An-Najah National University

Faculty of Graduate Studies

Developing Trip Generation Models Utilizing Linear Regression Analysis: Jericho City as a Case Study

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This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Roads and Transportation Engineering, Faculty of Graduate Studies, An-Najah National University, Nablus, Palestine.

2014

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Dedication

This research effort is dedicated to my family, friends, and instructors.

Without their love and support, I could not have achieved this goal.

Acknowledgment

First of all, thanks God!

My appreciation and thanks are extended to my instructors at An-Najah National University.

My special thanks to Professor Sameer Abu Eisheh for his continuous help, support and time in this thesis.

I would also like to thank the defense committee members for their valuable discussions.

Finally, I thank my friends at Jericho Municipality, who provided me with the required data (Arial Photo, Master Plan, and Auto CAD Maps) and my friends who helped me in data collection and analysis.

الإقرار

أنا الموقعة أدناه مقدم الرسالة التي تحمل العنوان:

Developing Trip Generation Models Utilizing Linear Regression Analysis: Jericho City as a Case Study

أقر بأن ما اشتملت عليه هذه الرسالة ، إنما هي نتاج جهدي الخاص ، باستثناء ما تمت الإشارة إليه حيثما ورد ، و أن هذه الرسالة ككل ، و أي جزء منها لم يقدم من قبل لنيل درجة علمية أو بحث علمي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name:	**اسم الطالب:**
Signature:	**التوقيع:**
Date:	**التاريخ:**

Table of Contents

List of Tables

List of Figures

List of Appendices

Developing Trip Generation Models Utilizing Linear Regression Analysis:
Jericho City as a Case Study

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Prof. Sameer Abu-Eisheh

Abstract

The aim of this research is to develop trip generation models to predict the number of trips generated by households in the Palestinian areas considering Jericho City as the case study. The models are developed using multiple linear regression analysis, which establishes relationship between the number of trips generated by households and some socioeconomic attributes.

The developed models include three types of models. The first model is a general trip generation model (i.e., a general model regardless of trip purpose and trip time). The second one includes trip generation models by trip purpose. These models include the work trip generation model, the education trip generation model, the shopping trip generation model, the social trip generation model, and the recreational trip generation model. Finally, five trip generation models by trip time are developed.

The data consists of primary data, which was collected by conducting a household survey. The survey consists of 713 randomly selected households from Jericho City, the study area.

The results indicated that the estimated general trip generation model has a good explanatory power. The R-square for this model is 0.69, indicating

that the explanatory variables included in the model explain 69% of the dependent variable. The variables that mostly affect trip generation are found to be the number of persons receiving education in the household, the number of employed persons in the household, as well as the household monthly income.

The work trip generation model has R-square value of 0.74. In this model, the number of employed persons in the household and the number of persons with age between 31 to 50 years are the variables that mostly affect work trips. The educational trip generation model has R-square value of 0.97. The number of persons who are receiving education in the household is the main factor in this model.

The shopping trip generation model depends on the number of persons in the household and the monthly household income. The social trip generation model depends mainly on the number of females in the household and the number of employed persons in the household. Finally, the recreational trip generation model depends mainly on the number of persons receiving education in the household, number of persons between 51 and 64 years old, and the monthly household income.

Chapter One

Introduction

Chapter One

Introduction

1.1 General Background

Transportation planning processes have been intensively used to estimate the demand for travel encountered in the future. The estimated travel demand is utilized as a basis to plan for future transportation facilities and services.

As for the transportation system, it is necessary to quantify the inputs and the outputs for the system. The system inputs are the quantum of demand for transportation in the future years, while the system outputs are system characteristics that are planned for meeting the demand on the horizon years (Hutchinson, 1974).

In order to quantify the inputs and outputs, a major and commonly used planning method suggests that there are four analytical steps followed to get the total demand in the horizon year, which is called Urban Traffic Management System (UTMS). The characteristics of the system that is proposed for the horizon year condition are to be assumed. The analytical steps are: trip generation, trip distribution, modal split, and route assignment. These steps are shown in Figure 1.1.

This research considers the first step of this sequence, which is related to trip generation where it will be thoroughly studied and analyzed for Jericho City as a case study of Palestinian cities. The expected outputs can be applied to other Palestinian cities with proper calibrations. However, how the model can be applied to other cities is out of the scope of this research.

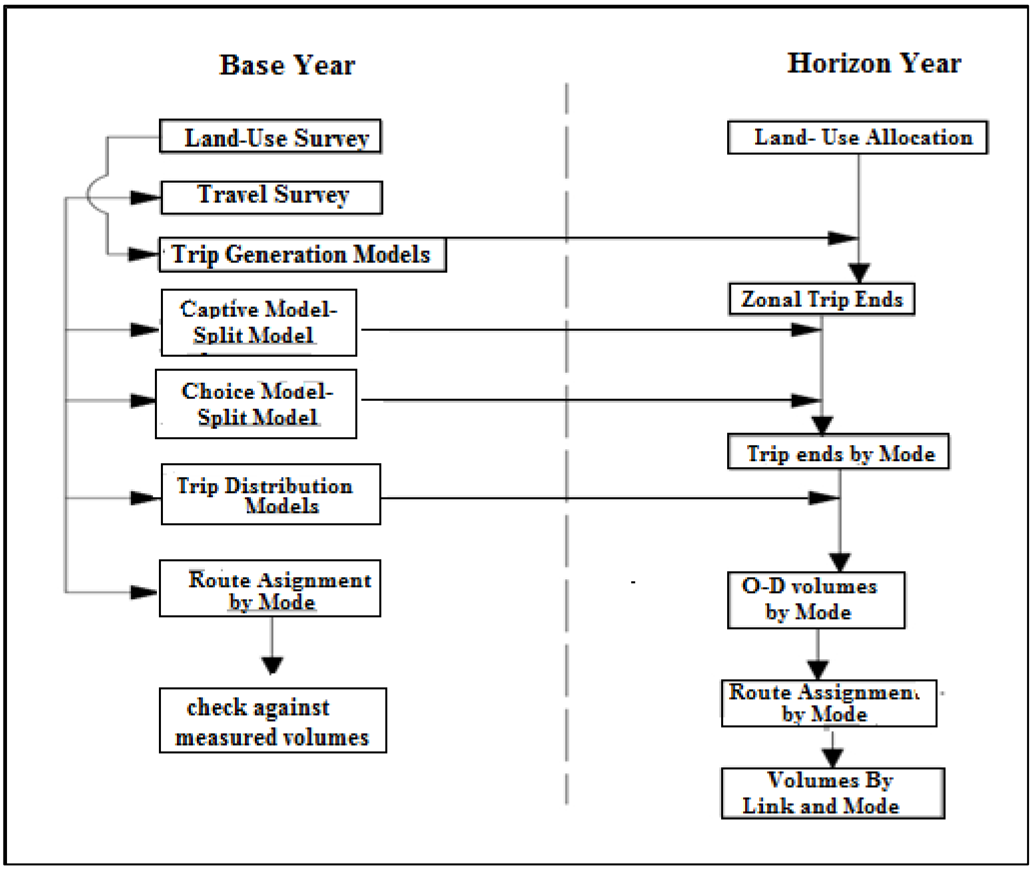

Figure 1.1: Sequences of Activities in Transportation Analysis

Source: Principles of Urban Transport Systems Planning (Hutchinson, 1974)

Trip generation analysis means understanding the trips generated in different traffic zones in an urban area. The trip for the purpose of analysis is defined as a one-way movement from an origin to a destination for a person.

The entire urban area is usually divided into smaller traffic zones, where the points of origins and destinations are fixed as zone centroid. This is illustrated in Figure1.2.

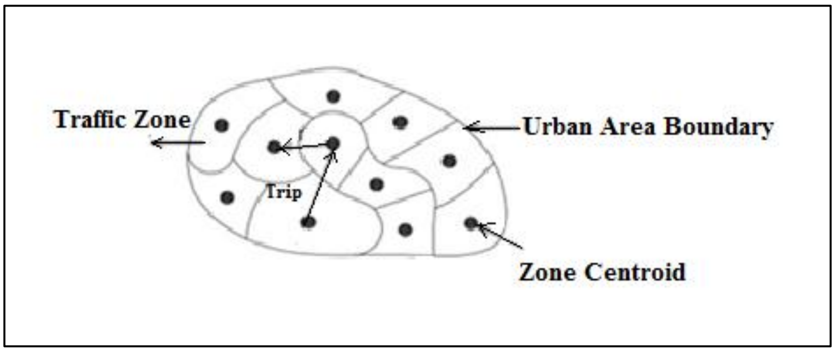

Figure 1.2: Origins and Destinations for Traffic Zones in an Urban Area

After delineating the urban area boundary and fixing the zone centroids as points of origin or points of destination, the trips can be classified according to spatial movement into four kinds (Meyer and Miller, 1986):

1. Internal to internal trip
2. Internal to external trip
3. External to internal trip
4. External to external trip

These types of trips according to movement are shown in Figure1.3.

Trip generation analysis is mainly related to the internal to internal trips and less to internal to external trips. Home interview survey is the major tool to establish trip generation models as will be discussed later. The other kinds (internal to external, external to internal, and external to external) can be identified by cordon surveys, which means surveys conducted at convenient points on the cordon line or at points of intersection of radiating roads.

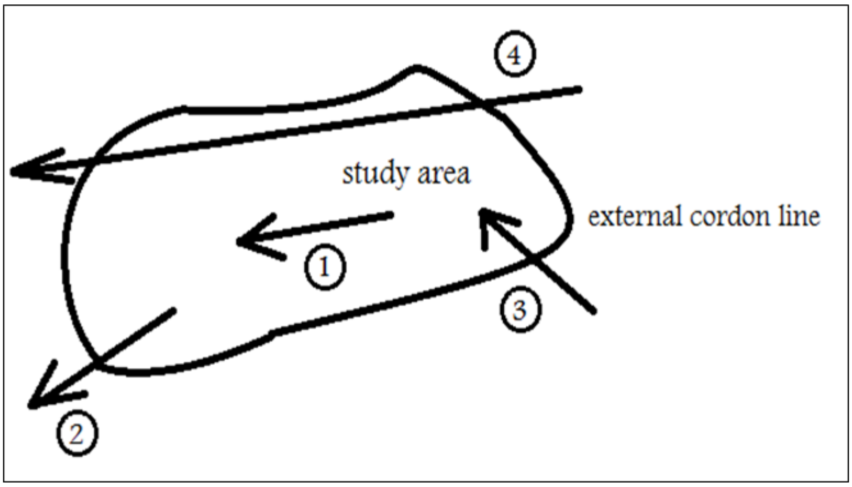

Figure 1.3: Types of Trips according to Movement in Study Area

The principal task in trip generation analysis is to relate the intensity of trip making (number of trips made from a point to several other points) to and from traffic zones to measures of the type and intensity of the land use in these zones and to other socio-economic characteristics.

There are two types of trip generation analysis that can be carried out; these are:

1. Trip production analysis
2. Trip attraction analysis

The term trip production refers to the trips generated by residential zones, where these trips are either trip origins or trip destinations (Papacostas and Prevedouros, 2004). Trips, which end at home, are called home-based trips or trip production, while the term trip attraction is used to describe trips generated by activities at the non-home ends (Hutchinson, 1974).

Home-based trips and non-home based trips are analyzed separately, because it is difficult to combine these categories of trips in developing models. There is a need to develop separate trip generation models for home and non-home based trips, as the type of variables that might influence such trips are to be different, or if the variables are the same, the effect of these variables on trip making might be different, so the models for these two types must be separated (Papacostas and Prevedouros, 2004).

The process of relating the trips produced by households to the factors influencing trip production by appropriate analytical technique is termed as trip production modeling and the process relating the trips attracted to non-residential ends to the factors influencing trip attraction by appropriate analytical technique is termed as trip attraction modeling (Papacostas and Prevedouros, 2004).

Although the individual is usually the trip makers, numbers of trips per household are usually estimated. The household is defined according to the Palestinian Central Bureau of Statistics (PCBS), as one person or a group of persons with or without family relationship, who live in the same housing unit, share meals, and make joint provision of food and other essentials of living. This is the general condition, where the persons may be related or unrelated to one another or both. The unrelated persons are called institutional household and are also considered in this study (Palestinian Central Bureau of Statistics, 2003).

Some factors that usually influence trip production are related to the household characteristics because the household is a major unit of trip production. These can be listed as follows (Arasan, 2012):

1. Household size and composition, where household size is number of persons in household, and composition like the average age of household, the distribution of the sex of the individuals
2. Number of employed persons
3. Number of students
4. Household income
5. Vehicle ownership
6. Number of persons in household who have driving license
7. Type of house if it is independent or apartment

The factors that usually influence trip attraction are related to non-home zones or non-residential zones like commercial zones, industrial zones, institutional zones, and recreational zones. These factors, which reflect the type and the intensity of land-use, can be as follows (Arasan, 2012):

1. Retail trade floor area
2. Service and office floor area
3. Manufacturing and wholesales floor area
4. Number of employment opportunities in retail trade
5. Number of employment opportunities in service and offices
6. Number of employment opportunities in manufacturing and whole sale
7. School and college enrollment

8. Number of special activity centers like transport terminals, sport stadium, major recreational, cultural, and religious places

On the other side, trip production or home-based trips can be classified into different categories based on trip purpose, which are:

1. Work trips
2. Education trips
3. Shopping trips
4. Social and recreational trips

Finally, trip production or home-based trips can also be classified into different categories based on time of making the trip.

According to the level of analysis, it could be analyzed on an aggregate level (zone or area), or disaggregate level (household or person). In this research, analysis on the level of households is adopted, because depending on this level, more accurate results can be obtained, through the study of movements for each household.

1.2 The Problem of Study

There is a lack of specialized studies, which are related to quantifying and modeling travel demand in the Palestinian cities.

Several factors led to considerable increases in trip generation in the Palestinian cities, including reduced taxes on prices of cars, which have led to the increase in their numbers, as well as the increasing need for mobility according to population growth. This is combined with the limited development of the transport networks within the cities, and the observed overloading of and congestion in the existing transport networks.

As the numbers of cars are expected to continue increasing in the future, the need of transportation planning appears to be essential for these cities. Proper modeling is lacking describing the four analytical steps; trip generation, trip distribution, modal split, and route assignment.

To provide strong basis for the transportation planning process, this research considers the need for studies in this area, through studying the trip production part of trip generation stage and its various categories.

1.3 Objectives of the Study

The aim of this study is to lay the basis to predict current and future traffic trips generated from different traffic zones that comprise a Palestinian city, thus studying and modeling trips produced from households according to their characteristics, relying on the principles of the regression analysis technique. It also aims to predict the number of trips according to trip purpose and trip timing of trip production or home-based trips for different traffic zones.

1.4 Study Area: Jericho City

Jericho City is chosen to be the study area. It is located in the middle part of the West Bank. The city is considered medium-sized in area. It has a total area of 57.43 km^2 (Palestinian Central Bureau of Statistics, 2012).

According to the latest population estimate conducted by the Palestinian Central Bureau of Statistics (PCBS) in 2012, the population of Jericho City was estimated to be about 20,253 people. The number of households was estimated to be 3,510 living in 3,386 buildings. The population density in Jericho City was estimated to be 1, 055 inhabitants/km^2. In the refugee camps- in Jericho, the population density ranges between 3,763-4,190 inhabitants/km^2. According to these statistics, Jericho City needs to expand between 2,000 and 7,000 acres.

According to the PCBS statistics, there are nearly 3,386 buildings in Jericho City containing 4,549 units. Around 84.4% of these buildings are the property of their owners. The city includes the city center, the old residential area, areas of moderate density expansion, urban areas, newly developed suburbs, as well as refugee camps. Each of these styles is different from the other depending on the purpose, number of housing units, the nature of the buildings, and population density. There are many housing projects in progress in the city. The position of Jericho City in the West Bank is shown in Figure 1.4.

Figure 1.4: Position of Jericho City in the West BankSource: The Palestinian Central Bureau of Statistics (2010)

1.5 Thesis Outline

This thesis is divided into six chapters. Chapter one presents a general background, the problem of the study, the objectives of the study, study area, and thesis outline. Chapter Two is concerned with the literature review. Chapter Three discusses the methodology, while Chapter Four describes the field survey and data collection. Chapter Five addresses data analysis and results. Finally, Chapter Six presents the main conclusions and recommendations of the study.

Chapter Two

Literature Review

Chapter Two

Literature Review

2.1 Overview of Trip Generation

Trip generation analysis involves estimation of the total number of trips entering or leaving a parcel of land as a function of the socio-economic, locational, and land use characteristics of the parcel. The function of trip generation analysis is to establish meaningful relationships between land use and trip making activity so that changes in land use can be used to predict subsequent changes in transport demand (Paquette and Ashford, 1982).

2.2 Literature Review of Trip Generation Variables

This section addresses the literature of the explanatory variables that are included in trip generation models in studies conducted both in developed as well as developing countries.

Indeed, several research papers studied the variables that affect trip generation and found some significant relationships between trip generation and the above mentioned characteristics. Most of the empirical research has been conducted in the US and other developed countries. However, some empirical research has been conducted in other developing countries.

2.2.1 In the Developed Countries

Hunt and Broadstock (2010) constructed a trip generation model for a cross section of residential developments around the UK. The empirical model tested whether trip making patterns for residential developments are independent of car ownership. The result was that trip generation is dependent upon car ownership, socio-economic factors and site-specific characteristics, in particular land-zone type. However, public transport services are not found to have a significant relationship with trip generation. Consequently, a policy implication of the results was that increasing bus services to residential developments is not associated with a reduction in generated trips.

Guiliano (2003), Guiliano and Dargay (2006), and Guiliano and Narayan (2003) found significant differences in travel behavior between different demographic groups in the USA and the UK. Their data showed that American participants made 4.4 trips per day travelling approximately 31 miles (49.6 km), whereas the British participants travelled only 16 miles (25.6 km) in 3 trips per day. The method of data collection however varied between the US and the British studies. The USA data was collected by telephone using a stratified sample with participants using a one day 'recall' diary. British participants were selected using a stratified random sample based on post code. The British participants were interviewed directly and were required to complete a seven day travel diary. Thus, methods of sampling and data collection varied between the two groups.

The authors found that participants aged 65 years or older in the UK travelled half the distance and were less likely to travel on any given day than participants aged 18 – 64 years. In the USA study, participants aged 65 years or more travelled 60% of the distance of the younger participants. The authors also suggested that lower household incomes in the UK compared with the USA produced lower travel demand and car ownership. Gender, age, and household income were all found to influence travel behaviors and that there were significant differences between travel behaviors in the USA and the UK. It was found that the significantly higher transport costs in the UK led to a decrease in trips.

Newbold et al. (2005) studied the travel behaviors of Canadians aged 65 years or more to determine if their travel patterns were different from younger Canadians. Their study used data from the General Social Survey (GSS) of Canada. The data from approximately 19,000 participants provided a partial confirmation of the research question but recognized that factors other than age can influence travel behavior.

The results showed that older Canadians make fewer daily trips than younger Canadians, but as expected, this could be caused by the fact that the participants in the study were no longer employed and hence were no longer making travel-to-work journeys. Thus, daily trip numbers and duration decreased significantly due to changes in employment and health status. In addition, there was a greater reliance on the car and a significant reduction in the use of public transport as the principal travel mode compared with younger Canadians.

Best and Lanzendorf (2005) conducted an empirical study in Cologne, Germany to determine if there were gender differences in car use and travel patterns for maintenance travel.

Overall, the authors found that there were no significant differences in the total number of trips or distances travelled between men and women.

However, the type or destination of trips did provide some gender differences.

The authors found that women made fewer journeys to work by car and more journeys for non-work activities such as shopping and child-care. This was also confirmed by Boarnet and Sarmiento (1998) in their study of travel behavior in southern California.

Moriarty and Honnery (2005) studied urban travel in all Australian State capital cities. Although the major emphasis was on studying the relationship between the distance from place of residence to the Central Business District (CBD) of each city and the impact on travel behavior. Their study found that women on average travel less often and for shorter distances than men.

Olaru et al. (2005) studied the travel behavior in the Sydney Metropolitan area, Australia and found that a number of socio-demographic variables influenced travel behavior. Women were more likely to travel closer to home than men, particularly if they came from a non-English speaking household.

Simma and Axhausen (2004) conducted a study to explore the impacts of personal characteristics and the spatial structure on travel behavior, especially mode choice in Upper Austria. The spatial structure is described among other things by accessibility measures. The models were estimated using structural equation modeling (SEM). The models were based on the 1992 Upper Austrian Travel Survey and the Upper Austrian Transport Model.

The results highlighted the key roles of car ownership, gender and work status in explaining the observed level and intensity of travel. The most important spatial variable was the number of facilities, which can be reached by a household. The municipality-based variables and the accessibility measures have rather little explanatory power. The reasons for this low explanatory power were considered. Although the findings in this study indicated that the spatial structure is not a decisive determinant of traffic. The results provided useful hints for possible policy alternatives.

Polk (2004) wrote a paper to test the influence of gender on daily car use and on willingness to reduce car use in Sweden. Car use was modeled in terms of practical factors combined with manifestations of the specific influence of gender. Willingness to reduce car use was modeled in terms of attitudinal factors using a theory of environmentalism.

The results confirmed the existence of a gender component. The author found a significant relationship between sustainable travel patterns and gender. Women were more willing to reduce their use of the car than men, more positive towards reducing the environmental impact of travel modes, and more positive towards ecological issues.

The concluding discussion suggested that more research is needed to further theoretical understanding and methodological expertise regarding how gender can be modeled in travel research in order to attain current policy regarding gender equal transportation system.

Georggi and Pendyala (2001) conducted a detailed analysis of long-distance travel behavior in the USA for two key socio-economic groups of the population: the elderly and the low income. The analysis utilized data from the 1995 American Travel Survey that provided a rich source of information on long-distance travel undertaken over a period of 12 months. The analysis focused on comparing the elderly and the low-income groups of the population against other groups with respect to various demographic and trips characteristics. The travel behavior comparison included an analysis by trip purpose, travel mode, distance, trip duration, and trip frequency. In addition, regression models of long-distance trip generation were estimated separately for different groups to examine differences in trip generation propensity across the groups.

The results showed that both the elderly and the low income undertake significantly fewer long-distance trips than other socio-economic groups. It was found that nearly half of the low income and elderly made no long-distance trips in the one-year survey period. In addition, it was found that long-distance trips made by these groups were more likely to be undertaken by bus and geared towards social and personal business activities.

Badoe and Steuart (1997) estimated the total number of household shopping trips for the Greater Toronto Metropolitan area, Canada by using such variables as household size, number of workers, number of licensed persons, and number of vehicles. Regression analysis was used with 1964 and 1986 data for the Greater Toronto Metropolitan area.

The different model specifications provided little explanation of the variation in household shopping trips. The household size was found to have little explanatory power. The authors concluded that different approaches are needed to explain the variation in non-work trips, including shopping trips.

Golob (1989) undertook a study in Germany to model the causal relationship, at the household level, among income, car ownership, with trip generation. The study was based on data obtained from the Dutch National Mobility Panel, which consisted of approximately 1,800 households, stratified by life cycle.

The author found that car ownership directly affects public transport trip making, with additional effects from income. The author also stated that there are direct links from the lowest and highest income categories to public transport demand.

Vickerman and Barmby (1984) analyzed the relationship between shopping expenditure and shopping trips. The data used in their study were collected as part of an earlier research project on shopping travel. The study sample consisted of 1,074 households in 25 districts in the County of Sussex, England.

The authors estimated the number of weekly shopping trips and the total weekly shopping expenditures using simultaneous equations. The explanatory variables included household size, income, and auto ownership. It was found that income has little effect on trip making, but that accessibility and the cost of travel are important factors.

Stopher and McDonald (1983) conducted a trip generation analysis on data from the Midwest, USA using multiple classification analysis (MCA) in contrast to linear regression analysis. The household-structure variable was tested using both analysis of variance and MCA to determine how well the variable performs in various model structures when compared with other variables. The variables tested were the number of cars or vehicles available to the household, household size, housing type, total number of employed persons, household income, and total number of licensed drivers. The analysis concluded that the household-structure variable did not perform significantly better than the other variables tested.

Supernak et al. (1983) presented a person-category model of trip generation as an alternative to household-based trip-generation models in Washington, D.C., USA. In their model, a homogeneous group of persons was used as an analysis unit. The variables of age, employment status, and automobile availability were found to be the most significant descriptors of a person's mobility. The final version of the model was based on eight person categories.

Oldfield (1981) carried out an analysis on the effect of income on bus travel in the UK. The study was based on Family Expenditure Surveys and the National Travel Survey and considered mainly the non-car-owning households. The author examined some cross-sectional data on bus travel as a function of household income, and the way in which it changed over time, with the intention of seeing whether demand elasticity with respect to earnings can be estimated. Unfortunately, no consistent pattern had emerged from the analysis to enable demand elasticity with respect to earnings to be fixed with precision.

Downes et al. (1978) conducted a study on household and person trip generation model. The authors used a single data bank, comprising over 60,000 trips from sample household surveys in the UK to compare two alternative types of trip generation models; one based on household trip rates and the other on person trip rates for each household. Their performance was found to be similar, each accounting for over 50% of the variability in household trip rates, but the person trip rate model had been shown to be simpler to use and statistically more acceptable.

The most important variables for modeling home-based trips were household size and car ownership in both types of models. Work trips required only household employment in a household rate model and car ownership in an employed person rate model. Household location and the year of study had a small but discernible effect on trip rates due to some reduction in the inner and middle area rates between the two years.

Robinson and Vickerman (1976) were concerned with the development of a basic methodology for the future study of shopping. The authors demonstrated how the existing methodology failed to allow for some of the most important dimensions of the shopping choice decision. A revised model was developed and tested against especially collected data from a cross-section of households in Sussex, South East England. The authors demonstrated the importance of attraction and accessibility in determining variations in levels of household shopping activity.

2.2.2 In the Developing Countries

Moussa (2013) conducted a study to develop a trip generation model for Gaza City, Palestine to determine the household travel characteristics pattern in the study area. The study also aimed to compare trip rates as modeled by the Conventional Cross Classification (CCA) method with that of Multiple Cross Classification (MCA) method in Gaza City. Furthermore, the researcher aimed to develop a trip attraction model using Multiple Linear Regression technique (MLR).

Household interview survey was conducted to collect the primary data. The survey was distributed to 425 households in different districts of Gaza City. The results indicated that vehicle ownership, household size, income level, and the number of licensed drivers in the household are the main factors that affected trip production in Gaza City.

In addition, the results showed that the Multiple Cross Classification (MCA) models are more effective in expressing trip rates for trip production than the Conventional Cross Classification (CCA) models.

Sofia et al. (2012) developed a relationship between the daily household trips and socio-economic characteristics for Al-Diwaniyah City, Iraq. The authors used the stepwise regression technique (multiple linear regression) after the collected data had been fed to the SPSS software. The city was divided into 5 sectors with 70 zones covering an area of 52 km^2.

Home questionnaire forms were distributed through arrangements with the secondary, industrial, commercial school administrations, and some colleges. The results showed that the trip generation model mainly depends on family size, gender, the number of workers, and the number of students in the family.

Sarsam and Al-Hassani (2011) developed statistical models to predict trip volumes for a proper target year in Al-Karkh side of Baghdad City, Iraq. Non-motorized trips were considered in the modeling process. The traditional method to forecast the trip generation volume according to trip rate, based on family type, was used in the study. Families were classified by three characteristics: social class, income, and number of vehicle ownership. The study area was divided into 10 sectors. Each sector was subdivided into a number of zones. The total number of zones was 45 based on the administrative divisions. The trip rate for the family was determined by sampling. A questionnaire was designed and interviews were made for data collection from the selected zones.

Two techniques were used, full interview and home questionnaire. The questionnaire forms were distributed in many educational institutes including intermediate, secondary, and commercial schools. The developed models were total trips per household, work trips per household, education trips per household, shopping trips per household, and social trips per household. These models were developed using stepwise regression technique after the collected data had been fed to the SPSS software.

The results showed that total trips per household are related to the family size and the structure variables such as the number of persons who are above 6 years of age, the number of males, the total number of workers, the total number of students in the household, and the number of private vehicles. The model had coefficient of determination equals to 0.67 for the whole study area.

The results also showed that the home-based work trips are related to the number of workers in the household, number of male workers in the household, number of female workers in the household, and number of persons between 25 and 60 years of age. This model has coefficient of determination equals to 0.82 for the whole study area. Home-based education trips are strongly related to the number of students in the household and this model had coefficient of determination equals to 0.90 for the whole study area.

Priyanto and Friandi (2010) developed a trip generation model for public transport passengers in Yogyakarta, Indonesia, using multiple linear regression analysis. The authors established a relationship between the number of trips and socio-economic attributes. The data consisted of primary and secondary data. Primary data were collected by conducting household surveys, which were randomly selected.

The resulted model showed that public transportation trips seem to have negative correlation with income, motorcycle ownership, and car ownership. This means that the number of trips made by people decreases as income, the number of motorcycles, and cars owned increase. It is different from the general trip generation model (the model for all trips by either private or public transportation) where the number of trips commonly rises with the increase in income, motorcycle, and car ownership.

The model also showed that the number of public transport trips increases as the family size increases. Commonly, the higher the number of family members, more public transport trips will be made.

Pettersson and Schmocker (2010) conducted a study to analyze travel patterns by those aged 60 or over in Metro Manila, The Philippines. Trip frequency and tour complexity were analyzed with ordered probit regression, separating the effects of socio-demographic characteristics as well as land-use patterns. The results were compared to observations made for cities in developed countries, in particular London as an example for a city in a first world country.

The authors showed that there is a pronounced decrease in total trips made with increasing age in Manila. However, analyzing for specific trip purposes, the authors found, similarly to trends in developed countries, that the number of recreational trips is fairly constant in all age groups.

Said (1990) conducted an empirical study to estimate work trip rates for households in Kuwait using a generalized linear model (GLM). Seven different household groups were identified from the 1985 census. One of these groups, Kuwaiti households living in villas, was used for some illustrative GLM analysis. The study showed that work trip rates of this household group are influenced by car ownership, household size, and the interactive effect of these two variables.

Deaton (1985) undertook an empirical analysis on income and trip making for developing countries and cities including Hong Kong, Sri Lanka, Tunisia, Thailand, and several suburbs of Delhi, India. In this paper, the author illustrated that data from household surveys from developing countries and cities could be used for analyzing the relationship between the household income/expenditure and the trip characteristic. The author also suggested that households spending anything on travel tended to increase with income in all surveys. The author also mentioned that conditional on vehicle ownership; both private and public transport demands were income elastic.

Maunder (1981) undertook extensive household surveys in two different income communities in Delhi, India. The two study areas were Shakarpur and West Patel Nagar. Shakarpur was a low/middle income unauthorized residential community while West Patel Nagar consisted of both middle and upper income residents. Although the average monthly household income in West Patel Nagar was 50% more than that in Shakarpur, the trip rate in the two communities was similar. However, it was worth noting that both communities had a large proportion of household in possession of bicycles (i.e. 30% in West Patel Nagar and 48% in Shakarpur). Also, in Shakarpur, the bicycle was the major personal vehicle.

Heraty (1980), with the cooperation of the Jamaican Government, carried out a study on the public transport in Kingston, Jamaica and its relation to low income households. In the study, the author analyzed the role public transport played in the life style of low-income households from the Jamaican Government survey data and in depth research with low-income households. The author concluded that household expenditures on travel increased with income. However, the percentage of total household income spent on travel was greater for low-income families. The author also mentioned that car ownership was strongly related to income so that the relationship of public transport was greater for the lower income group.

2.3 Summary of Literature Review

To summarize, a range of socio-demographic variables influences trip generation. These variables include gender, age, number of children, household income, employment status, number of workers in the household, retirement status, education status, vehicle ownership, family size, and type of house.

In terms of the methods that are used in developing trip generation models, the primary tool used in modeling trip generation is the regression analysis method.

Two types of regression are commonly used. The first uses data aggregated at the zonal level, with average number of trips per household in the zone as the dependent variable and average zonal characteristics as the explanatory variables. The second uses disaggregated data at the household or individual level, with the number of trips made by a household or individual as the dependent variable and the household and personal characteristics as the explanatory variables.

Chapter Three

Analytical Framework and Methodology

Chapter Three

Analytical Framework and Methodology

3.1 General Steps of the Methodology

The research will mainly rely on the following methodology:

1. Desk and Internet Research: This step is done by reviewing the related literature including publications on trip generation analysis using different methods including the linear regression method.
2. Study Area Selection: This involves selecting the boundaries of the study area and dividing the city into traffic zones according to set criteria and benefiting from maps made available by the Municipality of Jericho or other relevant agencies.
3. Selecting Sample Size and Designing Household Questionnaire: This involves identifying needed information and designing a questionnaire for proper data collection of relevant socio-economic variables and trip data.
4. Collecting the Required Data: This is related to field data collection from the sample of households in the different traffic zones. Required data include the total number of trips made by household members, number of trips made by household for each category of trip production, whether according to trip purpose or trip time, through home interview survey.
5. Analyzing Available Data: This is performed depending on relevant computerized programs.

6. Building Models: This includes estimation of feasible models for the total number of trips produced by the household, and the total number of trips for each category of home-based trips (either according to trip purpose or trip time) utilizing linear regression method.
7. Selection of Appropriate Models: This is done using statistical and rational methods available to choose the most appropriate model that predicts the total number of trips produced by the household, and the models that predict the number of trips for each category of home-based trips.
8. Verification of Results: This is done by comparing the outputs of models with the actual numbers to verify these models, and make calibration of the variables used in model building.

The details of steps of methodology are shown in the following sections and chapters.

3.2 Methods of Survey

Once the questionnaire is ready, the next step is to conduct the actual survey. There are various types of survey methods, and each has its own advantages and disadvantages. Before choosing the proper survey method, there is a need to know the characteristics of the people that will be surveyed, the sample size, the cost, the expected response rate, and the size of study area. For example, if the target population is composed of college students, the online survey method would be preferable. In terms of sample size, the number of respondents in the sample should be considered when choosing the survey method. Online surveys or mail-back surveys are best for surveys requiring a hundred or thousand responses. On the other hand, telephone surveys are ideal for studies requiring limited responses. If the cost or size of study area is limited, the online or mail-back surveys are preferable. For better response rates, the personal interview survey is preferable.

The most common methods of survey are discussed below.

3.2.1 Personal Interview Surveys

In this method, also known as a face-to-face survey, the researcher visits the home of the respondent and asks the questions and fills up the questionnaire by himself. This method is considered to be the most effective one. The purpose of conducting a personal interview survey is to explore the responses of the people to gather more and deeper information (Sincero, 2012).

There are two types of personal interview surveys according to how the interviewer approaches the respondents: intercept and door-to-door interviews. In an intercept interview, the interviewer usually conducts a short but concise survey by means of getting the sample from public places such as malls, theaters, food courts, or tourist spots. On the other hand, a door-to-door interview survey involves going directly to the house of the respondent and conducting the interview either on-the-spot or at a scheduled date (Sincero, 2012).

The personal interview surveys have many advantages including high response rate, more precise data, and better observation of respondents' behavior. However, personal interview surveys are more expensive than other types of surveys and more time-consuming because there is a need to travel and meet the respondents at different locations.

3.2.2 Telephone Interviews

Conducting interviews by telephone may offer potential advantages associated with access, speed and lower cost. This method allows the researcher to make contact with participants with whom it would be impractical to conduct an interview on a face-to-face basis because of the distance and prohibitive costs involved and time required. Even where 'long-distance' access is not an issue, conducting interviews by telephone may still offer advantages associated with speed of data collection and lower cost. In other words, this approach may be seen as more convenient.

However, there are a number of significant issues that are taken into account against attempting to collect qualitative data by telephone contact. Seeking to conduct qualitative interviews by telephone may lead to issues of reduced reliability, where the participants are less willing to engage in an exploratory discussion, or even a refusal to take part. There are also some other practical issues that would need to be managed. These relate to the researcher's ability to control the pace of a telephone interview and to record any data that were forthcoming.

Conducting an interview by telephone and taking notes is an extremely difficult process and so using audio-recording is recommended. In addition, with telephone interviews the researcher loses the opportunity to witness the non-verbal behavior of participants, which may adversely affect the interpretation of how far to pursue a particular line of questioning. Participants may be less willing to provide the researcher with as much time to talk to them in comparison with a face-to-face interview. The researcher may also encounter difficulties in developing more complex questions in comparison with a face-to-face interview situation.

For the above mentioned reasons, interviewing by telephone is likely to be appropriate only in particular circumstances. It may be appropriate to conduct a short, follow-up telephone interview to clarify the meaning of some data, where the researcher has already undertaken a face-to-face interview with a participant. It may also be appropriate where access would otherwise be prohibited because of long distance.

3.2.3 Mail-Back Surveys

The researcher sends the questionnaire to the respondents and asks them to fill the details and mail them back with required information. Care should be taken to design the questionnaire so that it is self-explanatory.

The mail-back surveys save the researchers' time. In addition, this method is considered a quick process of collecting data. It involves minimal cost in comparison with other methods of survey like face-to-face surveys.

The main disadvantages of mail-back surveys are that they need more effort in questionnaire designing because in order to be clear and concise to encourage every respondent to reply. This method has a low response rate and generates less precise data in comparison with other methods of survey.

3.2.4 Online Surveys

For the past few years, the Internet has been used by many companies in conducting all sorts of studies all over the world. Whether it is market or scientific research, the online survey has been a faster way of collecting data from the respondents as compared to other survey methods such as personal interviews (Sincero, 2012).

Advantages of online surveys include ease of data gathering, minimal cost, automation in data input and handling, an increase in response rate, and flexibility of questionnaire design.

However, online surveys have some disadvantages such as the absence of interviewer, inability to reach some target groups of population, and survey fraud.

3.2.5 Data Collection Method Used

The method of survey that is used in this research to collect data is the personal interview (door to door). This method is used because it generates the highest response rate and the most precise data. In addition, the area of study is not so large and the target population is comprised of all kinds of people.

3.3 Sample Size Calculation Methods

Unfortunately, there is no straightforward and one objective answer to the question of the calculation of sample size. Determining the sample size is a problem of trade-offs (Ortuzar and Willumsen, 1996):

1. A much too large sample may imply a data-collection and analysis process, which is too expensive given the study objective and its required degree of accuracy.
2. A far too small sample may imply results which are subject to an unacceptably high degree of variability reducing the value of the whole exercise.

Therefore, between these two extremes lies the most efficient (in cost terms) sample size for the given the study objective. Two major methods of sample size calculation are usually used, which are presented below.

3.3.1 Standards of Bureau of Public Roads (BPR):

The sample size can be determined based on the basis of population of the study area, and the standards given by the USA Bureau of Public Roads (BPR) are as shown in Table 3.1.

Table 3.1: Standards of Bureau of Public Roads (BPR) for Sample Size Calculation

Population of Study Area	Sample size (Dwelling Units)	
	Recommended	Minimum
Under 50,000	1 in 5 (20%)	1 in 10 (10%)
50,000 – 150,000	1 in 8 (12%)	1 in 20 (5%)
150,000 – 300,000	1 in 10 (10%)	1 in 35 (2.86%)
300,000 – 500,000	1 in 15 (6.67%)	1 in 50 (2%)
500,000 – 1,000,000	1 in 20 (5%)	1 in 70 (1.43%)
Over 1,000,000	1 in 25 (4%)	1 in 100 (1%)

Source: U.S Bureau of Public Roads, 1967

3.3.2 Sample Size Statistical Formulas:

The sample size can be calculated according to statistical formulas. These formulas can be found in most statistics textbooks, especially descriptive statistics dealing with probability.

The sample size of infinite population can be calculated as:

$$S_s = \frac{Z(1 - 0.5\alpha) \times P \times (1 - P)}{C^2}$$

Where:

S_s: Sample size required.

$Z(1 - 0.5\alpha)$: Standard normal statistic corresponding to $(1 - \alpha)$ confidence level.

α: Fraction of area under normal curve representing events not within confidence level (Thus, $1-\alpha$ is the desired level of confidence).

P: Percentage of population picking a choice, expressed in decimal.

C: Confidence interval or tolerable margin of error, expressed in decimal.

The sample size of finite population is calculated as follows:

$$\text{Modified } S = \frac{S}{1+(S-1)/P}$$

Where:

S: Old sample size.

P: Population of the study area.

Therefore, the sample size is calculated using the infinite population formula first. Then the sample size derived from that calculation is used to calculate a sample size for a finite population.

3.4 Overview of Linear Regression Method

There are several methods used in relating trips produced or attracted to the causal factors, which include the regression method and the cross-classification method.

Linear regression method assumes that observations of the magnitude of the dependent variable, Y (number of trips), can be obtained for n observations of explanatory variables (Xs), and that an equation of the form$Y=\alpha+\beta X$is to be fitted to the data. This equation is for the single independent variable case. The equation may be for independent variables as in the equation:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

Estimating the best regression line depending on the coefficient of determination (R^2), the t–test for the parameters, and the F-test can be done using computer programs like Excel, SPSS or XLSTAT.

3.4.1 The Linear Regression Analysis Process

Regression equations can be developed through the following sequence of steps (Hutchinson, 1974):

1. Examining the relationships between the dependent variable and each of the independent variables in order to detect nonlinearities. If nonlinearities are detected, the relationship must be linearized by transforming the dependent variable, the independent variable, or both.
2. Developing the inter-correlation matrix involving all the independent variables.
3. Examining the simple correlation matrix in order to detect the potential sources of multicollinearity between pairs of the independent variables.
4. After examining the correlation matrix, if there is multicollinearity between two independent variables (much closer to one), then one of them must be eliminated from the regression process.

5. After choosing the correlated independent variables, some of regression equations are suggested, and then the parameters of each of the potential regression equations are estimated.
6. For every model built, relevant tests are conducted to assess the goodness of the model based on logic and statistics testing. The statistical tests include the coefficient of determination (R^2), the t-test for the parameters of the models, and the F-test for each model. In addition, there are logical aspects that must be taken in consideration, because the model must be valid statistically and logically.
7. After all the models or equations are examined based on test results, the outcome is summarized. The best model is then chosen.

3.4.2 Regression Model Building Approaches

The most commonly used approaches in selecting the explanatory variables to be included in the regression model are the forward selection approach and the backward elimination approach.

The forward selection approach starts with a model that contains only the constant term. At each step, the explanatory variable that results in the largest change in overall fitness is added to the model. This process is repeated until there is no more variable that results in a significant increase in overall fitness.

The backward elimination approach starts with a regression model that contains all the explanatory variables. At each step, the explanatory variable that changes the overall fitness least is removed. The removal process is repeated until removal of any variable results in a significant change in overall fitness. When deciding which explanatory variable should be removed from the regression model, the t-test is usually employed. Generally speaking, the explanatory variable with the least t-value is selected for removal.

In this research, the backward elimination approach is employed for building the trip generation models.

3.5 Unit of Analysis

Variables can generally be inferred from the unit of analysis. For travel modeling, two units are normally considered: the household and the individual. The household unit is preferred for various reasons: from a trip making point of view, the home is the basis where most trips start and end; from an economic point of view, income or car-ownership are usually shared by all members of the household; or from a social context, the family constitutes the ‘cell society’ where all basic needs are usually met.

Alternatively, if the individual is considered to be the base unit then the problem of allocation of some of the above mentioned variables needs to be overcome, or different quantities have to be taken into consideration. Therefore, the household is used as the unit of analysis in this research.

3.6 Data Analysis Software

There are many statistical softwares that can be used for data analysis. The Statistical Package for the Social Sciences (SPSS) is one of the most widely used statistical analysis packages. The SPSS program provides a wide range of procedures and tests used in statistics. Moreover, it offers descriptive statistics such as frequencies, means, and correlations. Finally, it is useful for making charts.

In this research, the SPSS software will be used to estimate the trip generation models using the linear regression analysis method.

3.7 Model Specification

The multiple regression analysis is one of the popular forms of model structure, which can be applied for trip generation models. Consequently, multiple regression equations will be used for developing the trip generation models for this study. The most common form of trip generation models is the linear function of the form

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_i X_i + u$$

Where α is the constant term, X_i are the explanatory variables, β_i are the partial slope coefficients of the regression equation, and u is an error term that is assumed to be a random variable. The coefficients of the regression equation can be obtained by doing regression analysis using statistical analysis software. The above equation is called multiple linear regression equation.

3.8 Models Estimation

After reviewing the related literature, the trip generation models will be estimated. The models will be estimated using the multiple linear regression technique by regressing the dependent variable on each of the explanatory variables.

In this research, the trip generation models are divided into three categories. The first includes a general trip generation model. The second includes trip generation models according to trip purpose. The final category includes trip generation models according to trip time.

3.8.1 General Trip Generation Model

The general trip generation model will be estimated according to the following linear regression equation:

$$\mathrm{Y} = \alpha + \beta_1 \mathrm{X}_1 + \beta_2 \mathrm{X}_2 + \cdots + \beta_i \mathrm{X}_i + u$$

3.8.2 Trip Generation Models by Trip Purpose

The work trip generation model, the education trip generation model, the shopping trip generation model, the social trip generation model, and the recreational trip generation model will be estimated according to the general form of linear regression equation:

$$\mathrm{Y}_i = \alpha + \beta_1 \mathrm{X}_1 + \beta_2 \mathrm{X}_2 + \cdots + \beta_i \mathrm{X}_i + u$$

Where i=1 to 5, covering the five trip purposes.

3.8.3 Temporal Trip Generation Models

Five temporal trip generation models will be estimated. These models include the trip generation model for trips made before 8 AM, the trip generation model for trips made between 8-9 AM, the trip generation model for trips made between 9 AM-12 PM, the trip generation model for trips made between 12-4 PM, and the trip generation model for trips made after 4 PM. The trip generation models according to timing will be estimated according to the following equation:

$$Y_k = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_i X_i + u$$

Where k=6 to 10, covering the five periods under consideration.

3.9 Statistical Tests

The most common statistical tests that are used in model selection process are discussed below.

3.9.1 Correlation Matrix and VIF: Testing for Multicollinearity

The problem of multicollinearity arises when two or more explanatory variables included in the regression model have linear relationships. There are two types of multicollinearity: exact or perfect multicollinearity and inexact or imperfect multicollinearity.

If two or more independent variables have exact or perfect linear relationships, then we have exact or perfect multicollinearity. On the other hand, inexact multicollinearity occurs in the case that two or more independent variables are highly correlated.

In the case of exact multicollinearity, there is no unique solution to the normal equations derived from the least squares principle. As a result, the regression coefficients cannot be estimated. By contrast, when explanatory variables have less than exact linear relationships, the normal equations can usually be solved to yield unique estimates.

However, there are some consequences. First, regression coefficients are still best linear unbiased estimators (BLUE). Second, it is more difficult to precisely identify the separate effects of the correlated explanatory variables. Finally, variances and standard errors are usually higher, making t-statistics lower and possibly insignificant.

Analysis often relies on what is called the Variance Inflation Factor (VIF) to detect multicollinearity more formally. The VIF shows how the variance of an estimator is inflated by the presence of multicollinearity.

As R^2, the coefficient of determination of a given explanatory variable with other remaining explanatory variables in the model, increases toward one, the VIF also increases. The larger value of VIF, the greater the degree of muticollinearity of one explanatory variable with the other explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10, that variable is said be highly collinear (Kleinbaum et al., 1988).

3.9.2 R-Squared: Goodness of Fit

The R-squared (R^2), also known as the coefficient of determination, measures the goodness of fit of the regression model. It measures the proportion of the total variation in the dependent variable that can be explained by the explanatory variables included in the model. The value of R-squared lies between 0 and 1. A value of R-squared closer to 1 indicates that the model has good fit, whereas a value closer to 0 indicates that the model has poor fit.

However, there is no standard on how high R^2 value is “good” enough. It depends on the application.

The R-squared is calculated as follows:

$$R^2 = \frac{\text{Regression Sum of Squares (RSS)}}{\text{Total Sum of Squares (TSS)}}$$

The ANOVA test results are used to show the analysis of the total variance in the dependent variable. This variance is divided into two sources: variance due to regression and variance due to errors.

3.9.3 F-Test: Testing Overall Significance of Model

The F-statistic is used to test whether the regression coefficients are jointly equal to zero or not. In other words, the F-test is used to test the overall significance of the regression model.

The null hypothesis for testing the overall significance of the model is that the regression coefficients for the explanatory variables are all equal to zero. The alternative hypothesis is that at least one of these coefficients is not equal to zero. Usually, a 95% level of significance for the F-value is accepted.

Table 3.2 is a format of ANOVA test results table.

Table 3.2: ANOVA Test Results Table

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-Statistic	Significance
Regression					
Residual					
Total					

3.9.4 T-Test: Testing Individual Coefficients

The t-statistic is used to test the significance of individual regression coefficients. As a rule of thumb, if the calculated t-statistic is greater than two in absolute value, it is concluded that the estimate is statistically different from zero at the 95% level of significance.

3.10 Logical Aspects Used in Model Selection

The following is a list of logical aspects that should be taken into consideration in selecting the best regression model:

1. The regression coefficients must have the correct expected sign and their magnitudes must be reasonable. For example, an explanatory variable is expected to have a positive effect on the dependent variable, whereas the result of regression analysis shows a negative effect.
2. The constant (intercept) term must be reasonable both in value and sign.

3.11 Determination of Study Area

Urban transportation planning means planning the transportation facilities based on the potential of growth of urban area for the next coming decades. So, the study area must cover the existing and potential continuously built-up areas of the city.

The study area is specified by imaginary line representing the city boundaries, called external or outer cordon line. There are four factors for selecting and fixing this cordon line (Arasan, 2012):

1. The external cordon line should cover the built-up areas and the areas that will be developed in the future during the planning period. Figure 3.1shows the Draft Master Plan of Jericho City for the year 2013.There is an imaginary line representing the approved expansion areas, and depending on this line, the external cordon line is fixed as the boundary of the study area.
2. The external cordon line should include all areas of systematic daily life of people, oriented towards the city center and should in

effect be the commuter shed. Because there are areas beside Jericho City that include systematic daily life and affect travel patterns, these areas are included in the external cordon line. These areas are Al-Nwe'ma and Ein Dyok Alfoqa.

3. The external cordon line should be continuous and uniform in its course, so the movements cross it only in one point. The line should intersect roads where it is safe and convenient for carrying out traffic surveys.
4. The external cordon line should be compatible with the previous studies of the area or studies planned for the future. These previous studies could be related to census operation or population census.

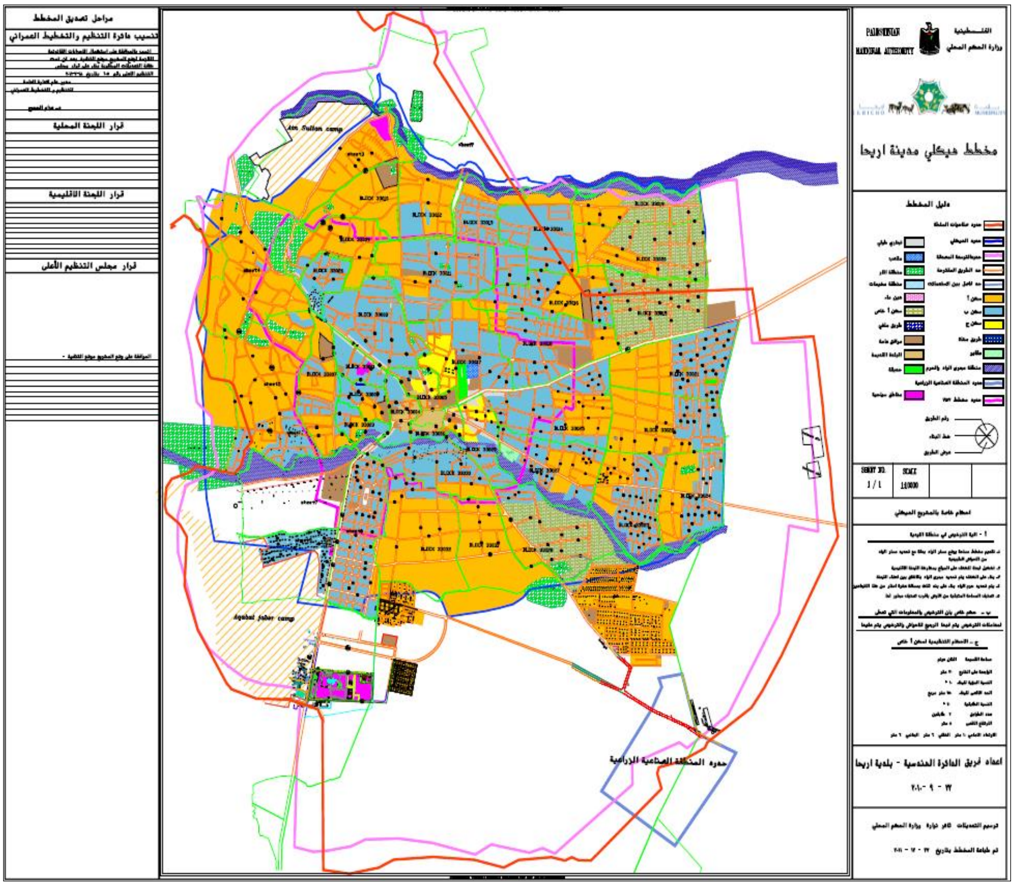

Figure 3.1: Draft Master Plan of Jericho City (2013)

Source: Jericho Municipality, 2013.

3.12 Zoning System

Zoning means dividing the study area after defining the boundary into smaller land use areas called traffic analysis zones (TAZ) or simple zones.

The zones within the study area or external cordon line are called internal zones. The division of internal zones and their numbers will depend on a compromise between a series of criteria discussed in this section. The region external to the study area is normally divided into a number of external zones. In some cases, as in this case, it might be enough to consider each external zone to represent the rest of the surrounding regions in a particular direction; the boundaries of these different slices of the rest of the surrounding regions could represent the natural catchment areas of transport links feeding into the study area (Ortuzar and Willumsen, 1996).

Zones are modeled as if all their attributes and properties were concentrated in a single point called the *zone centroid*. The centroids are connected to the nearest road junction or transport station by *centroid connectors*. The centroid and the centroid connectors are notional and it is assumed that all people have same travel cost from the centroid to the nearest transport facility which is the average for a zone (Ortuzar and Willumsen, 1996).

The following are the general guidelines for zoning process (Ortuzar and Willumsen, 1996):

1. The zoning system must be compatible with other administrative divisions, particularly with census zones, this is probably the

fundamental criterion and the rest should only be followed if they do not lead to inconsistencies with it.

2. Zones should be as homogenous as possible in their land use and population composition, so as to reflect accurately the associated trip making behavior. There are different types of land uses in urban areas including residential, industrial, institutional, and recreational.
3. The anticipated changes in land use should be considered when sub-dividing the study area into zones.
4. Zone boundaries must be compatible with cordons and screen lines and with those of previous zoning systems. In this study, major roads are considered as zone border and commuter shed for particular traffic zone. On the other hand, external cordon lines are considered as part of boundaries of traffic zones, and wadis or rivers are also considered as zone boundaries.
5. The shape of the zones should allow an easy determination of their centroid connectors. This is important for later estimation of intra-zonal characteristics, and important for determination of the centroid, which represents the origin and destination of travel.
6. Zones do not have to be of equal size, if anything, they could be of similar dimensions in travel time units, therefore generating smaller zones in congested than in uncongested areas.
7. In general, zones should not be too large or too small, because the too large zone causes considerable errors in data and the too small zone causes difficulty in handling and analyzing the data. As a general guide, a population of 1,000-3,000 may be the optimum of

small area, a population of 5,000-10,000 may be the optimum of large urban areas, and as a whole the size of each TAZ between 0.25 to 1 squared mile, or 0.5 to 2.5 square kilometer. Also, no generated more than 15,000 person trips in base and future years (Cambridge Systematics, Inc., 2007).

8. Natural or physical barriers such as canals, rivers, and so on can form convenient zone boundaries. In this case, there are two rivers which can be considered as screen lines and zone boundaries as shown in Figure 3.2. (Cambridge Systematics, Inc., 2007).

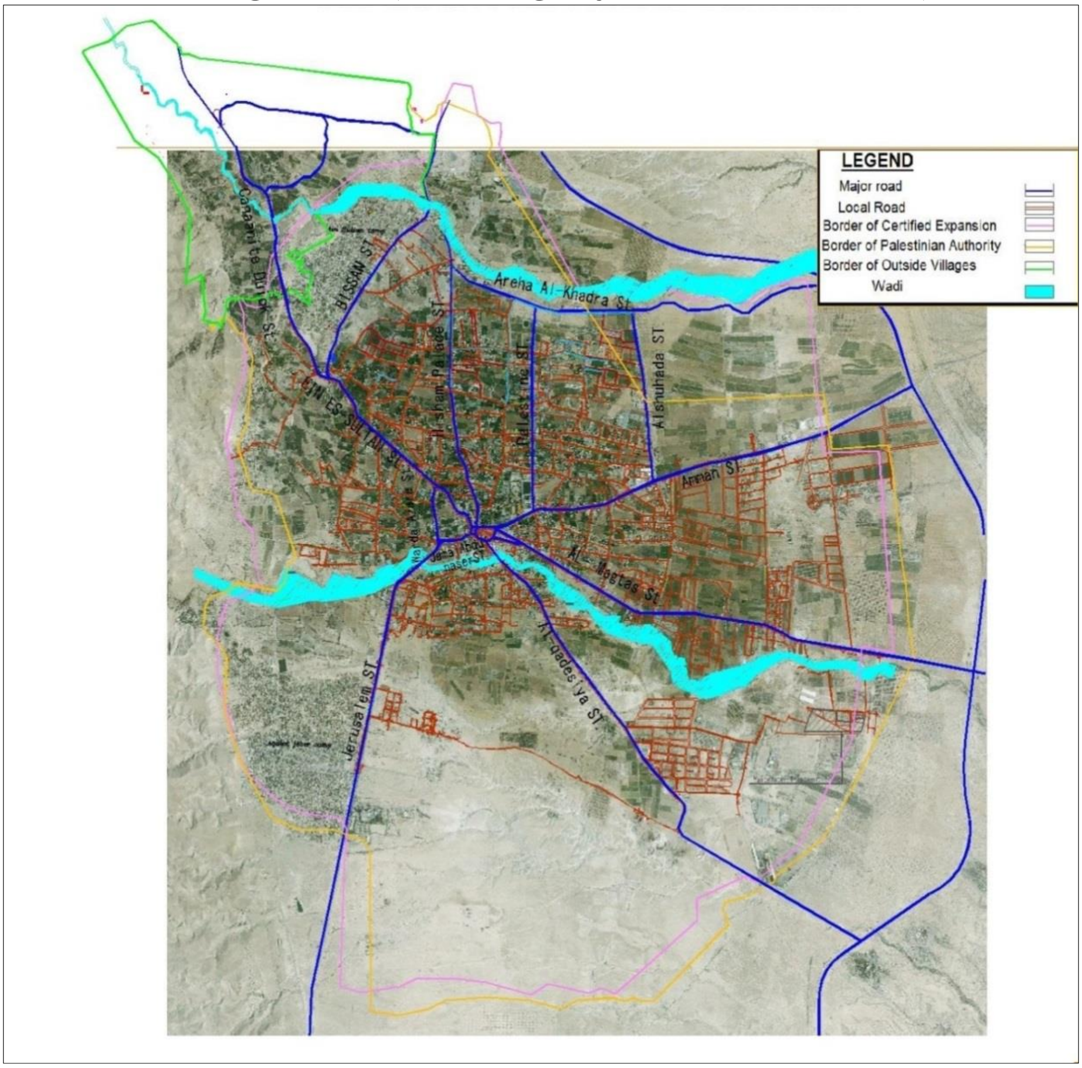

Figure 3.2: Major Roads and Natural Barriers in Jericho City Used for Specifying Zones Boundaries

9. Zone boundaries should preferably be watersheds of trip making (Arasan, 2012). If there are arterial roads, and there are a lot of commuters towards that arterial road for commuting that joining area, then the adjoining area becomes a commuter shed for this particular road, like the catchment area and the watershed (Arasan, 2012). Explanation of commuter shed is shown in Figure 3.3. Arterial roads in Jericho City, which are considered as a commuter shed, are shown in Figure3.3.

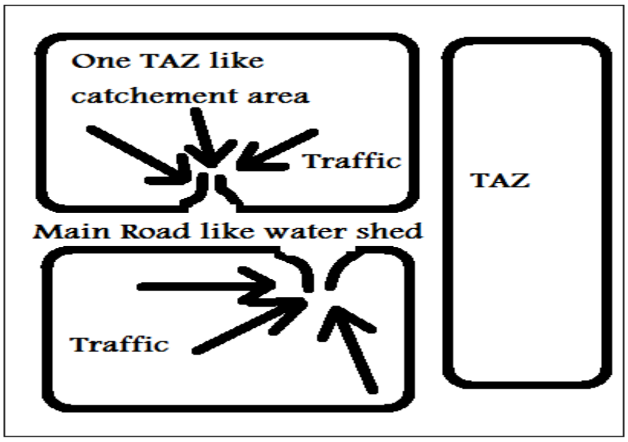

Figure 3.3: Explanation of Commuter Shed

The purpose of zoning system is to:

1. Facilitate spatial quantification of land use and economic factors, which influence travel pattern (Arasan, 2012). This can be done by matching the land-use plan with the boundaries of traffic zones as shown in Figure 3.4.

After matching the land-use plan with zone boundaries, the area and land-use of each traffic zones are specified for this research as shown in Table 3.3.

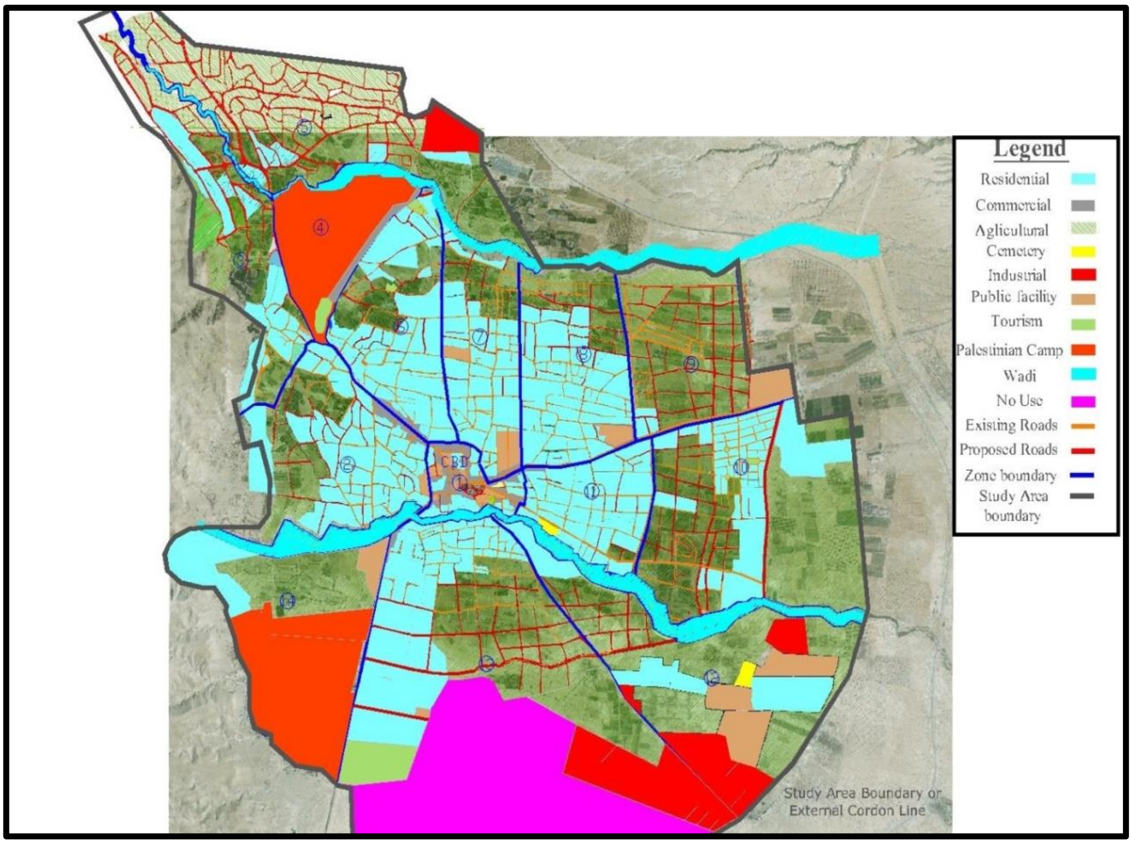

Figure 3.4: Land Uses Plan with the Boundaries of Traffic Zones

Source: Master Plan of Jericho (Jericho Municipality, 2010)

Table 3.3: Land Uses and Areas for Traffic Zones

Traffic Zone No.	Area (Km^2)	Land Uses in Traffic Zone
1	0.547	Residential, commercial, public facility.
2	2.479	Residential, commercial, public facility, agricultural, heritage.
3	2.409	Residential, agricultural, heritage.
4	1.254	Residential, commercial, public facility, parking, industrial, agricultural.
5	3.726	Residential, agricultural, commercial, heritage, cemetery.
6	2.049	Residential, agricultural, commercial, public facility, park.
7	1.668	Residential, agricultural, commercial, public facility, park, heritage.
8	2.142	Residential, agricultural, commercial, public facility.
9	2.113	Residential, agricultural, public facility.
10	4.185	Residential, commercial, public facility, agricultural.
11	1.262	Residential, commercial, public facility, agricultural, cemetery.
12	3.864	Residential, agricultural, public facility, cemetery, parking, industrial, commercial.
13	10.182	Residential, agricultural, public facility, commercial.
14	3.005	Residential, public facility, commercial, parking, agricultural.

Source: Master Plan of Jericho (Jericho Municipality, 2010)

2. Help in geographically associating the origins and destinations of travel (Arasan, 2012).

According to all previous points, the final TAZ's adopted for Jericho City are shown in Figure 3.5.

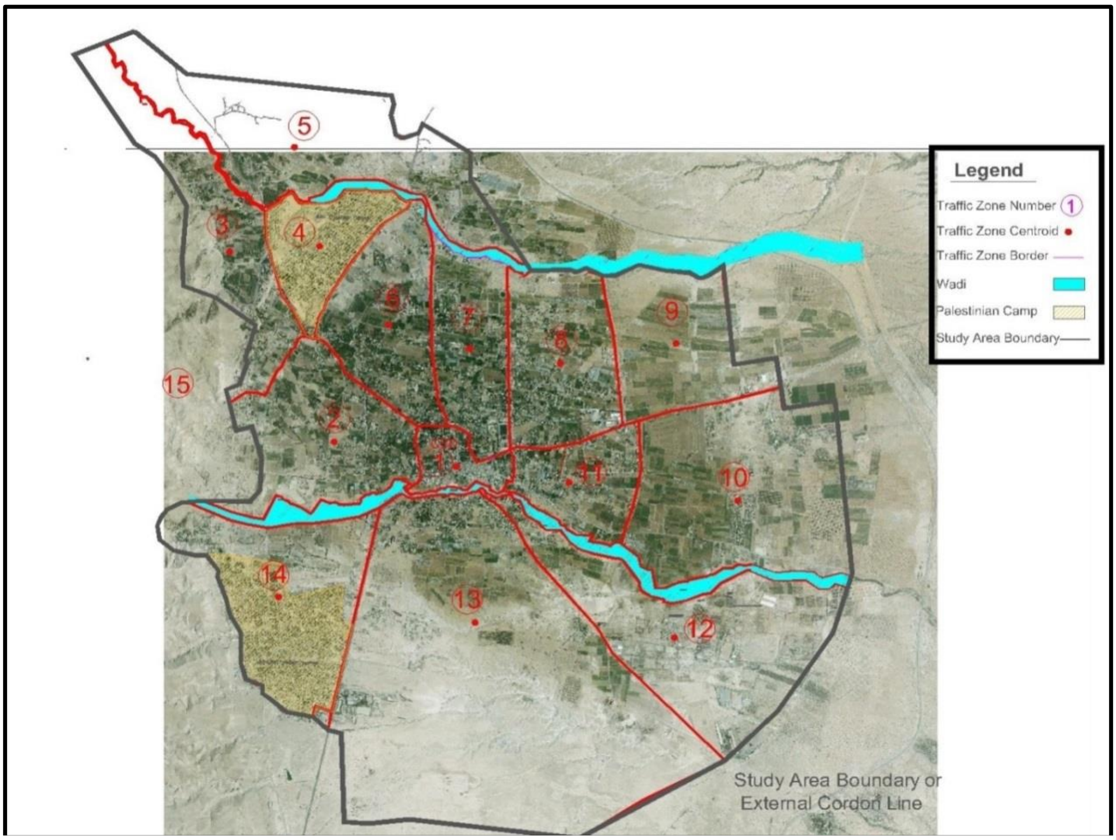

Figure 3.5: TAZ's of Jericho City

Chapter Four

Field Survey and Data Collection

Chapter Four

Field Survey and Data Collection

4.1 Population of Study Area

In general, to specify the population of study area, statistics from the Palestinian Central Bureau of Statistics (PCBS) will be used. According to the specified borders of study area, there are refugee camps and villages outside the borders of Jericho Municipality, but these camps and villages, which are located just beyond the municipality borders have systematic daily life and affect the travel pattern of Jericho City. On the other hand, there are villages considered as part of Jericho and Valleys Governorate, but these villages will not be considered in this research because they are far from Jericho City.

In order to calculate the sample size that will be used in this study, first the population size is specified from the PCBS as appears in Table 4.1.

The population that will be considered in this study is 35,885 people. Based on a random sample of 100 household respondents, the average household size in the study area is calculated to be 5.03 persons. The number of households in the study area is thus 7,134households (35,885/5.03).

Table 4.1: Localities in the Study and Estimates of Population, 2013

Locality Name	Locality Code	Locality Type	Population
Jericho City	351920	Urban	21,411
Al New'ma	351840	Rural	1,453
Ein Dyok Alfoqa	351845	Rural	958
Ein Al Sultan Refugee Camp	351865	Refugee Camp	3,688
Aqbat Jaber Refugee Camp	351975	Refugee Camp	8,375
Total urban			**21,411**
Total rural			**2,411**
Total refugee camps			**12,063**
Total of Study Area			**35,885**

Source: The Palestinian Central Bureau of Statistics, 2013.

4.2 Sample Size of Study Area

According to the standards of the USA Bureau of Public Roads (BPR, 1967), the minimum sample size that will be taken in this study is 1 in 10 of dwelling units since the population of the study area is under 50,000.The sample size that will be considered in this study is 10% of the total number of households in the study area, 713 households (10% times 7,134), distributed over 14 TAZ's according to percentages and numbers shown in Table 4.2.

In order to calculate the sample size based on Statistical Formulas, a random sample of 100 household respondents is initially taken to calculate the percentages of population (P) that make different types of trips. Then, these percentages are used in the equation to calculate the actual sample size required for this study as shown in Table 4.3.

Table 4.2 Number of Households per Traffic Zone for Study Area and Sample Size Required

Traffic Zone No.	# of Housing Units *	Population **	% of Housing Units	Sample Size
1	188	946	3%	19
2	489	2458	7%	49
3	190	958	3%	19
4	733	3,688	10%	73
5	289	1,453	4%	29
6	647	3256	9%	65
7	560	2816	8%	56
8	606	3047	8%	61
9	55	275	1%	5
10	301	1512	4%	30
11	580	2915	8%	58
12	162	814	2%	16
13	632	3179	9%	63
14	1703	8,838	24%	171
Total	**7,134**	**35,886**	**100%**	**713**

*Number of Housing Units in every traffic zone was found depending on the field survey.
** Population in every traffic zone was found by multiplying the number of housing units by the average size of household (5.03 person/household).

Table 4.3: Sample Size Calculation According to Statistical Formulas

Trip Type	P	1-P	α	Z	c	S_s	Modified S
Work	0.22	0.78	0.05	1.96	0.04	412	407
Education	0.29	0.71	0.05	1.96	0.04	494	488
Social	0.17	0.83	0.05	1.96	0.04	339	336
Shopping	0.24	0.76	0.05	1.96	0.04	438	433
Recreational	0.09	0.91	0.05	1.96	0.04	197	196
Total	**1.00**					**1,880**	**1,859**

So, the sample size according to the statistical formula is 370households (1,859/5.03). However, as the sample size calculated from the BPR is found to be 713, which is higher than the 370 households, the later will be adopted in this study. This higher sample size is adopted to get a higher degree of accuracy.

4.3 Sampling Method

The sample that is drawn from the household population is a stratified random sample that includes 713 households. Stratification reflects geographic locations defined as TAZ. Therefore, the study area is divided into 14 TAZ's. The samples are randomly selected from each of the 14 TAZ's. The sample size of each TAZ is shown in Table 4.2.

4.4 Questionnaire Design

In terms of layout, the order of the questions normally seeks to minimize the respondent’s resistance to answering them; the survey instrument (and any personal interviews) should try to satisfy the following criteria (Ortuzar and Willumsen, 1996):

1. The questions should be simple and direct.
2. The number of open questions should be minimized, so long answer avoided and use of code for answer preferable.
3. Difficult questions (e.g. relating to income) are usually put at the end.
4. Travel information must include the purpose of the trip.
5. Because of the growth of non-car modes, seek information about all modes of travel, including non-motorized travel.
6. Due to the growing importance of independent trips by children, and of non-motorized modes, all people in the household should be included in the survey, including non-family members, like maids in developing countries.

7. To facilitate the respondents task of recording all travel, it is recommended that an activity-recall framework be used; people record travel in the context of activities they have undertaken rather than simply trips they have made; this has been shown to result in much more accurate travel measurement.
8. Since people have difficulty recalling infrequent and discretionary activities, even when they are recent, it is recommended that travel day or days be assigned to each household in advance, they should be given a brief diary in advance of these days: The information in the diary may be then transferred to the self-completion form or reported to the interviewer at the end of the day. Anyhow, in this study, the recalling of trips or activities depended on the memory of persons in the household.

4.5 Required Information

For any type of household survey, it is recommended that the survey be divided into two parts:

1. Personal and household characteristics and identification: This part includes questions designed to classify the household members according to their relation to the head of household (e.g. wife or son), sex, age, possession of a driving license, educational level, and occupation. In order to reduce the possibility of a subjective classification, it is important to define a complete set of occupations (non-household surveys are usually concerned only with person being interviewed; however, the relevant questions are the same or

very similar). This part also includes questions designed to obtain socio-economic data about the household, such as characteristics of the house, identification of the household vehicles, house ownership and family (Ortuzar and Willumsen, 1996).

2. Trip data: This part of survey aims at detecting and characterizing all trips made by the household members identified in the first part. A trip is defined as any movement outside a building or premise with a given purpose; but the information sought considers trips by stages, where a stage is defined by a change of mode (including walking). Each stage is characterized on the basis of variables such as origin and destination (normally expressed by their nearest road junction), purpose, start and ending times, mode used, amount of money paid for the trip, and so on (Ortuzar and Willumsen,1996).

According to the points mentioned in the questionnaire design and the required information, the questionnaire form used in this thesis is shown in Appendix B. This questionnaire aims to collect in the first part personal and identification characteristics of households, which are considered as explanatory variables. These variables are used in the attempt to build the models, which will be examined statistically and logically to adapt the most appropriate model that can predict the trips generated by the TAZ's.

The questionnaire contains two tables. The first table gives details about the socio-economic variables of households. Such details contain: gender, age, possession of driving license, possession of transportation facilities like private cars, bicycles, and motorcycles, house type (independent home or apartment), and household income. The bicycles are taken into consideration because Jericho City is flat and there are bikes in almost every household.

The explanatory variables that have been considered for possible use in the modeling process are summarized in Table 4.4.

The age variable is divided into five groups as shown in Table 4.4. The first age group of ages up to 16 years includes persons who are assumed to be in schools. The second age group of ages between 17 to 30 includes persons who are either continuing education in universities or part of the labor force. The third and fourth age groups include persons who are heads of families and part of the labor force, which are divided into an age group from 31 to 50 and another from 51 to 64. Finally, the fifth age group of ages 65 and above includes elderly persons who are usually retired.

The second table is designed to collect data concerned with the second part of survey (trip data). This table is made to calculate the total trips generated by the household and the number of trips for each type of trips (work trips, education trips, shopping trips, social trips, and recreational trips), and the trips according to their time. These trips are divided into five groups. The first group includes trips made before 8 AM. Trips made during this period are called the morning peak period trips which are usually made by most students and employees. The second time group includes trips that are made between 8-9 AM. During this time period, some students and employees make their trips. The third and fourth time periods include trips made between 9 AM -12 PM and 12-4 PM, respectively. These time groups are usually considered to be the AM and PM off peak periods. The fifth time group includes trips made after 4 PM. This time period is considered to be the evening peak period. Usually, most of shopping, social, and recreational trips are made during this time period. All these trips are summarized as shown in Table 4.5.

Table 4.4 : Explanatory Variables Used in the Models

X_1	Number of persons in the household
X_2	Number of males in the household
X_3	Number of females in the household
X_4	Number of employed persons in the household
X_5	Number of persons receiving education in the household
X_6	Number of persons under 16 years in the household
X_7	Number of persons between 17 and 30 years in the household
X_8	Number of persons between 31 and 50 years in the household
X_9	Number of persons between 51 and 64 years in the household
X_{10}	Number of persons above 65 years in the household
X_{11}	Number of licensed drivers in the household
X_{12}	Number of cars owned by a household
X_{13}	Number of bicycles owned by a household
X_{14}	Number of motorcycles owned by a household
X_{15}	Monthly household income (Thousand New Israeli Shekel)
X_{16}	House type: 1if Independent, 0 if Apartment

Table 4.5: Dependent Variables Used in the Models

Y	Number of daily trips made by household
Y_1	Number of daily work trips made by household
Y_2	Number of daily educational trips made by household
Y_3	Number of daily shopping trips made by household
Y_4	Number of daily social trips made by household
Y_5	Number of daily recreational trips made by household
Y_6	Number of daily trips made by household before 8 AM
Y_7	Number of daily trips made by household between 8-9 AM
Y_8	Number of daily trips made by household between 9-12 AM
Y_9	Number of daily trips made by household between 12 AM - 4 PM
Y_{10}	Number of daily trips made by household after 4 PM

4.6 Conducting Field Survey

After determining the sample size, designing the questionnaire, and choosing the method of survey, the field survey in this study was conducted according to the following steps (Mathew, 2011):

1. Two skilled enumerators are chosen to help in the survey process.
2. Enumerators have to be trained by briefing them about the details of the survey and how to conduct the survey.
3. The enumerators will be given random household addresses.
4. The random sample of households in different traffic zones will be numbered on a printed map and the same numbers are put on the questionnaire layout, where each number on the map and the questionnaire represents one household.
5. Since the actual survey may take place any time during the day, the respondents are required to answer the question about the travel details according to the previous day. This previous day must be typical working day because working days represent the most critical situation. In Palestine, the typical working days are from Sunday to Thursday.
6. The enumerators have to first get permission to be surveyed from the household. Then, they ask the household members about the details required in the questionnaire. Each member of the household should give answers about his or her own travel details, except for children below 12 years. Trip details of children below 5 years are normally ignored.

Chapter Five

Data Analysis and Results

Chapter Five

Data Analysis and Results

5.1 Descriptive Data

In this section, descriptive statistics for both the dependent variables as well as the explanatory variables will be shown and discussed. This section is intended to give an overview of the distribution of various trips according to their purpose as well as to their time. This shows which trips are the most frequent.

Moreover, this section includes figures that relate the number of daily trips with each of the explanatory variables so as to show graphically if these variables are related or not. This also shows if these relationships are linear or not.

5.1.1 Descriptive Data of Dependent Variables

Table 5.1 lists discriptive statistics for the total daily household trips. There has been a total of 4,913 trips made by 713 households.

Table 5.1: Descriptive Data for the Total Daily Household Trips

Total Trips	Mean	Standard Deviation	Maximum	Minimum	Range
Y	6.89	3.096	16	0	16

It is apparent from Table 5.1 that the average daily trips per household is around 7. The maximum number of daily trips per household is 16 whereas the minimum number is 0.

The discriptive statistics for the daily household trips according to their purpose are shown in Table 5.2.

Table 5.2: Descriptive Data for the Daily Household Trips by Purpose

Trip Purpose	Mean	Standard Deviation	Maximum	Minimum	Range
Work	1.60	0.817	5	0	5
Education	1.84	1.575	6	0	6
Shopping	1.52	0.996	7	0	7
Social	1.03	1.143	7	0	7
Recreational	0.92	1.450	6	0	6

The discriptive statistcs for the temporal daily household trips according are shown in Table 5.3.

Table 5.3: Descriptive Data for the Daily Household Trips by Time

Trip Time	Mean	Standard Deviation	Maximum	Minimum	Range
Before 8 AM	2.58	1.640	7	0	7
8-9 AM	0.57	0.820	5	0	5
9-12 AM	0.24	0.501	3	0	3
12 AM - 4 PM	0.54	0.653	4	0	4
After 4 PM	2.95	1.820	10	0	10

Classification of trips according to their purpose is important to be carried out since people make the trips for various reasons. In this research, among 4,913 trips generated by 713 surveyed households, most of the trips (27%) are education trips. Work trips account for 23% of total trips generated. The distripution of household trips according to purpose is shown in Table 5.4. The same data are shown graphically in Figure 5.1.

Table 5.4: Distribution of Daily Household Trips by Purpose

Trip Purpose	Number	%
Work	1,141	23%
Education	1,310	27%
Shopping	1,085	22%
Social	727	15%
Recreational	650	13%
Total	**4,913**	**100%**

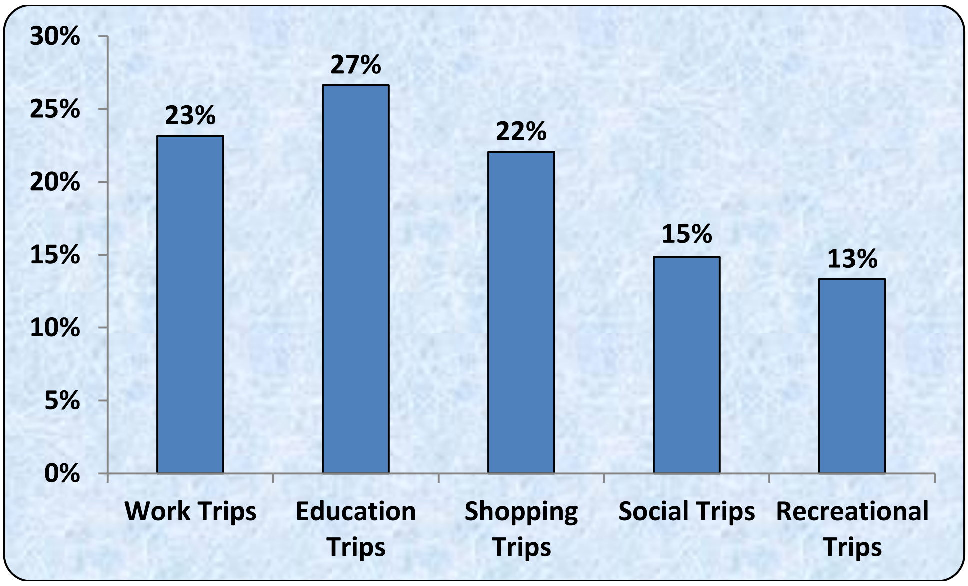

Figure 5.1: Distribution of Daily Household Trips by Purpose

People do their activities in different times within a day. Hence, it is essential to carry out the temporal distribution of trips generated. According to the survey data, most of the trips are distributed within peak hours where 37% of trips are made during morning peak hours (before 8:00 AM) and 43% are made during afternoon peaks (after 4:00 PM). The temporal distribution of daily household tripsis shownin Table 5.5. The same data are presented graphically in Figure 5.2.

Table 5.5: Temporal Distribution of Daily Household Trips

Trip Time	Number	%
Before 8 AM	1,841	37%
8 AM - 9 AM	409	8%
9 AM - 12 PM	174	4%
12 PM - 4 PM	383	8%
After 4 PM	2,106	43%
Total	**4,913**	**100%**

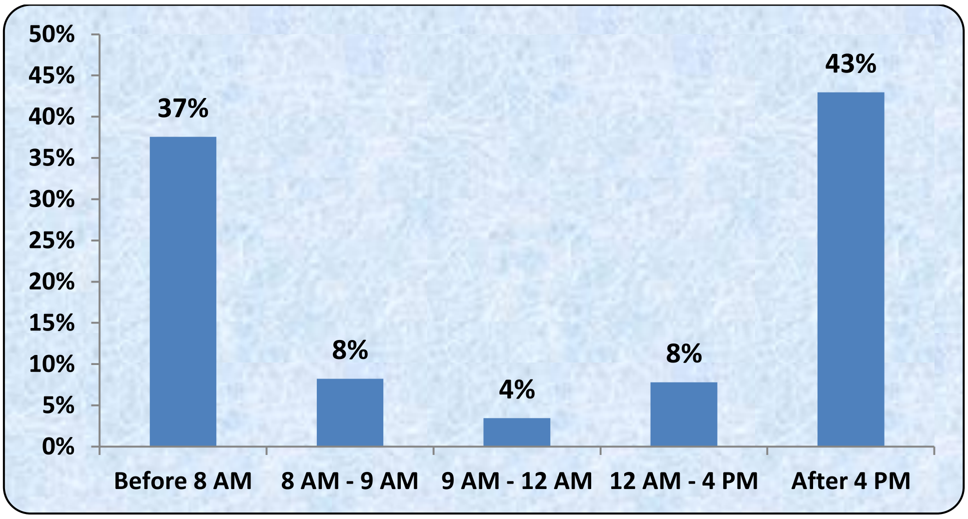

Figure 5.2: Temporal Distribution of Daily Household Trips

5.1.2 Descriptive Data of Explanatory Variables

The descriptive statistics for the household size are shown in Table 5.6.

Table 5.6: Descriptive Data for Household Size

Mean	Standard Deviation	Maximum	Minimum	Range
4.66	1.626	9	1	8

Table 5.6 shows that the average household size for the selected sample is around 5 persons.

The relationship between the number of daily trips generated per household and the household size as measured by the number of persons in the household is depicted in Figure 5.3.

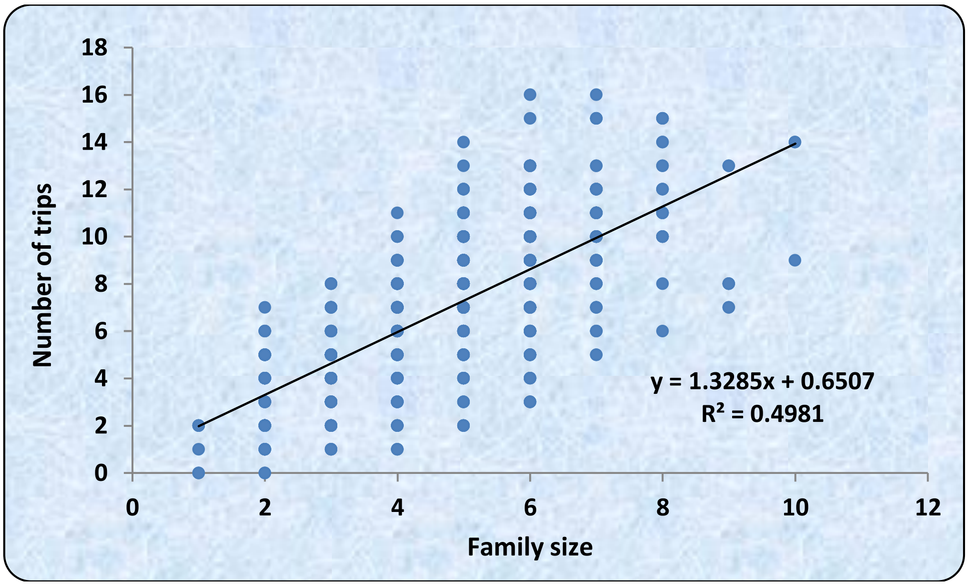

Figure 5.3: Daily Household Trips and Household Size

Gender distribution of survey respondents is shown in Table 5.7. It is also shown graphically in Figure 5.4.

Table 5.7: Gender Distribution for the Sample

Gender	Number	%
Male	1,655	49%
Female	1,694	51%

Table 5.7 shows that the sample is nearly divided evenly between males and females.

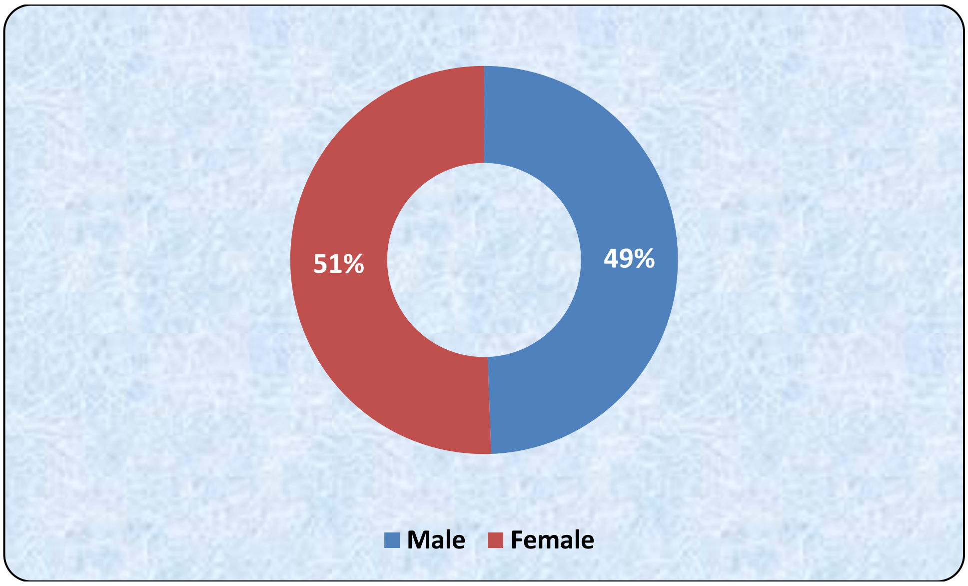

Figure 5.4: Gender Distribution for the Selected Sample

Gender descriptive statistics are shown in Table 5.8.

Table 5.8: Descriptive Data for Gender Distribution in the Household

Gender Variable	Mean	Standard Deviation	Maximum	Minimum	Range
Number of males	2.32	1.216	7	0	7
Number of females	2.38	1.206	7	0	7

The relationship between the total number of trips made by a household and the number of males in the household is shown in Figure 5.5. The figure shows a positive relationship between these two varaiables. In other words, as the number of males increases in a household, the number of trips made by that household also increases.

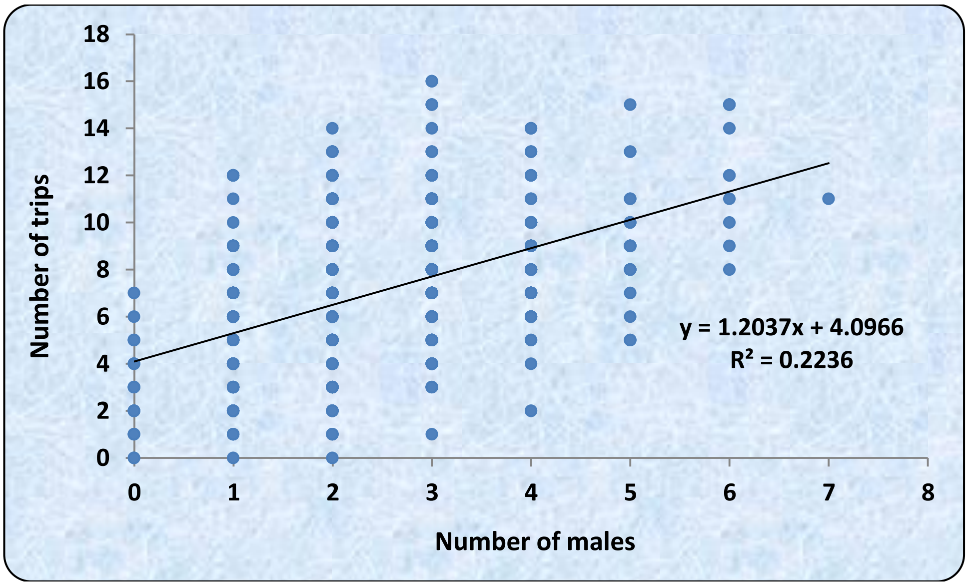

Figure 5.5: Daily Household Trips and Number of Males

Figure 5.6 shows the relationship between the total number of trips made by a household and the number of females in the household. Generally speaking, as the number of females increases in the household, the total number of trips made by the household also increases.

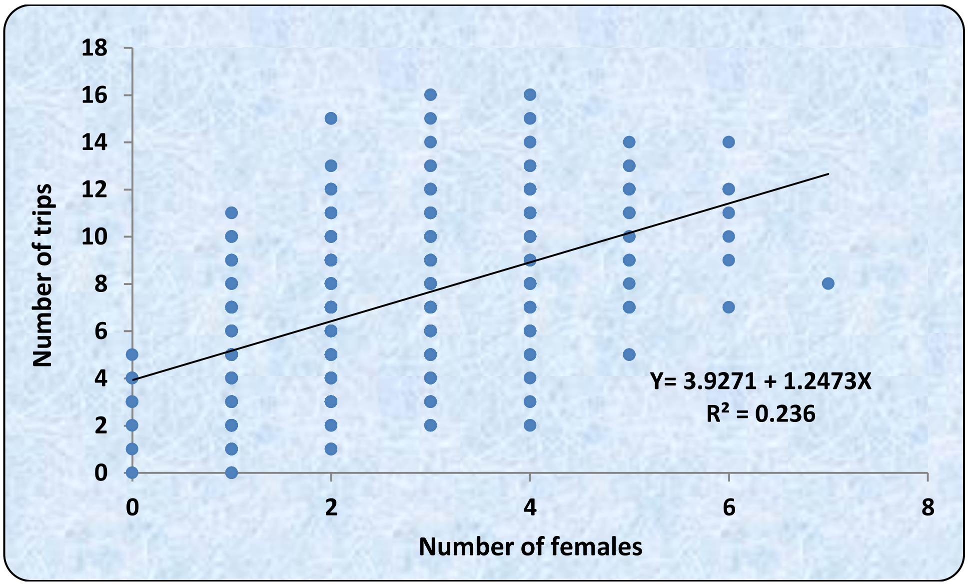

Figure 5.6: Daily Household Trips and Number of Females

Table 5.9 shows descriptive statistics for the number of employed persons in the survey sample.

Table 5.9: Descriptive Data for the Number of Employed Persons

Mean	Standard Deviation	Maximum	Minimum	Range
1.46	0.722	4	0	4

As Table 5.9 shows, the average number of employed persons per household is around 1.5.

The relationship between the total number of daily trips made by a household and the number of employed persons in the household is shown in Figure 5.7. The figure shows a relatively positive relationship between these two variables.

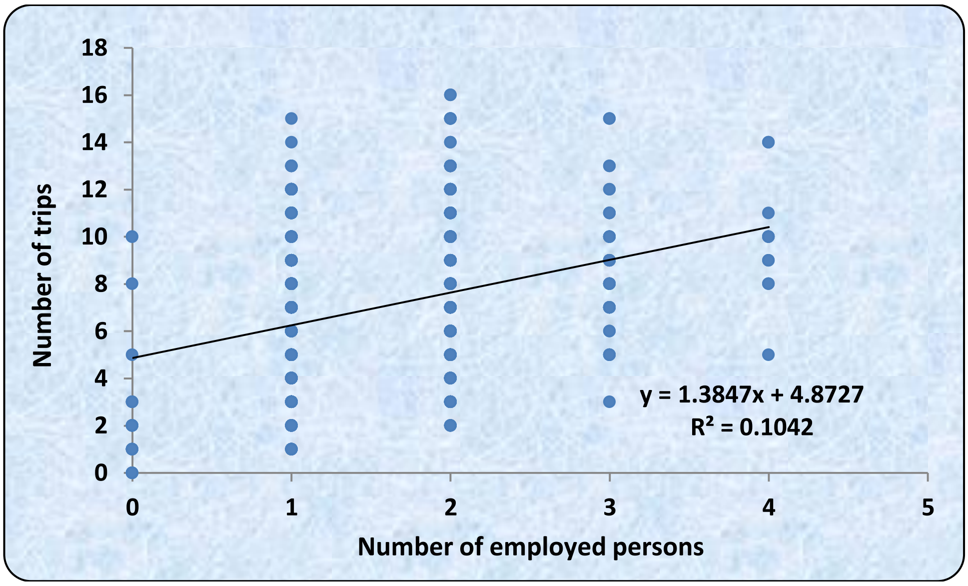

Figure 5.7: Daily Household Trips and Number of Employed Persons

Table 5.10 shows descriptive statistics for the number of persons receiving education in the household.

Table 5.10: Descriptive Data for the Number of Persons Receiving Education in the Household

Mean	Standard Deviation	Maximum	Minimum	Range
1.88	1.589	7	0	7

The average number of persons receiving education per household is around 2.

Figure 5.8 depicts the relationship between the number of daily trips per household and the number of persons receiving education.

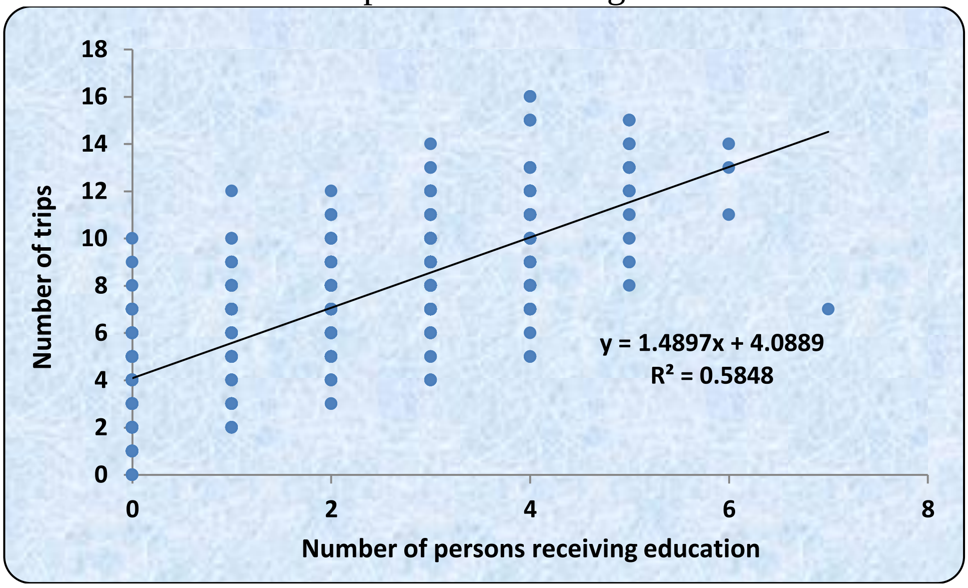

Figure 5.8: Daily Household Trips and Number of Persons Receiving Education

Table 5.11 shows the distribution of survey respondents according to age groups. These data are also shown graphically in Figure 5.9.

Table 5.11: Distribution of Household Survey Respondentsby Age Groups

Age Group	Number	%
Under 16	1,084	32%
17 - 30	1,105	33%
31 - 50	905	27%
51 - 64	198	6%
Above 65	57	2%

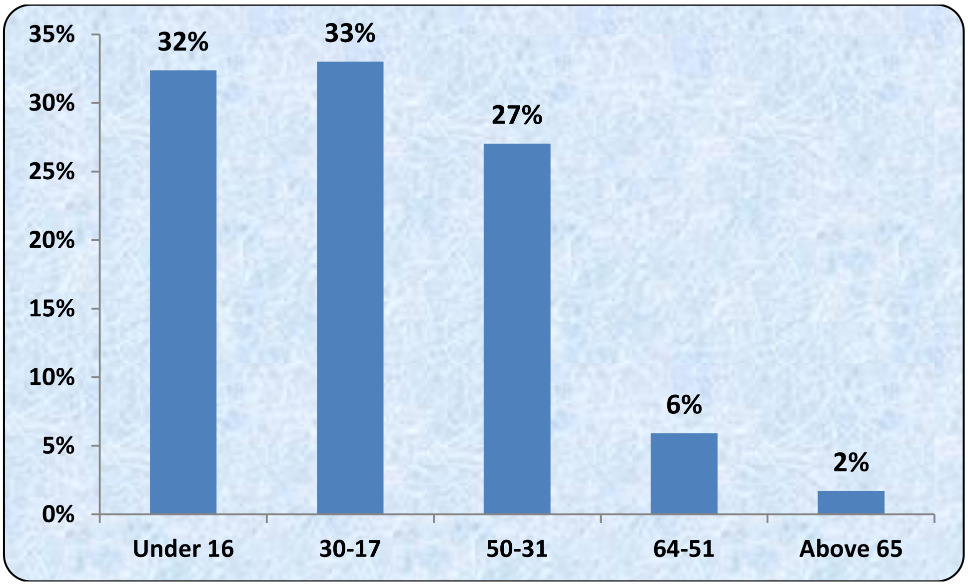

Figure 5.9: Distribution of Survey Respondents by Age Groups

Table 5.12 presents the key descriptive statistics for the number of licensed drivers per household.

Table 5.12: Descriptive Data for the Number of Licensed Drivers per Household

Mean	Standard Deviation	Maximum	Minimum	Range
1.06	0.892	5	0	5

Figure 5.10 shows the scatter diagram for the number of daily trips generated by a household and the number of licensed drivers. The diagram shows a weak relationship between these two variables.

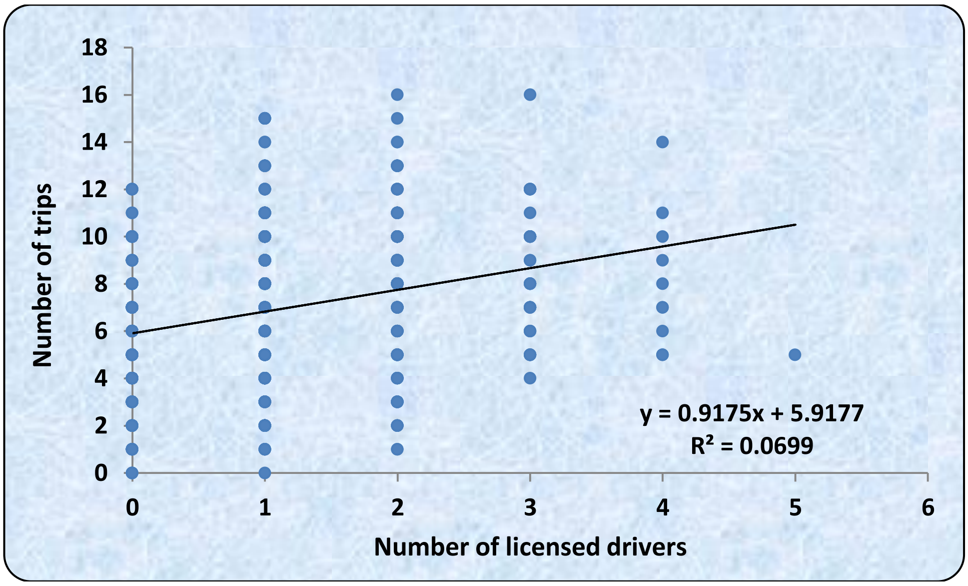

Figure 5.10: Daily Household Trips and Number of Licensed Drivers

The distribution of transportation vehicles that are used by the respondents among car, bicycles and motorcycles is shown in Table 5.13. It is also shown graphically in Figure 5.11.

Table 5.13: Distribution of Transportation Vehicles within All Households

Transportation Vehicle	Number	%
Cars	419	76%
Bicycles	129	23%
Motorcycles	4	1%

Table 5.13 and Figure 5.11 show the majority of households (76%) indicated that they use their own cars, 23% said that they use bicycles, whereas only 1% said that they use motorcycles.

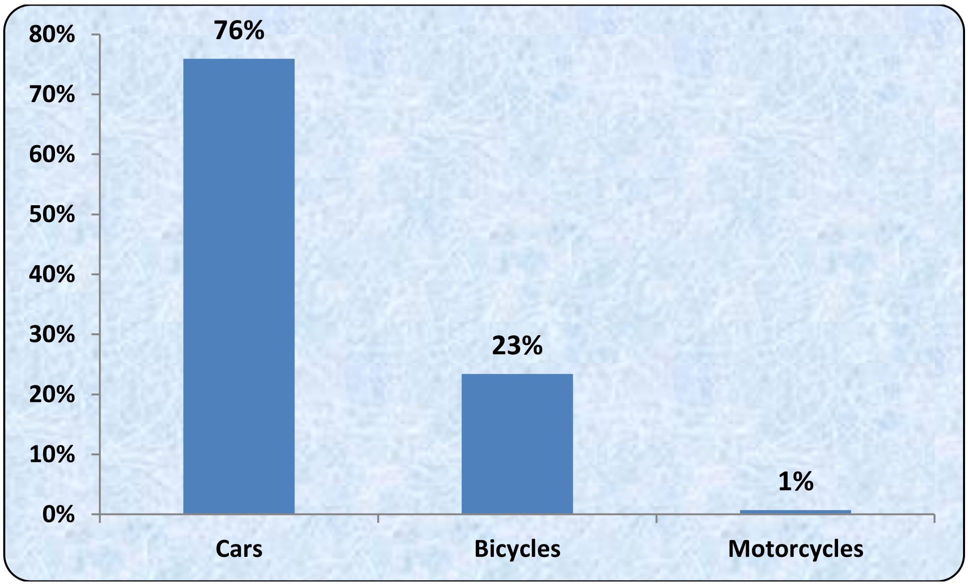

Figure 5.11: Distribution of Transportation Vehicles

Table 5.14 presents descriptive data on the number of vehicles owned per household.

Table 5.14: Descriptive Data for the Number of Vehicles Owned per Household

Vehicle	Mean	Standard Deviation	Maximum	Minimum	Range
Cars	0.59	0.586	3	0	3
Bicycles	0.18	0.443	3	0	3
Motorcycles	0.01	0.075	1	0	1

The diagram for the number of daily trips made by a household and the number of cars owned by the household is shown in Figure 5.12. It is apparent from the figure that there is no apparent relationship between these two variables.

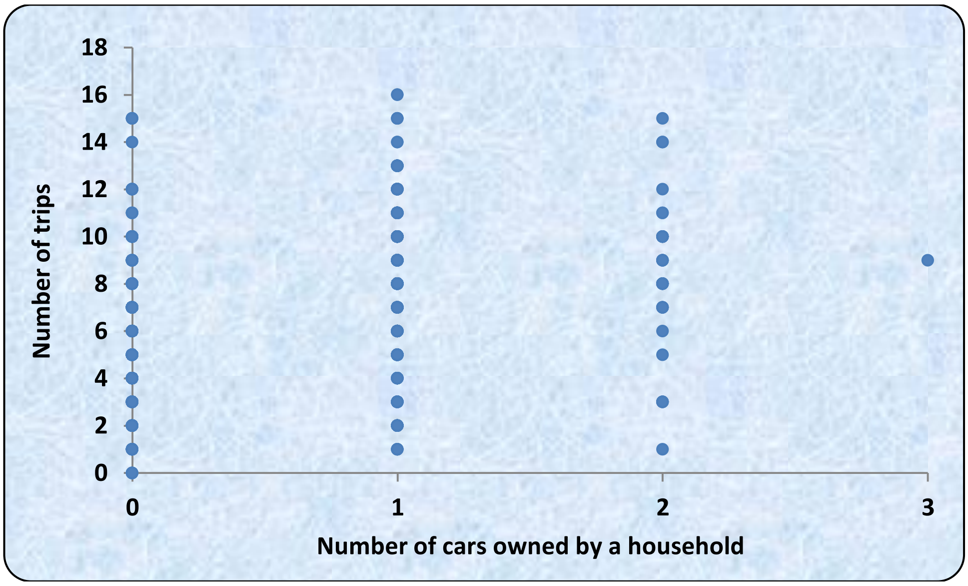

Figure 5.12: Daily Household Trips and Number of Cars per Household

The relationship between the number of daily trips generated by a household and the number of bicycles owned by the household is depicted in Figure 5.13. The figure does not show a clear pattern of relationship between these two variables. This relationship will be tested formally.

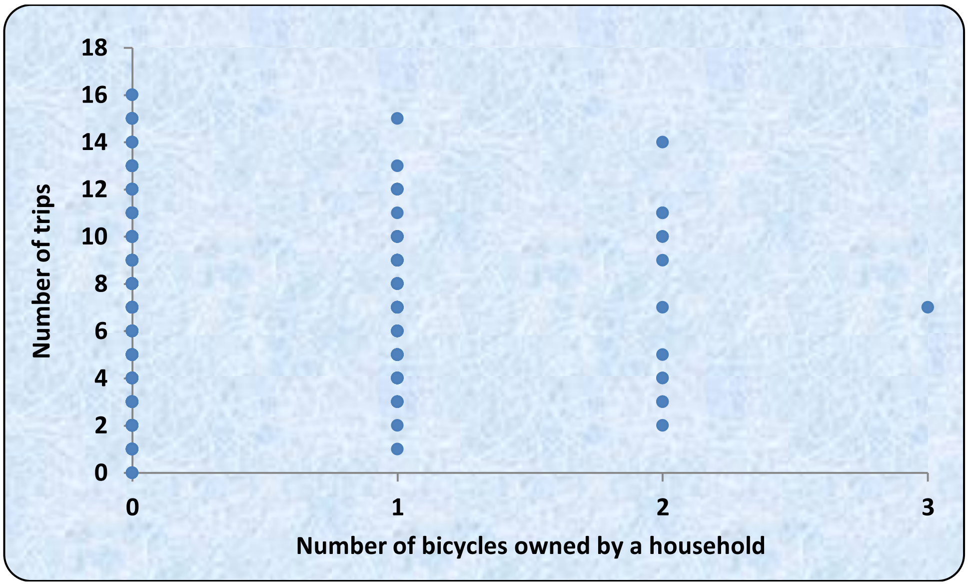

Figure 5.13: Daily Household Trips and Number of Bicycles per Household

Figure 5.14reveals the relationship between the number of daily trips generated by a household and the number of motorcycles owned by the household. The figure does not show any type of relationship whatsoever between these two variables.

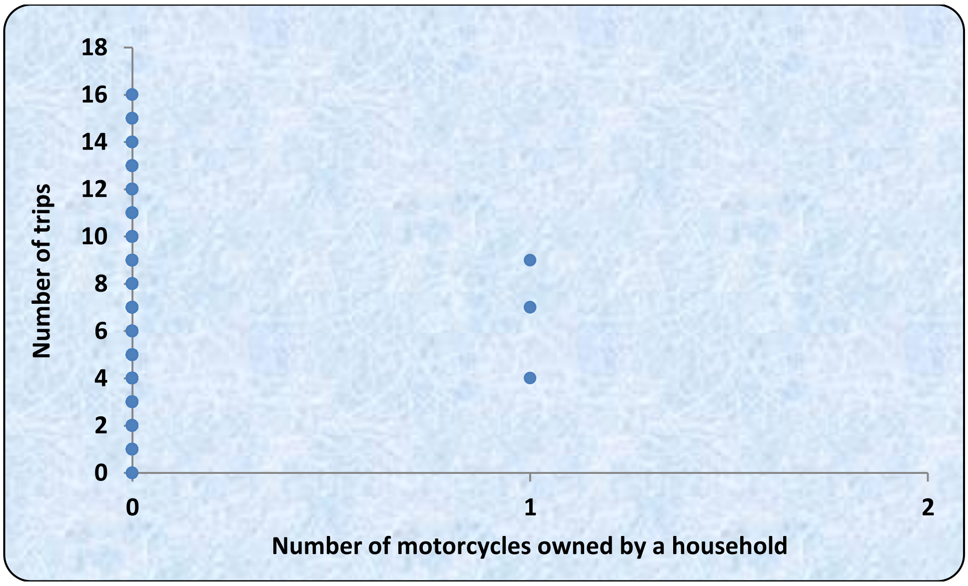

Figure 5.14: Daily Household Trips and Number of Motorcycles per Household

Table 5.15 shows the descriptive statistics for the monthly income per household.

Table 5.15: Descriptive Data for the Monthly Income per Household

Mean	Standard Deviation	Maximum	Minimum	Range
3.88	2.158	20	1	19

The average monthly income for the households included in the survey is 3,880 NIS.

Figure 5.15 shows the relationship betweenthe number of trips generated by a household and the household monthly income. The figure shows a relatively positive relationship between these two variables. In general, as the household income increases, the number of trips generated also increases.

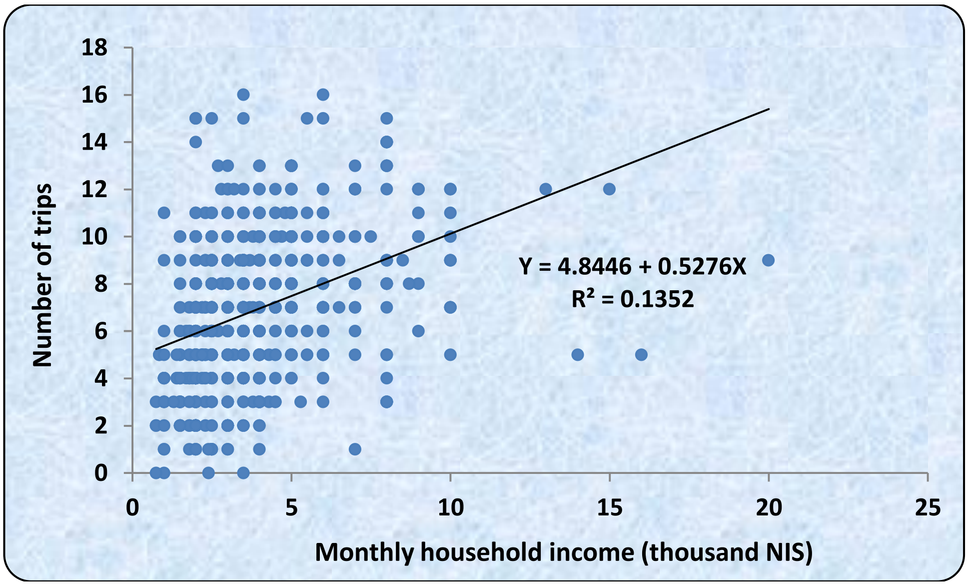

Figure 5.15: Number of Daily Household Trips AndMonthly Household Income

5.2 General Trip Generation Model

Using the cross-section data from the 713 respondents, the general trip generation model is estimated using the multiple linear regression analysis. The regression analysis is conducted several times. In each stage, the regression model is evaluated according to the statistical tests. The iteration is made by reducing the independent variables that have the least t-value. The final estimated general trip generation model is

$$Y = 1.83 + 1.29X_4 + 1.35X_5 + 0.20X_6 + 0.28X_9 + 0.07X_{15}$$

Table 5.16 summarizes the regression results for the estimated general trip generation model. The full results of the general trip generation model using the SPSS package are included at Appendix C.

Table 5.16: Regression Results for the General Trip Generation Model (Number of Daily Trips per Household)

Intercept & Variables	Coefficient	Standard Error	t-Value	Significance	VIF
Intercept	1.83	0.184	9.92	0.0001	
X_4	1.29	0.098	13.21	0.0001	1.183
X_5	1.35	0.058	23.04	0.004	2.060
X_6	0.20	0.068	2.91	0.038	2.114
X_9	0.28	0.136	2.08	0.038	1.176
X_{15}	0.07	0.034	2.07	0.0001	1.280
R^2			0.691		
F-value			315.590		
Sample Size			713		

The interpretations of these results are discussed below.

5.2.1 Interpretation of Regression Coefficients

The coefficient of X_4 (number of employed persons in the household) is 1.29. It is worth saying that the coefficient has a positive sign. This means that as the number of employed persons increases in the household, the average number of daily household trips will also increase.

Similarly, the coefficient of X_5 (number of persons receiving education in the household) is 1.35. This coefficient also has a positive sign as expected. This indicates that the number of persons receiving education in the household is positively related to the number of daily household trips.

X_6 (number of persons under 16 years in the household) has a coefficient of 0.20. It is apparent that the number of persons under 16 years in the household and the number of daily household trips are positively correlated. In other words, an increase in the number of persons under 16 years in the household will lead to an increase in the daily household trips. This is due to the fact that school students are mainly within this age group. The regression coefficient of X_9 (number of persons between 51 and 64 years in the household) is 0.28. The sign of the coefficient is also positive. This means that the number of persons between 51 and 64 years in the household is positively associated with the daily household trips. This is due to the fact that persons between 51 and 64 years are normally part of the labor force.

Finally, the coefficient for X_{15} (monthly household income in thousand NIS) is 0.07. The coefficient shows that as the monthly household income increases, the daily household trips will also increase. This means a positive relationship between the monthly household income and the daily household trips.

5.2.2 Testing Individual Coefficients: T-Test

The t-value for the coefficient of X_4 (number of employed persons in the household) is 13.21. This value is statistically significantly different from zero at the 99.99% level of significance. Thus, the hypothesis that the number of employed persons in the household has no effect on daily household trips (Y) is rejected and the alternative hypothesis that the number of employed persons in the household and the number of daily household trips are positively correlated is thus accepted.

Similarly, the coefficient of X_5 (number of persons receiving education in the household) has a t-statistic value of 23.04, which is statistically significant at the 99.6% level of significance. This indicates that the hypothesis that the number of persons receiving education in the household has a positive effect on the number of daily trips per household is accepted.

The t-statistic value for the hypothesis that the number of persons under 16 years in the household (X_6) has no effect on the dependent variable (number of daily trips per household) is 2.91. This shows that this hypothesis is rejected at the 96.2% level of significance against the alternative hypothesis that the number of persons under 16 years in the household has a positive effect on the dependent variable.

The coefficient of X_9 (number of persons between 51 and 64 years in the household) has a t-statistic value of 2.08, which is statistically significant at the 96.2% level of significance. Therefore, the hypothesis that the number of persons between 51 and 64 years in the household has no effect on the number of daily trips per household is rejected and the alternative hypothesis that these two variables are positively associated is accepted.

Finally, the t-statistic for the coefficient on monthly household income (X_{15}) is 2.07. This, statistically, is significantly different from zero at the 99.99% level of significance. Therefore, the hypothesis that monthly household income has no effect whatsoever on the number of daily trips per household is rejected, and the alternative hypothesis that monthly household income and the number of daily trips per household are positively related, is thus accepted.

In summary, all of the regression coefficients have t-statistics above two. Thus, each of the independent variables (X_4, X_5, X_6, X_9, and X_{15}) is significant at the 95% level of significance. This means that each of the independent variables has an effect on the dependent variable (number of daily trips per household).

5.2.3 Testing for Multicollinearity: Correlation Matrix and (VIF)

To test for multicollinearity, the correlation matrix is usually obtained. Appendix A at the end of this study gives what is called the correlation matrix, which will be used in the model building process. In the correlation matrix, the entries on the main diagonal (those running from the upper left-hand corner to the lower right-hand corner) give the correlation of one variable with itself, which is always 1 by definition. The entries off the main diagonal are the pair-wise correlations among the explanatory variables (Xs).

The first row of the correlation matrix gives the correlation of X_1 with the other explanatory variables. For example, 0.646 is the correlation between X_1 and X_2, 0.626 is the correlation between X_1 and X_3, and so on. As can be seen from the correlation matrix, most of these pair-wise correlations are not high, suggesting that there is no severe multicollinearity problem.

Table 5.16 shows the variance inflation factors (VIFs) for each of the explanatory variables that are included in the general trip generation model. Each of the explanatory variables has a VIF less than 10. Therefore, the problem of multicollinearity does not exist in the developed general trip generation model.

5.2.4 Testing Goodness of Fit: R-Squared (R^2)

The R-squared (R^2) measures the goodness of fit of the model. It measures the proportion of the total variation in the dependent variable that can be explained by the independent variables included in the model.

The R-squared value reported for the general trip generation model indicates how much of the variation in the dependent variable (number of daily trips per household) is greatly explained by the independent variables entered into the regression model.

Table 5.17 is an ANOVA table for the estimated general trip generation model that shows the analysis of the total variance in the dependent variable. This variance is divided into two sources: variance due to regression and variance due to errors or residuals.

Table 5.17: ANOVA Table for the General Trip Generation Model

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-value	Significance
Regression	4713.56	5	942.71	315.59	0.0001
Residual	2111.91	707	2.99		
Total	**6825.47**	**712**			

The R-squared value of 0.69 indicates that the independent variables entered into the model explain about 69% of the variation in the dependent variable. In the case of cross-section data, such an R-squared value is considered reasonable.

5.2.5 Testing Overall Significance of Model: F-Test

The F-statistics tests the hypothesis that all the slope coefficients of the multiple regression model are simultaneously zero; that is, all the independent variables jointly have no impact on the dependent variable.

As the ANOVA table shows, the F-statistics for the general trip generation model is 315. Since this is a highly significant value, the hypothesis that all the independent variables entered into the general trip generation model (X_4, X_5, X_6, X_9, and X_{15}) have no impact on the dependent variable (number of daily trips per household) is rejected at the 99.99% level of significance and the alternative hypothesis that all these variables jointly affect the dependent variable is thus accepted. In summary, it is concluded that X_4, X_5, X_6, X_9, and X_{15} do explain the variation in the number of daily trips per household (Y).

5.2.6 Model Verification

Model verification tests the ability of the model to predict future behavior. This requires comparing estimated model results to survey observations. If the estimated model results and the survey observations are in acceptable agreement, the model can be considered verified.

Specifically, in order to verify the estimated general trip generation model, a comparison of the estimated total daily trips per household (as calculated from the estimated regression model) with the actual total daily trips per household (from observed values) is included in Table 5.18 for 30 randomly selected observations.

Table 5.18: General Trip Generation Model Verification

Observation No.	Actual Y	Estimated Y	Variance
25	7	6.36	0.64
51	8	7.85	0.15
101	10	9.59	0.41
117	5	4.71	0.29
119	7	7.69	-0.69
134	5	5.11	-0.11
142	7	6.24	0.76
148	4	3.45	0.55
167	3	3.42	-0.42
184	9	7.84	1.16
231	3	3.32	-0.32
246	7	8.08	-1.08
256	7	5.03	1.97
287	11	10.60	0.40
298	7	8.14	-1.14
313	5	6.51	-1.51
319	7	6.10	0.90
348	8	7.91	0.09
356	13	10.80	2.20
368	10	9.18	0.82
420	5	3.52	1.48
507	2	2.04	-0.04
538	10	9.47	0.53
546	3	6.51	-3.51
549	3	4.97	-1.97
549	3	4.97	-1.97
563	2	5.05	-3.05
595	5	6.10	-1.10
693	10	10.88	-0.88
713	8	6.42	1.58
Total	**194**	**197.86**	**-3.86**

The results in Table 5.18 show a good match between the estimated total daily trips per household and the actual total daily trips per household for each randomly selected observation. Overall, the model is successfully verified by comparing its result with the field data. Thus, the results support the estimated multiple linear regression model as a good model for daily trip generation per household.

5.3 Trip Generation Models by Purpose

Five trip generation models will be developed based on trip purpose. These models are work, education, shopping, social, and recreational models.

5.3.1 Work Trip Generation Model

The estimated work trip generation model using the multiple linear regression analysis is

$$Y_1 = 0.16 + 0.97X_4 + 0.04X_8$$

Table 5.19summarizes the most important regression results for the estimated work trip generation model. The full results of the work trip generation model using the SPSS package are included at Appendix D.

Table 5.19: Regression Results for the Work Trip Generation Model (Number of Daily Work Trips per Household)

Intercept & Variables	Coefficient	Standard Error	t-Value	Significance	VIF
Intercept	0.16	0.042	3.674	0.0001	
X_4	0.97	0.022	44.198	0.0001	1.005
X_8	0.04	0.019	2.162	0.031	1.005
R^2			0.737		
F-value			660.797		
Sample Size			713		

The coefficients of X_4 and X_8 (the number of employed persons in the household and the number of persons between 31 and 50 years in the household, respectively) are significant at the 95% level of significance.

These coefficients have positive signs as expected. This means that these two variables positively affect the number of daily work trips.

Each of the explanatory variables included in the model has a variance inflation factor less than 10. Thus, there is no muticollinearity problem in the developed model

In terms of goodness of fit, the R^2 value of about 0.74 indicates that the two independent variables entered into the model explain about 74 % of the variation in the dependent variable (number of daily work trips per household).

The F-statistic for the work trip generation model is 661. Since this is a highly significant value, the hypothesis that these two variables jointly affect the dependent variable is accepted at the 99.99% level of significance. In summary, it is concluded that X_4 and X_8do explain the variation in the number of daily work trips per household (Y_1).

5.3.2 Education Trip Generation Model

The education trip generation model is estimated using the multiple linear regression analysis. The estimated education trip generation model is

$$Y_2 = 0.007 + 0.975X_5$$

Table 5.20summarizes the most important regression results for the estimated educational trip generation model. The full results of the educational trip generation model using the SPSS package are included at Appendix E.

Table 5.20: Regression Results for the Education Trip Generation Model (Number of Daily Education Trips per Household)

Intercept & Variables	Coefficient	Standard Error	t-Value	Significance
Intercept	0.007	0.016	0.418	0.676
X_5	0.975	0.007	146.432	0.0001
R^2	0.968			
F-value	21,442.257			
Sample Size	713			

The coefficient of X5 (number of persons receiving education in the household is significant at the 99.99% level of significant. This coefficient has a positive sign as expected. This means that as the number of persons receiving education in the household increases, the average number of daily education trips per household will also increase.

The R-squared value of around 0.97 for the model indicates that the independent variable entered into the model explains about 97% of the variation in the dependent variable. This R-squared value is excellent. It is concluded that the education trip generation model has strong explanatory power.

The F-statistic for the education trip generation model is 21,442. Since this is a highly significant value, the hypothesis that the independent variable entered into the education trip generation model (X_5) has no impact on the dependent variable is rejected at the 99.99% level of significance (number of daily education trips per household) and the alternative hypothesis is thus accepted.

5.3.3 Shopping Trip Generation Model

The estimated shopping trip generation model using the multiple linear regression analysis is

$$Y_3 = 0.282X_1 + 0.035X_{15}$$

Table 5.21summarizes the most important regression results for the estimated shopping trip generation model. The full results of the shopping trip generation model using the SPSS package are included at Appendix F.

Table 5.21: Regression Results for the Shopping Trip Generation Model
(Number of Daily Shopping Trips per Household)

Intercept & Variables	Coefficient	Standard Error	T-Value	Significance	VIF
X_1	0.282	0.016	18.016	0.0001	4.363
X_{15}	0.035	0.017	2.010	0.045	4.363
R^2			0.706		
F-value			855.615		
Sample size			713		

The coefficients of $X_1$and X_{15} (number of persons in the household and the monthly household income) are all significant at the 99.99% and 95.5%levels of significance, respectively. These coefficients have positive signs. This means that as each of these variables increases, the average number of daily shopping trips per household will also increase.

Each of the two explanatory variables included in the model has a VIF of about 4. This value indicates that there is no multicollinearity problem in the developed model since the value is less than 10.

The shopping model has an R-squared value of about 0.71 indicating that the independent variables entered into the model explain about 71% of the variation in the dependent variable (number of daily shopping trips per household).

The F-statistic for the shopping trip generation model is 856. Since this is a significant value, the hypothesis that all the independent variables jointly affect the dependent variable is accepted at the 99.99% level of significance.

5.3.4 Social Trip Generation Model

The social trip generation model is estimated using the multiple linear regression analysis as

$$Y_4 = 0.29X_3 + 0.29X_4 - 0.11X_7$$

Table 5.22 summarizes the most important regression results for the estimated social trip generation model. The full results of the social trip generation model using the SPSS package are included at Appendix G.

The coefficients of X_3, $X_4$and X_7 (number of females in the household, number of employed persons in the household, and number of persons between 17 and 30 years in the household, respectively) have t-values above 2 in absolute value. Thus, these coefficients are significant at the 95% level of significance.

Table 5.22: Regression Results for the Social Trip Generation Model (Number of Daily Social Trips per Household)

Variables	Coefficient	Standard Error	t-Value	Significance	VIF
X_3	0.29	0.028	10.188	0.001	2.971
X_4	0.29	0.053	5.409	0.001	4.022
X_7	-0.11	0.037	-2.857	0.004	2.944
R^2			0.435		
F-value			182.453		
Sample size			713		

The coefficient of X_3 indicates that as the number of females increases in the household, the average number of daily social trips per household will increase. This result is not surprising since females have more social activities than males.

As the number of employed persons in the household increases, the average number of daily social trips per household will also increase. This is indicated by the positive coefficient of X_4 (number of employed persons in the household).

Persons who are between 17 and 30 years old are either studying or working. Hence, the coefficient of this variable is negative indicating that as the number of persons between 17 and 30 years old in the household increases, the average daily social trips per household decreases.

None of the explanatory variables included in the developed model has a VIF that exceeds 10. Therefore, the developed model does not have a multicollinearity problem.

The social model has R-squared value of about 0.45 indicating that the independent variables entered into the model explain 45% of the variation in the dependent variable (number of daily social trips per household). This value is not considered good.

The F-statistic for the social trip generation model is 142. Since this is a significant value, the hypothesis that all the independent variables jointly affect the dependent variable is accepted at the 99.99% level of significance.

5.3.5 Recreational Trip Generation Model

The recreational trip generation model is estimated using the multiple linear regression analysis as

$$Y_5 = 0.18X_5 + 0.22X_9 + 0.14X_{15}$$

Table 5.23 summarizes the most important regression results for the estimated recreational trip generation model. The full results of the recreational trip generation model using the SPSS package are included at Appendix H.

Table 5.23: Regression Results for the Recreational Trip Generation Model (Number of Daily Recreational Trips per Household)

Variables	Coefficient	Standard Error	t-Value	Significance	VIF
X_5	0.18	0.032	5.436	0.0001	2.356
X_9	0.22	0.100	2.172	0.030	1.301
X_{15}	0.14	0.019	7.038	0.0001	2.738
R^2			0.36		
F-value			133.12		
Sample size			713		

The coefficients that are significant at the 95% level of significance in the recreational trip generation mode are X_5, X_9 and X_{15} (number of persons receiving education in the household, number of persons between 51 and 64 years in the household, and monthly household income, respectively).

These coefficients have t-values above 2. The first coefficient indicates that as the number of persons receiving education in the household increases, the average number of daily recreational trips per household will also increase. The second coefficient indicates that as the number of persons between 51 and 64 years in the household increases, the average number of daily recreational trips per household will also increase.

Finally, the monthly household income is positively related to the number of daily recreational trips per household. This means that as the monthly household income increases, the average number of daily recreational trips per household will also increase.

The variance inflation factor for each of the explanatory variables included in the model is less than 10. Hence, there is no multicollinearity problem in the developed model.

The R-squared value of 0.36 indicates that the independent variables entered into the model explain 36% of the variation in the dependent variable (number of daily recreational trips per household). This value is not good in terms of explanatory power.

The F-statistic for the recreational model is 133. Thus, the model as a whole is significant at the 99.99% level of significance. Therefore, the hypothesis that all the independent variables that are included in the model jointly affect the dependent variable is accepted.

5.4 Temporal Trip Generation Models

Trips occur at different rates at different times of the day. Typically, there are one or more peaks in daily travel. The dominant weekday peak periods are in the morning (AM peak period) and in the late afternoon (PM peak period). A peak period can be characterized by its maximum trip rate (trips per unit time). The peak hour is the hour during which the maximum traffic occurs.

In this section, five trip generation models according to time are developed. The purpose of estimating these models is to predict the number of trips generated during peak periods as well as off peak periods so as to make transportation planning accordingly.

5.4.1 Trip Generation Model for Trips Made before 8 AM

The trip generation model for trips made before 8 AM is estimated using the multiple linear regression analysis as

$$Y_6 = 0.11 + 0.08X_1 + 0.42X_4 + 0.79X_5$$

The results of the estimated trip generation model for trips made before 8 AM are displayed in Table 5.24.

The full results of the recreational trip generation model using the SPSS package are included at Appendix I.

The estimated model for trips made before 8 AM can be called the morning peak period model. Not surprisingly, the three variables that are significant in this model are the household size (X_1), the number of employed persons in the household (X_4), and the number of persons receiving education in the household (X_5).

Table 5.24: Regression Results for the Trip Generation Model (Number of Daily Trips Made before 8 AM per Household)

Intercept & Variables	Coefficient	Standard Error	t-Value	Significance	VIF
Intercept	0.11	0.113	0.933	0.351	
X_1	0.08	0.032	2.480	0.013	2.633
X_4	0.42	0.047	9.025	0.0001	1.131
X_5	0.79	0.032	25.128	0.0001	2.494
R^2			0.73		
F-value			649.90		
Sample size			713		

All these variables have coefficients with positive values as expected. Specifically, the coefficient of household size (X_1) is 0.08, the coefficient of the number of employed persons in the household (X_4) is 0.42 and the coefficient of the number of persons receiving education in the household (X_5) is 0.79. This means that an increase in any of these explanatory variables will lead to an increase in the number of trips made before 8 AM.

The t-value for the first explanatory variable (household size) is 2.48. This value indicates that the variable is significant at the 98.7% level of significance. Therefore, the null hypothesis that household size does not affect the dependent variable is rejected and the alternative hypothesis that household size positively affects the dependent variable is thus accepted.

X_4 (the number of employed persons in the household) has t-value of 9.03. Thus, X_4 is significant at the 99.99% level of significance. Therefore, the null hypothesis that the number of employed persons in the household does not affect the dependent variable is rejected and the alternative hypothesis that this variable is positively associated with the dependent variable is thus accepted.

Finally, the t-value for X_5 (the number of persons receiving education in the household) is 25.13. This means that the hypothesis that the number of persons receiving education in the household has no effect on the dependent variable is rejected at the 99.99% level of significance and the alternative hypothesis that this variable has a positive effect on the dependent variable is thus accepted.

The VIF test indicates that there is no multicollinearity problem in the developed model since each explanatory variable included in this model has a VIF value that is less than 10.

In terms of explanatory power, the model has R^2 value of 0.73. This R^2 value means that these three variables jointly explain 73% of the variation in the trips made in the morning peak period.

In terms of overall significance of the model, the F-statistic is 650.This value is significant at the 99.99% level of significance. Thus, the hypothesis that all the three explanatory variables included in the model have no effect on the dependent variable is rejected against the alternative hypothesis that these variables do explain the variation in the dependent variable.

5.4.2 Trip Generation Model for Trips Made between 8-9 AM

The trip generation model for trips made between 8-9 AM is estimated using the multiple linear regression analysis as

$$Y_7 = 0.24X_4 + 0.07X_5 + 0.09X_{11} + 0.15X_{13}$$

The results of the estimated trip generation model for trips made between 8-9 AM are displayed in Table 5.25.

The full results of the recreational trip generation model using the SPSS package are included at Appendix J.

Table 5.25: Regression Results for the Trip Generation Model (Number of Daily Trips Made between 8-9 AM per Household)

Variables	Coefficient	Standard Error	t-Value	Significance	VIF
X_4	0.240	0.031	7.789	0.0001	3.184
X_5	0.069	0.017	4.172	0.0001	2.124
X_{11}	0.092	0.035	2.662	0.0080	2.914
X_{13}	0.154	0.065	2.388	0.0170	1.207
R^2			0.44		
F-value			137.65		
Sample size			713		

As the regression results indicate, the explanatory variables that are included in the regression model are all positive. Specifically, the coefficient of X_4 (number of employed persons in the household) is 0.24, the coefficient of X_5 (number of persons receiving education in the household) is 0.07, the coefficient of X_{11} (number of licensed drivers in the household) is 0.09 and the coefficient of X_{13} (number of bicycles owned by a household) is 0.15. The positive coefficient signs indicate that each of these coefficients has a positive influence on the dependent variable (number of daily trips made between 8-9 AM per household).

In terms of t-test, the t-value for X_4 (number of employed persons in the household) is 7.79. This value indicates that the variable is significant at the 99.99% level of significance. Therefore, the null hypothesis that X_4 does not affect the dependent variable is rejected and the alternative hypothesis that it affects the dependent variable is thus accepted.

X_5 (number of persons receiving education in the household) has t-value of 4.17. Thus, X_5 is significant at the 99.99% level of significance. Therefore, the null hypothesis that the number of persons receiving education in the household does not affect the dependent variable is rejected and the alternative hypothesis that this variable is positively associated with the dependent variable is thus accepted.

It is worth saying that X_5 (number of persons receiving education in the household) has a coefficient value of 0.79 in the trip generation model for trips made before 8 AM whereas in this model it has a coefficient value of 0.07.

The t-value for the coefficient of X_{11} (number of licensed drivers in the household) is of 2.66. This value is significant at the 99.2% level of significance. This means that the hypothesis stating that the number of licensed drivers in the household has no effect on the dependent variable is rejected and the alternative hypothesis is thus accepted.

Finally, the t-value for X_{13} (number of bicycles owned by a household) is 2.39. This means that the hypothesis that the number of bicycles owned by a household has no effect on the dependent variable is rejected at the 98.3% level of significance and the alternative hypothesis that this variable has a positive effect on the dependent variable is thus accepted.

As Table 5.25 shows, each of the explanatory variables included in the developed model has a variance inflation factor that is less than 10. So, there is no problem regarding multicollinearity.

The explanatory variables that are included in the model explain 44% of the variation in the dependent variable since the model has R^2 value of 0.44. This value is not considered good.

The F-statistic for the model is 138.This value is significant at the 99.99% level of significance. Thus, the hypothesis that all the explanatory variables that are included in the model have no effect on the dependent variable is rejected against the alternative hypothesis that these variables do explain the variation in the dependent variable.

5.4.3 Trip Generation Model for Trips Made between 9 AM - 12 PM

The trip generation model for trips made between 9 AM - 12 PM is estimated using the multiple linear regression analysis as

$$Y_8 = 0.09X_7 + 0.01X_8 + 0.04X_9$$

The results of the estimated trip generation model for trips made between 9-12 AM are displayed in Table 5.26.The full regression results are shown in Appendix K.

Table 5.26: Regression Results for the Trip Generation Model (Number of Daily Trips Made between 9 AM - 12 PM per Household)

Variables	Coefficient	Standard Error	t-Value	Significance	VIF
X_7	0.09	0.013	6.929	0.0001	1.978
X_8	0.01	0.015	2.656	0.008	1.446
X_9	0.04	0.038	3.474	0.001	1.453
R^2			0.23		
F-value			68.91		
Sample size			713		

As the regression results in Table 5.26 indicate, the explanatory variables that are included in the regression model for trips made between 9-12 AM are all positive. Specifically, the coefficient of X_7 (number of persons between 17 and 30 years in the household) is 0.09, the coefficient of X_8 (number of persons between 31 and 50 years in the household) is 0.01, and the coefficient of X_9 (number of persons between 51 and 64 years in the household) is 0.04. The positive coefficient signs indicate that each of these coefficients has a positive influence on the dependent variable (number of daily trips made between 9-12 AM per household). It is worth noting that this model is explained by age groups only, since the explanatory variables include persons between 17 to 64 and can explain the variation in the dependent variable.

In terms of t-test, the t-value for X_7 (number of persons between 17 and 30 years in the household) is 6.93. This value indicates that the variable is significant at the 99.99% level of significance. Therefore, the null hypothesis that X_7 does not affect the dependent variable is rejected and the alternative hypothesis that it affects the dependent variable is thus accepted.

X_8 (number of persons between 31 and 50 years in the household) has t-value of 2.66. Thus, X_8 is significant at the 99.2% level of significance. Therefore, the null hypothesis that number of persons between 31 and 50 years in the household does not affect the dependent variable is rejected and the alternative hypothesis that this variable is positively associated with the dependent variable is thus accepted.

Finally, the t-value for the coefficient of X_9 (number of persons between 51 and 64 years in the household) is of 3.47. This value is significant at the

99.9% level of significance. This means that the hypothesis stating that the number of persons between 51 and 64 years in the household has no effect on the dependent variable is rejected and the alternative hypothesis is thus accepted.

Each of the explanatory variables included in the developed model has a variance inflation factor that is less than 10. So, there is no problem regarding multicollinearity.

In terms of explanatory power of the estimated model, the R^2 value of 0.23 for the model indicates that the explanatory variables that are included in the model explain 23% of the variation in the dependent variable. This value is not considered good.

The overall significance of the model can be tested using the F-test. Specifically, the F-value for the model is 68.91. This value is significant at the 99.99 % level of significance. Thus, the hypothesis that all the explanatory variables that are included in the model have no effect on the dependent variable is rejected against the alternative hypothesis that these variables do explain the variation in the dependent variable.

5.4.4 Trip Generation Model for Trips Made between 12 - 4 PM

The trip generation model for trips made between 12 and 4 PM is estimated using the multiple linear regression analysis as

$$Y_9 = 0.17X_4 + 0.10X_6 + 0.08X_{11}$$

The results of the estimated trip generation model for trips generated between 12 AM and 4 PM are displayed in Table 5.27. The full regression results are shown in Appendix L.

The explanatory variables for this model are X_4 (number of employed persons in the household), X_6 (number of persons under 16 years in the household) andX_{11} (number of licensed drivers in the household). The coefficients are 0.17, 0.10 and 0.08, respectively. Each of these coefficients has a positive sign.

Table 5.27: Regression Results for the Trip Generation Model (Number of Daily Trips Made between 12 - 4 PM per Household)

Variables	Coefficient	Standard Error	t-Value	Significance	VIF
X_4	0.17	0.026	6.578	0.0001	2.950
X_6	0.10	0.016	6.397	0.0001	1.698
X_{11}	0.08	0.029	2.874	0.004	2.618
R^2			0.40		
F-value			154.42		
Sample size			713		

The t-test indicates that each of the explanatory variables that are included in the model is significant. Specifically, X_4 (number of employed persons in the household) and X_6 (number of persons under 16 years in the household) have t-values of 6.58 and 6.40, respectively. Thus, these two variables are significant at the 99.99% level of significance. Therefore, it is concluded that the hypotheses that the number of employed persons in the household and the number of persons under 16 years in the household have no effect on the dependent variable is rejected and the alternative hypotheses that each of these variables has a positive effect on the dependent variable is thus accepted.

The t-value for X_{11} (number of licensed drivers in the household) is 2.87, which is significant at the 99.6 % level of significance. Thus, the hypothesis that the number of licensed drivers in the household has no effect on the dependent variable is rejected against the alternative hypothesis that this variable has a positive effect on the dependent variable. Each of the explanatory variables included in the developed model has a variance inflation factor that is less than 10. So, there is no problem regarding multicollinearity.

The R^2 value of 0.40 for this model indicates that 40% of the variation in the dependent variable is explained by the three explanatory variables that are included in the model. This value is not considered good.

The F-value of 154 for this model, which is significant at the 99.99% level of significance, indicates that the model as a whole is significant.

5.4.5 Trip Generation Model for Trips Made after 4 PM

The trip generation model for trips made after 4 PM is estimated using the multiple linear regression analysis as

$$Y_{10} = 0.79X_4 + 0.56X_5 + 0.15X_{15}$$

The results of the estimated trip generation model for trips made after 4 PM are displayed in Table 5.28.The full regression results are shown in Appendix M.

The trip generation model for trips made after 4 PM can be called the evening peak period trip generation model.

Table 5.28: Regression Results for the Trip Generation Model (Number of Daily Trips Made after 4 PM per Household)

Variables	Coefficient	Standard Error	t-Value	Significance	VIF
X_4	0.788	0.077	10.260	0.0001	3.875
X_5	0.555	0.040	13.987	0.0001	2.373
X_{15}	0.148	0.031	4.740	0.0001	4.791
R^2			0.762		
F-value			758.914		
Sample size			713		

The significant explanatory variables that are included in the regression model for trips made after 4 PM are all positive. Specifically, the coefficient of X_4 (number of employed persons in the household) is 0.38, the coefficient of X_5 (number of persons receiving education in the household) is 0.25, and the coefficient of X_{15} (monthly household income) is 0.09. The positive coefficient signs indicate that each of these coefficients has a positive influence on the dependent variable (number of daily trips made after 4 PM per household).

X_4 (number of employed persons in the household) has a t-value of 4.04. This means that the coefficient is significant at the 99.99% level of significance. Therefore, the hypothesis that the number of employed persons in the household has no effect on the dependent variable is rejected and the alternative hypothesis is thus accepted.

Similarly, X_5 (number of persons receiving education in the household) has a t-value of 4.24. This indicates that this coefficient is significant at the 99.99% level of significance. Therefore, the hypothesis that the number of persons receiving education in the household does not affect the dependent variable is rejected and the alternative hypothesis is thus accepted.

Finally, X_{15} (monthly household income) has a t-value of 2.82. This indicates that this coefficient is significant at the 99.5% level of significance. Therefore, the hypothesis that the monthly household income does not affect the dependent variable is rejected and the alternative hypothesis is thus accepted.

Each of the explanatory variables included in the developed model has a variance inflation factor that is less than 10. So, there is no problem regarding multicollinearity.

In terms of explanatory power, the R^2 value of 0.78 for this model indicates that 78% of the variation in the dependent variable is explained by the explanatory variables that are included in the model.

In terms of the overall significance of the model, the F-value of 623for this model, which is significant at the 99.99% level of significance, indicates that the model as a whole is significant.

Chapter Six

Conclusions and Recommendations

Chapter Six

Conclusions and Recommendations

6.1 Summary and Conclusions

Trip generation is the first step of the four-stage travel modeling process. It involves the estimation of the total number of trips entering or leaving a parcel of land per time period as a function of the socioeconomic and land-use characteristics of the parcel.

Jericho City is selected to be the study area. This study area was divided into 14 Traffic Analysis Zones (TAZ's) in order to draw the representative samples. The samples were randomly selected from each of the 14 TAZ's. The sample size was 713 households. Home interviews were made with the selected samples to obtain the necessary data using a questionnaire. The multiple linear regression method, which is one of the popular methods used to predict the trips generated, was used in this research.

Three types of trip generation models were developed. The first type is the general trip generation model. The second type is trip generation models according to trip purpose. Specifically, work, education, shopping, social, and recreational trip generation models were estimated. Finally, five temporal trip generation models were estimated. These models are the morning peak period (before 8 AM) trip generation model, the trip generation model for trips made between 8-9 AM, the trip generation model for trips that are generated between 9AM - 12PM, the trip generation model for trips generated between 12-4 PM and the trip generation model for the evening peak period (after 4 PM).

Relevant conclusions can be drawn as follows:

1. The general trip generation model has reasonable explanatory power with R^2 value of 0.69, indicating that the explanatory variables entered into the model explain 69% of the variation in the daily trips per household.

2. The variables that mostly affect the number of daily trips per household are the monthly household income, the number of employed persons in the household, and the number of persons receiving education in the household. This result is consistent with the findings of previous studies in developing as well as developed countries.

3. The general trip generation model is successfully verified by comparing its result with the field data.

4. The variables that are significant in the work trip generation model are the number of employed persons in the household and the number of persons between 31 and 50 years in the household. This result is reasonable and is consistent with the results of similar previous studies. This model has R^2 value of 0.74. Thus, the model has a good explanatory power.

5. As expected, the research confirmed the result that the most important variable that affects education trip generation model is the

number of persons receiving education in the household. Its R^2 value is 0.97, where the education trip generation model has the largest explanatory power, in terms of R^2, among all models.

6. The shopping trip generation model has an R^2 value of 0.71. This indicates that the explanatory variables included in the model explain 71% of the shopping trip generation model. The most relevant explanatory variables for the shopping trip generation model are found to be the number of persons in the household and the monthly household income.

7. The social trip generation model has R^2 value of 0.45 indicating that the explanatory variables that are included in the social trip generation model explain 45% of the dependent variable (number of social trips per household). Thus, the explanatory power not good in this model. The variables that are the most relevant in the social trip generation model are the number of persons in the household, the number of females in the household and the number of employed persons in the households.

8. The most important explanatory variable in the recreational trip generation model is the monthly household income. This result makes sense. The model has R^2 value of 0.36, indicating that the explanatory variables explain 36% of the dependent variable. Thus, the explanatory power not good in this model.

9. The two temporal trip generation models for the morning peak period and the evening peak period have the largest R^2 values among all temporal trip generation models. This is due to the fact that most trips are made during these two peak periods, and can be well linked with relevant independent variables. The trip generation model for the morning peak period (before 8 AM) has R^2 value of 0.73. Hence, the explanatory variables in the morning peak period trip generation model explain 73% of the variation in trips made during this period. The R^2 value for the evening peak period model (after 4 PM) is 0.78, indicating that 78% of the variation in the trips during this period can be explained by the explanatory variables that are entered into the model.

6.2 Recommendations

The following recommendations can be drawn from the results of this research:

1. It is recommended to develop trip generation models as the primary tool for travel demand modeling process in order to get better modeling of traffic flow in the future for better transportation planning processes in the Palestinian cities.

2. Researchers are encouraged to investigate transferability of models estimated in this research in other Palestinians towns and cities.

3. Officials and planners are encouraged to use the results of trip generation models that are estimated in this research in the

modeling of trip distribution and the subsequent models within the four-steps of urban transportation planning process.

4. Researchers are recommended to use the results found in this research to compare with disaggregated models on trip generation.

5. When planning for any Palestinian city, it is recommended to follow the procedures mentioned in this thesis to adopt regression analysis method as part of the travel demand modeling for urban transportation planning purposes.

6. Conducting research related to the temporal stability and dynamics of travel behavior in order to understand how trip generation model parameters change over time.

7. The Palestinian Central Bureau of Statistics (PCBS) should conduct Household Travel Survey (HTS) that includes detailed data about trips made by households. This survey can be used by researchers to estimate trip generation models.

8. Researchers are encouraged to check model validation. This can be made by using part of the collected data in developing the models and using the rest of the data to validate the model, or by collecting a new data set and using it to validate the model.

9. Researchers are encouraged to collect a new data set in the future and to use the new data in the models developed in this research in order to ensure that the models are still valid in the future by comparing the estimated trips from the developed models with the observed trips.

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Appendices

Appendix A:

Correlation Matrix

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
X1	1	0.646	0.626	0.230	0.755	0.558	0.339	0.405	0.109	-0.148	0.190	0.253	0.016	-0.054	0.329	0.071
X2	0.64	1	-0.078	0.346	0.456	0.277	0.410	0.207	0.186	-0.142	0.180	0.151	0.129	-0.004	0.213	0.127
X3	0.626	-0.078	1	0.028	0.620	0.530	0.105	0.352	-0.037	-0.065	0.120	0.212	-0.075	-0.070	0.265	-0.013
X4	0.230	0.346	0.028	1	0.010	-0.117	0.389	0.067	0.182	-0.086	0.330	0.181	0.062	0.004	0.354	0.059
X5	0.755	0.456	0.620	0.010	1	0.673	0.037	0.536	-0.072	-0.230	0.209	0.319	0.035	-0.030	0.285	0.000
X6	0.558	0.277	0.530	-0.117	0.673	1	-0.384	0.385	-0.306	-0.230	-0.004	0.169	0.039	-0.056	0.088	-0.039
X7	0.339	0.410	0.105	0.389	0.037	-0.384	1	-0.315	0.325	-0.083	0.195	0.037	-0.012	-0.033	0.203	0.087
X8	0.405	0.207	0.352	0.067	0.536	0.385	0-.315	1	-0.407	-0.171	0.080	0.236	0.067	0.044	0.184	0.027
X9	0.109	0.186	-0.037	0.182	-0.072	-0.306	0.325	-0.407	1	0.029	0.158	0.008	-0.023	-0.004	0.149	0.077
X10	-0.148	-0.142	-0.065	-0.086	-0.230	-0.230	-0.083	-0.171	0.029	1	-0.087	-0.117	-0.046	-0.020	-0.091	0.046
X11	0.190	0.180	0.120	0.330	0.209	-0.004	0.195	0.080	0.158	-0.087	1	0.636	-0.163	0.079	0.467	0.001
X12	0.253	0.151	0.212	0.181	0.319	0.169	0.037	0.236	0.008	-0.117	0.636	1	-0.226	0.021	0.491	0.034
X13	0.016	0.129	-0.075	0.062	0.035	0.039	-0.012	0.067	-0.023	-0.046	-0.163	-0.226-	1	0.012	-0.127	-0.048
X14	-0.054	-0.004	-0.070	0.004	-0.030	-0.056	-0.033	0.044	-0.004	-0.020	0.079	0.021	0.012	1	0.030	-0.035
X15	0.329	0.213	0.265	0.354	0.285	0.088	0.203	0.184	0.149	-0.091	0.467	0.491	-0.127	0.030	1	0.142
X16	0.071	0.127	-0.013	0.059	0.000	-0.039	0.087	0.027	0.077	0.046	0.001	0.034	-0.048	-0.035	0.142	1

Appendix B:

Questionnaire Form

An-Najah National University

Faculty of Graduate Studies

Master of Roads and Transport Engineering

Questionnaire

This questionnaire aims to collect social and economic data related to the household. These data will be used to study their effect on the number of trips (i.e. work trips, education trips, shopping trips, recreational trip, and so on) that the household makes and to develop a mathematical model that connects these socioeconomic data with the number of trips made by the household. This model can benefit urban transportation planning of Jericho City.

Thanks for Your Cooperation

Researcher: Alaa Dodeen

Section One:

Please fill the table below with required information about each family member regarding age, gender, current work, current education, driving license, and transportation facility.

Person No.	Age	Gender (M / F)	Current Education *	Driving License	Transportation Facility **
1		M / F		Yes / No	
2		M / F		Yes / No	
3		M / F		Yes / No	
4		M / F		Yes / No	
5		M / F		Yes / No	
6		M / F		Yes / No	
7		M / F		Yes / No	
8		M / F		Yes / No	
9		M / F		Yes / No	
10		M / F		Yes / No	
* Education: kindergarten (K), School (S), College (C), University (U), Other (O), or None (N).					
** Transportation facility: Private car (C), Bicycle (B), Motorcycle (M), and Public car (P).					

Section Two:

Fill the table below with the number of trips that each household member makes during a typical working day.

(From Sunday to Thursday, normally the previous day)

	Work				Education				Social				Shopping				Recreational			
	#	Place	Time	Facility	#	Place	Time	Facility	#	Place	Time	Facility	#	Place	Time	Facility	#	Place	Time	Facility
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
Facility: Private car (C), Bicycle (B), Motorcycle (M), and Public car (P).																				
Place: Number of TAZ that the household lives in, from 1- 15																				

Section Three:

Fill the table below with the TAZ that the household lives in, type of house, and average monthly household income.

Household No. (Leave for the Enumerator)		
Place or TAZ number (from 1-15), where the household lives in.(Leave for the Enumerator)		
Type of house:	☐ Independent House.	☐ Apartment.
Average monthly household income (NIS)		

Appendix C:
SPSS Results
(General Trip Generation Model)

The regression results for the estimated general trip generation model from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_4, X_5, X_6, X_9, X_{15}	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.831	0.691	0.688	1.728

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	4,713.560	5	942.712	315.590	0.0001
Residual	2,111.907	707	2.987		
Total	**6,825.467**	**712**			

Coefficients					
Constant & Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
Constant	1.824	0.184	9.915	0.0001	
X_4	1.289	0.098	13.208	0.0001	1.183
X_5	1.347	0.058	23.039	0.0040	2.060
X_6	0.199	0.068	2.907	0.0380	2.114
X_9	0.282	0.136	2.076	0.0380	1.176
X_{15}	0.070	0.034	2.074	0.0001	1.280

Appendix D:
SPSS Results
(Work Trip Generation Model)

The regression results for the estimated work trip generation model from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_4, X_8	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.858	0.737	0.735	0.420

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	349.928	3	116.643	660.797	0.0001
Residual	125.152	709	0.177		
Total	**475.080**	**712**			

Coefficients					
Constant & Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
Constant	0.156	0.042	3.674	0.0001	
X_4	0.971	0.022	44.198	0.0001	1.005
X_8	0.042	0.019	2.162	0.0310	1.005

Appendix E:
SPSS Results
(Education Trip Generation Model)

The regression results for the estimated education trip generation model from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_5	Remaining Variables	Linear Regression

Model Summary			
R	$\mathbf{R^2}$	**Adjusted** $\mathbf{R^2}$	$\mathbf{S_e}$
0.984	0.968	0.968	0.282

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	1709.101	1	1709.101	21,442.257	0.0001
Residual	56.672	711	0.080		
Total	**1765.773**	**712**			

Coefficients				
Constant & Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**
Constant	0.007	0.016	0.418	0.6760
X_5	0.975	0.007	146.432	0.0001

Appendix F:
SPSS Results
(Shopping Trip Generation Model)

The regression results for the estimated shopping trip generation model from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_1, X_{15}	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.841	0.706	0.706	0.988

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	1669.386	2	834.693	855.615	0.000
Residual	693.614	711	0.976		
Total	**2363.000**	**713**			

Coefficients					
Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
X_1	0.282	0.016	18.016	0.0001	4.363
X_{15}	0.035	0.017	2.010	0.0450	4.363

Appendix G:

SPSS Results

(Social Trip Generation Model)

The regression results for the estimated social trip generation model from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_3, X_4, X_7	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.660	0.435	0.433	1.156

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	730.910	3	243.637	182.453	0.0001
Residual	948.090	710	1.335		
Total	**1,679.000**	**713**			

Coefficients					
Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
X_3	0.285	0.028	10.188	0.001	2.971
X_4	0.289	0.053	5.409	0.001	4.022
X_7	-0.106	0.037	-2.857	0.004	2.944

Appendix H:
SPSS Results
(Recreational Trip Generation Model)

The regression results for the estimated recreational trip generation model from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_5, X_9, X_{15}	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.600	0.360	0.357	1.376

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	755.965	3	251.988	133.115	0.0001
Residual	1,344.035	710	1.893		
Total	**2,100.000**	**713**			

Coefficients					
Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
X_5	0.175	0.032	5.436	0.0001	2.356
X_9	0.217	0.100	2.172	0.0300	1.301
X_{15}	0.135	0.019	7.038	0.0001	2.738

Appendix I:

SPSS Results:

(Trip Generation Model for Trips Made before 8 AM)

The regression results for the estimated trip generation model for trips made before 8 AM from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_1, X_4, X_5	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.856	0.733	0.732	0.849

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	1,404.652	3	468.217	649.897	0.0001
Residual	510.798	709	.720		
Total	**1,915.450**	**712**			

Coefficients					
Constant & Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
Constant	0.105	0.113	0.933	0.3510	
X_1	0.079	0.032	2.480	0.0130	2.633
X_4	0.423	0.047	9.025	0.0001	1.131
X_5	0.794	0.032	25.128	0.0001	2.494

Appendix J:

SPSS Results:

(Trip Generation Model for Trips Made between 8-9 AM)

The regression results for the estimated trip generation model for trips made between 8-9 AM from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_4, X_5, X_{11}, X_{13}	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.661	0.437	0.434	0.750

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	309.480	4	77.370	137.647	0.0001
Residual	398.520	709	0.562		
Total	**708.000**	**713**			

Coefficients					
Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
X_4	0.240	0.031	7.789	0.0001	3.184
X_5	0.069	0.017	4.172	0.0001	2.124
X_{11}	0.092	0.035	2.662	0.0080	2.914
X_{13}	0.154	0.065	2.388	0.0170	1.207

Appendix K:

SPSS Results:

(Trip Generation Model for Trips Made between 9 AM - 12 PM)

The regression results for the estimated trip generation model for trips made between 9-12 AM from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_7, X_8, X_9	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.475	0.226	0.222	0.489

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	49.385	3	16.462	68.907	0.0001
Residual	169.615	710	0.239		
Total	**219.000**	**713**			

Coefficients					
Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
X_7	0.089	0.013	6.929	0.0001	1.978
X_8	0.039	0.015	2.656	0.0080	1.446
X_9	0.131	0.038	3.474	0.0010	1.453

Appendix L:

SPSS Results

(Trip Generation Model for Trips Made between 12 - 4 PM)

The regression results for the estimated trip generation model for trips made between 12-4 PM from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_4, X_6, X_{11}	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.628	0.395	0.392	0.659

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	200.981	3	66.994	154.423	0.0001
Residual	308.019	710	0.434		
Total	**509.000**	**713**			

Coefficients					
Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
X_4	0.171	0.026	6.578	0.0001	2.950
X_6	0.100	0.016	6.397	0.0001	1.698
X_{11}	0.083	0.029	2.874	0.0040	2.618

Appendix M:

SPSS Results

(Trip Generation Model for Trips Made after 4 PM)

The regression results for the estimated trip generation model for trips made after 4 PM from the SPSS software are shown below:

Variables Entered/Removed		
Variables Entered	**Variables Removed**	**Method**
X_4, X_5, X_{15}	Remaining Variables	Linear Regression

Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
0.873	0.762	0.761	1.695

ANOVA Table					
Source	**Sum of Squares**	**d.f.**	**Mean Square**	**F**	**Sig.**
Regression	6,538.861	3	2,179.620	758.914	0.0001
Residual	2,039.139	710	2.872		
Total	**8,578.000**	**713**			

Coefficients					
Variables	**Coefficient**	**Standard Error**	**t-Value**	**Sig.**	**VIF**
X_4	0.788	0.077	10.260	0.0001	3.875
X_5	0.555	0.040	13.987	0.0001	2.373
X_{15}	0.148	0.031	4.740	0.0001	4.791

جامعة النجاح الوطنية
كلية الدراسات العليا

تطوير نماذج تولد الرحلات باستخدام تحليل الانحدار الخطي: مدينة أريحا كحالة دراسية

إعداد
علاء محمد يوسف دودين

إشراف
أ.د. سمير أبو عيشة

قدمت هذه الأطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في هندسة الطرق والمواصلات بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

2014

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الملخص

يهدف هذا البحث إلى تطوير نماذج لتولد الرحلات من أجل التنبؤ بعدد الرحلات المتولدة من قبل الأسر في المناطق الفلسطينية مع اعتبار مدينة أريحا كمنطقة للحالة الدراسية. لقد تم تطوير هذه النماذج باستخدام طريقة تحليل الانحدار الخطي والتي تربط بين عدد الرحلات المتولدة من قبل الأسر وبعض الخصائص الاجتماعية والاقتصادية لهذه الأسر.

تشمل النماذج التي تم تطويرها ثلاثة أنواع من النماذج. النموذج الأول هو نموذج عام لتولد الرحلات (أي أنه نموذج عام بغض النظر عن هدف وتوقيت الرحلة المتولدة). أما النوع الثاني من النماذج فهي نماذج تولد الرحلات بناءً على هدف الرحلة. وتشمل هذه النماذج نموذج تولد رحلات العمل، ونموذج تولد رحلات التعليم، ونموذج تولد رحلات التسوق، ونموذج تولد الرحلات الاجتماعية، ونموذج تولد الرحلات الترفيهية. وأخيراً، فقد تم تطوير خمسة نماذج لتولد الرحلات وفقاً للفترات الزمنية التي تتولد الرحلات خلالها.

تتكون البيانات من البيانات الأولية التي تم جمعها عن طريق إجراء مسح للأسر. وتكون المسح من 713 أسرة تم اختيارها عشوائياً منطقة الدراسة، مدينة أريحا.

أشارت النتائج إلى أن النموذج العام لتولد الرحلات لديه قدرة تفسيرية جيدة بلغت 0.69. ويشير ذلك إلى أن المتغيرات المستقلة التي تم تضمينها في النموذج تفسر 69% من التغير في المتغير التابع. كما أشارت الدراسة إلى أنَّ أهم المتغيرات التي تؤثر في تفسير تولد الرحلات في النموذج العام هي عدد العاملين في الأسرة وعدد الذين يكملون تعليمهم في الأسرة ومعدل الدخل الشهري للأسرة.

يتمتع نموذج تولد رحلات العمل بقوة تفسيرية تصل إلى 0.74. وأظهرت الدراسة أن عدد العاملين في الأسرة وعدد الأفراد الواقعة أعمارهم بين 31 و50 عاماً في الأسرة هما العاملان الرئيسان في تحديد عدد الرحلات المتولدة للعمل. أما نموذج تولد الرحلات التعليمية فيتمتع بقوة تفسير بلغت 0.97. إن عدد الأفراد الذين يكملون تعليمهم في الأسرة هو العامل الأهم في تفسير الرحلات المتولدة بهدف التعليم.

ويعتمد نموذج تولد الرحلات بهدف التسوق على عدد أفراد الأسرة والدخل الشهري للأسرة. ويعتمد نموذج تولد الرحلات الاجتماعية بشكل أساسي على عدد الأفراد الإناث في الأسرة وعدد العاملين في الأسرة. وأخيراً، فإن نموذج تولد الرحلات الترفيهية يعتمد بشكل أساسي على عدد الأفراد الذين يكملون تعليمهم في الأسرة، وعدد أفراد الأسرة الذين تقع أعمارهم بين 51–64 عاماً، ومعدل الدخل الشهري للأسرة.