions of the last day of long weekends (such as Memorial Day, Independence Day, and Thanksgiving) and regular Sundays frequently stay at lower positions (less traffic) compared to other distributions. This may imply that there is less northbound tourism traffic on regular Sundays and the last day of long weekends. For southbound rural traffic, the daily traffic distributions of the first day of long weekends and regular Saturdays frequently stay at lower positions compared to other daily distributions. Daily traffic distributions on New Year's Day, Halloween, Thanksgiving, and Christmas frequently stay at lower positions compared to the distributions for other days of the month. For traffic in urban areas, the daily traffic distributions of regular Sundays frequently stay at lower positions compared to the distributions for other days of the week. An example of three clusters of daily traffic distributions is exhibited in Figure 3-7. In Figure 3-7, the thin black curves clustering at higher positions are weekday traffic (including Friday), the thin gray curves are Saturday traffic, the heavy gray dash curves are Sunday traffic, and the black dash curve at the lowest position is the traffic on Halloween.

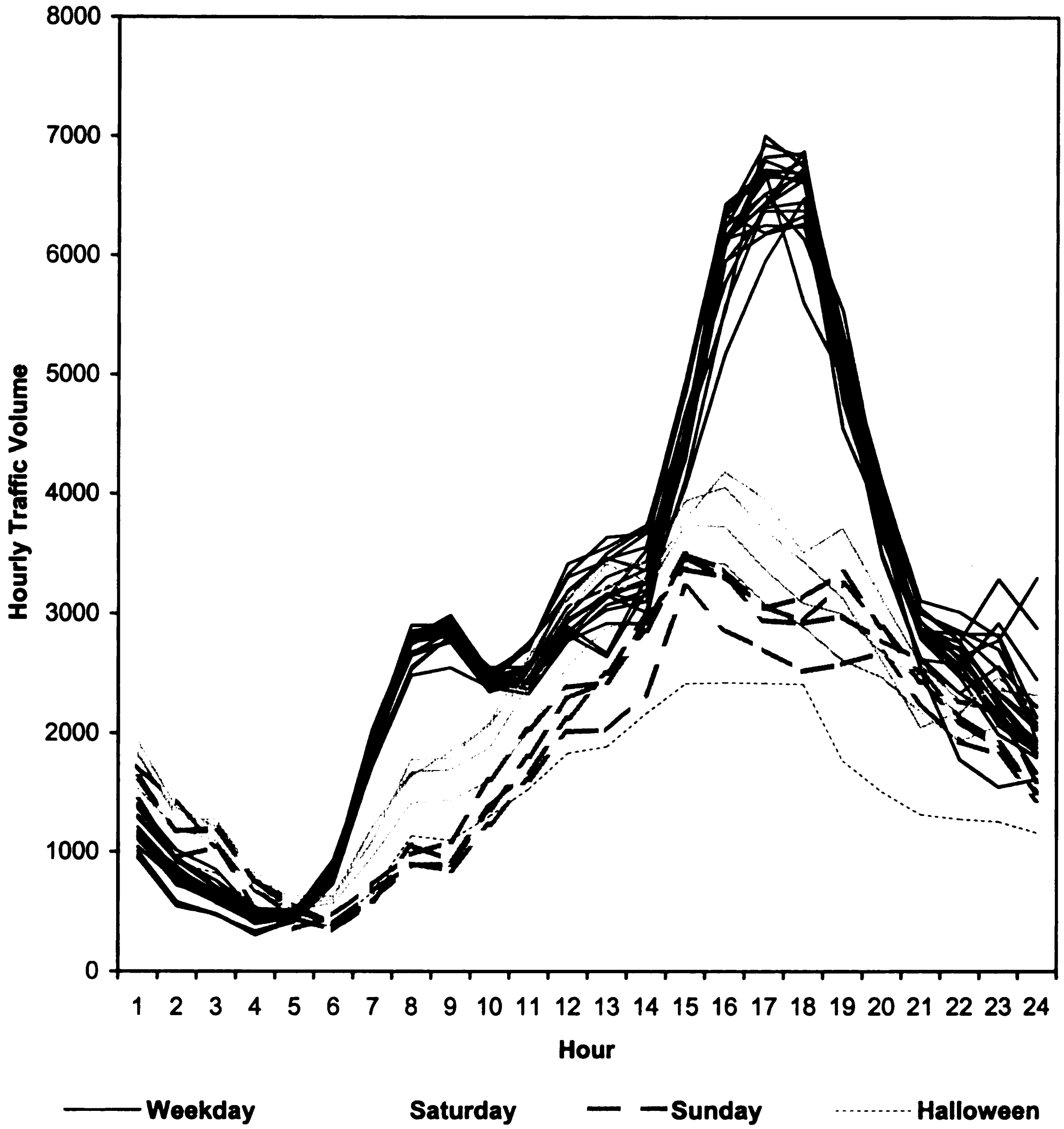


Figure 3-7. An Example of Three Clusters of Daily Traffic Distributions (9969 East, October 1998).

It appears that collective changes in travel behavior of highway travelers are reflected in the different patterns of daily traffic distributions. This characteristic of traffic data definitely connotes valuable information that is not regularly exploited by most tourism researchers. Therefore, the differences in daily traffic flow distributions could be used to derive information for tourism studies.

3.2.3 Seasonality

Seasonality is one of the most familiar topics to tourism researchers. Highway traffic data also display seasonal variations. To study highway traffic seasonality the author examined traffic data within a year as a whole. It is a macro-view of traffic data.

Highway traffic data exhibit three kinds of periodicity:

1) 24-hour daily period,
2) 7-day weekly period, and
3) 12-month (or 4-season) annual period.

In the previous sections, daily and weekly periodicities have been considered in the classical decomposition operation when the random process of the data were examined, and in the analysis of daily traffic distributions when the differences in daily traffic flows were compared. In this section, the author focuses on the 12-month (4-season) annual periodicity. In the following discussion, seasonality is referred to as the 12-month annual periodicity.

One would expect that non-tourism traffic flow would be relatively more stable over time than tourism traffic flow and that tourism traffic varies widely due to the seasonal variations of tourist visitations. Thus, traffic data exhibiting significant seasonal variations are likely to contain a greater proportion of tourism traffic.

Observation of the traffic data reveals that seasonality is much less significant in urban areas than in rural areas. For example, rural north-southbound highways exhibit significant increases in traffic volumes at the beginning of the summer season, usually in late May or early June. The Michigan highway traffic peak season is during the summer and early fall. Since seasonality is more significant in rural highway traffic, annual seasonality is a useful characteristic of traffic data for deriving rural tourism related information.

3.2.4 Vehicle Type Distributions

The Federal Highway Administration (1995) has pointed out that "[t]rucks and other commercial vehicles serve different purposes and may have travel patterns which differ from those of automobiles." Thus, one could expect that the vehicle type distributions on more tourism-dominant routes would be different from those on less tourism-dominant routes. CPTR data were used in this section of study, because CPTR data sets provide all information included in the PTR data sets plus vehicle type information.

To derive more useful tourism related information, it is better if one removes traffic volumes generated by non-recreation type vehicles from overall traffic data set. An initial analysis of vehicle type distribution reveals that, on average, about 90% of traffic volume is generated by recreation type vehicles, that is FHWA vehicle Classes 1-6. Variations occur across regions, seasons, directions, and days of week (i.e., weekday vs.

weekend day). Generally speaking, the percentage of traffic volume generated by recreation type vehicles is higher on weekend days than during weekdays. One-way analysis of variances (ANOVA) was applied in testing the significance of differences between weekdays and weekend days and also in testing the significance of differences across seasons. Information derived from vehicle type distribution also suggests which highway routes and which days of the week are more tourism dominant. More details about tourism dominance are presented in Chapter 4.

3.2.5 Geographical Locations of Traffic Counters

Location can be the most important factor in determining what kinds of traffic data are recorded. For example, traffic counter stations located in urban areas record a higher proportion of commuter, service and freight traffic than rural traffic counter stations; and rural traffic counters record a higher proportion of tourism traffic than urban traffic counters. However, this does not necessarily mean that more tourism activities (in quantity) take place in rural areas than in urban areas. It simply means that tourism traffic flow may be a more dominant component in total traffic flow in rural areas than in urban areas. The previously identified highway traffic data characteristics are strongly affected by the locations of traffic counters. Theoretically, a counter's location should be an important factor in determining the tourism dominance of a highway route. Later in this study, this postulation will be tested.

3.3 A Conceptual Model Linking Highway Traffic Data to Tourism Studies

Based on observed highway traffic characteristics, the author developed the conceptual model introduced in this section. It depicts a simple theory of the collective behaviors of highway travelers that can be used to link highway traffic data to tourism studies. The model also suggests possible uses of highway traffic data in tourism studies.

3.3.1 The Conceptual Model

In a primitive society, people's daily life follows nature's schedule closely. They work and collect foods during the day and rest during the night. They plant during the spring and harvest during the fall. As human societies became civilized, institutions and laws become the norm and regulate people's behaviors. In an industrialized society, most people's daily lives closely follow an 8-to-5 (i.e., 8 work hours and one lunch hour), weekday-and-weekend, workday-and-holiday calendar schedule. Therefore, people's behaviors are influenced by the institutional (social) factors and natural settings of their societies. Naturally, their travel behaviors are also under the influence of these institutional and natural settings. As a matter of fact, there is a school of scholars that use institutional settings of a society and property rights to explain human social and economic behaviors (e.g., Eggertsson, 1990; Furubotn and Richter, 1998)

While tourism studies are about travelers' behaviors, traffic data characteristics, such as the autocorrelation functions, daily traffic distributions, and seasonality of traffic time series, provide information about the collective behaviors of highway travelers for tourism studies. Since not all types of vehicles are used for leisure and recreation, vehicle classification information allows researchers to derive even more relevant information from traffic data for tourism studies.

However, these special characteristics of highway traffic data are not only determined by peoples' travel behaviors under the influence of institutional and natural settings of society but are also determined by the geographical location (environmental factors) of traffic counters that record the data. Thus, conceptually, the random processes of highway traffic time series, daily traffic distributions, seasonality, vehicle type distributions, and geographical locations of traffic counters provide concordant evidence about tourism traffic flow.

In the model, the connection between the concept of patterned travel behaviors and tourism studies is based on highway traffic data characteristics. Therefore, information about traffic data characteristics will be used to develop a new data processing method to estimate tourism traffic for tourism studies. The derived tourism traffic information can be more confidently used (i.e., data relevancy to tourism is improved) in tourism research and planning in either a site-specific or a regional tourism monitoring system. The conceptual model in a graphic format is presented in Figure 3-8.

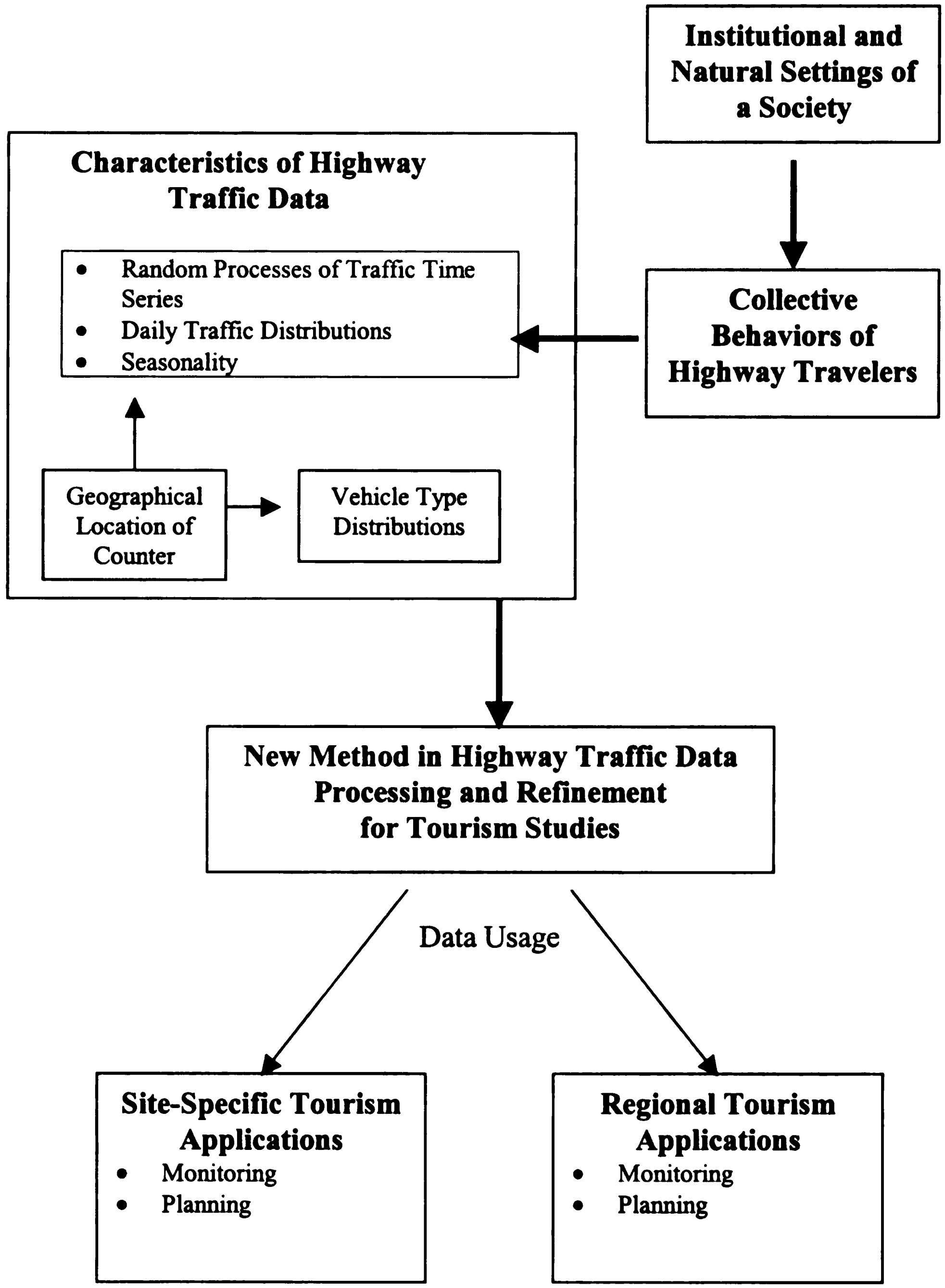


Figure 3-8. A Conceptual Model Linking Highway Traffic Data to Tourism Studies.

3.3.2 Patterned Behaviors and Routine Traffic

For purposes of tourism studies and planning, traffic data need to be divided into their tourism and non-tourism components. As previously mentioned, it is technically impossible to precisely separate tourism traffic from non-tourism traffic, because no researcher knows the trip purposes of all vehicles running on highways. However, a possible way to mitigate the problem of separating tourism from non-tourism traffic is to remove what it is believed to be the most unlikely tourism-related traffic from the total traffic. Thus, the remaining traffic flow would be more relevant for tourism studies than the original untreated data sets. It has already been shown that we can remove traffic generated by vehicles that are not likely to be used for leisure and recreation. Further, the concept of patterned behaviors of highway travelers can help us in the data refinement process.

Based on the conceptual model and initial observations of the random process, daily traffic distributions, and seasonality of highway traffic time series, the author assumes that there is a necessary amount of highway traffic that people have to take in order to satisfy society's institutional settings and individuals' societal functions. For example, people have to travel to work, to attend schools, to do grocery shopping, to see doctors, to deliver goods and services. Most public and private offices operate between 8AM and 5PM (i.e., 8 work hours and one lunch hour), and most stores are closed after 10PM. These scheduled and patterned collective behaviors are necessary so that the entire society can function normally. To perform each individual's societal functions, most people follow a fixed work schedule (for example an 8-to-5 and 40-hour workweek). Those who don't have to follow a fixed work schedule most often adhere to the majority's schedule, because the services they need are often not readily available at other times (i.e., the majority rules). Collectively, random behaviors of individuals in performing their roles in the society and to take care of their own personal business as well public affairs lead to relatively stable traffic patterns. In other words, as the result of people's patterned travel behaviors, this necessary amount of traffic can be characterized as routine. Although, routine traffic may vary across places and seasons and differ between weekday and weekend, it is often non-discretionary and less likely to be considered tourism-related.

Based on this observation, the author developed a new data refinement method and calls it the Removal of Routine Traffic Method in this study. The method uses the differences among daily traffic distributions to remove routine traffic. Mathematically, it performs the following operation:

$$\textit{Tourism traffic} = \textit{Total traffic} - \textit{NRV traffic} - \textit{Routine traffic},$$

where NRV traffic refers to traffic generated by non-recreation type vehicles (i.e., the FHWA vehicle Classes 7-13), easily abstracted from Classified Permanent Traffic Record data. Since routine traffic is unknown, it has to be estimated. Tourism traffic is the residual after removal of routine traffic. In Figure 3-9, each vertical bar represents the total traffic volume within an hour. Each vertical bar is comprised of three parts—the gray-colored portion represents the traffic generated by non-recreational type vehicles (NRV), the black-colored portion represents routine traffic, and the white-colored portion represents estimated tourism traffic during each hour interval. Estimated tourism traffic for a day is the sum of white-colored bars across a 24-hour period.

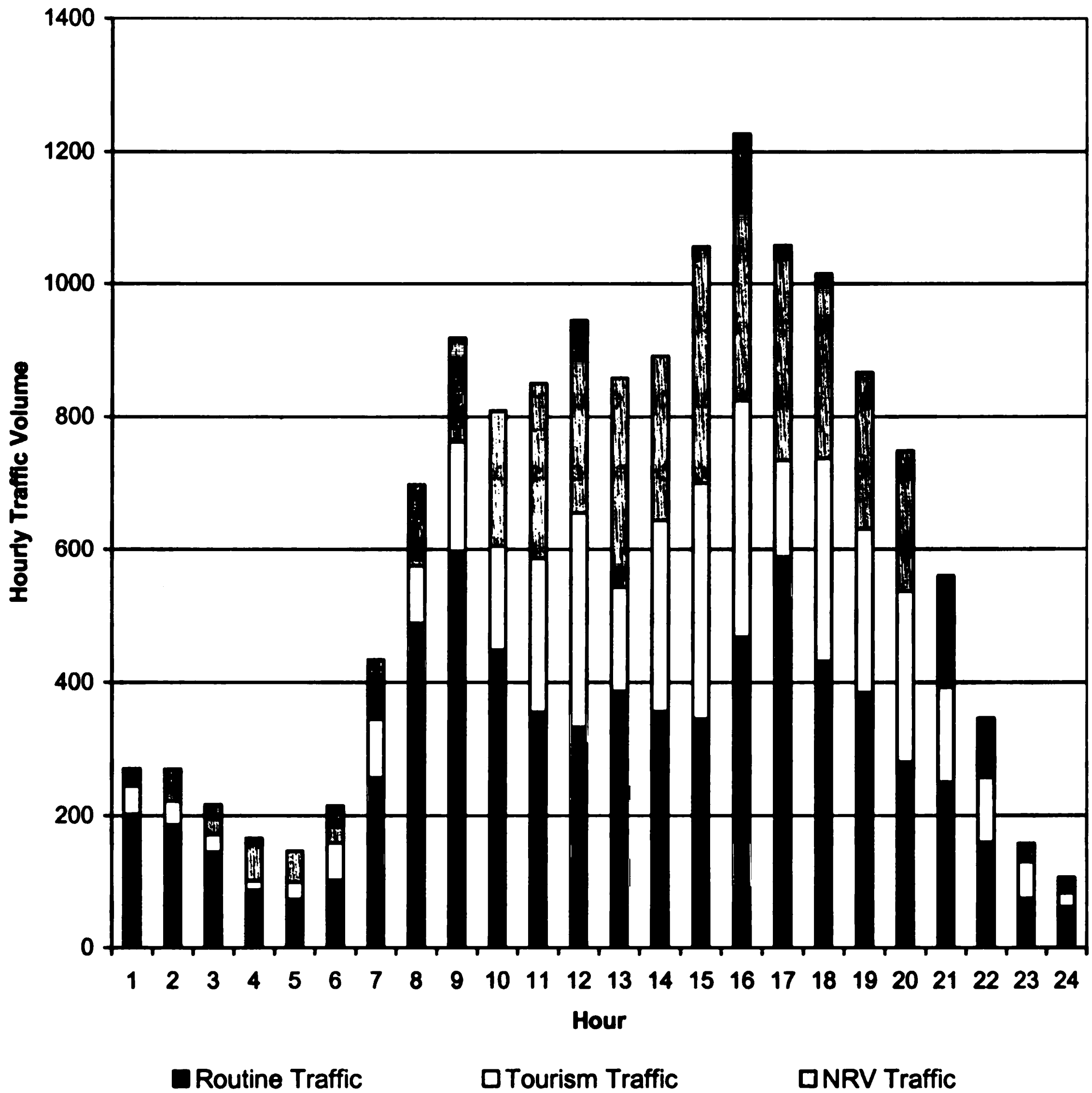
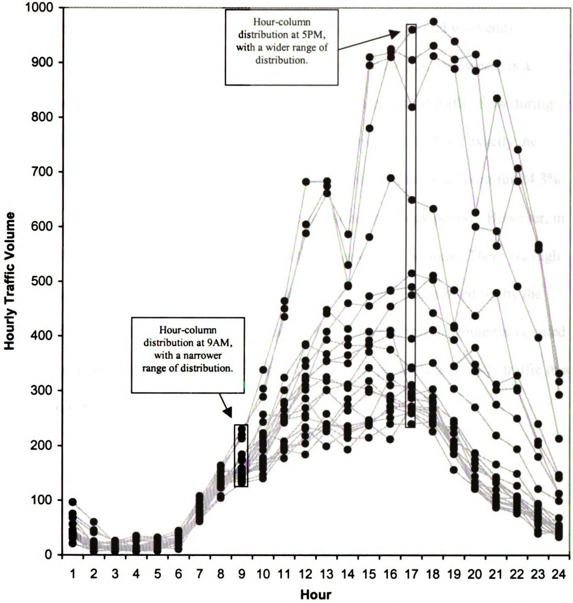


Figure 3-9. A Hypothetical Graph Showing the Separation of Hourly Traffic Volume into Three Components.

3.3.3 Method for Estimating Routine Traffic

Unlike NRV traffic, routine traffic needs to be estimated, because there are no statistics available for this kind of traffic. In order to estimate routine traffic, we need to select an appropriate cut-off point to separate routine from tourism traffic for each hour's traffic data. The following is the author's rationale and suggestion for how to select this cut-off point. First let us look at a special distribution of traffic data.

So far, we have examined the traffic data in a longitudinal way, that is from 1AM to 12PM, a 24-hour period, period by period. We have called each of the 24-hour's distribution "daily traffic distribution". We can also look at the data in a cross-sectional way, that is to examine traffic data recorded at the same hour point across different days. These hourly traffic data points from different days form a distribution. Let us call this kind of hourly traffic distribution the "hour-column distribution". Since there are 24 hours in a day, there are 24 hour-column distributions in any group of daily traffic distributions. For example, Figure 3-10 displays these 24 hour-column distributions from October's traffic data on highway I-75 around Station 4049 North. Each hour-column has its own distribution. Some distributions are wider and some distributions are narrower. For example, in Figure 3-10, the distribution range of hour-column at 9AM is much narrower than that at 5PM. A narrower range of hour-column distribution suggests that the traffic registered at that hour is primarily routine traffic, because traffic volumes vary slightly across days. A wider distribution suggests that there is more variation which may be due to non-routine traffic at that hour.



Note: Each point in the figure represents the hourly traffic volume for one day. Each vertical stack of points is an hour-column distribution (across days). Hourly traffic data points on the same day are connected by the gray-colored lines (i.e., daily traffic distributions). Most of the outliers in this figure are Fridays' traffic, which may lead to the proposition that Friday noon is the beginning time of a weekend. However this kind of observations often associated with traffic on rural highways. This proposition may not be true for traffic in urban areas (see Figure 3-6 for an example).

Figure 3-10. Examples of Hour-Column Distributions of Traffic Data (4049 North, Weekdays in October 1998).

Now let us consider the following scenario. Generally speaking, most people's lives and activities are scheduled on a weekly basis (i.e., weekdays and weekend) throughout the calendar year. Therefore, a period of seven days (i.e., one week) is a logical time frame to study people's travel behaviors and patterns. If traffic flow during the seven days distributed evenly across the period (i.e., everyone follows exactly the same travel pattern day by day), then each day's traffic volume should account for 14.3% (i.e., 100% ÷ 7 = 14.3%) of the total traffic volume during the 7-day period. However, in reality, traffic volumes do not distribute evenly across any 7-day periods. There are high and low traffic days. Therefore, the percentage of traffic volume accounted for by the lowest traffic day will be less than 14.3%, and the percentage of traffic volume accounted for by the highest traffic day will be more than 14.3%. The percentage of daily traffic in a 7-day period (***DP***) is calculated as:

$$DP_t = \frac{DV_t}{Sum(DV_t + DV_{t+1} + ... + DV_{t+6})}$$

where DP_t = Percentage of Day t traffic volume in a 7-day period, and

DV_t = Daily traffic volume on Day t.

For example, the third column in Table 3-5 exhibits the percentages of daily traffic in the 7-day period (***DP***s) 10/1/1998 to 10/31/1998 (using data from 4049 North). It is very likely that, on the lowest traffic day, there is more routine traffic but little tourism traffic. Thus, the traffic on lowest traffic day may suggest a cut-off point to estimate routine traffic.

We can also calculate the percentage of lowest daily traffic volume in a 7-day period (***LP***) as:

$$LP_t = \frac{Minimum(DV_t, DV_{t+1}, \ldots, DV_{t+6})}{Sum(DV_t + DV_{t+1} + \ldots + DV_{t+6})}$$

where LP_t = Percentage of lowest daily traffic volume in a 7-day period for Day t, and

DV_t = Daily traffic volume on Day t.

The fourth column of Table 3-5 exhibits the percentages of lowest daily traffic volume in the 7-day period (***LP***s) 10/1/1998 to 10/31/1998.

During a period of time (e.g., a month or a year), the percentages of daily traffic in any 7-day periods (***DP***s) form a probability distribution. Theoretically, the lowest possible percentage is 0% when the day has no traffic on the monitored highway. This may happen when all traffic is stopped due to some catastrophe. On the other hand, the highest possible percentage of daily traffic in a 7-day period can come close to 100%. This happens when the other 6 days have no traffic at all. Although these extreme cases usually do not happen, theoretically they are possible. Therefore, the theoretical distribution range of ***DP***s is from 0% to 100%, and the percentages of lowest daily traffic in a 7-day period (***LP***s) are points within the distribution range of ***DP***s.

Table 3-5. Examples of Percentages of Daily Traffic and Percentages of Lowest Daily Traffic Volume in a 7-Day Period (4049 North, October 1998).

Date (1)	Daily Traffic Volume (DV_t) (2)	Percentage of Daily Traffic Volume in a 7-Day Period (DP_t) (3)	Percentage of Lowest Daily Traffic Volume in a 7-Day Period (LP_t) (4)
10/1/98	6537	15%	10%
10/2/98	11492	27%	10%
10/3/98	6591	15%	10%
10/4/98	5679	13%	9%
10/5/98	4673	10%	9%
10/6/98	4159	9%	9%
10/7/98	4258	9%	9%
10/8/98	6424	14%	9%
10/9/98	11950	27%	9%
10/10/98	7753	18%	9%
10/11/98	6053	14%	9%
10/12/98	4795	12%	10%
10/13/98	3907	10%	10%
10/14/98	4364	11%	9%
10/15/98	5707	15%	9%
10/16/98	11348	30%	9%
10/17/98	6239	18%	10%
10/18/98	4695	14%	10%
10/19/98	3922	12%	10%
10/20/98	3402	10%	10%
10/21/98	3640	11%	10%
10/22/98	4672	14%	10%
10/23/98	8242	25%	11%
10/24/98	5322	17%	11%
10/25/98	4567	16%	11%
10/26/98	3766	13%*	12%*
10/27/98	3479	13%*	11%*
10/28/98	3688	14%*	10%*
10/29/98	3967	15%*	11%*
10/30/98	6322	25%*	11%*
10/31/98	3315	13%*	11%*

Note: $DP_t = \dfrac{DV_t}{Sum(DV_t + DV_{t+1} + ... + DV_{t+6})}$, $LP_t = \dfrac{Minimum(DV_t, DV_{t+1}, ..., DV_{t+6})}{Sum(DV_t + DV_{t+1} + ... + DV_{t+6})}$,

where DP_t = Percentage of Day t traffic volume in a 7-day period,

DV_t = Daily traffic volume on Day t,

LP_t = Percentage of lowest daily traffic volume in a 7-day period on Day t.

* Some data from November were used in the calculation in order to form a period of 7 days.

Using CPTR data, the author calculated the percentages of daily traffic (***DP*s**) and lowest daily traffic (***LP*s**) in a 7-day period throughout the entire year for each CPTR counter. Then, he averaged the derived percentages (***LPs***) from a counter according to traffic direction. The results are exhibited in Table 3-6. The overall average of these percentages (***LPs***) from all CPTR data sets is about 11%. Since it is possible that, on the lowest traffic day, some tourism trips are taken by people, the amount of routine traffic, on average, would most likely be a bit less than the amount of traffic represented by the 11% derived here. The author therefore made a decision to lower the 11% to 10% and then move on in the processes of estimating routine traffic. (The 10% position is a point in the distribution of ***DP*s** whose range is from 0% to 100%.)

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Table 3-6. Average Percentage of Lowest Daily Traffic Volume in a Seven-Day Period (in 1998).

Station	Direction	Location	Average Percent
3069	N	US-131, M-66 Kalkaska	10.71%
3069	S		12.13%
4049	N	I-75 Vanderbilt	9.88%
4049	S		10.28%
4129	N	US-27 Houghton Lake	10.17%
4129	S		10.43%
5029	N	US-27 St. Johns	10.50%
5029	S		11.74%
5039	S	US-27 By-Pass, St. Johns	11.75%
5059	NE	I-196 Hudsonville	9.75%
5059	SW		10.04%
5249	N	US-131 Morley	10.85%
5249	S		11.32%
5299	W	I-96 Ionia	11.41%
5309	N	US-131 Big Rapids	10.88%
5309	S		11.68%
6369	E	I-69 Capac	12.15%
7029	E	I-94 Grass Lake	11.85%
7109	N	US-131 Schoolcraft	10.81%
7109	S		11.26%
7159	E	I-94 Battle Creek	12.00%
7159	W		12.61%
7179	E	I-94 Coloma	12.06%
7179	W		11.79%
8219	E	I-96 Howell	11.84%
8219	W		11.68%
8229	N	US-23 Brighton, S of M-59	10.39%
8229	S		12.36%
8249	N	I-75 Luna Pier, S of Luna Pier Rd.	11.74%
8249	S		11.94%
8689	N	US-23 Dundee	12.33%
8689	S		12.22%
8729	N	US-23 Lambertville	11.79%
8729	S		11.75%
9049	N	US-127 Lansing, N. of Grand	10.08%
9049	S		11.09%
9369	E	I-94 Kalamazoo	11.13%
9369	W		11.00%
9829	W	I-696, E of Southfield Rd.	9.54%
9829	E		9.51%
9959	N	I-75, at Mack Ave	10.73%
9959	S		10.40%
9979	N	I-75, at Wattles Rd.	9.08%
9979	S		9.38%
Overall Average			**11.09%**

Although one could use the 10% position to estimate weekly (i.e., 7-day) tourism traffic, this method would be too general and look coarse, since the percentage of tourism traffic would then be consistently greater than 30% of each week's total traffic (see Table 3-7).

In Table 3-7, a day's tourism traffic percentage (based on 7-day's total traffic) is equal to DP_t - 10%. If the subtraction is less than 0%, a 0% is used as the day's tourism traffic. Adding these daily tourism traffic percentages in a group of 7 days, we can see that the estimated weekly tourism traffic percentages are consistently greater than 30%. The same problem arises on each CPRT data set (i.e., on each highway route).

The use of the 10% position from the distribution of ***DP*s** is therefore a very coarse way to estimate weekly tourism traffic. Further, while traffic data are collected in an hourly basis, the above method utilizes daily total traffic data only, that is, it fails to utilize hourly (more detailed) information from traffic data sets. Based on these concerns, it appears better to find a method which utilizes the information from hourly traffic data to estimate routine traffic and tourism traffic.

Now, let us explore the "hour-column distribution" which is a distribution of hourly traffic volume at the same hour across different days. Conceptually, an hour-column distribution is similar to the distribution of ***DP*s**, because both are distributions of traffic across days. The difference is that the former is on an hourly basis and the latter is on a daily basis.

Table 3-7. An Example of Coarse Estimation of Weekly Tourism Traffic Based on Average Percentage of Lowest-Traffic Day in a 7-Day Period.

Date	Percentage of One Day Traffic Volume in a 7-Day Period (DP_i) (2)	10% position as Routine Traffic (3)	Estimated Tourism Traffic (4)* = (2) – (3)	Percentage of Tourism Traffic for a 7 Day Period (5)**
10/1/98	15%	10%	5%	
10/2/98	27%	10%	17%	
10/3/98	15%	10%	5%	
10/4/98	13%	10%	3%	30%
10/5/98	10%	10%	0%	
10/6/98	9%	10%	0%*	
10/7/98	9%	10%	0%*	
10/8/98	14%	10%	4%	
10/9/98	27%	10%	17%	
10/10/98	18%	10%	8%	
10/11/98	14%	10%	4%	36%
10/12/98	12%	10%	2%	
10/13/98	10%	10%	0%	
10/14/98	11%	10%	1%	
10/15/98	15%	10%	5%	
10/16/98	30%	10%	20%	
10/17/98	18%	10%	8%	
10/18/98	14%	10%	4%	40%
10/19/98	12%	10%	2%	
10/20/98	10%	10%	0%	
10/21/98	11%	10%	1%	
10/22/98	14%	10%	4%	
10/23/98	25%	10%	15%	
10/24/98	17%	10%	7%	
10/25/98	16%	10%	6%	37%
10/26/98	13%	10%	3%	
10/27/98	13%	10%	3%	
10/28/98	14%	10%	4%	
10/29/98	15%	10%	5%	
10/30/98	25%	10%	15%	
10/31/98	13%	10%	3%	

Note: This table is using the same data as Table 3-5.
*The values in Column (4) = (2) – (3). If (4) is less than zero, zero is used.
**The values in Column (5) are sum of every 7 values in Column (4).

The distribution of ***DP*s** is within a range from 0% to 100%, which matches the hour-column distribution whose range is from 0 to some larger number of traffic count (i.e., the maximum traffic volume that a highway can carry in one hour). Conceptually, it should be feasible to apply the 10% position in the distribution of ***DP*s** (0% to 100%) to hour-column distributions. Practical difficulties arise when the 10% position in a range of 0 to some larger number is selected. If the choice of the 10% position in an hour-column distribution were based on the maximum traffic volume in the distribution (i.e., maximum traffic volume × 10%), a problem would occur if there was an extremely high volume (outlier) in the distribution. The estimated routine traffic would become much higher when there is an outlier than when there is no outlier. Since routine traffic is generally more stable than tourism traffic, it is desirable that the effects of an outlier are on tourism traffic rather than on routine traffic. Using the 10% position to estimate routine traffic does not obviate this problem; using a "percentile" position on the other hand can help avoid this difficulty.

If there are 100 data points in a distribution which are ordered from minimum to maximum according to their values, the data point in the middle of the rank is called median. A median point is also called the 50th percentile point, because 50% of data points in the distribution are smaller than the median and 50% of the data points are greater than the median. The most commonly used percentile points are the 25th, 50th, and 75th percentiles. A median is not equal to the mean value, unless the data are normally or evenly distributed. So, if traffic data points are evenly distributed, the 10% position is also equal to the 10th percentile position in the distribution.

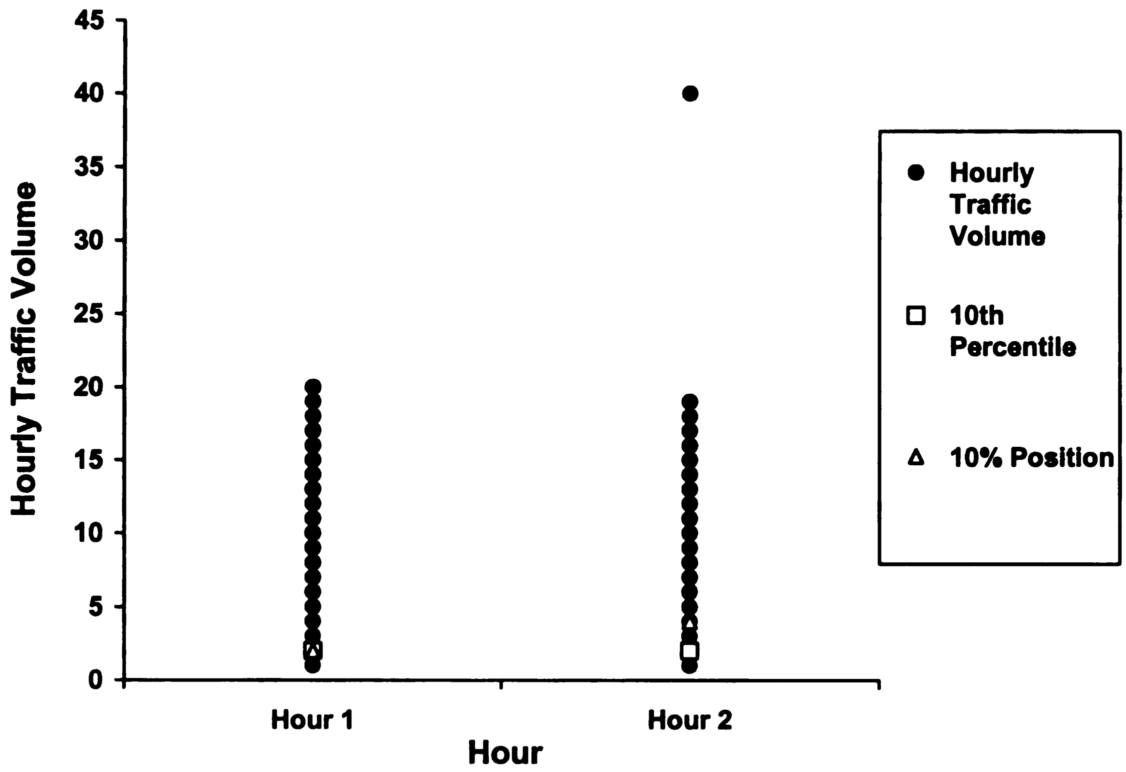
There are two benefits to using the 10th percentile position as compared to using the 10% position in a distribution like the hour-column distribution:

1) It is easier to locate in an hour-column distribution. Since the calculation is not based on the maximum value in the distribution, it is not necessary to know what the maximum value is, and

2) It can prevent the distorting effects of an outlier on estimating routine traffic, so that there is no need to be concerned about how large the maximum value is.

In this approach, outliers which may be caused by tourism activities will not affect the estimation of routine traffic. They instead contribute to the estimation of tourism traffic since a percentile is used as the cut-off point. For example, Figure 3-11 hypothetically displays two hour-column distributions. The two distributions are almost identical except that there is an outlier in the distribution of Hour 2. Using the 10th percentile position to estimate routine traffic, we will derive exactly the same estimates for both hour-column distributions. However, using the10% of the maximum value in the distribution, the estimate routine traffic in hour-column 2 is greater than that in hour-column 1. The rationale for selection of the 10th percentile in this case is analogous to the common practice by analysts that the median rather than the mean is used as descriptor of central tendency of a distribution when outliers exist.

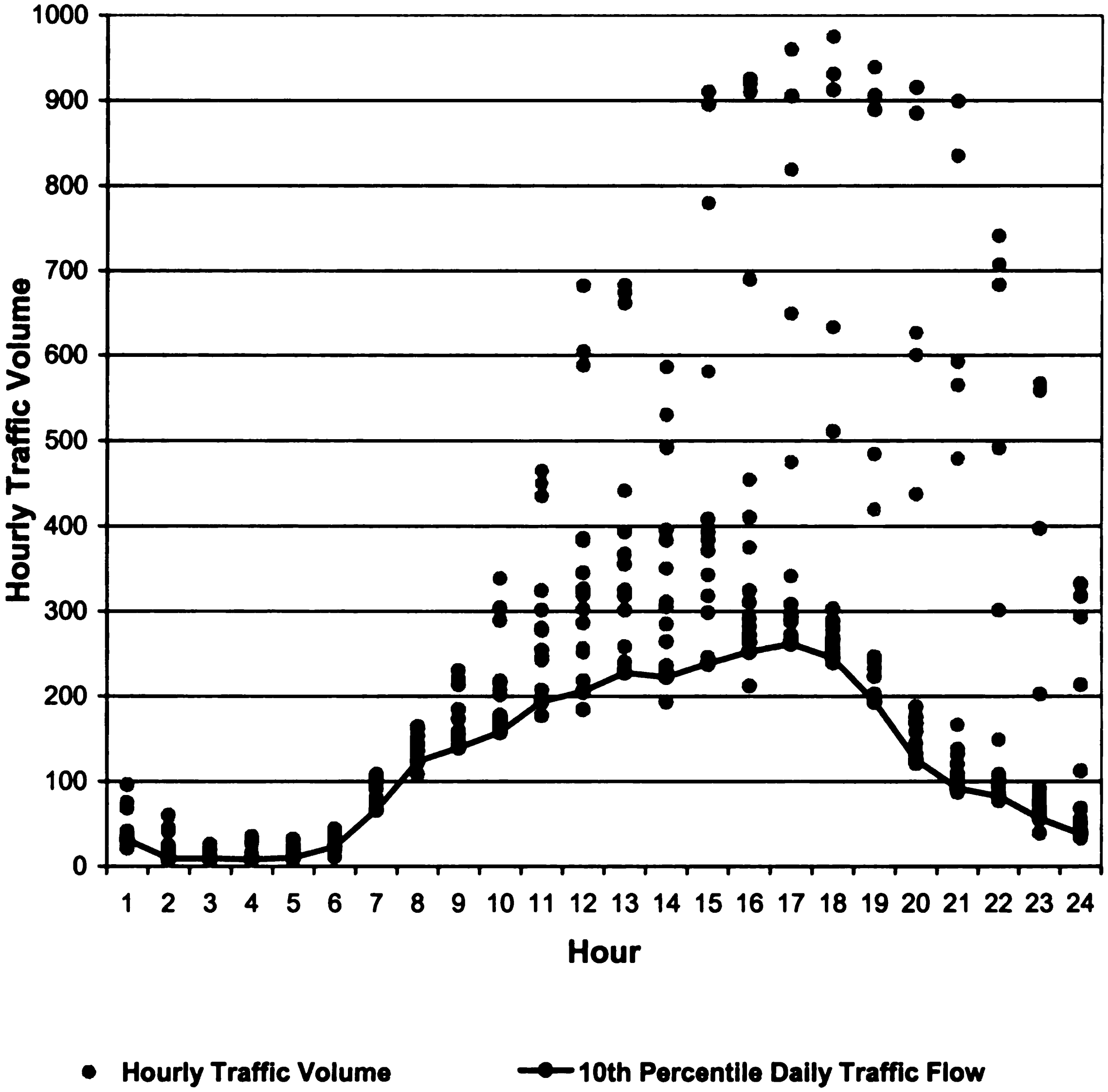
In view of the above demonstration, the author recommends the use of the 10th percentile position in each hour-column distribution to estimate routine traffic. Further, he would like to point out that this selection is reasonable since, on average, the estimated tourism traffic is close to what the Federal Highway Administration has estimated by using telephone surveys (see Chapter 4).



Note: The 10% and 10th percentile positions as the estimates of routine traffic volumes overlap in Hour-Column 1.

Figure 3-11. A Hypothetical Example Showing an Outlier's Effect on the Estimation of Routine Traffic.

Therefore, in an hour-column distribution, each data point can be ranked from minimum to maximum and referred to by a percentile position in the distribution. When connecting the Nth ($N = 1$ to 100) percentile points across these 24 hour-column distributions, a curve similar to daily traffic distribution is obtained and the curve is associated with the Nth percentile. Figure 3-12 depicts an example of using the 10th percentile daily traffic flow to estimate routine traffic.



Note: The 10th percentile daily traffic flow is the estimated daily routine traffic for each day in the month. For each data point in an hour-column, the difference between the point and the corresponding 10th percentile point is the estimated hourly tourism traffic volume. If a data point is lower than the 10th percentile point, its tourism traffic volume is assumed to be zero.

Figure 3-12. Example of Using the 10th Percentile Traffic Flow to Estimate Routine Traffic (4049 North, Weekdays in October 1998).

3.4 Estimating Tourism Traffic

The following demonstrates the use of hour-column distributions and their 10th percentile positions in the Removal of Routine Traffic Method. This method is designed to achieve the main objective of the study, that is to estimate tourism traffic. It is designed to remove hourly NRV traffic, estimate and remove hourly routine traffic, and leave the residual as the estimate of hourly tourism traffic. This section presents the detailed procedures for implementing the method. The cleaned hourly CPTR data were used as major data sets to be fed into the removal of routine traffic procedure. For illustration, the author used October 1998 CPTR data from 4049 North (I-75 at Vanderbilt) to demonstrate the removal of routine traffic operation in this section. To help readers understand the procedures, matrix terminology is used in the following description.

3.4.1 Step One--Data Filtering and Transposing

1. Data Filtering.

   In matrix terms, the CPTR data from each day's recording comprise a 24 by 13 matrix (24 hours and 13 vehicle types)—24 is the number of rows and 13 is the number of columns. Among the 13 vehicle types, only Classes 1 to 6 are considered recreation-related vehicle types; therefore, data points generated by non-recreational type vehicles need to be removed. Table 3-8 displays the separation of NRV traffic data points from RV traffic data points on October 1, 1998.

Table 3-8. Separating NRV Traffic from RV Traffic (4049 North, 10/1/1998).

MONTH	DAY	HOUR	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
10	1	1	0	31	24	0	0	1	0	1	6	0	0	0	2
10	1	2	0	15	7	0	0	0	0	0	5	0	0	1	1
10	1	3	0	13	10	0	0	0	0	0	1	0	1	0	1
10	1	4	0	12	10	0	3	0	0	2	4	0	1	0	0
10	1	5	0	13	9	1	3	0	0	0	1	1	0	0	0
10	1	6	0	16	7	0	1	0	0	6	10	4	1	0	3
10	1	7	0	42	28	0	3	1	0	5	15	2	0	2	4
10	1	8	0	82	43	0	5	4	2	5	16	8	1	0	3
10	1	9	0	106	65	2	1	2	0	4	10	7	0	0	5
10	1	10	0	151	84	0	7	1	0	6	20	8	1	0	5
10	1	11	0	161	100	1	2	1	0						4
10	1	12	0	236	102	5	10	2	0						6
10	1	13	1	297	143	1	5	1	0						5
10	1	14	0	270	135	2	5	1	0						7
10	1	15	0	324	141	3	4	1	0	10	13	13	0	0	7
10	1	16	0	343	131	1	4	4	0	19	8	3	0	0	7
10	1	17	0	356	153	0	4	2	0	15	17	7	0	0	7
10	1	18	0	343	152	2	4	2	0	10	8	8	1	0	6
10	1	19	0	227	112	1	3	2	1	10	18	1	1	1	3
10	1	20	0	251	122	0	3	3	0	6	7	2	0	0	2
10	1	21	0	200	101	1	0	0	0	9	7	2	0	0	6
10	1	22	0	214	86	1	3	1	0	5	7	0	0	0	3
10	1	23	0	124	83	0	0	1	0	7	8	0	0	2	0
10	1	24	0	93	45	1	2	0	1	5	9	3	0	0	3
10	2	1	0	36	31	0	1	0	0	2	3	0	0	0	1
10	2	2	0	19	21	0	1	0	0	0	6	0	0	0	1
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Remove C7 to C13, traffic of non-recreational vehicle types

Notations: NRV -- Traffic of non-recreational vehicle type (C1 to C6)
RV -- Traffic of recreational vehicle type (C7 to C13).

Vehicle Classes: C1. Motorcycle, C2. Car, C3. Pickup, C4. Bus, C5. SU2AX, C6. SU3AX, C7. SU4AX, C8. ST4AX, C9. ST5AX, C10. ST6AX, C11. DT5AX, C12. DT6AX, C13. DT7AX

(Please see Section 3.1.2 for detailed definitions of FHWA vehicle types.)

2. Data Transposing.

After removing NRV traffic data points, a matrix of 24 by 6 remains for each day's recording. Add the 6 columns horizontally, the result is a 24 by 1 column vector. Transpose the column vector (24 by 1) into a row vector (1 by 24) which results in a set of 24 hourly traffic data points generated by recreational type vehicles (Table 3-9).

Table 3-9. Transposing RV Traffic Data Points (4049 North, 10/1/1998).

MONTH	DAY	HOUR	C1	C2	C3	C4	C5	C6	Sum of C1 to C6 (RV Traffic)
10	1	1	0	31	24	0	0	1	56
10	1	2	0	15	7	0	0	0	22
10	1	3	0	13	10	0	0	0	23
10	1	4	0	12	10	0	3	0	25
10	1	5	0	13	9	1	3	0	26
10	1	6	0	16	7	0	1	0	24
10	1	7	0	42	28	0	3	1	74
10	1	8	0	82	43	0	5	4	134
10	1	9	0	106	65	2	1	2	176
10	1	10	0	151	84	0	7	1	243
10	1	11	0	161	100	1	2	1	265
10	1	12	0	236	102	5	10	2	355
10	1	13	1	297	143	1	5	1	448
10	1	14	0	270	135	2	5	1	413
10	1	15	0	324	141	3	4	1	473
10	1	16	0	343	131	1	4	4	483
10	1	17	0	356	153	0	4	2	515
10	1	18	0	343	152	2	4	2	503
10	1	19	0	227	112	1	3	2	345
10	1	20	0	251	122	0	3	3	379
10	1	21	0	200	101	1	0	0	302
10	1	22	0	214	86	1	3	1	305
10	1	23	0	124	83	0	0	1	208
10	1	24	0	93	45	1	2	0	141

Transposing the column vector to a row vector

Hourly traffic volumes on October 1, 1998

1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 PM
56	22	23	25	26	24	74	134	176	243	265	355	448	413	473	483	515	503	345	379	302	305	208	141

3.4.2 Step Two--Data Grouping

3. Data Sorting by Direction.

   After the Step-One operation, the data format is the same as for PTR data with 24 data points on each record. For each counter station, sort the data records by direction of traffic flow.

4. Data Sorting by Month.

   For each directional record set, separate the data records into monthly groups.

5. Data Sorting by Day of the Week.

   For each monthly group, separate the traffic data records into weekend and weekday groups (see examples in Table 3-10a and 3-10b). Weekend days are Saturdays and Sundays and weekdays are Monday through Friday. Holidays are grouped into weekend day group. An example of data grouping is displayed in Table 3-10. The selection of holidays is in accordance with observed national holidays. Specifically, the selected holidays in 1998 were New Year's Day (January 1st), January 2nd, Martin Luther King, Jr. Day (January 19th), President's Day (February 16th), Memorial Day (May 25th), July 3rd, Independence Day (July 4th), Labor Day (September 7th), Thanksgiving (November 26), November 27, and Christmas (December 25th). A copy of a 1998 calendar is provided in Appendix C. While each of these days is not a paid day off for all people employed, a substantial percentage of all households' normal travel routines are altered on these days because, for example, schools, post offices, and some businesses may be closed.

Table 3-10a. Example of Data Grouping--Weekend Groups (4049 North, 10/ 1998).

DATE	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 PM	Day of Week *
10/4	33	26	20	14	17	10	27	70	104	215	287	388	502	548	561	499	477	438	370	336	255	159	88	61	1
10/11	51	31	20	21	12	12	43	55	127	190	344	467	537	619	606	613	311	471	429	320	247	165	96	60	1
10/18	49	26	21	18	17	18	42	42	102	170	249	334	426	457	417	439	429	363	273	231	203	105	77	59	1
10/25	40	24	13	9	10	23	26	74	95	145	268	328	367	390	404	409	397	332	303	272	217	145	64	53	1
10/3	167	94	62	60	42	78	94	145	248	423	560	407	708	381	532	507	424	339	309	236	155	139	117	71	7
10/10	157	74	55	34	41	48	79	160	291	424	613	813	818	707	695	310	501	436	292	283	208	180	138	95	7
10/17	141	64	66	38	42	54	91	146	266	439	384	719	418	597	566	282	232	358	334	238	171	173	96	64	7
10/24	121	69	43	23	39	59	83	110	190	293	349	429	477	406	420	371	315	284	241	196	184	174	112	68	7
10/31	102	39	28	32	28	44	68	98	163	205	277	266	254	210	195	236	189	169	113	113	124	75	48	36	7

Table 3-10b. Example of Data Grouping--Weekday Groups (4049 North, 10/1998).

DATE	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 PM	Day of Week *
10/5	36	17	17	15	13	35	93	137	159	218	301	345	393	383	383	375	341	289	195	134	99	91	56	33	2
10/12	31	22	20	11	20	26	107	144	141	201	280	385	367	395	408	410	293	303	241	175	132	98	60	55	2
10/19	21	9	20	14	19	24	81	145	139	178	247	256	301	264	298	291	268	265	202	121	87	77	78	38	2
10/26	34	16	10	10	21	34	99	135	155	157	207	251	240	230	243	251	261	239	233	144	109	91	39	43	2
10/6	21	7	9	8	14	11	69	108	173	175	277	302	325	305	342	310	308	281	196	125	98	87	69	51	3
10/13	37	21	11	8	10	18	73	128	142	201	242	286	232	285	318	282	269	249	200	132	120	103	65	35	3
10/20	35	17	13	7	9	24	64	104	132	140	191	231	199	227	238	271	259	226	156	124	90	82	66	45	3
10/27	36	14	14	10	14	24	61	130	136	147	200	204	235	214	215	240	240	244	185	125	91	76	45	42	3
10/7	39	17	13	16	27	26	69	131	151	192	252	269	302	312	303	284	311	277	209	185	143	127	94	54	4
10/14	38	19	13	12	17	27	77	137	159	173	245	326	318	311	371	324	297	249	223	168	132	108	83	49	4
10/21	32	12	18	8	8	31	67	124	146	162	193	184	227	193	237	272	271	256	195	158	138	107	72	52	4
10/28	32	7	9	7	13	29	67	135	147	170	195	204	258	222	240	212	272	269	193	144	104	105	71	41	4
10/1	56	22	23	25	26	24	74	134	176	243	265	355	448	413	473	483	515	503	345	379	302	305	208	141	5
10/8	37	24	20	26	26	41	87	131	144	257	253	310	408	460	455	484	490	442	415	348	312	328	240	147	5
10/15	39	21	13	15	23	29	80	160	147	217	275	320	354	365	384	402	395	411	393	336	275	250	180	113	5
10/22	45	20	13	13	14	23	71	123	159	223	208	234	226	274	247	326	343	351	304	270	219	194	121	99	5
10/29	33	15	7	11	10	24	80	142	146	167	177	218	239	236	245	263	287	279	246	187	166	149	91	68	5
10/2	68	41	26	27	30	30	91	161	213	338	464	682	683	491	780	925	905	931	906	915	565	707	558	293	6
10/9	96	60	21	31	32	36	93	152	220	304	435	604	674	530	895	910	960	975	939	885	899	741	567	332	6
10/16	75	45	25	35	32	44	102	164	230	289	450	588	661	586	910	919	819	912	889	626	835	683	564	317	6
10/23	68	19	26	15	25	28	108	124	184	215	324	383	441	493	581	689	649	633	419	600	592	491	397	213	6
10/30	41	25	21	10	26	26	66	154	150	207	254	319	355	350	392	454	475	511	484	437	479	301	202	112	6

* Day of the week: 1 = Sunday, 2 = Monday, 3 = Tuesday, 4 = Wednesday,
5 =Thursday, 6 = Friday, 7 = Saturday.

3.4.3 Step Three--Estimating and Removing Routine Traffic

6. Estimating Routine Traffic.

After performing the prescribed data grouping procedures (according to travel direction, month, and day of the week), each traffic data block is a matrix of ***n*** rows by 24 columns, $\mathbf{C}_{nx24}$, where ***n*** is the available number of records in each month (either a weekday or a weekend group). The value in each cell represents traffic volume of a given hour of the day. From the ***n*** x 24 matrix, $\mathbf{C}_{nx24}$, the 10th percentile value ($\mathbf{P}_j$) of each hour-column is calculated. This results in a 1 x 24 row vector, $\mathbf{P}_{1x24}$, which is an estimate of the routine traffic flow for the traffic data group ($\mathbf{C}_{nx24}$).

$\mathbf{C}_{nx24}$ =

$C_{1\,1}$	$C_{1\,2}$	$C_{1\,3}$	...	$C_{1\,24}$
$C_{2\,1}$	$C_{2\,2}$	$C_{2\,3}$	...	$C_{2\,24}$
$C_{3\,1}$	$C_{3\,2}$	$C_{3\,3}$	...	$C_{3\,24}$
|	|	|	...	|
$C_{n\,1}$	$C_{n\,2}$	$C_{n\,3}$	...	$C_{n\,24}$

↓ ↓ ↓ ↓ ↓

$\mathbf{P}_{1x24}$ =

P_1	P_2	P_3	...	P_{24}

$\mathbf{C}_{ij}$ represents traffic volume of the *i*th day at the *j*th hour, and $\mathbf{P}_j$ represents the 10th percentile value of the *j*th hour-column. Table 3-11 and Figure 3-13 display an example of estimating hourly routine traffic volume from the hour-column distributions of weekend days' traffic data in October 1998.

Table 3-11. Example of Estimating Hourly Routine Traffic for 4049 North, Weekends in October 1998.

DATE	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 PM	Day of Week *
10/4	33	26	20	14	17	10	27	70	104	215	287	388	502	548	561	499	477	438	370	336	255	159	88	61	1
10/11	51	31	20	21	12	12	43	55	127	190	344	467	537	619	606	613	311	471	429	320	247	165	96	60	1
10/18	49	26	21	18	17	18	42	42	102	170	249	334	426	457	417	439	429	363	273	231	203	105	77	59	1
10/25	40	24	13	9	10	23	26	74	95	145	268	328	367	390	404	409	397	332	303	272	217	145	64	53	1
10/3	167	94	62	60	42	78	94	145	248	423	560	407	708	381	532	507	424	339	309	236	155	139	117	71	7
10/10	157	74	55	34	41	48	79	160	291	424	613	813	818	707	695	310	501	436	292	283	208	180	138	95	7
10/17	141	64	66	38	42	54	91	146	266	439	384	719	418	597	566	282	232	358	334	238	171	173	96	64	7
10/24	121	69	43	23	39	59	83	110	190	293	349	429	477	406	420	371	315	284	241	196	184	174	112	68	7
10/31	102	39	28	32	28	44	68	98	163	205	277	266	254	210	195	236	189	169	113	113	124	75	48	36	7
Hourly Routine Traffic	**39**	**26**	**19**	**13**	**12**	**12**	**27**	**52**	**101**	**165**	**264**	**316**	**344**	**347**	**362**	**273**	**223**	**261**	**215**	**179**	**149**	**99**	**61**	**50**	

Note: The calculation of each hourly routine traffic volume was based on the 10th percentile position in each hour column. This table uses the same data as Table 3-10a. * Day of the week: 1 = Sunday, 7 = Saturday.

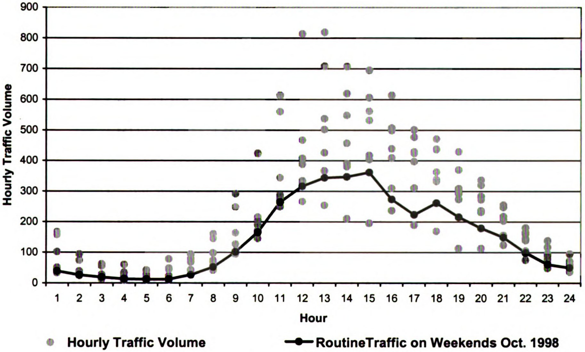


Figure 3-13. Routine Traffic for 4049 North, Weekends in October 1998.

7. Removing Routine Traffic.

The Removal of Routine Traffic is completed by subtracting the 10th percentile value calculated for each hour column from the value in each cell of the column. Let $\mathbf{D}_{ij}$ represent the difference of the value in a cell from the 10th percentile value for the column. If $\mathbf{D}_{ij}$ is less than zero, then zero should be assigned to this value. Therefore, a matrix of differences, $\mathbf{D}_{nx24}$, is derived as follows:

$\mathbf{D}_{nx24}$ =

$C_{1\,1} - P_1$	$C_{1\,2} - P_2$	$C_{1\,3} - P_3$	...	$C_{1\,24} - P_{24}$
$C_{2\,1} - P_1$	$C_{2\,2} - P_2$	$C_{2\,3} - P_3$	...	$C_{2\,24} - P_{24}$
$C_{3\,1} - P_1$	$C_{3\,2} - P_2$	$C_{3\,3} - P_3$	...	$C_{3\,24} - P_{24}$
|	|	|	...	|
$C_{n\,1} - P_1$	$C_{n\,2} - P_2$	$C_{n\,3} - P_3$	...	$C_{n\,24} - P_{24}$

Also, $\mathbf{D}_{nx24}$ =

$D_{1\,1}$	$D_{1\,2}$	$D_{1\,3}$	...	$D_{1\,24}$
$D_{2\,1}$	$D_{2\,2}$	$D_{2\,3}$	...	$D_{2\,24}$
$D_{3\,1}$	$D_{3\,2}$	$D_{3\,3}$	...	$D_{3\,24}$
|	|	|	...	|
$D_{n\,1}$	$D_{n\,2}$	$D_{n\,3}$	...	$D_{n\,24}$

$\mathbf{D}_{ij} \geq \mathbf{0}$ for all $\mathbf{i}$ = 1 to $\mathbf{n}$, and $\mathbf{j}$ = 1 to 24. An example of this operation is displayed in Table 3-12. Table 3-12 is derived from Table 3-11 by subtracting the corresponding hourly routine traffic volume from cells in each column.

All negative values were replaced by zeros during the operation, because traffic volume cannot be less than zero. For example, in Table 3-11, the traffic volume at 1AM on 10/4/1998 is 33, but the routine traffic volume is 39. A negative value would occur in the subtraction; therefore, a zero value is used in Table 3-12 to represent the tourism traffic volume at this hour on 10/4/1998 (at Station 4049 North).

Table 3-12. Examples of Estimating Hourly Tourism Traffic for 4049 North, Weekend Days in October 1998.

DATE	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 PM	Day of Week*
10/4	0	0	1	1	5	0	0	18	3	50	23	72	158	201	199	226	254	177	155	157	106	60	27	11	1
10/11	12	5	1	8	0	0	16	3	26	25	80	151	193	272	244	340	88	210	214	141	98	66	35	10	1
10/18	10	0	2	5	5	6	15	0	1	5	0	18	82	110	55	166	206	102	58	52	54	6	16	9	1
10/25	1	0	0	0	0	11	0	22	0	0	4	12	23	43	42	136	174	71	88	93	68	46	3	3	1
10/3	128	68	43	47	30	66	67	93	147	258	296	91	364	34	170	234	201	78	94	57	6	40	56	21	7
10/10	118	48	36	21	29	36	52	108	190	259	349	497	474	360	333	37	278	175	77	104	59	81	77	45	7
10/17	102	38	47	25	30	42	64	94	165	274	120	403	74	250	204	9	9	97	119	59	22	74	35	14	7
10/24	82	43	24	10	27	47	56	58	89	128	85	113	133	59	58	98	92	23	26	17	35	75	51	18	7
10/31	63	13	9	19	16	32	41	46	62	40	13	0	0	0	0	0	0	0	0	0	0	0	0	0	7

Note: The values in this table is based the data in Table 3-11.
* Day of the week: 1 = Sunday, 2 = Monday, 3 = Tuesday, 4 = Wednesday, 5 =Thursday, 6 = Friday, 7 = Saturday.

3.4.4 Estimating Tourism Traffic

By summing values in the difference matrix (e.g., Table 3-13) vertically ($D_{\bullet j} = \sum_{i=1}^{n} D_{ij}$) and then averaging the sum ($\overline{D}_{\bullet j} = {D_{\bullet j}}/{n}$), an average of hourly tourism traffic volume is derived. Further, the average daily tourism traffic (ADTT) is calculated by summing the hourly averages horizontally ($ADTT = \sum_{j=1}^{24} \overline{D}_{\bullet j}$). Table 3-13 displays this operation using the weekend data for October 1998 at 4049 North. The sum of the column average (the last row) is the average daily tourism traffic (ADTT) which represents the average tourism traffic volume on each weekend day in October 1998.

The above procedures are applied to both weekend and weekday groups in every month to estimate weekend day ($ADTT_e$) and weekday ($ADTT_d$) tourism traffic. An estimation of a week's tourism traffic (TTw) thus is:

$$TTw = ADTT_d \times 5 + ADTT_e \times 2$$

The above details the three-step operation for removing routine traffic from total traffic with the residual traffic being the desired estimate of tourism traffic.

Table 3-13. Example of Difference Matrix Derived from Removal of Routine Traffic Operation (4049 North Weekend Days in October 1998).

DATE	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 PM	Sum
10/4	0	0	1	1	5	0	0	18	3	50	23	72	158	201	199	226	254	177	155	157	106	60	27	11	
10/11	12	5	1	8	0	0	16	3	26	25	80	151	193	272	244	340	88	210	214	141	98	66	35	10	
10/18	10	0	2	5	5	6	15	0	1	5	0	18	82	110	55	166	206	102	58	52	54	6	16	9	
10/25	1	0	0	0	0	11	0	22	0	0	4	12	23	43	42	136	174	71	88	93	68	46	3	3	
10/3	128	68	43	47	30	66	67	93	147	258	296	91	364	34	170	234	201	78	94	57	6	40	56	21	
10/10	118	48	36	21	29	36	52	108	190	259	349	497	474	360	333	37	278	175	77	104	59	81	77	45	
10/17	102	38	47	25	30	42	64	94	165	274	120	403	74	250	204	9	9	97	119	59	22	74	35	14	
10/24	82	43	24	10	27	47	56	58	89	128	85	113	133	59	58	98	92	23	26	17	35	75	51	18	
10/31	63	13	9	19	16	32	41	46	62	40	13	0	0	0	0	0	0	0	0	0	0	0	0	0	
Col. Avg.	58	24	18	15	16	27	35	49	76	115	108	151	166	148	145	139	144	104	92	75	50	50	34	15	**1854**

Note: The horizontal sum of column averages is the average daily tourism traffic (ADTT). This table uses the same data as Table 3-12.

The desired estimate of tourism traffic for each day can be calculated by summing the cells in each difference matrix horizontally ($D_{i\bullet} = \sum_{j=1}^{24} D_{ij}$). The derived estimates are the estimated tourism traffic of corresponding dates (see Table 3-14). Let us call these values the "daily tourism estimates (DTEs)" and distinguish them from average daily tourism traffic (ADTT). ADTT is used as a general estimate of daily tourism traffic for a period of time (e.g., a month), which is useful in a statistical summary and comparison to other ADTTs from different periods of time. A DTE is simply the estimated tourism traffic on a specific day (e.g., in Table 3-14, tourism traffic volume is 1,905 on October 4,

1998) and is useful for creating further statistical analyses. Note that, in the same time frame, the average of the DTEs is equal to its corresponding ADTT. For example, the last number, 1854, in Table 3-14 is equal to the last number, 1854, in Table 3-13.

Table 3-14. Daily Tourism Estimates (DTEs) for 4049 North, Weekend Days in October 1998.

DATE	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 AM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 PM	DTE
10/4	0	0	1	1	5	0	0	18	3	50	23	72	158	201	199	226	254	177	155	157	106	60	27	11	1905
10/11	12	5	1	8	0	0	16	3	26	25	80	151	193	272	244	340	88	210	214	141	98	66	35	10	2240
10/18	10	0	2	5	5	6	15	0	1	5	0	18	82	110	55	166	206	102	58	52	54	6	16	9	985
10/25	1	0	0	0	0	11	0	22	0	0	4	12	23	43	42	136	174	71	88	93	68	46	3	3	840
10/3	128	68	43	47	30	66	67	93	147	258	296	91	364	34	170	234	201	78	94	57	6	40	56	21	2691
10/10	118	48	36	21	29	36	52	108	190	259	349	497	474	360	333	37	278	175	77	104	59	81	77	45	3845
10/17	102	38	47	25	30	42	64	94	165	274	120	403	74	250	204	9	9	97	119	59	22	74	35	14	2372
10/24	82	43	24	10	27	47	56	58	89	128	85	113	133	59	58	98	92	23	26	17	35	75	51	18	1449
10/31	63	13	9	19	16	32	41	46	62	40	13	0	0	0	0	0	0	0	0	0	0	0	0	0	356
Avg																									**1854**

Note: A Daily Tourism Estimate (DTE) is the horizontal sum of hourly tourism traffic of a day. This table uses the same data as Table 3-12.

3.5 Validation of the Removal of Routine Traffic Method

3.5.1 Validation Designs

In addition to developing the Removal of Routine Traffic Method, this section presents study designs for assessing the validity of the method in estimating tourism traffic. From the above discussion, it is clear that the Removal of Routine Traffic Method is designed to remove non-tourism traffic and leave residual traffic serving as an estimate of tourism traffic. Thus, this method meets face validity (or content validity) requirements for a valid procedure to estimate tourism traffic volume. However, the method's construct validity must also be confirmed. Construct validation involves determining whether or not the method measures what it is intended to measure (i.e., tourism traffic). Assessing construct validity involves accumulating evidence that measurement results are consistent with what relevant or established theory would suggest.

Five hypotheses were developed to assess the construct validity of the proposed method for estimating tourism traffic. The first hypothesis is to test whether there exists any difference in the percentages of tourism traffic on weekend day and weekday traffic. A paired two-sample *T* test will be used to test this hypothesis. The other hypotheses (i.e., Hypotheses II to V) test the theoretical expectations of variables, such as region, long weekend, direction, and percentage of recreational vehicle type traffic, on either weekend day or weekday tourism traffic. Rather than using several *T* tests to examine these hypotheses individually, these four hypotheses are combined and tested in two regression models. Note that Regression Analysis is simply a variation of *T* tests. Using Regression Analyses is more efficient to handle Null hypotheses II to V in this study.

The two regression models are: (1) a weekend regression model using percentage of weekend day tourism traffic as dependent variable, and (2) a weekday regression model using percentage of weekday tourism traffic as dependent variable. Region, long weekend, direction, and percentage of recreational vehicle type traffic are used as independent variables in both regression analyses to examine whether each variable provides theoretically expected explanatory power for the dependent variables (i.e., percentages of weekend and weekday tourism traffic). A stepwise method is used in both the weekend and weekday regression analyses. Independent variables are entered into or removed from the regression models depending on the significance of the F values. Criteria for entering and removing are the following: to enter a variable if its F value is less than or equal to 0.05; to remove a variable if its F value is greater than or equal to 0.10. In order to be entered into the regression models, all the above variables must pass the collinearity tolerance criterion of 0.0001. A variable is not entered if it would cause the tolerance of another variable already in the model to drop below the collinearity tolerance criterion.

3.5.2 Hypotheses

Null Hypothesis I: There is no significant difference in the "percentages" of tourism traffic on weekend days and weekdays.

Intuitively, weekend day tourism traffic should be proportionally greater than weekday tourism traffic. Therefore, statistical results should lead to rejecting this hypothesis. A paired two-sample *T* test will be used to test this hypothesis. The paired samples are the percentages of weekend day and weekday tourism traffic.

Null Hypothesis II: Region has no effect on the percentages of tourism traffic on either weekend days or weekdays.

Region (REG) indicates the location of the traffic counter. A counter's region is coded according to its location in one of the three major regions in Michigan. The variable is coded 1 for the Upper Peninsula (UP), 2 for the Northern Lower Peninsula (NLP), and 3 for the Southern Lower Peninsula (SLP). However, counters with 9000-level ID numbers (i.e., those located in urban areas) are coded 4, because populations are more concentrated in urban areas. Thus, a smaller value of this variable indicates a less populated (rural) area, and a higher value indicates a more populated area. The population estimates of Michigan counties in 1998 are exhibited in Appendix D.

This hypothesis is based on previous tourism infrastructure research findings that highway development has different influences in rural and urban areas (Stephanedes and Eagle, 1986; Humphrey and Sell, 1975; Kuehn and West, 1971). The theoretical expectation is that there is less routine, especially commuter, traffic in rural areas; thus, tourism traffic should be proportionally higher in less populated areas than in more populated areas. Therefore, statistical results should lead to rejecting Null Hypothesis II by indicating that the regression coefficient on this variable is negative and significantly different from zero in both weekend and weekday regression models.

Null Hypothesis III: Percentages of recreational vehicle type traffic have no effect on the percentages of tourism traffic on either weekend days or weekdays.

Percentage of recreational vehicle type (PRV) traffic is derived by dividing recreational vehicle type traffic volume by total traffic volume. Recreational vehicle type (RV) traffic is the base (or a superset) of tourism traffic. This variable should have positive explanatory power on the dependent variables. In another words, if a route has more non-recreational vehicle type traffic (i.e., truck traffic), then there will be less tourism traffic. Therefore, statistical results should lead to rejecting Null Hypothesis III by indicating that the regression coefficient on this variable is positive and significantly different from zero in both weekend and weekday regression models.

Null Hypothesis IV: Long weekends have no significant effect on the percentages of tourism traffic on either weekend days or weekdays.

A long weekend (LW) is a weekend with at least three non-work days. This variable indicates whether a month contains any long weekend. If a month contains a long weekend, the month is coded 1; otherwise the month is coded 0 thereby creating a dummy variable for insertion in the regression models. In 1998, January, February, May, July, September, November, and December each contained a long weekend. The theoretical perception is that a long weekend should have a significant positive effect on the percentage of weekend tourism traffic, but it should not have an effect on weekday tourism traffic of that week. Therefore, statistical results should lead to rejecting the Null Hypothesis IV on weekend regression model by indicating that the regression coefficient on this variable is positive and significantly different from zero. However, statistical results should lead to accepting the Null Hypothesis IV on weekday regression model by indicating that the regression coefficient on this variable is not significantly different from zero. Therefore, the variable, long weekend (LW), can be removed from the weekday regression equation.

Null Hypothesis V: Direction of traffic flow has no significant effect on the percentages of tourism traffic on either weekend days or weekdays.

Direction (DIR) indicates recorded traffic direction. North-and southbound are generally perceived as the major tourism traffic flow directions in Michigan. In this study, counters providing east and westbound traffic data are coded 0; otherwise, they are coded 1. The theoretical expectation is that, during weekends, counters on north-southbound highways should record higher percentages of tourism traffic than do counters on east-westbound highways. Therefore, statistical results should lead to rejecting Null Hypothesis V by indicating that the regression coefficient for this variable is positive and significantly different from zero in the weekend regression model. However, the effect of DIR on weekday tourism traffic is not as intuitive as its effect on weekend tourism traffic. Basically, there is no clear theoretical expectation about the direction of weekday tourism traffic. Although north-southbound rural-type tourism traffic can take place during weekdays, it is also possible that a large amount of east-westbound urban-type tourism traffic take place during weekdays. Thus, it is likely that this variable is not significant in the weekday regression model.

3.6 Measurement of Data Improvement

This section provides a discussion on how to measure the degree to which the Removal of Routine Traffic Method improves the tourism relevancy of original traffic data. A data improvement measurement was derived to evaluate the performance of the Removal of Routine Traffic Method.

Let's assume that there is x% tourism traffic in total traffic and x is between 0 and 100. The tourism relevancy of traffic data can be indicated as x%. However, the true percentage of tourism traffic in total traffic is usually unknown; therefore, x' % is used as an estimates of the percentage of tourism traffic. If we remove *y*% of non-tourism traffic from the total, the adjusted data relevancy to tourism becomes $(\frac{x}{100-y})\times 100\%$. In this study, ***(100 − y)%*** is the proposed estimate of tourism traffic (***x′ %***) after removing routine and non-recreational vehicle type traffic from the original data. Thus, a measurement of the degree to which the Removal of Routine Traffic Method improves the tourism relevancy of traffic data can be derived as follows:

$$\text{Percentage of Data Improvement} = \frac{\frac{x}{100-y}-\frac{x}{100}}{\frac{x}{100}} = \frac{\frac{x}{x'}-\frac{x}{100}}{\frac{x}{100}}$$

$$= \frac{100-x'}{x'}$$

$$= \frac{y}{100-y},$$

where ***x*** is the true percentage of tourism traffic, ***y*** is the estimated non-tourism traffic, and ***x′*** is the estimated percentage of tourism traffic and ***x′*** is equal to ***100 − y***. Note that both ***x′*** and ***y*** are percentage values, their possible values are between 0 and 100.

The possible range of data improvement after the Removal of Routine Traffic operation is from zero percent (i.e., when all traffic is tourism and ***x′*** = 100) to infinity (i.e., when tourism traffic is very small and ***x′*** is close to zero). In normal situations, these extreme cases are unlikely to happen. Nonetheless, the formula suggests that when a substantial amount of non-tourism traffic exists in untreated data, the Removal of Routine Traffic Method can greatly improve the data's relevancy to tourism. For example, when the percentage of non-tourism traffic, ***y***, is greater than 50%, the method will improve the tourism relevancy of traffic data by more than 100% (Table 3-15). Table 3-11 also displays that the amount of non-tourism traffic removed from the total has an exponential relationship with the percent change of data improvement. This exponential characteristic in data improvement strengthens the utility of the Removal of Routine Traffic Method in tourism studies.

Table 3-15. A Chart of Data Improvement at Hypothesized Percentage Points.

Percentage of Non-Tourism Traffic Removed	Improved Data Relevancy to Tourism
10%	11%
20%	25%
30%	43%
40%	67%
50%	100%
60%	150%
70%	233%
80%	400%
90%	900%

Chapter 4

Results

This chapter presents statistical results derived from the highway traffic data refinement procedures introduced in Chapter 3. It consists of four parts: (1) a data processing phase--a set of descriptive and inferential statistics derived from the initial analyses and the Removal of Routine Traffic operation from Michigan's highway traffic data, (2) a method validation phase--the results of hypotheses tests using paired samples T test and regression analyses for the verification of the Removal of Routine Traffic Method in estimating tourism traffic, (3) an evaluation phase--the results of measured data improvement, and (4) some example results from daily tourism estimates (DTEs).

4.1 Results from the Data Processing Phase

4.1.1 Results from Data Preparation

Prior to removing of routine traffic from hourly CPTR data, a couple of initial analyses were performed. The results of these statistical analyses are presented in this section. The overall distributions of highway traffic counts generated by the 13 FHWA vehicle types, on average, are:

- Class 1: motorcycle traffic accounts for 1.92% of total traffic,
- Class 2: passenger cars, 67.84%,
- Class 3: other two-axle, four-tire single unit vehicles (pickups), 16.11%,
- Class 4: buses, 0.23%,
- Class 5: two-axle, six-tire single unit trucks (SU2AX), 2.64%,

- Class 6: three-axle single unit trucks (SU3AX), 0.69%,
- Class 7: four or more axle single unit trucks (SU4AX), 0.13%,
- Class 8: four or less axle single trailer trucks (ST4AX), 1.18%,
- Class 9: five-axle single trailer trucks (ST5AX), 5.19%,
- Class 10: six or more axle single trailer trucks (ST6AX), 1.09%,
- Class 11: five or less axle multi-trailer trucks (DT5AX), 0.77%,
- Class 12: six-axle multi-trailer trucks (DT6AX) 0.69%, and
- Class 13: seven or more axle multi-trailer trucks (DT7AX), 1.53%.

The distribution of traffic according to vehicle classification is also visually displayed in Figure 4-1.

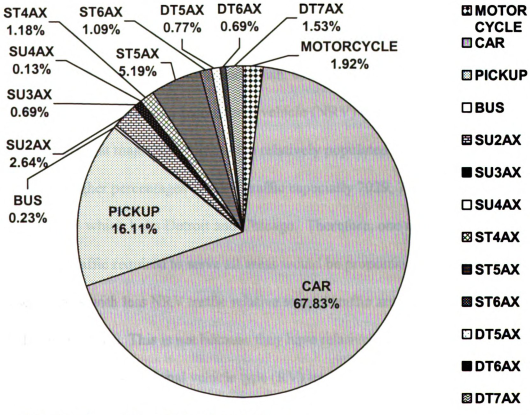


Figure 4-1. Distribution of Traffic by Vehicle Types.

Traffic generated by recreational type vehicles (that is, Classes 1-6) account for 89% of total traffic generated on Michigan's highways. Passenger cars alone account for about two-thirds of highway traffic. Motorcycles, passenger cars, and pickups account for more than 85% of traffic. Among the 13 vehicle types, buses usually carry much more (probably, 10 or 20 times more) passengers than the other types of vehicles. Although buses generate only 0.23% of the total traffic, this small percentage of traffic is highly tourism related and should not be neglected. Overall traffic generated by each non-recreational type vehicle is relatively small. On average, Classes 7 to 13 only account for 11% of the total traffic.

The distribution of traffic generated by recreational and non-recreational vehicle types on each monitored route are presented in Table 4-1. Among the counters, 3069 North, 5249 North, 5299 West, 6369 East, 7029 East, 5159 West and East, 7179 West and East, 8249 North and South, 8689 North and South, 8729 North and South, and 9369 West and East bear above average non-recreational vehicle (NRV) traffic as can be seen in Table 4-1. It appears that major highways in the relatively populated Southern Lower Peninsula bear much higher percentages of NRV traffic especially 7029, 7159, 7179, and 7369 all located on I-94 which links Detroit and Chicago. Therefore, one might generally assume that the NRV traffic required to serve all areas would be proportional to their population bases. Areas with less NRV traffic relative to total traffic are likely to be more tourism dominant areas. This is not because they have relatively less NRV traffic but because they have more recreational vehicle type (RV) traffic. This suggests that highways in more populated areas are potentially less tourism dominant routes as compared to highways in less populated areas.

Table 4-1. Traffic Distributions by Vehicle Types on Different Routes (%).

Station	Location	Motor-Cycle (Class 1)	Car (Class 2)	Pickup (Class 3)	Buses (Class 4)	Su2ax (Class 5)	Su3ax (Class 6)	Class 1-6	Class 7-13
3069N	US-131, M-66 Kalkaska	0.42	55.40	21.21	0.05	0.58	8.55	86.2	13.8
3069S		0.58	57.76	23.78	0.08	0.87	6.17	89.2	10.8
4049N	I-75 Vanderbilt	0.09	64.36	26.29	0.13	0.94	0.37	92.2	7.8
4049S		0.15	68.82	22.82	0.05	0.76	0.41	93.0	7.0
4129N	US-27 Houghton Lake	0.52	65.46	25.27	0.10	0.77	0.31	92.4	7.6
4129S		0.31	65.55	24.95	0.12	1.08	0.33	92.3	7.7
5029N	US-27 St. Johns	0.06	73.30	20.92	0.05	0.67	0.29	95.3	4.7
5029S		0.08	72.26	21.88	0.07	0.74	0.29	95.3	4.7
5039S	US-27 By-Pass, St. Johns	0.15	66.70	22.79	0.19	3.67	0.31	93.8	6.2
5059NE	I-196 Hudsonville	0.00	64.94	20.29	0.25	3.04	1.44	90.0	10.0
5059SW		0.00	71.51	14.50	0.20	2.54	1.10	89.8	10.2
5249N	US-131 Morley	0.46	55.84	19.89	0.10	8.06	0.38	84.7	15.3
5249S		0.04	63.26	22.48	0.09	4.88	0.44	91.2	8.8
5299W	I-96 Ionia	0.03	68.96	14.68	0.16	1.78	0.30	85.9	14.1
5309N	US-131 Big Rapids	0.02	59.03	26.19	0.10	3.89	0.49	89.7	10.3
5309S		0.07	63.73	22.92	0.13	3.50	0.39	90.7	9.3
6369E	I-69 Capac	0.42	51.79	16.09	0.22	8.55	0.58	77.6	22.4
7029E	I-94 Grass Lake	0.19	53.59	12.35	0.24	2.47	0.64	69.5	30.5
7109N	US-131 Schoolcraft	3.62	71.73	14.95	0.06	0.85	0.97	92.2	7.8
7109S		2.86	69.75	16.97	0.06	1.13	0.84	91.6	8.4
7159W	I-94 Battle Creek	0.44	60.84	15.27	0.24	0.96	2.79	80.5	19.5
7159E		0.12	59.48	13.32	0.29	1.31	0.60	75.1	24.9
7179W	I-94 Coloma	0.59	61.79	13.36	0.24	0.93	0.55	77.5	22.5
7179E		0.14	61.75	13.21	0.26	0.99	0.53	76.9	23.1
8219W	I-96 Howell	0.02	70.80	20.12	0.15	1.11	0.30	92.5	7.5
8219E		0.02	72.58	18.91	0.12	1.04	0.23	92.9	7.1
8229N	US-23 Brighton	0.17	70.37	19.39	0.11	1.07	0.46	91.6	8.4
8229S		0.07	65.78	24.52	0.32	1.19	0.38	92.3	7.7
8249N	I-75 Luna Pier	1.38	50.68	14.37	0.00	1.77	2.39	70.6	29.4
8249S		0.80	52.79	11.62	0.47	1.76	2.18	69.6	30.4
8689N	US-23 Dundee	0.41	68.60	14.67	0.10	1.34	2.19	87.3	12.7
8689S		0.29	66.59	15.27	0.05	0.75	1.98	84.9	15.1
8729N	US-23 Lambertville	0.83	55.14	24.85	0.92	2.11	0.42	84.3	15.7
8729S		0.61	68.09	13.42	0.07	0.77	1.62	84.6	15.4
9049N	US-127 Lansing	0.09	70.23	16.07	0.09	5.00	0.25	91.7	8.3
9049S		0.04	69.46	16.94	0.14	6.13	0.44	93.1	6.9
9369W	I-94 Kalamazoo	0.03	63.10	13.80	0.15	2.71	0.40	80.2	19.8
9369E		0.00	60.45	12.73	0.16	5.55	0.39	79.3	20.7
9829W	I-696, E of Southfield Rd.	0.29	87.33	6.41	0.15	0.89	0.24	95.3	4.7
9829E		0.08	80.95	13.85	0.07	1.09	0.25	96.3	3.7
9959N	I-75, at Mack Ave	0.09	67.87	20.22	0.31	5.11	0.45	94.0	6.0
9959S		0.08	75.69	15.06	0.26	2.85	0.54	94.5	5.5
9979N	I-75, at Wattles Rd.	0.02	71.64	17.44	0.12	4.90	0.33	94.4	5.6
9979S		0.01	72.79	19.36	0.09	2.07	0.34	94.7	5.3
	Overall Average	1.92	67.84	16.11	0.23	2.64	0.69	89.43	10.57

After coding the direction variable north-southbound highways as 1 and east-west bound as 0, one can observe the relationship between traffic flow and vehicle type. A Pearson correlation analysis demonstrates that the correlation coefficient between direction (**DIR**) and percentage of recreational vehicle type traffic (**PRV**) is 0.403 (*p*-value = 0.007) (Table 4-2). This correlation analysis indicates that north-southbound highways are more likely to be associated with a higher percentage of RV traffic than east-westbound highways. This goes along with the general perception that that north-south bound highways are likely to be more tourism dominant routes in Michigan.

Table 4-2. Correlations between Direction (NS vs. EW) and Percentage of RV Traffic.

		Direction	**% of RV Traffic**
Direction	Pearson Correlation	1.000	.403**
	Sig. (2-tailed)	.	.007
	N	44	44
% of RV Traffic	Pearson Correlation	.403**	1.000
	Sig. (2-tailed)	.007	.
	N	44	44

**Correlation coefficient is significant at the 0.01 levels.

After performing data filtering and transposing, the original CPTR data sets (containing 214,319 records) were transformed into a set of data with 8,645 records (in a format similar to PTR data sets). In Step Two of the data preparation operation (i.e., Data Grouping), the data were grouped according to traffic flow directions and months. Due to missing values, the data grouping operation resulted only in 315 monthly groups. A complete data set should result in 576 monthly groups (i.e., 24 CPTR stations x 12 months x 2 directions).

After the monthly groups were further broken down into weekend and weekday groups, 315 weekend and 315 weekday groups result. In both weekday groups and weekend groups, there are 102 north-, 130 south-, 37 east-, 24 west-, 11 northeast-, and 11 southwest-bound traffic record sets. Data for the month of June 1998 were not available from any of the CPRT traffic counters. Thus, there are 630 groups (i.e., 315 weekend groups and 315 weekday groups) to feed into the Removal of Routine Traffic operation. A summary of the number of records and groups in the Data Preparation Phase is presented in Table 4-3.

Table 4-3. Summary of Data Preparation.

	Group Description		Number of Groups
Original	Counter Stations		24
	Hourly CPTR data		214,319 (records)
Step One	Filtered and Transposed CPTR		8,645 (records)
Step Two	Monthly groups*		315
	Weekday groups**		315
	Northbound	102	
	Southbound	130	
	Eastbound	37	
	Westbound	24	
	Northeast-bound	11	
	Southwest-bound	11	
	Weekend groups**		315
	Northbound	102	
	Southbound	130	
	Eastbound	37	
	Westbound	24	
	Northeast-bound	11	
	Southwest-bound	11	
	Total week groups (i.e., weekend and weekday)		630

* June 1998's data are not available from all CPTR.

** No CPTR is Northwestern and Southeastern oriented.

A statistical summary indicates that, on average, the percentage of traffic generated by recreational type vehicles is 89.43%. After being broken down to weekend and weekday groups, the percentage of RV traffic is 93.37% during weekend days and 85.49% during weekdays. After being broken down to directional groups, the results indicate that the percentages of north-southbound RV traffic are greater than the percentages of east-westbound RV traffic during the weekend days as well as during the weekdays (Table 4-4).

Table 4-4. Percentages of RV Traffic in Total Traffic.

Day of Week	Direction	N	Mean of Average Daily Traffic	Average of RV traffic Percentages (%)
Weekend day	North	102	13714.92	93.49
	South	130	15142.84	94.49
Weekday	North	102	15968.09	86.31
	South	130	16837.85	86.96
Weekend day	East	37	27526.43	89.62
	West	24	21187.50	90.39
Weekday	East	37	35322.35	79.69
	West	24	24466.25	80.82
Weekend day	All directions	315	19392.92	93.37
Weekday	All directions	315	23148.63	85.49
All Days	All Direction	630	21270.7776	89.43

The statistics derived from comparing weekday RV traffic to weekend day RV traffic indicate that, in all directions, weekday RV traffic volumes are significantly higher than weekend day RV traffic volumes. However, the opposite results are derived when comparing percentages of weekday RV traffic to weekend day RV traffic. The percentages of RV traffic during the weekend day are significantly higher than during the weekday. The statistics from a paired two-sample *T* test are presented in Table 4-5. For visual convenience, the opposite results are graphically presented in Figure 4-2 and Figure 4-3. Figure 4-2 displays that the RV traffic volumes are higher during the weekday, and Figure 4-3 displays that the percentages of RV traffic are higher during the weekend day.

Results presented in Table 4-5 reveal that most *t* statistics are significant at the 0.01 levels of significance. The only exception is the westbound pair (p-value = 0.03), where the difference in RV traffic volumes between weekend day and weekday is only significant at 0.05 levels. Note that the negative signs on the *t* statistics (i.e., the sixth column in Table 4-5) indicate stations where the weekend days have a lower traffic volume (or percentage) than do weekdays, and the positive *t* statistics indicate stations where weekend days have a higher traffic volume (or percentage) than do weekdays. Although the weekday RV traffic volume appears to be higher than that of the weekend day, it is possible that the higher volume of weekday RV traffic is mainly generated by commuters.

In Table 4-5, the statistics also indicate that the percentage of north-southbound weekend day RV traffic is higher than that of east-westbound weekend day RV traffic. Also, the percentage of north-southbound weekday RV traffic is higher than that of east-westbound weekday RV traffic. This re-confirms that north-southbound highways are potentially more tourism dominant than east-westbound highways.

Table 4-5. Paired Two-Sample T-Test: Weekend Day vs. Weekday.

Direction	Paired Variables	Paired Differences Mean	Std. Deviation	Std. Error Mean	*t*	Degree of Freedom	*P* (Sig. 2-tailed)
North	RV Traffic Volume	-2253.1690	5505.5034	545.1261	-4.133**	101	.000
	Total Traffic Volume	-3525.1815	6119.5993	605.9306	-5.818**	101	.000
	RV Traffic Percentage	7.176E-02	4.357E-02	4.314E-03	16.634**	101	.000
South	RV Traffic Volume	-1695.0085	6896.2619	604.8422	-2.802**	129	.006
	Total Traffic Volume	-3001.1816	7477.3236	655.8047	-4.576**	129	.000
	RV Traffic Percentage	7.530E-02	4.953E-02	4.344E-03	17.334**	129	.000
East	RV Traffic Volume	-7795.9189	13003.8560	2137.8208	-3.647**	36	.001
	Total Traffic Volume	-10524.1622	13243.3145	2177.1875	-4.834**	36	.000
	RV Traffic Percentage	9.935E-02	5.941E-02	9.766E-03	10.173**	36	.000
West	RV Traffic Volume	-3278.7500	6990.3542	1426.9001	-2.298*	23	.031
	Total Traffic Volume	-6088.1250	7337.4116	1497.7429	-4.065**	23	.000
	RV Traffic Percentage	9.572E-02	3.867E-02	7.893E-03	12.128**	23	.000
All Directions	RV Traffic Volume	-2823.4709	7474.8135	421.1580	-6.704**	314	.000
	Total Traffic Volume	-4416.8702	8051.2059	453.6341	-9.737**	314	.000
	RV Traffic Percentage	7.877E-02	4.719E-02	2.659E-03	29.621**	314	.000

* Statistic is significant at 0.05 levels.
** Statistic is significant at 0.01 levels.

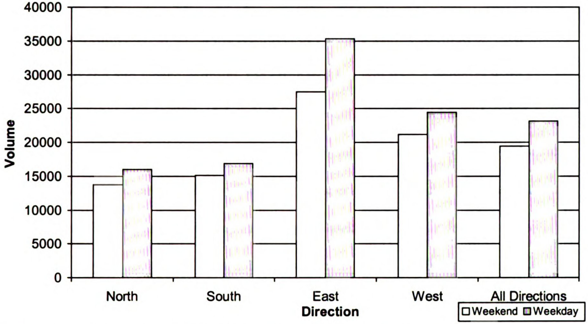


Figure 4-2. Volumes of RV Traffic: Weekend Day vs. Weekday.

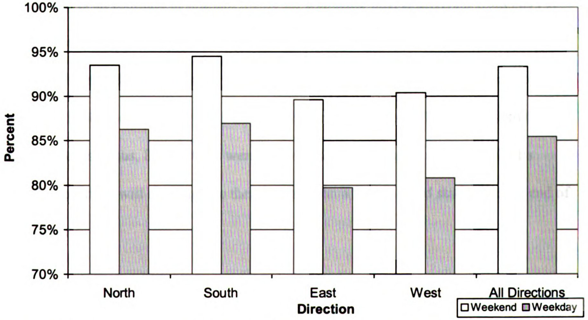


Figure 4-3. Percentages of RV Traffic: Weekend Day vs. Weekday.

4.1.2 Results from the Removal of Routine Traffic Operation

The 10th percentile traffic flow, as noted earlier, was used to estimate routine traffic on each route. After using the Removal of Routine Traffic Method on each monthly weekend and weekday group, the estimated tourism traffic volumes were derived. Examples of using actual data in the processing procedures have already been provided in the fourth section of Chapter 3. The estimated average daily tourism traffic (ADTT) volumes are summarized in Table 4-6. The estimates indicate that the volumes of tourism traffic are generally higher in more populated areas than in less populated areas. This may be due partially to the higher volumes of total traffic in populated areas as well as the definition of tourism (including both pleasure and business day trips and overnight trips) in this study. As ADTT is a summarized statistic, its major use is for the derivation of percentage of daily tourism traffic (PDTT). As mentioned in Chapter 3, another useful gauge for tourism traffic is the daily tourism estimate (DTE). Note that a DTE, which is an estimate of tourism traffic for a specific day, is different from ADTT. The number of DTEs created by the Removal of Routine Traffic Method are as many as the available records which are fed into this data refinement procedure. For example, there were 8,645 records (after the Data Filtering and Transposing Phase) fed into the removal process; thus, 8,645 DTEs were created. Due to the large amount of DTEs created, the author will demonstrate their use only on a few selected stations at the end of this chapter.

Table 4-6. Estimated Average Daily Tourism Traffic Volumes (ADTT).

Station	Location	Day of Week	Jan	Feb	Mar	Apr	May	Jul	Aug	Sep	Oct	Nov	Dec
3069N	US-131, M-66 Kalkaska	weekend	863	620	566	635	792	673	812	795	848	664	646
		weekday	648	622	756	485	727	693	954	715	807	676	742
3069S		weekend			975	716	847	1002	1083	1100	1349	742	707
		weekday			1036	526	464	463	728	857	678	524	698
4049N	I-75 Vanderbilt	weekend					2131	2259	3314	3061	1854	1496	1693
		weekday					2361	3826	2917	2858	2168	1602	1336
4049S		weekend					3706	5060	3692	5664	4695	3172	1610
		weekday					1340	2639	2343	1704	1931	1718	1168
4129N	US-27 Houghton Lake	weekend									1302	1605	1156
		weekday									1700	1429	1057
4129S		weekend									3085	2087	1114
		weekday									822	981	801
5029N	US-27 St. Johns	weekend							3175	6636	2961	4788	2463
		weekday							3906	5547	3333	4488	3347
5029S		weekend							5873	6776	5908	3573	2418
		weekday							1843	1905	2045	2369	2773
5039S	US-27 By-Pass, St. Johns	weekend	2138	2925	2490	2677	3574	4784		4967	4269	3570	2307
		weekday	970	1070	1218	1163	1277	1674		1971	2092	2285	2929
5059NE	I-196 Hudsonville	weekend	3063	3078	2499	2867	3142	3289	2897	2535	2727	2947	2508
		weekday	2695	3117	3783	2758	3451	3461	3994	3626	2893	2568	4089
5059SW		weekend	3308	2644	2621	2904	3400	3282	3623	2847	3117	3158	3076
		weekday	2999	2690	4103	2993	2824	2544	2468	2411	2982	3241	4301
5249N	US-131 Morley	weekend	1752	1850	1474	2416	2655	3183		2945	2634	3605	2348
		weekday	1866	1872	1701	2801	2387	3436		3113	3254	2426	1802
5249S		weekend	1752	1850	1474	2416	2655	3183		2945	2634	3605	2348
		weekday	1866	1872	1701	2801	2387	3436		3113	3254	2426	1802
5299W	I-96 Ionia	weekend	3040	4075	3567	3922	4112	4420	3399				
		weekday	3401	3824	4894	3642	3148	3250	3431				
5309N	US-131 Big Rapids	weekend								3162	2203	2366	1240
		weekday								2933	2118	1713	1184
5309S		weekend	2405	2291	2179	2746	4267	4578	3664	4853	4217	3251	1741
		weekday	931	849	950	905	1129	2260	2153	1130	1066	1256	1088
6369E	I-69 Capac	weekend	982	928	1105	1198	1089	1532	2333				
		weekday	855	658	829	765	872	1008	1415				
7029E	I-94 Grass Lake	weekend				5151					5126		3233
		weekday				3538					4208		3420
7109N	US-131 Schoolcraft	weekend				1606	1598	1663		2241	1909	1647	2000
		weekday				1424	1363	1943		1792	2020	1582	2785
7109S		weekend				1567	1653	2244	1583	1898	2116	1692	2052
		weekday				1300	1897	2035	1798	1656	1464	1180	1902
7159W	I-94 Battle Creek	weekend					4589			2629			
		weekday					4806			3193			
7159E		weekend					3318			4922	4203	5562	3509
		weekday					4286			3509	3874	3904	2587
7179W	I-94 Coloma	weekend								2085	3141	4078	2981
		weekend								2364	3174	3491	3305
7179E		weekend								1956	3379	4649	3537
		weekday								2410	3167	2720	2788

Table 4-6. (cont'd)

Station	Location	Day of Week	Jan	Feb	Mar	Apr	May	Jul	Aug	Sep	Oct	Nov	Dec
8219W	I-96 Howell	weekend										7774	4717
		weekday										6980	7431
8219E		weekend										5915	4482
		weekday										6100	5884
8229N	US-23 Brighton	weekend	3796							6706	5301	5899	3928
		weekday	4726							5591	5392	5451	4482
8229S		weekend	5138							7706	7249	7259	3163
		weekday	4212							3496	4531	3679	2915
8249N	I-75 Luna Pier.	weekend	3223	3916	3291	3304	2521	4403					
		weekday	2460	3149	3436	2549	3330	3012					
8249S		weekend	2536	2858	2517	2980	3149	2499	2713	2526	3178	3511	3886
		weekday	1626	2156	1831	2413	2114	3160	3327	1873	1667	2146	2841
8689N	US-23 Dundee	weekend	2495	2353	2587	2612	3458	4579	4803	3884	3615	4052	2583
		weekday	2099	2395	2441	2463	2758	3475	3856	2897	2773	2609	2514
8689S		weekend	2371	1932	2565	2462	2309	4578	4534	3810	3170	3167	2884
		weekday	1978	2015	2541	2825	2795	3167	2964	2389	2934	2849	2916
8729N	US-23 Lambertville	weekend	3626	2371	3603	3732	3821	3954	4644	3455			
		weekday	2254	2381	3379	2624	3055	4399	5202	3159			
8729S		weekend	3817			3347	2871	4819	4312	3579	3221	3935	3568
		weekday	2613			3344	2678	3247	2607	3029	2674	3052	3172
9049N	US-127 Lansing	weekend	4431	3080	2943	3198	4197	4395	3962	4450	4839	4795	4644
		weekday	3566	3431	3591	4831	4247	3681	4815	4819	5236	5532	6205
9049S		weekend	4332	3002	2770	2853	3132	4569	4302	6177	5901	5655	5096
		weekday	3682	3887	4382	3640	4256	3836	3756	4072	3505	3944	7008
9369W	I-94 Kalamazoo	weekend	6538	4673	4872	6494	5221	5097					6090
		weekday	3872	4810	5489	7899	4641	5476					5925
9369E		weekend	6825	5156	4670	6183	4430	6057					
		weekday	5134	4929	5895	7530	4086	4574					
9829W	I-696, E of Southfield	weekend		18807			13962						
		weekday		16961			15213						
9829E		weekend		14662	14860	14895	15100	17065	11979	14810	14761	13845	14124
		weekday		15887	14274	15973	13926	13255	16758	16334	14692	15429	20380
9959N	I-75, at Mack Ave.	weekend	13626	7921	8656	9114	9586	9447	8339				9628
		weekday	12492	7352	7875	8520	7687	8312	8557				10995
9959S		weekend	13488	9652	9028	9138	12073	11559	6975			9347	8519
		weekday	9872	9879	12189	10685	9368	10329	7764			9799	12062
9979N	I-75, at Wattles Rd.	weekend	11802			8687				7879	8620	10147	10687
		weekday	12169			11804				8239	11382	10559	17208
9979S		weekend	11583	9839	7366	8089	7680	9216	7106	7123	7464	10130	11145
		weekday	10274	9799	10160	13640	10669	9671	8216	9871	9295	10306	16750

As tourism dominance is defined by the percentage of tourism traffic on a route, the percentages of daily tourism traffic (PDTT) are summarized and displayed in Table 4-7. The percentage of daily tourism traffic is calculated by dividing the average daily tourism traffic (ADTT) by the average daily traffic (ADT) of a counter: $PDDT = \frac{ADTT}{ADT}$.

For instance, the average daily traffic (ADT) on a January weekend day around Station 3069 North was 2,616 vehicles (derived along with the Removal of Routine Traffic Method) and the estimated average daily tourism traffic (ADTT) is 863 vehicles (i.e., the first traffic volume data point displayed in Table 4-6). Therefore, the percentage of daily tourism traffic (PDDT) is 33% (i.e., the first percentage data point displayed in Table 4-7). Estimates in Table 4-7 indicate that the percentages of tourism traffic were higher during weekend days than during weekdays for most routes and months in 1998.

In September 1998, Station 5029 (on US-27) northbound weekend day tourism traffic accounted for more than 50% of the total traffic; therefore, this highway segment can be considered to be "absolutely" tourism dominant. Generally, the observations of tourism dominance in Table 4-7 are consistent with the fact that north-southbound highways are the major corridors accessing most visited destinations and natural recreation areas in northern Michigan. For example, Stations 4049 (on I-75), 4129, 5029, 5039 (on US-27), 5309 (on US-131), and 8729 (on US-23) frequently registered higher percentages of tourism traffic and displayed "relative" tourism dominance as compared to other routes. Also, highways in more populated areas (e.g., stations with ID number greater than 7000) during the weekday are generally less tourism dominant. Applications of tourism dominance will be discussed in Chapter 5.

Table 4-7. Percentages of Tourism Traffic.

Station	Location	Day of Week	Jan	Feb	Mar	Apr	May	Jul	Aug	Sep	Oct	Nov	Dec
3069N	US-131, M-66 Kalkaska	weekend	33%	21%	21%	21%	24%	17%	20%	21%	23%	23%	23%
		weekday	20%	18%	24%	13%	18%	15%	21%	17%	19%	18%	21%
3069S		weekend			35%	23%	23%	22%	24%	25%	33%	24%	25%
		weekday			35%	15%	12%	11%	17%	22%	17%	14%	20%
4049N	I-75 Vanderbilt	weekend					38%	23%	33%	39%	33%	40%	47%
		weekday					36%	37%	32%	39%	38%	40%	39%
4049S		weekend					43%	35%	24%	46%	48%	45%	39%
		weekday					23%	28%	24%	24%	31%	32%	28%
4129N	US-27 Houghton Lake	weekend									27%	36%	28%
		weekday									37%	35%	30%
4129S		weekend									45%	39%	30%
		weekday									21%	27%	25%
5029N	US-27 St. Johns	weekend							25%	57%	20%	44%	23%
		weekday							31%	46%	27%	43%	32%
5029S		weekend							35%	39%	36%	28%	23%
		weekday							15%	16%	18%	22%	28%
5039S	US-27 By-Pass, St. Johns	weekend	33%	40%	35%	35%	38%	48%		35%	31%	33%	25%
		weekday	19%	19%	21%	18%	19%	20%		19%	20%	24%	34%
5059NE	I-196 Hudsonville	weekend	31%	28%	23%	24%	24%	23%	21%	20%	22%	24%	22%
		weekday	17%	19%	24%	16%	19%	21%	23%	20%	16%	15%	25%
5059SW		weekend	32%	22%	24%	24%	27%	23%	26%	22%	25%	26%	26%
		weekday	19%	16%	26%	17%	15%	14%	14%	14%	17%	18%	25%
5249N	US-131 Morley	weekend	29%	29%	22%	29%	28%	24%		27%	26%	39%	31%
		weekday	28%	27%	25%	35%	25%	30%		30%	35%	28%	23%
5249S		weekend	29%	29%	22%	29%	28%	24%		27%	26%	39%	31%
		weekday	28%	27%	25%	35%	25%	30%		30%	35%	28%	23%
5299W	I-96 Ionia	weekend	25%	30%	24%	22%	27%	27%	19%				
		weekday	22%	23%	29%	18%	16%	16%	17%				
5309N	US-131 Big Rapids	weekend								39%	31%	36%	22%
		weekday								34%	29%	27%	21%
5309S		weekend	36%	32%	30%	33%	42%	35%	29%	44%	45%	41%	30%
		weekday	18%	15%	15%	12%	14%	23%	23%	17%	17%	21%	21%
6369E	I-69 Capac	weekend	22%	18%	22%	21%	17%	20%	32%				
		weekday	15%	11%	14%	11%	12%	13%	20%				
7029E	I-94 Grass Lake	weekend				27%					26%		24%
		weekday				18%					20%		20%
7109N	US-131 Schoolcraft	weekend				20%	20%	23%		30%	25%	24%	30%
		weekday				15%	14%	21%		19%	22%	19%	36%
7109S		weekend				20%	21%	29%	20%	24%	26%	23%	30%
		weekday				14%	20%	22%	19%	17%	15%	13%	22%
7159W	I-94 Battle Creek	weekend					24%			17%			
		weekday					21%			18%			
7159E		weekend					17%			25%	23%	29%	29%
		weekday					18%			18%	20%	19%	17%
7179W	I-94 Coloma	weekend								14%	22%	29%	24%
		weekend								15%	20%	23%	24%
7179E		weekend								12%	22%	29%	27%
		weekday								15%	19%	17%	18%

Table 4-7 (cont'd)

Station	Location	Day of Week	Jan	Feb	Mar	Apr	May	Jul	Aug	Sep	Oct	Nov	Dec
8219W	I-96 Howell	weekend										27%	18%
		weekday										22%	23%
8219E		weekend										20%	17%
		weekday										18%	18%
8229N	US-23 Brighton	weekend	27%							30%	25%	31%	24%
		weekday	25%							22%	22%	24%	21%
8229S		weekend	29%							31%	30%	33%	17%
		weekday	23%							14%	18%	15%	13%
8249N	I-75 Luna Pier.	weekend	26%	32%	24%	25%	17%	29%					
		weekday	16%	20%	22%	18%	20%	18%					
8249S		weekend	21%	21%	19%	21%	22%	15%	16%	16%	22%	24%	26%
		weekday	10%	13%	11%	14%	12%	18%	18%	11%	10%	12%	16%
8689N	US-23 Dundee	weekend	29%	28%	26%	22%	26%	27%	28%	25%	29%	32%	24%
		weekday	23%	28%	25%	23%	21%	21%	25%	21%	23%	22%	23%
8689S		weekend	27%	20%	27%	27%	20%	29%	27%	28%	25%	28%	27%
		weekday	20%	19%	23%	25%	21%	20%	19%	17%	23%	24%	27%
8729N	US-23 Lambertville	weekend	45%	22%	34%	25%	25%	24%	25%	26%			
		weekday	23%	22%	29%	18%	18%	25%	28%	23%			
8729S		weekend	54%			32%	23%	27%	23%	21%	21%	28%	27%
		weekday	32%			26%	19%	19%	16%	18%	16%	19%	21%
9049N	US-127 Lansing	weekend	30%	19%	19%	19%	25%	27%	22%	23%	24%	25%	27%
		weekday	17%	16%	17%	21%	17%	16%	20%	18%	19%	21%	25%
9049S		weekend	28%	18%	17%	17%	18%	27%	23%	29%	26%	29%	29%
		weekday	17%	18%	21%	17%	18%	17%	16%	15%	13%	15%	29%
9369W	I-94 Kalamazoo	weekend	26%	18%	19%	22%	19%	18%					23%
		weekday	12%	15%	17%	22%	13%	15%					18%
9369E		weekend	30%	20%	19%	22%	17%	22%					
		weekday	17%	16%	19%	21%	12%	13%					
9828W	I-696, E of Southfield	weekend		31%			26%						
		weekday		19%			18%						
9829E		weekend		23%	24%	23%	25%	27%	18%	23%	22%	23%	23%
		weekday		17%	15%	17%	14%	14%	17%	17%	15%	16%	23%
9959N	I-75, at Mack Ave.	weekend	33%	19%	21%	22%	24%	23%	22%				25%
		weekday	23%	14%	14%	16%	14%	16%	18%				20%
9959S		weekend	32%	22%	21%	20%	28%	27%	19%			24%	23%
		weekday	17%	17%	21%	18%	16%	19%	16%			18%	22%
9979N	I-75, at Wattles Rd.	weekend	36%			23%				20%	26%	24%	27%
		weekday	22%			20%				14%	20%	17%	28%
9979S		weekend	33%	26%	22%	22%	20%	25%	17%	17%	19%	26%	30%
		weekday	18%	17%	18%	24%	17%	15%	13%	16%	15%	17%	29%

A summary of estimated tourism traffic volumes (i.e., ADTTs in Table 4-6) and percentages (i.e., PDTTs in Table 4-7) is displayed in Table 4-8. On average, the daily tourism traffic volume was 4,350 during the weekend day and 4,108 during the weekday. Among the monthly groups, the percentages of estimated weekend day tourism traffic range from 12.12% to 56.86%. On average, weekend day tourism traffic is 26.50% of the day's traffic. The percentages of estimated weekday tourism traffic range from 9.92% to 46.47%. On average, weekday tourism traffic is 20.56% of the day's traffic (Table 4-8). A paired *T*-test of the weekend day versus weekday comparisons indicates that the difference in percentages of tourism traffic between weekend days and weekdays is significant at 0.01 levels. The difference in daily tourism traffic volumes is also significant at 0.01 levels (Table 4-8). These results confirm the theoretical expectation that weekend day has more tourism traffic (in volume and percent) than weekday.

Table 4-8. A Paired Two-Sample T-Test on Tourism Traffic: Weekend Day vs. Weekday.

Tourism Traffic	Day of Week	N	Minimum	Maximum	Mean	Mean Difference
Volume						
	Weekend day	315			4349.7462	
	Weekday	315			4108.0989	241.6474**
Percent						
	Weekend	315	12.12%	56.86%	26.50%	
	Weekday day	315	9.93%	46.47%	20.56%	5.93%**

** Statistic is significant at 0.01 levels.

In the previous section, statistical results (Table 4-4) show that there is 93.37% RV traffic in weekend day traffic and 85.49% RV traffic in weekday traffic. Therefore, a simple calculation reveals that the Removal of Routine Traffic Method has removed 66.87% of routine traffic from weekend day traffic and 64.93% of routine traffic from weekday traffic (see Table 4-9). To date, the Federal Highway Administration has conducted two Nationwide Personal Transportation Surveys (telephone surveys). Survey results indicate that 24% and 18% of highway traffic was tourism traffic in 1990 and 1995, respectively (FHWA, 1997). Therefore, the estimates derived by the Removal of Routine Traffic Method are comparable to the Federal Highway Administration's estimates.

Table 4-9. Summary of Traffic Components after the Removal of Routine Traffic Operation.

		RV Traffic		
	NRV Traffic	Routine Traffic	Tourism Traffic	Total
Weekend Day	6.63%	66.87%	26.50%	100%
Weekday	14.51%	64.93%	20.56%	100%

Notations: NRV—non-recreational vehicle type, RV--recreational vehicle type.

The percentages of weekend day and weekday tourism traffic by direction are summarized in Table 4-10. On average, the percentage of northbound tourism traffic was 27.12% of the total traffic on weekend days and 23.73% on weekdays. The percentage of southbound tourism traffic was 28.09% of the total traffic on weekend days and 19.78%

on weekdays. On average, the percentage of eastbound tourism traffic was 22.67% of the total traffic on weekend days and 16.66% on weekdays. The percentage of westbound tourism traffic was 22.93% of the total traffic on weekend days and 19.00% on weekdays.

Table 4-10. Summary of Tourism Traffic Percentages by Weekend Day, Weekday, and Direction

Day of Week	Direction	N	Mean (%)	Std. Deviation
Weekend day	North	102	27.12	6.62E-03
	South	130	28.09	6.85E-03
Weekday	North	102	23.73	7.22E-03
	South	130	19.78	4.69E-03
Weekend day	East	37	22.67	4.38E-02
	West	24	22.93	4.59E-02
Weekday	East	37	16.66	2.89E-02
	West	24	19.00	4.02E-02

The results from a correlation analysis indicate that weekend day and weekday tourism traffic volumes are significantly correlated with each other with a correlation coefficient equal to 0.981 and p-value < 0.001 (Table 4-11). Another correlation analysis indicates that the percentages of weekend day and weekday tourism traffic are significantly correlated with a correlation coefficient equal to 0.478 and p-value < 0.001 (Table 4-12). The significant correlation between weekend day and weekday tourism traffic may imply that the variations in these two variables are simultaneously affected by a third variable, such as the same seasonality or geographical (spatial) factors. Therefore, when a month is in a tourism season, then both weekend day and weekday traffic appear to have higher tourism traffic volumes and percentages. Also, when a route is an access to tourist destinations, then both weekend day and weekday traffic appear to have higher tourism traffic volumes and percentages. In other words, the statistical results from these correlation analyses indicate that the seasonal and spatial variation natures of tourism are preserved in the estimated tourism traffic with the Removal Routine Traffic Method.

Table 4-11. Correlation of Weekend Day and Weekday Tourism Traffic Volumes.

Tourism Traffic Volume	Weekday	Weekend day
Weekday	1.00	.918** (.000)
Weekend day	.918** (.000)	1.00

Table 4-12. Correlation of Weekend Day and Weekday Tourism Traffic Percentages.

Percentage of Tourism Traffic	Weekday	Weekend day
Weekday	1.00	.478** (.000)
Weekend day	.478** (.000)	1.00

** Correlation is significant at the 0.01 levels (2-tailed). Numbers in the parentheses are the p-value.

4.2 Results from the Method Validation Phase

This section presents test statistics from hypotheses testing which utilized a paired two-sample *T* test and two regression analyses. These tests were conducted to assess construct validity of the Removal of Routine Traffic Method in estimating tourism traffic. The results of the test statistics suggest that the Removal of the Routine Traffic Method provides construct validity in estimating tourism traffic.

4.2.1 Results from Paired Samples T Test on Null Hypothesis I

The general perception is that weekend day tourism traffic should be proportionally greater than weekday tourism traffic. If the Removal of Routine Traffic Method is effective in removing routine traffic and leaving the residual traffic as the closest estimate of tourism traffic, then the statistical results from estimated tourism traffic should lead to the rejection of the Null Hypothesis I that there is no significant difference in percentages of tourism traffic between weekend days and weekdays.

In Table 4-13, the test statistics from a paired two-sample *T* test indicate that significant differences exist between the percentages of weekend day and weekday tourism traffic. The difference is so significant that the p-value of the t statistic is less than 0.001. Thus, the test statistic leads to rejecting Null Hypothesis I. The positive sign on the t statistic also indicates that percentages of tourism traffic on weekend days are higher than that on weekdays (Table 4-13). Statistics in Table 4-8 indicate that the percentages of weekend day tourism traffic on the average are 6 percentage points higher than the percentages of weekday tourism traffic. These results support the validity of the Removal of Routine Traffic Method by showing that the estimated results from the method do not deviate from the general perception of most people (criterion-related validity).

Table 4-13. Paired Samples T Test.

Paired Differences					*t*	D.F	*P* (Sig. 2-tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
5.93E-02	6.75E-02	3.80E-03	5.18E-02	6.68E-02	15.606**	314	.000

** Statistic is significant at 0.01 levels.
D.F. = Degree of Freedom

4.2.2 Results from Regression Analyses on Hypothesis II to V

Hypotheses II to V were collectively tested in two regression analyses. In other words, two regression analyses were used to test the theoretical expectations associated with Hypotheses II to V. In the regression models, percentages of weekend day and weekday tourism traffic (**PWETT** and **PWDTT**) were used as the dependent variables and were regressed on region (**REG**), percentage of traffic generated by recreational type vehicles (**PRV**), long weekend (**LW**), and direction (**DIR**). The author would like to indicate that these regression analyses were not used to identify the best prediction model for tourism traffic, rather, they were designed to assess the construct validity of the Removal of Routine Traffic Method.

Regression Analysis I--Weekend Tourism Traffic Stepwise Regression Models

Using stepwise method (i.e., variables are entered into the model one by one with the most significant variable entered first), the analysis of weekend tourism traffic suggests the following four models:

Dependent Variable: Percentage of weekend day tourism traffic (**PWETT**)

Model 1-- **PWETT**: (Constant), **REG**

Model 2-- **PWETT**: (Constant), **REG, PRV**

Model 3-- **PWETT**: (Constant), **REG, PRV, LW**

Model 4-- **PWETT**: (Constant), **REG, PRV, LW**, and **DIR**

All of the models are significant at 0.01 levels (Table 4-14b). The final stepwise regression model (with R square equal to 0.194) explains 19.4% of the variations in PWETT (Table 4-14a). The statistical results indicate that region (**REG**), percentage of traffic generated by recreational type vehicles (**PRV**), long weekend (**LW**), and direction (**DIR**) have significant explanatory power for the percentage of weekend day tourism traffic (Table 4-14b and c). All the *p*-values of these variables are smaller than 0.01 expect the value on (DIR) (Table 4-14c). However, DIR is significant at the 0.05 levels. Note that **REG** (i.e., location) was the most significant and the first variable entered into the model. **PRV** was the second most significant variable with the largest unstandardized coefficient (0.257 in Model 4 Table 4-14c). **LW** was the third most significant, and **DIR** was the least significant. After standardization, **REG** has the largest standardized coefficient (-5.529 in Model 4 Table 4-14c).

Table 4-14a. Summary of Weekend Tourism Traffic Regression Models.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.307	.094	.092	6.596E-02
2	.399	.159	.154	6.366E-02
3	.424	.180	.172	6.297E-02
4	.440	.194	.183	6.254E-02

Table 4-14b. ANOVA of Weekend Regression Models.

Model		Sum of Squares	df	Mean Square	F	*p* (Sig.)
1	Regression	.142	1	.142	32.664**	.000
	Residual	1.362	313	4.350E-03		
	Total	1.504	314			
2	Regression	.239	2	.120	29.529**	.000
	Residual	1.264	312	4.053E-03		
	Total	1.504	314			
3	Regression	.270	3	9.015E-02	22.732**	.000
	Residual	1.233	311	3.966E-03		
	Total	1.504	314			
4	Regression	.291	4	7.285E-02	18.627**	.000
	Residual	1.212	310	3.991E-03		
	Total	1.504	314			

** Statistic is significant at 0.01 levels.

Table 4-14c. Coefficients of Weekend Tourism Traffic Regression Models.

Model	Variables	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	*t*	*p* (Sig.)
1	(Constant)	.363	.018		20.713**	.000
	REG	-3.190E-02	.006	-.307	-5.715**	.000
2	(Constant)	7.794E-02	.061		1.287	.199
	REG	-3.512E-02	.005	-.338	-6.471**	.000
	PRV	.316	.064	.256	4.898**	.000
3	(Constant)	6.770E-02	.060		1.128	.260
	REG	-3.494E-02	.005	-.337	-6.506**	.000
	PRV	.311	.064	.252	4.878**	.000
	LW	2.104E-02	.008	.144	2.801**	.005
4	(Constant)	8.727E-02	.060		1.449	.148
	REG	-3.097E-02	.006	-.298	-5.529**	.000
	PRV	.257	.068	.209	3.806**	.000
	LW	2.174E-02	.007	.149	2.912**	.004
	DIR	2.274E-02	.010	.130	2.314*	.021

* Statistic is significant at 0.05 levels.
** Statistic is significant at 0.01 levels.

The results from weekend regression analysis agree with theoretical expectations about these variables. That is, the effects of REG, PRV, LW, and DIR on PWETT are significantly negative, positive, positive, and positive, respectively, which lead to the rejection of the Null Hypotheses II to V on weekend tourism traffic model. Therefore, this study confirms that:

(1) Tourism traffic is proportionally higher in less populated areas than in more populated areas during weekend.

(2) Routes with smaller percentages of non-recreational vehicle type traffic have higher percentage of tourism traffic during weekend.

(3) A long weekend has significant positive effects on the percentage of tourism traffic on that weekend.

(4) North-south oriented highways in Michigan have higher percentages of tourism traffic during weekend than do east-west oriented highways.

Regression Analysis II--Weekday Tourism Traffic Stepwise Regression Models

Using a stepwise method, the analysis on weekday tourism traffic suggests the following two models:

Dependent Variable: Percentage of weekday tourism traffic (**PWDTT**)

Model 1-- **PWDTT**: (Constant), **REG**

Model 2-- **PWDTT**: (Constant), **REG** and **PRV**

The weekday regression models examined provide similar results to those reported for weekend models, except that the regression terminated on the second step.

The final stepwise regression model has R-square equal to 0.258 (Table 4-15a). As predicted in Chapter 3, the indicator of the long weekend (**LW**) was dropped out of the weekday's regression model, because it had no explanatory power on weekday tourism traffic (Table 4-15a, b and c). DIR was also dropped out of the models. Again REG was the most significant and the first variable entered into the model, and **PRV** was entered next though it has the largest unstandardized coefficient (in Model 2 Table 4-15c).

Table 4-15a. Summary of Weekday Tourism Traffic Regression Models.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.434	.188	.186	5.638E-02
2	.508	.258	.253	5.401E-02

Table 4-15b. ANOVA of Weekday Regression Models.

Model		Sum of Squares	df	Mean Square	F	*p* (Sig.)
1	Regression	.231	1	.231	72.689	.000
	Residual	.995	313	3.179E-03		
	Total	1.226	314			
2	Regression	.316	2	1.58	54.144	.000
	Residual	.910	312	2.917E-03		
	Total	1.226	314			

Table 4-15c. Coefficients of Weekday Tourism Traffic Regression Models.

Model	Variables	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	*t*	*p* (Sig.)
1	(Constant)	.330	.012		22.064	.000
	REG	-4.068E-02	.002	-.434	-8.526	.000
2	(Constant)	.181	.015		5.777	.000
	REG	-4.472E-03	.002	-.477	-9.654	.000
	PVR	.190	.008	.367	5.392	.000

The results from weekday regression analysis also agree with theoretical expectations about these variables. That is, the effects of REG and PRV on PWDTT are significantly negative and positive, respectively, but the effects of LW and DIR on PWDTT are not significant (or show no effect). The statistical results lead to the rejection the Null Hypotheses II and III and to the acceptance of the Null hypotheses IV and V on weekday tourism traffic regression analysis. Therefore, this study confirms the following:

(1) Tourism traffic is also proportionally higher in less populated areas than in more populated areas during weekdays.

(2) It is also true that routes with smaller percentages of non-recreational vehicle type traffic have higher percentages of tourism traffic during weekdays.

(3) A long weekend has no effect on the percentages of tourism traffic on weekdays.

(4) There is no clear pattern of tourism traffic direction (i.e., north-south versus. eats-west) during weekdays.

Overall, the results from hypotheses tests correspond to the opinions of tourism experts as well as to theoretical expectations. The inferential statistical results demonstrate that the tourism traffic estimates derived from the Removal of Routine Traffic Method provide construct validity.

4.3 Results from Data Improvement Measurement

The evaluation of to what degree the Removal of Routine Traffic Method improves the relevancy of highway traffic data to tourism is based on the estimated percentages of daily tourism traffic (PDTT) for each of the counter stations in Table 4-7. Using the formula derived in Chapter 3, percentage of data improvement = $\frac{100 - x'}{x'}$, where x' is the estimated percentage of tourism traffic.

As previously described, the amount of non-tourism traffic removed from total traffic has an exponential relationship with the percentage change of data relevancy to tourism. Based on non-recreational vehicle type traffic information in Table 4-1, even simply removing NRV traffic would improve overall traffic data relevancy to tourism by 12% (i.e., 10.57 ÷ (100 - 10.57) = 0.12). The measurement results indicate that, on average, the application of the Removal of Routine Traffic Method on Michigan highway traffic data improved the overall data relevancy to tourism by 364% (Table 4-16). The improvements on weekend and weekday data relevancy to tourism are 301% and 427%, respectively. The reason that weekday traffic estimates exhibit more improvement is due to the fact that there is more non-tourism traffic in weekday data. Estimated improvements for each counter station are presented in Appendix E.

Table 4-16. Improvement Measures Using Methods Developed in This Study.

Operational Phase	Percentage Change in Data Relevancy to Tourism
Only NRV Traffic Removed	12%
Weekend day--with NRV & routine traffic removed	301%
Weekday-- with NRV & routine traffic removed	427%
Overall	364%

4.4 Example Results from Using Daily Tourism Estimates (DTEs)

The previous statistical analyses were based on the estimated average daily tourism traffic (ADTT) and percentage of daily tourism traffic (PDTT). This section provides statistical results based on the derived daily tourism estimates (DTEs) for some selected counter stations.

As previously mentioned, differences in daily traffic flows should be studied, because they provide useful information about tourism traffic flow. For example, using DTEs the author estimated that, during the Memorial Day weekend (May 22nd to 25th, 1998) around Station 4049 on I-75 at Vanderbilt, there were 23,155 counts of tourism traffic going north and most took place on Friday May 22nd, and there were 26,352 counts of tourism traffic going south and most took place on Monday May 25th (Table 4-17). Using the smaller of the two numbers, one may say that there were about 23,000 counts of tourism traffic passing through Vanderbilt on I-75 during the Memorial weekend in 1998.

Table 4-17. Example of Using the Removal of Routine Traffic Method to Estimate Tourism Traffic on Memorial Day Weekend.

Day of the Week	4049 North Tourism Traffic	4049 South Tourism Traffic
May 22nd, 1998 (Friday)	12,128	2,745
May 23rd, 1998 (Saturday)	8,235	2,642
May 24th, 1998 (Sunday)	2,072	6,313
May 25th, 1998 (Monday)	720	14,651
Total	**23,155**	**26,352**

Also, two statistical summaries of average DTEs for each day of the week from Station 4049 and 9369 are presented in Table 4-18 and Table 4-19, respectively. Note that these examples are utilized to demonstrate possible practical use of the Removal of Routine Traffic Method. The results relate to Station 4049 on highway I-75 (north-south) and Station 9369 on I-94 (east-west) only. Three time frames are specified: (1) all weeks—including all available days of any weeks, (2) regular weeks—including any days that are not in the vicinity of any long weekends (i.e., 2 days before and 2 days after a long weekend, totally 7 days), (3) weeks with a long weekend—including any days that are in a long weekend or its neighboring days.

Around Station 4049 the results from average weekly tourism traffic flow indicate that, in all of the three time frames, most rural-type tourism trips started on Friday and returned on Sunday (Table 4-18). Readers may notice that a significant portion of trips started even earlier (on Thursday) and ended later (on Monday), also notice that a high portion (19%) of tourism trips flowed from north to south on Friday in a regular week. Figures 4-4a, 4-4b, and 4-4c display substantial differences between northbound and southbound weekly tourism traffic flows.

Table 4-18. Averaged Weekly Tourism Traffic Flows around Station 4049.

Time Frame	Day of the week	North	South	% North	% South
All weeks					
	Sunday	1551	5903	9%	34%
	Monday	1091	3403	7%	20%
	Tuesday	671	1390	4%	8%
	Wednesday	1228	1316	7%	8%
	Thursday	2654	1233	16%	7%
	Friday	6237	2683	38%	16%
	Saturday	2950	1364	18%	8%
	Total	16383	17292	100%	100%
Regular weeks					
	Sunday	1327	5493	9%	36%
	Monday	942	1994	7%	13%
	Tuesday	525	882	4%	6%
	Wednesday	965	1234	7%	8%
	Thursday	2073	1307	15%	9%
	Friday	5951	2869	42%	19%
	Saturday	2484	1301	17%	9%
	Total	14267	15080	100%	100%
Weeks with a Long Weekend					
	Sunday	2630	7871	10%	29%
	Monday	1776	9885	7%	36%
	Tuesday	1368	3832	5%	14%
	Wednesday	2800	1810	10%	7%
	Thursday	4885	948	18%	3%
	Friday	7957	1566	30%	6%
	Saturday	5283	1677	20%	6%
	Total	26699	27589	100%	100%

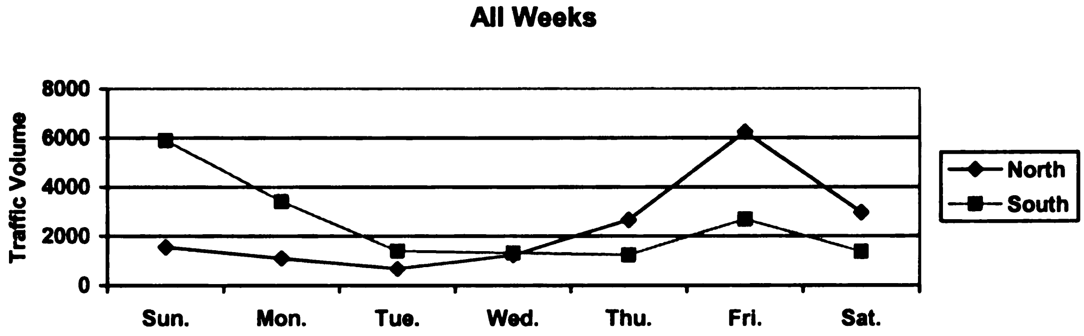


Figure 4-4a. Weekly Tourism Traffic Flow around Station 4049, All Weeks.

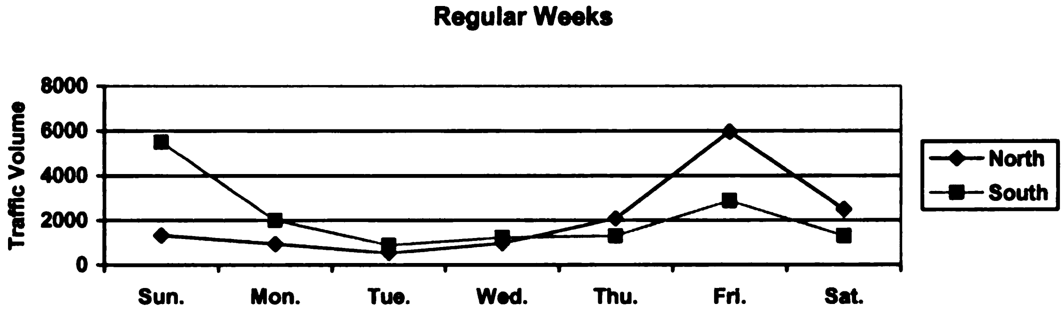


Figure 4-4b. Weekly Tourism Traffic Flow around Station 4049, Regular Weeks.

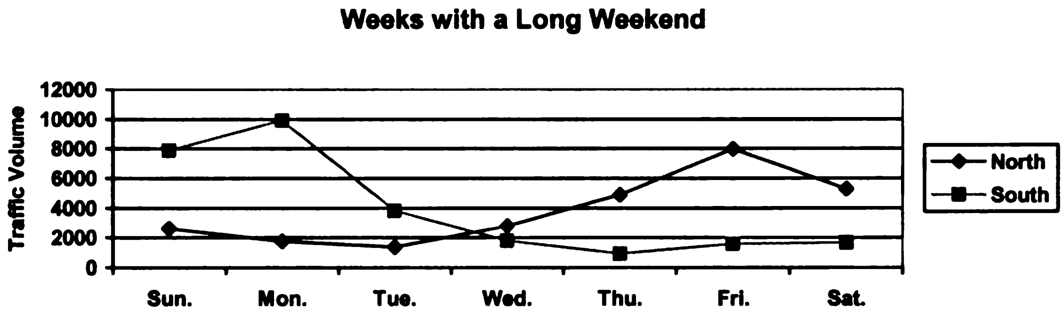


Figure 4-4c. Weekly Tourism Traffic Flow around Station 4049, Weeks with a Long Weekend.

The weekly tourism traffic flows around Station 9369 indicate that in all of the three time frames most urban-type tourism trips took place on Friday (Table 4-19). The weekly flow patterns displayed in Figure 4-5a, 4-5b, and 4-5c suggest that these urban-type tourism trips are likely to be day trips. This is because there are no substantial differences between westbound and eastbound tourism flows except that, during a long weekend, a greater portion of tourism trips started on Friday and ended on Monday.

Table 4-19. Averaged Weekly Tourism Traffic Flows around Station 9369.

Time Frame	Day of the week	West	East	% West	% East
All weeks					
	Sunday	3993	4392	11%	12%
	Monday	4539	5071	12%	13%
	Tuesday	4164	4338	11%	11%
	Wednesday	4511	4220	12%	11%
	Thursday	5433	5089	14%	13%
	Friday	8544	8644	23%	23%
	Saturday	6749	6116	18%	16%
	Total	37932	37870	100%	100%
Regular weeks					
	Sunday	3940	4104	10%	11%
	Monday	4083	4614	11%	12%
	Tuesday	4136	4158	11%	11%
	Wednesday	4869	4348	13%	12%
	Thursday	5827	5397	15%	14%
	Friday	8661	8511	23%	23%
	Saturday	6808	6216	18%	17%
	Total	38324	37346	100%	100%
Weeks with a Long Weekend					
	Sunday	4194	5486	12%	14%
	Monday	6180	6718	17%	17%
	Tuesday	4247	4877	12%	12%
	Wednesday	3078	3710	8%	9%
	Thursday	4094	4043	11%	10%
	Friday	8100	9152	22%	23%
	Saturday	6466	5643	18%	14%
	Total	36359	39628	100%	100%

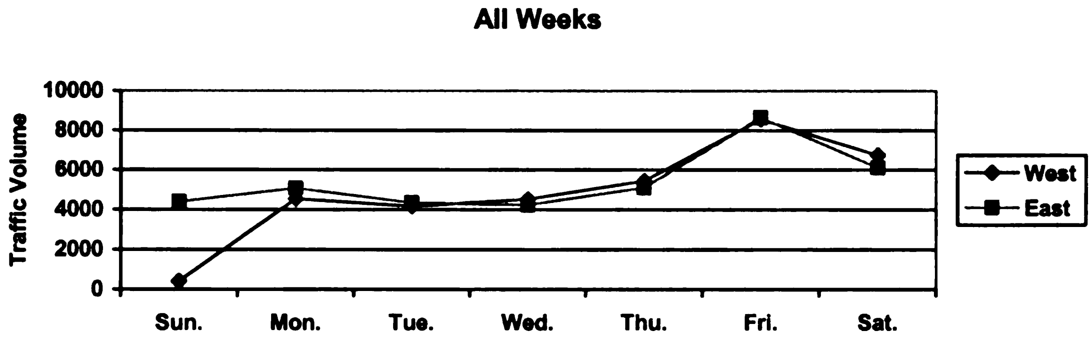


Figure 4-5a. Weekly Tourism Traffic Flow around Station 9369, All Weeks.

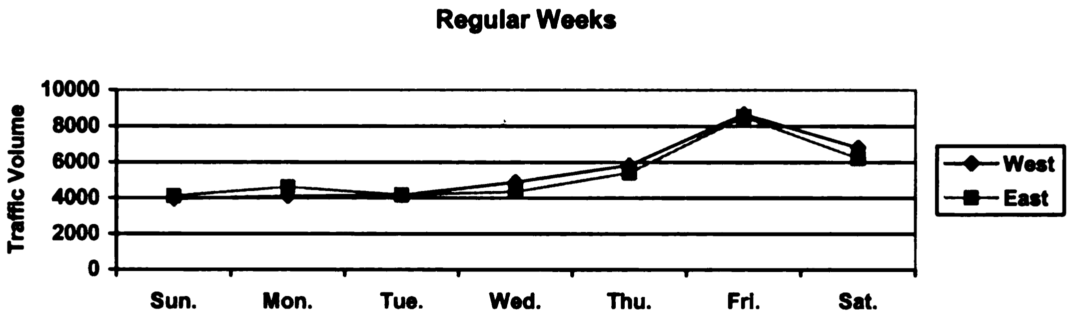


Figure 4-5b. Weekly Tourism Traffic Flow around Station 9369, Regular Weeks.

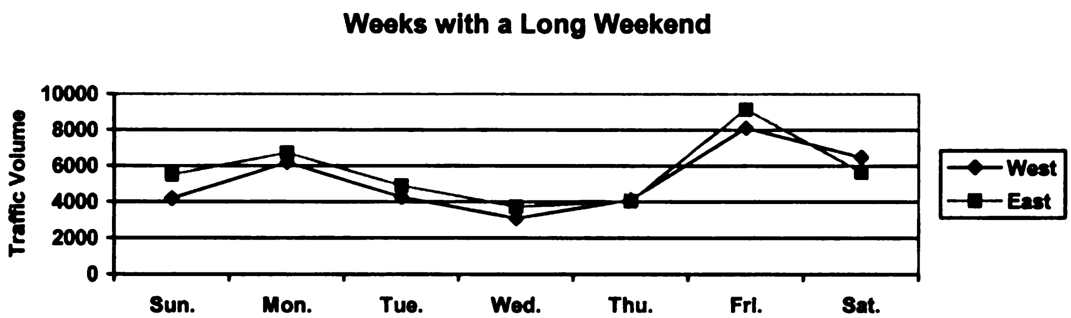


Figure 4-5c. Weekly Tourism Traffic Flow around Station 9369, Weeks with a Long Weekend.

CHAPTER 5

SUMMARY AND CONCLUSIONS

A number of topics were discussed in previous chapters including: the inherent problems in highway traffic data, related literature, traffic data characteristics, a conceptual model linking traffic data to tourism studies, and statistical results derived from applying the Removal of Routine Traffic Method to highway traffic data in Michigan. This chapter presents the major findings and their implications, and concludes with discussion of applications and recommendations for further research.

5.1 Summary of the Study

Almost all tourism trips involve using ground vehicles and highways either exclusively or in concert with other means of transportation. Although the highway traffic data collected by the Department of Transportation is a potentially useful set of comprehensive recording of highway travel activities, inherent problems in the data have deterred tourism researchers from using the data to their fullest potential. Neither the government agencies that collect these data nor tourism researchers who look for useful sources of information have exerted much effort toward creating scientifically sound tourism information out of highway traffic data that are both readily available and of high quality. When researches do use highway traffic data, they often utilize untreated traffic data that contain both tourism and non-tourism traffic information. The derived results are often difficult to interpret and can be misleading.

The purposes of this study were to improve the relevance of remotely sensed highway traffic to tourism studies, to enhance the connections between highway traffic data and tourism studies by developing sound procedures for removing non-tourism elements from highway traffic data sets, and to demonstrate that valuable tourism information can be derived from underutilized highway traffic data. These goals have been achieved by the development of a new data processing method called the Removal of Routine Traffic Method. The method is designed to mitigate the problem of separating tourism traffic from non-tourism traffic thereby facilitating the use of highway traffic by tourism researchers, planners, and business operators.

Prior to the development of the method, highway traffic time series were studied. Useful but less known characteristics of traffic data were identified for tourism studies. Characteristics of the highway traffic data indicated that the behavior of travelers was highly patterned. Based on the patterned behavior of highway travelers, a conceptual model was constructed to link highway traffic data to tourism studies. The behavior theory in the model was used to guide the development of the Removal of Routine Traffic Method that mitigates the inherent problems in the traffic data.

To demonstrate its validity, the method was applied to a set of Classified Permanent Traffic Recorder (CPTR) data acquired from the Michigan Department of Transportation (MDOT). The estimates derived by the Removal of Routine Traffic Method were demonstrated to provide face validity for measuring tourism traffic. In summary, the Removal of Routine Traffic Method functions as a filter to screen out non-tourism traffic from total traffic and leaves the residual as the closest estimate of tourism traffic. Further, statistical results from hypotheses tests indicate that the estimates from the method satisfy theoretical expectations. The study has thus verified that:

(1) Weekend day tourism traffic is proportionally greater than weekday tourism traffic.

(2) Tourism traffic is proportionally higher in less populated areas than in more populated areas during either weekend days or weekdays.

(3) Routes with smaller percentages of non-recreational vehicle type traffic have higher percentages of tourism traffic during either weekend days or weekdays.

(4) A long weekend has significant positive effects on the percentage of tourism traffic on that weekend but has no effect on tourism traffic on weekdays.

(4) North-south oriented highways in Michigan have higher percentages of tourism traffic during weekend days than do east-west oriented highways. This pattern is not significant (or may not exist) on weekday tourism traffic.

Previously, tourism researchers avoided using highway traffic data in tourism studies, because there was no appropriate and cost effective method to estimate tourism traffic on highways. Now, with the Removal of Routine Traffic Method, researchers not only can better understand the behavior of highway travelers but also utilize the extensively collected highway traffic data with confidence that resulting estimates are closer to the true values. An estimate of the overall improvement in traffic data relevancy to tourism is 364%. Even simply removing traffic generated by non-recreational type vehicles would improve overall data relevancy to tourism by 12%. Hopefully, the method will encourage more researchers to use highway traffic data for regional tourism studies and planning.

5.2 Major Findings and Implications

The results of this study demonstrate that mitigating the problem of separating tourism traffic and non-tourism traffic is possible and that more valuable tourism information can be derived from highway traffic data. This section summarizes the major findings and associated implications from the study.

Vehicle Types and Tourism Traffic

On Michigan highways, traffic generated by recreational type vehicles (RV traffic) accounted for 89% of total traffic. Since RV traffic is the base of tourism traffic, in the regression analyses, the percentage of RV traffic (**PRV**) always had the largest regression coefficients (Table 4-14c, and 4-15c). Passenger cars and pickups (including SUVs, vans, and mini vans) are the major vehicle types used on highways (Figure 4-1). Before the removal of routine traffic process, weekday RV traffic volume was significantly higher than on weekend day. However, after the removal of routine traffic process, weekend day tourism traffic volume was significantly higher than on weekday (Table 4-8). This indicates that the higher volume of RV traffic is most likely generated by commuters during weekdays.

On average, weekend day tourism traffic is 26.50% of total traffic and weekday tourism traffic is 20.56% of total traffic, also the percentages and volumes of tourism traffic during weekend days are significantly higher than during weekdays (Table 4-8). Therefore, this study confirms the general perception that weekend day traffic is more tourism dominant than weekday traffic. The author believes that the differences between weekend day and weekday statistics would be even more significant if Friday evening is included as a part of weekend. However, the purpose of defining weekday and weekend day as they are in this study is to facilitate the comparison of different traffic patterns across days. That is, the purpose is to include 24 hours in each "day" and not to regard its social meaning fully (especially for Friday). To decide the starting time of a weekend is beyond the scope of this study.

The significant correlation between weekend day and weekday tourism traffic (Table 4-11 and 4-12) may imply that the variations in these two variables are simultaneously affected by a third variable, such as the same seasonality or geographical (spatial) factors. For example, when a month is in a prime tourism season, both weekend day and weekday traffic appear to have higher tourism traffic volumes and percentages. Also, when a route is along a major access route to tourist destinations, both weekend day and weekday traffic appear to have higher tourism traffic volumes and percentages. In other words, the statistical results from these correlation analyses indicate the seasonal and spatial variation natures of tourism are preserved in the estimates of tourism traffic with the Removal Routine Traffic Method.

Regions

The major highways on the Southern Lower Peninsula of Michigan carry much higher percentages of traffic generated by non-recreational type vehicles (NRV traffic) (Table 4-1). This observation agrees with the author's postulation that highways on more populated areas are "potentially" less tourism dominant as compared to highways in rural areas. Further, in the regression analyses, region (**REG**) was the most significant variable among the independent variables and entered the regression models before other variables (Table 4-14c and Table 4-15c). This verifies the proposition that the location of a traffic counter is the dominant factor that affects the recording of tourism traffic data.

Directions

North-southbound highways carry higher percentages of RV traffic than east-westbound highways (Table 4-4). As a matter of fact, the most beautiful scenery and natural outdoor recreation areas of Michigan are in the Northern Lower and Upper Peninsulas. The statistical results indicate that north-southbound highways in Michigan are more tourism dominant than east-westbound highways during weekends (Table 4-10).

Another interesting observation is that travelers tended to start their northbound tourism trips before the weekend (e.g., on Friday or even earlier) and return south at the end of the weekend or even later on Monday (Table 4-18). There are substantial differences between northbound and southbound weekly tourism traffic patterns, which indicate that a lot of north-southbound rural-type trips are overnight trips (Figure 4-4a, 4-4b, and 4-4c). On the other hand, most urban-type tourism trips are likely to be day trips. This is so because there are no substantial differences between westbound and eastbound tourism flow patterns, except, during a long weekend, when a greater portion of tourism trips started on Friday and ended on Monday (Table 4-19 and Figure 4-5a, 4-5b, and 4-5c).

5.3 Applications

Application of the Removal of Routine Traffic Method on highway traffic data can be straightforward, because the final results derived from the method are estimated tourism traffic volumes and percentages. The method and its results can easily be applied by tourism researchers, planners, and business operators.

The Removal of Routine Traffic Method can be effectively used to estimate tourism traffic for a specific day or period of time. If one is interested in knowing the amount of tourism traffic going through a site during certain holidays, the Removal of Routine Traffic Method can promptly provide that information. A couple of such kinds of examples have been presented at the fourth section of Chapter 4.

While the estimated tourism traffic going through a site may be valuable to business operators, long-term tourism tracking may be the focus of tourism researchers and planners. In a long-term study, the estimated tourism traffic can be used in comparing tourism traffic for the same location over different periods of time, for example a year-to-year or month-to-month comparisons, to observe its trend line.

Traffic counter data can be used individually or in a group. In the conceptual model, two major applications were suggested: site-specific and regional tourism applications.

5.3.1 Site-Specific Tourism Application

In a site-specific tourism monitoring system, the ideal traffic counter location should be right at the entrance of a recreational site. For a multiple-entrance site, multiple counters will be needed. For instance, at the University of California at Los Angeles

(UCLA) an automated traffic monitoring system is installed at all entrances to the campus. This system records entering and exiting traffic information for historical trend analysis and long-range development strategies (UCLA, 2001).

The benefits of site-specific traffic tracking accrue only to that site. However, its advantage is that it provides more accurate tourism traffic estimates for that site. Usually, a site-specific tourism monitoring system is developed and maintained by the administrators of the site who can quickly adopt and use the Removal of Routine Traffic Method. Thus, the method need not be limited to traffic data collected by a state's Department of Transportation. Usually, the officially installed permanent traffic recorders are always some distance away from most recreational sites. As the distance between a traffic counter and monitored site increases, the availability of the Removal of Routine Traffic Method should serve to encourage installation of more site-specific traffic monitoring system by individual communities or larger businesses..

5.3.2 Regional Tourism Application

In a regional tourism monitoring system, a logical configuration is to set traffic counters on a region's borders to monitor highway traffic flowing into and out of the region. A regional tourism monitoring system is an enlarged version of a multiple entrance site-specific tourism monitoring system. Consider an island as a tourist destination which can only be accessed by ferries or by a bridge, tracking its tourism traffic can be accomplished simply by counting how many people use the ferries or drive over the bridge during a period of time. Analogously, traffic counters can be installed at all of the major highway entrances to a region to monitor in-flow and out-flow tourism traffic. Since international air traffic data collection fits with the analogy of regional tourism monitoring, this may be the reason why international arrival data are more often utilized in monitoring international travel and tourism activity (Witt and Martin, 1987; Martin and Witt, 1989).

5.3.3 Applications of Tourism Dominance

Tourism dominance is defined by the percentage of tourism traffic on a route. In application, tourism dominance is used to compare tourism–relatedness of different routes or locations. Also it can be used to infer the tourism-dependence of a location by a set of near-by counters when no traffic data are available specific to that location.

One may also use tourism dominance in the following ways.

1) For surveys that need to target tourists, researchers may select strong tourism dominant routes to improve sampling efficiency. Or, researchers may balance the sampling proportionally according to the tourism dominance on different routes or days of the week.

2) A region's tourism planning and marketing strategies may rely on tourism traffic flowing through the region. After highway traffic data have been collected, tourism researchers and planners can determine the tourism dominance of each route according to the Removal of Routine Traffic Method, and then design marketing and promotion strategies. For example, installing highway display boards along more tourism dominant routes to promote the attractions in the region.

3) Researchers can select the most tourism dominant locations to incorporate in regional and/or statewide travel activity monitoring systems such as that used by Michigan State University's Tourism Center.

5.4 Projected Cost for Using the Removal of Routine Traffic Method

The above discussion demonstrates selected applications of the Removal of Routine Traffic Method. Readers may be interested in knowing the cost and time required to apply the method. Projected costs and time involved in using the Removal of Routine Traffic Method are provided in Table 5-1. Compared to most tourism research methods, the Removal of Routine Traffic is efficient and economical, because operation of the method can be highly automated by computers and source data can be obtained at no or minimum cost from state Departments of Transportation.

Table 5-1. Projected Cost and Time Investments Required to Implement the Removal of Routine Traffic Method.

Phase	Cost	Description	Needed Time
Data acquisition	Minor	Government traffic data are readily available to the general public.	Relatively short
Data storage	$3,000	The cost of a database server.	Relatively short--Data transferring
Data cleaning	$1,200 (recursive)	Two-week wages of a data analyst ($15 x 80 hours)	2 weeks--(semi-automation is possible)
Data Processing			
Database programming	$4,800	Three-week wages of a database programmer ($40 x 120 hours)	3 weeks--program for automation of the operation
Creating computer repots	$100 (recursive)	A few hour wages of a computer operator	A few hours
First Time Cost	**$9,100**		
Recursive Cost	**$1,300**		

5.5 Limitations

It was previously mentioned that it is not possible to perfectly separate tourism traffic from non-tourism traffic. The major limitation of the Removal of Routine Traffic Method is that it can only mitigate the problem of separating tourism from non-tourism traffic. However, until a perfect separation method is invented, the Removal of Routine Traffic is a theoretically suitable method for estimating highway tourism traffic. To perfectly separate tourism traffic from non-tourism traffic, one would need to overcome inherent invasion of privacy, traveler inconvenience, and traffic disruption problems. Using the Removal of Routine Traffic Method to estimate tourism traffic avoids all of these problems and yields much improved, but not perfect, tourism traffic estimates at a very little cost in comparison to what would be required to make further improvements in estimates. Nonetheless, the accuracy of tourism traffic estimates is affected by traffic counters' ability to accurately count vehicles and to classify them correctly. The accuracy would also be affected by the selected percentile point used to estimate routine traffic when applying the method.

The statistical results for this study were limited by the availability of classified Permanent Traffic Recorder data (i.e., the number of CPTR stations and the regions where data were available). The author believes that more complete CPTR data from more counters and from different regions especially the Upper Peninsula would have enhanced the results of this study and the test statistics developed would have proven to be even more significant. The application of the method in a regional tourism study is also limited by the locations of traffic counters. Although, the method can be used to estimate highway tourism traffic, the estimates can only be used to infer tourism traffic on major highways. There is always a small portion of tourists who enjoy driving on meandering country roads and estimating their numbers falls outside the scope of this study.

5.6 Recommendations

This study has demonstrated that highway traffic data are a useful source of information for tourism studies. Throughout the study process, some useful characteristics of highway traffic data were identified and a conceptual model and traveler behavior theory were developed to guide the use of highway traffic data in tourism studies. There are many questions and issues that this study failed to explore. The following ideas are the author's recommendations to the Department of Transportation and tourism researchers to begin to resolve these questions and issues.

5.6.1 Recommendations to the Department of Transportation

As discussed in the study, location is an import factor affecting the potential uses of collected traffic data. For regional tourism studies, the locations of traffic counters are even more important. The ideal locations for traffic counters should be at the major highways entering the region. However, when installing traffic counters, a state's Department of Transportation usually does not consider the information needs of the tourism industry. Thus, to improve the usefulness of the traffic data in tourism studies, the author recommends that the Department of Transportation install new traffic counters in the future at the major entrances to major tourism regions. Regional tourism planners, such as local Conventions and Visitors Bureaus (CVBs), should also request that the

Department of Transportation install traffic counters at entry points to major tourism regions.

Another way of improving the usefulness of government collected traffic data is to process and report the data by vehicle types so that more relevant and meaningful information can be derived from the data. If the Department of Transportation fails to process the data in more creative ways, the uses of data will be continuously limited to a narrow range of public sector applications.

While the in-flow and out-flow of traffic are accurately recorded in bridge crossing data, these data are currently only available on a daily basis and not by the hour. Yet, bridge crossing data are very important in a regional tourism monitoring system, because bridges are usually the only connection between two regions. For example, for this study Mackinaw Bridge crossings were not available on an hourly basis; therefore, one could only use the near-by counter (e.g., 4049) to estimate how much tourism traffic visited the Upper Peninsula. Thus, the author recommends that the Department of Transportation provide hourly bridge crossing counts along with vehicle classification information in the future. By providing more useful traffic data, the Department of Transportation can help tourism researchers to improve highway tourism studies.

5.6.2 Recommendations for Future Research

The Removal of the Routine Traffic Method is in a preliminary stage, and there is room for improvements. As mentioned in Chapter 3, routine traffic may vary across seasons and locations. The appropriate cut-off point may vary with studied areas and time periods. It may be that a higher percentile cut-off point should be applied in urban areas, because there is a higher percentage of commuter traffic in urban areas. A lower percentile cut-off point should probably be applied in rural areas, because there is less commuter traffic in rural areas. Also, a higher percentile cut-off point may have to be applied on weekdays and a lower percentile cut-off point, on weekends, because commuter traffic is higher on weekdays than on weekends. Further research could be directed to fine tuning the method, to discover the best cut-off point for each traffic counter location for example.

More creative ways of using traffic data and traffic data characteristics could also be developed. When vehicle speed data are widely available, vehicle speed would become valuable information on traveler behavior for example. Based on the consumer behavior theory in economics, researchers can study travelers' preferences about time spent on highways. Some travelers may enjoy highway scenery; therefore, they drive at lower speeds for example. Some travelers may dislike the boredom of traveling; therefore, they drive at higher speeds (Yang, 1996).

As more complete CPTR data are collected, regression analyses can be applied to examine the relationship between regional tourism traffic and tourist spending. Researchers may also study the relationship between tourism traffic and weather conditions. In this study, only Michigan data were used. The Removal of Routine Traffic Method could also be applied to highway traffic data in different states and countries to test the generalizability of the method.

APPENDICES

APPENDIX A

Format of Permanent Traffic Recorder Data

Format of Permanent Traffic Recorder Data

Statnum	direction	trav_lane	all_year	all_month	all_day	all_1am	all_2am	all_3am	...	all_11pm	all_12pm	total_no	del_flag	reason_ln	day_of_wk
9969	7	0	1995	12	1	884	607	38	...	2454	1823	74712	FALSE		6
9969	7	0	1995	12	2	1221	866	448	...	2468	1916	59752	FALSE		7
9969	7	0	1995	12	3	1348	950	483	...	1772	1305	47490	FALSE		1
9969	7	0	1995	12	4	729	552	263	...	1820	1168	67439	FALSE		2
9969	7	0	1995	12	5	807	514	48	...	1935	1465	67749	FALSE		3
9969	7	0	1995	12	6	790	517	463	...	1807	1453	67887	FALSE		4
9969	7	0	1995	12	7	766	523	265	...	2063	1394	69905	FALSE		5
9969	7	0	1995	12	8	775	673	465	...	1868	1311	70618	FALSE		6
9969	7	0	1995	12	9	916	593	536	...	2058	1643	50337	FALSE		7
9969	7	0	1995	12	10	1164	885	443	...	1514	1104	41706	FALSE		1
9969	7	0	1995	12	11	660	450	240	...	1911	1220	60485	FALSE		2
9969	7	0	1995	12	12	653	444	251	...	1948	1307	65886	FALSE		3
9969	7	0	1995	12	13	726	480	297	...	1437	965	63603	FALSE		4
9969	7	0	1995	12	14	538	391	258	...	2137	1420	63588	FALSE		5
9969	7	0	1995	12	15	869	693	333	...	2634	2102	74469	FALSE		6
9969	7	0	1995	12	16	1329	872	737	...	2586	2274	59908	FALSE		7
9969	7	0	1995	12	17	1512	1119	529	...	1854	1282	48701	FALSE		1
9969	7	0	1995	12	18	745	589	305	...	1946	1346	67547	FALSE		2
9969	7	0	1995	12	19	756	562	279	...	2048	1411	66951	FALSE		3
9969	7	0	1995	12	20	733	547	287	...	2046	1446	68254	FALSE		4
9969	7	0	1995	12	21	820	540	352	...	2423	1686	70382	FALSE		5
9969	7	0	1995	12	22	1020	863	652	...	2785	2024	73563	FALSE		6
9969	7	0	1995	12	23	1431	984	614	...	2417	2030	55873	FALSE		7
9969	7	0	1995	12	24	1419	917	793	...	2525	2193	48726	FALSE		1
9969	7	0	1995	12	25	1217	955	324	...	2555	1812	45194	FALSE		2
9969	7	0	1995	12	26	1168	696	297	...	1747	1349	55600	FALSE		3
9969	7	0	1995	12	27	777	561	295	...	1896	1447	60018	FALSE		4
9969	7	0	1995	12	28	871	565	289	...	2005	1570	62234	FALSE		5
9969	7	0	1995	12	29	1087	860	320	...	2274	1965	64433	FALSE		6
9969	7	0	1995	12	30	1407	905	457	...	2125	1811	52427	FALSE		7
9969	7	0	1995	12	31	1196	839	461	...	2117	1257	44141	FALSE		1

APPENDIX B

Format of Classified Permanent Traffic Recorder Data

Format of Classified Permanent Traffic Recorder Data

CLSCODE	STATECODE	COUNTY	STATNUM	DIRECTION	LANE	YEAR	MONTH	DAY	HOUR	TOTVEH	MOTORCYLE	CAR	PICKUP	BUS	SU2AX	SU3AX	SU4AX	ST4AX	ST5AX	ST6AX	DT5AX	DT6AX	DT7AX
C	26	58	8689	5	0	98	10	19	1	153	0	88	22	0	1	2	0	3	0	24	1	6	6
C	26	58	8689	5	0	98	10	19	2	105	0	46	16	0	1	4	0	1	0	23	2	6	6
C	26	58	8689	5	0	98	10	19	3	85	0	23	19	0	1	2	0	1	1	23	2	5	8
C	26	58	8689	5	0	98	10	19	4	78	0	21	8	0	4	5	0	2	2	29	0	2	5
C	26	58	8689	5	0	98	10	19	5	114	0	45	20	0	1	7	0	2	6	19	1	4	9
C	26	58	8689	5	0	98	10	19	6	179	0	60	39	0	5	5	2	5	13	29	3	5	13
C	26	58	8689	5	0	98	10	19	7	414	0	229	85	0	9	5	1	4	18	41	5	8	9
C	26	58	8689	5	0	98	10	19	8	493	0	241	120	1	8	12	0	11	29	44	8	2	17
C	26	58	8689	5	0	98	10	19	9	719	0	464	125	1	5	3	0	11	7	58	7	12	26
C	26	58	8689	5	0	98	10	19	10	747	1	485	135	0	1	3	0	16	0	53	21	9	23
C	26	58	8689	5	0	98	10	19	11	418	2	157	121	0	0	11	0	23	2	40	24	9	29
C	26	58	8689	5	0	98	10	19	12	475	0	197	116	0	3	7	1	13	2	73	35	5	23
C	26	58	8689	5	0	98	10	19	13	469	0	213	109	0	7	35	0	35	4	35	10	4	17
C	26	58	8689	5	0	98	10	19	14	553	0	254	103	0	13	13	0	28	0	69	10	12	51
C	26	58	8689	5	0	98	10	19	15	810	0	512	110	1	9	7	1	17	4	66	26	6	51
C	26	58	8689	5	0	98	10	19	16	965	0	643	120	0	14	5	0	38	10	57	29	13	36
C	26	58	8689	5	0	98	10	19	17	101	2	704	143	1	3	25	0	37	4	46	14	7	26
C	26	58	8689	5	0	98	10	19	18	102	0	755	115	0	5	13	1	10	2	85	11	11	16
C	26	58	8689	5	0	98	10	19	19	779	0	535	110	0	1	5	0	20	0	76	11	8	13
C	26	58	8689	5	0	98	10	19	20	519	0	348	58	0	2	14	0	21	1	45	5	8	17
C	26	58	8689	5	0	98	10	19	21	397	0	213	59	0	1	3	0	6	3	81	4	12	15
C	26	58	8689	5	0	98	10	19	22	354	0	203	46	0	2	2	0	6	1	51	3	20	20
C	26	58	8689	5	0	98	10	19	23	281	0	127	32	0	2	2	0	3	1	63	6	22	23
C	26	58	8689	5	0	98	10	19	24	229	0	102	14	0	4	2	0	5	1	51	8	19	23

APPENDIX C

1998 Calendar and Major Holidays

1998

Calendar and Major Holidays

January

1 New Year's Day

2 January 2nd

19 Martin Luther King, Jr.

February

16 President's Day

May

25 Memorial Day

July

3 July 3rd

4 Independence Day

September

7 Labor Day

October

31 Halloween

November

26 Thanksgiving

27 After Thanksgiving

December

25 Christmas

January

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

February

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

March

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

May

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

June

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

July

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

August

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

September

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

October

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

November

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

December

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

APPENDIX D

Population Estimates of Michigan Counties, 1998

Population Estimates of Michigan Counties, 1998

County	Population	UP	County	Population	NLP	County	Population	SLP
Baraga	8602	1	Antrim	21473	2	Clinton	63407	3
Dickinson	27062	1	Benzie	14743	2	Gratiot	40145	3
Gogebic	17243	1	Charlevoix	24496	2	Ionia	66710	3
Houghton	35617	1	Clare	29514	2	Kent	544781	3
Iron	12882	1	Emmet	28633	2	Montcalm	60602	3
Keweenaw	2099	1	Grand Traverse	74224	2	Muskegon	166849	3
Marquette	62585	1	Kalkaska	15554	2	Ottawa	225407	3
Menominee	24393	1	Lake	10424	2	Bay	109980	3
Ontonagon	7842	1	Leelanau	19142	2	Genesee	435691	3
Alger	9984	1	Manistee	23485	2	Huron	35273	3
Chippewa	37906	1	Mason	27896	2	Lapeer	88229	3
Delta	38936	1	Missaukee	13887	2	Midland	81562	3
Luce	6791	1	Osceola	22138	2	Saginaw	210032	3
Mackinac	11041	1	Wexford	29118	2	St. Clair	159465	3
Schoolcraft	8782	1	Alcona	11061	2	Sanilac	43051	3
			Alpena	30475	2	Shiawassee	72489	3
			Arenac	16405	2	Tuscola	57965	3
			Cheboygan	23813	2	Allegan	101680	3
			Crawford	14128	2	Barry	54465	3
			Gladwin	25341	2	Berrien	159831	3
			Iosco	25715	2	Branch	43702	3
			Montmorency	9999	2	Calhoun	140806	3
			Ogemaw	21085	2	Cass	49975	3
			Oscoda	8890	2	Eaton	101022	3
			Otsego	22232	2	Jackson	156130	3
			Presque Isle	14535	2	Kalamazoo	229627	3
			Roscommon	23355	2	St. Joseph	61141	3
			Isabella	58394	2	Van Buren	75637	3
			Mecosta	40156	2	Hillsdale	46572	3
			Newaygo	45769	2	Ingham	285874	3
			Oceana	24745	2	Lenawee	98609	3
						Livingston	146317	3
						Macomb	786866	3
						Monroe	143365	3
						Oakland	1175057	3
						Washtenaw	302787	3
						Wayne	2116540	3
Sub-total	**311,765**			**770,825**			**8,737,641**	
State Total	**9,820,231**							

Source: U.S. Bureau of the Census, Population Estimates and Population Distribution Branches.

Notations: UP--Upper Peninsula, NLP--Northern Lower Peninsula, and SLP--Southern Lower Peninsula.

APPENDIX E

Detailed Percentages of Improvement in Highway Traffic Data Relevancy to Tourism

Detailed Percentages of Improvement in Highway Traffic Data Relevancy to Tourism

Station	Location	Day of Week	Jan	Feb	Mar	Apr	May	Jul	Aug	Sep	Oct	Nov	Dec
3069N	US-131, M-66 Kalkaska	weekend	203%	377%	378%	377%	316%	495%	402%	371%	337%	340%	338%
		weekday	402%	468%	318%	652%	465%	588%	387%	505%	431%	446%	373%
3069S		weekend			184%	337%	338%	361%	317%	292%	205%	317%	296%
		weekday			182%	560%	716%	839%	504%	350%	484%	590%	388%
4049N	I-75 Vanderbilt	weekend					166%	337%	204%	154%	201%	153%	114%
		weekday					178%	168%	209%	156%	161%	150%	154%
4049S		weekend					130%	184%	309%	117%	108%	121%	156%
		weekday					331%	257%	316%	311%	221%	214%	264%
4129N	US-27 Houghton Lake	weekend									267%	175%	254%
		weekday									173%	184%	232%
4129S		weekend									122%	159%	238%
		weekday									367%	276%	298%
5029N	US-27 St. Johns	weekend							297%	76%	396%	130%	340%
		weekday							227%	115%	266%	131%	208%
5029S		weekend							182%	154%	181%	254%	333%
		weekday							570%	507%	471%	350%	253%
5039S	US-27 By-Pass, St. Johns	weekend	199%	150%	183%	189%	166%	110%		184%	228%	200%	299%
		weekday	425%	421%	365%	448%	437%	388%		428%	395%	320%	196%
5059NE	I-196 Hudsonville	weekend	222%	262%	334%	320%	310%	326%	380%	404%	352%	311%	354%
		weekday	484%	417%	313%	527%	414%	380%	329%	393%	510%	585%	307%
5059SW		weekend	211%	347%	315%	309%	276%	331%	282%	352%	296%	290%	280%
		weekday	420%	510%	282%	479%	553%	602%	615%	608%	475%	455%	297%
5249N	US-131 Morley	weekend	239%	242%	364%	241%	260%	310%		267%	278%	159%	225%
		weekday	252%	267%	296%	188%	297%	230%		230%	188%	258%	330%
5249S		weekend	239%	242%	364%	241%	260%	310%		267%	278%	159%	225%
		weekday	252%	267%	296%	188%	297%	230%		230%	188%	258%	330%
5299W	I-96 Ionia	weekend	296%	229%	310%	353%	274%	274%	428%				
		weekday	357%	329%	243%	462%	521%	538%	492%				
5309N	US-131 Big Rapids	weekend								155%	228%	179%	347%
		weekday								193%	249%	276%	369%
5309S		weekend	176%	214%	232%	205%	141%	186%	247%	126%	121%	147%	236%
		weekday	460%	587%	589%	715%	629%	327%	327%	502%	487%	387%	379%
6369E	I-69 Capac	weekend	362%	456%	349%	380%	491%	411%	214%				
		weekday	553%	814%	599%	774%	743%	688%	402%				
7029E	I-94 Grass Lake	weekend				272%					280%		310%
		weekday				453%					400%		388%
7109N	US-131 Schoolcraft	weekend				402%	397%	338%		232%	306%	318%	229%
		weekday				547%	627%	368%		423%	346%	433%	180%
7109S		weekend				400%	383%	241%	400%	317%	287%	329%	235%
		weekday				612%	411%	357%	428%	480%	546%	676%	363%
7159W	I-94 Battle Creek	weekend					312%			493%			
		weekday					375%			452%			
7159E		weekend					492%			297%	344%	244%	241%
		weekday					442%			451%	412%	418%	474%
7179W	I-94 Coloma	weekend								632%	357%	249%	309%
		weekend								580%	413%	336%	319%
7179E		weekend								725%	360%	239%	274%
		weekday								581%	423%	496%	463%

Detailed Percentages of Improvement in Highway Traffic Data Relevancy to Tourism (cont'd)

Station	Location	Day of Week	Jan	Feb	Mar	Apr	May	Jul	Aug	Sep	Oct	Nov	Dec
8219W	I-96 Howell	weekend										269%	448%
		weekday										357%	326%
8219E		weekend										389%	493%
		weekday										447%	449%
8229N	US-23 Brighton	weekend	267%							231%	297%	222%	311%
		weekday	293%							364%	358%	316%	366%
8229S		weekend	247%							227%	236%	200%	491%
		weekday	342%							610%	442%	556%	671%
8249N	I-75 Luna Pier.	weekend	283%	211%	310%	297%	475%	242%					
		weekday	542%	405%	361%	456%	394%	454%					
8249S		weekend	379%	375%	429%	375%	357%	555%	529%	528%	350%	316%	278%
		weekday	876%	686%	810%	634%	743%	460%	447%	841%	907%	743%	526%
8689N	US-23 Dundee	weekend	248%	252%	278%	354%	278%	271%	259%	295%	248%	208%	311%
		weekday	342%	262%	306%	342%	379%	366%	305%	371%	342%	345%	332%
8689S		weekend	276%	406%	274%	274%	409%	244%	269%	256%	294%	259%	270%
		weekday	412%	432%	338%	306%	381%	403%	439%	487%	336%	311%	276%
8729N	US-23 Lambertville	weekend	120%	348%	197%	305%	297%	309%	294%	283%			
		weekday	342%	357%	250%	467%	449%	307%	255%	338%			
8729S		weekend	87%			216%	337%	277%	344%	368%	370%	264%	276%
		weekday	216%			292%	429%	417%	541%	455%	511%	413%	367%
9049N	US-127 Lansing	weekend	231%	422%	429%	422%	302%	274%	353%	332%	318%	301%	277%
		weekday	474%	506%	475%	366%	476%	537%	409%	461%	417%	369%	294%
9049S		weekend	262%	469%	479%	492%	465%	265%	329%	244%	283%	244%	244%
		weekday	486%	447%	380%	505%	441%	472%	542%	578%	688%	583%	249%
9369W	I-94 Kalamazoo	weekend	281%	470%	436%	355%	429%	469%					340%
		weekday	717%	573%	492%	359%	662%	554%					448%
9369E		weekend	236%	398%	433%	362%	505%	352%					
		weekday	484%	538%	431%	371%	744%	667%					
9828W	I-696, E of Southfield	weekend		225%			283%						
		weekday		414%			459%						
9829E		weekend		341%	322%	331%	305%	265%	464%	329%	345%	338%	339%
		weekday		480%	555%	487%	605%	640%	475%	494%	553%	509%	343%
9959N	I-75, at Mack Ave.	weekend	201%	419%	384%	351%	313%	340%	355%				302%
		weekday	344%	640%	600%	541%	617%	539%	462%				407%
9959S		weekend	209%	355%	376%	390%	261%	269%	430%			325%	344%
		weekday	481%	489%	388%	444%	528%	421%	538%			450%	355%
9979N	I-75, at Wattles Rd.	weekend	180%			329%				392%	286%	312%	268%
		weekday	349%			402%				607%	402%	504%	260%
9979S		weekend	201%	280%	360%	350%	391%	301%	502%	506%	433%	282%	229%
		weekday	453%	490%	465%	318%	488%	549%	681%	543%	577%	491%	250%

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