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Faculty of Graduate Studies

Establishing Parking Generation Rates for Selected Land Uses in the West Bank

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Dedication

بسم الله الرحمن الرحيم

(وَقُلِ اعْمَلُوا فَسَيَرَى اللّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ)

My beloved parents, my brothers, my sisters

My Holy Homeland Palestine

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All praise and glory be to Allah for his limitless help and guidance. Peace pleasing of Allah be upon His prophet Mohammed.

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Establishing Parking Generation Rates for Selected Land Uses in the West Bank Cities

أقر بأن ما اشتملت عليه هذه الرسالة إنما نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجه علمية أو بحث علمي أو لدى أي مؤسسة تعليمية 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.

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Date:	التاريخ: 13-12-2015

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List of Abbreviations

AH	Attached housing class
AM	Morning period
ANOVA	Analysis of variance
APH	Apartment housing class
B_1	Slope (coefficient)
B_0	Intercept (constant)
CBD	Central business district
CV	Coefficient of variation
df	Degree of freedom (N-1)
DH	Detached housing class (villas/ separate houses)
DU	Dwelling unit
EA	Engineers Association
F-Test	Statistical test has F distribution under H0
GFA	Gross floor area
GLA	Gross leasable area
GLFA	Gross leasable floor area
H0	Null hypothesis
H1	Alternative hypothesis
ITE	Institute of Transportation Engineers
LGU	Local government unit
Ln	Natural logarithm
MoLG	Ministry of Local Government
MS	Mean square error
N	Sample size
NZ	New Zealand
P	Parking demand (passenger car)
PM	Afternoon period
P value	The probability of type one error used
R	Coefficient of correlation
R^2	Coefficient of determination
RMSE	Root mean square error (standard error of the estimate)
SA	Site area
Sig	Significant
SPSS	Statistical Package for the Social Sciences
SS	Sum of squares
Std	Standard deviation
TIS	Traffic impact study
TRICS	Trip Rate Information Computer System
TSM	Transportation systems management
T-Test	Statistical hypothesis test, in which the test statistic follows a Student's t-distribution if the null hypothesis is supported.
UAE	United Arab Emirates
UK	United Kingdom
USA	United States of America
Weekdays	Normal days (all days of week except the weekend, first day and last

	day of calendar days)
X_1	Independent variable
ϵ_{i}:	Random error
σ	Sigma; standard deviation

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Abstract

Estimating parking demand in Palestine needs more oriented studies towards parking generation to enrich transportation planning, design and management by valuable information. The available local studies are partial studies and not based on comprehensive specialized studies. Furthermore, using regional or international models and rates of parking demand may not be appropriate for Palestine. This research is conducted to establish reliable reference for provision of parking supply for three major types of land uses, which are residential, office, and retail land uses.

Seventy three sites of different land uses were selected through field investigations, interviews, and availability of information for each site. These sites cover all the targeted land use types and their classes (three classes for each type).The study covered all main cities in the West Bank. Data collection was conducted manually, which contains site characteristics and average of two days of parking counts during three periods (AM, PM, and Peak of the Development).

The analysis of the attained data produced several parking models and rates that might be used as local specifications for parking demand and supply of the three selected land uses. Following the American Institute of Transportation Engineers procedure, simple linear or logarithmic/power model forms were investigated.

The produced models have various levels of statistical significance for identifying the required parking spaces for a current and proposed development.

The developed models are applicable in the peripheral areas of the cities. Fifty six models and rates were produced with variable accuracy. Good statistical models and rates were summarized and highlighted for each type of land use in tables. Parking generation models with good statistical significance (R^2, etc.) were recommended, otherwise, parking generation rates are recommended. Simple linear regression, natural logarithmic linear regression and power were the forms of the recommended models for the studied land uses.

Therefore, the parking demand of residential, office, retail land uses with the same characteristics can be identified based on the produced models and rates. This thesis forms the first step of a future Palestinian *"Parking Generation Manual"* that will contain various local land use types, as well as guidance for the Ministry of Local Government requirements of parking spaces for various developments.

Chapter One

Introduction

5.1 Background

Many states around the world have published trip and parking generation rates/equations in multi-forms such as books, manuals, handbooks, etc., and as a result, they produced trip and parking generation rates/equations that have been used in many areas of planning and for the support of the preparation of Traffic Impact Studies (TIS). Trip and parking generation contributes in the formation of urban areas (Urban Morphology) and supports the decision makers in the planning of the urban areas. For example, changing the land use pattern of specific area from residential to commercial will affect the road network system, but at what level this effect will be? Trip and parking generation rate for each type of land use will assist in making decisions through conducting TIS and notice the effects on the adjacent road network system.

The transportation planning system in Palestine does not have a comprehensive policy or strategy for providing parking spaces for different land use types. Therefore, there should be clear. Policies and strategies, which could assist in building better transport mobility and accessibility at major movements in different areas of cities and contribute in making planning decisions.

In addition to a few studies that deal with parking generation, Palestine has a law that deals with operational issues of parking spaces called "Traffic Laws No. 5 for year 2000" (Ministry of Transport, 2005).

The State of Palestine has some standards/regulations for parking spaces required for different types of developments, and these standards were set by municipalities, the Ministry of Local Government (MoLG), and Engineers Association (EA). These standards are not based on specialized studies and may not consider the detailed characteristics of land use types. Other operational studies were prepared by Palestinian government that deals with parking operation and management rather than parking provision. Therefore, Palestine does not have any partially or completed parking generation rates/equations in the form of a manual or a book. On the other hand, MoLG has set and updated parking requirements for various developments, and these requirements have been used by engineers for design.

In this study parking generation for residential, retail, and office land uses is investigated.

The available parking generation documents that were published around the world may not be compatible with local patterns in Palestine due to different conditions and environment.

5.2 Research Problem

Traffic is still growing every year in the road network as a product of several factors such as economic, technology, population growth, etc. The traffic volumes on road network are increasing due to the creation of new developments or changing the land use type of specific developments from one to another without changing parking supply, and some of these actions are taken without precautions or proper traffic impact studies. The available parking regulations, which are used in urban development, are outdated and these regulations did not depend on a specific study. As a result, the transportation network is congested and needs quick actions due to the increased parking demand generated from land uses. In urban areas of Palestine, especially in major cities in the West Bank, has been suffering from traffic congestion at critical locations, and one of many causes of congestion is the extensive use of on-street parking by adjacent land uses. Therefore, estimating the parking generation for each type of land use (development) will provide for the evaluation of the parking spaces required because different land uses have different parking demands. The decision makers or transport planners will assess the impacts of construction of new development on the road network at the preliminary stage (i.e. before development construction) and decide on the mitigation measures based on anticipated impacts.

5.3 Justification and Research Significance

Parking generation has helped professionals working in transportation and urban planning due to its effects and impacts in managing the traffic and guiding the urban/transport planners in making decisions about land use patterns of the city based on the amount of parking demand generated by specific land uses. Adequate provision of off-street parking discourages on-street parking and improves safety and the level of service.

This work has been done in several cities, states, provinces, etc. around the world, but in Palestine it is still lacking of a comprehensive study. Studies conducted abroad (i.e., USA, Abu Dhabi, UK, etc.) cannot be applied as a whole locally due to major differences in factors like travel habits, economic size, people, developments types, sizes, Israeli occupation, and others. Therefore, it is necessary to conduct and establish local parking generation rates/equations for Palestinian cities in order to form the initial stage in making local parking generation guide, manual, or book.

This research supports and enriches planners with information, but also it fills the gap in the planning and engineering process. And this research forms the base point for planners to decide about proposed/new development, and it assists in preparing reliable Traffic Impact Studies (TIS), where parking characteristics are key input data to TIS. Therefore, producing local parking generation rates for the Palestinian cities will fulfill one of the important requirements of TIS and engineering designs.

Main cities in Palestine suffer from congestion at critical sites due to improper planning for parking facilities regarding new developments or identifying the type of suitable land use. As a result, this guides the transportation planners in managing the transportation system and assists them in their planning decisions. Furthermore, this thesis assists the key stakeholders (i.e., government agencies and municipalities) to institutionalize TIS and update any available regulations regarding parking facilities.

The existing of major developments such as: residential, shopping centers, hotels, hospitals, supermarkets, and others need parking facilities such as on-street and off street parking. These parking areas affect traffic on roadways; roadways are able to accommodate limited number of parking due to the limited available capacity and space as well as other factors. Conducting parking generation analysis will enable the decision makers to take in their accounts the traffic issues and the capacity of road network through preparing policies related to institutionalizing TIS. This will create a room to determining regulations for buildings in different land uses and as well as a cost sharing mechanism (i.e., impact of parking supply on the network ought to require investors to contribute to mitigation measures) that will assist the agencies in developing their cities.

In summary, this research establishes the ground for estimating the number of parking spaces required for each land use type as well as assists in developing strategies for mitigating their adverse impacts. Therefore, the process will make stakeholders get involved in decision making by participating in finding solutions and conducing proper actions.

5.4 Thesis Objectives

The following is the main objective of this thesis is to establish a parking generation document to be used in predicting the needs of three main land use types (residential, office, and retail) for parking spaces.

Whilst, the envisaged outcomes of this thesis are shown below:

- Specify limitations of the study for the future research.
- Support the transportation planning process and the parking management through several policies and actions such as TIS.
- Develop a new tool that assists in Transportation Systems Management (TSM).
- Provide foreseen results about proposed land use for decision makers. For example, accepting, rejecting, or demanding modifications as related to changing or creating new development/land use in one place.
- Support urban planning development and assist the municipalities and ministries in making planning decisions.

In essence; the output of this study is to evaluate how many spaces are required for parking for specific land use/development. Developing local parking generation rates or equations for the selected land uses will contribute to establishing a Palestinian "*Parking Generation Manual*."

5.5 Study Area

Urban areas outside the CBDs of cities in the West Bank were selected as a study area as shown in Figure 5.1. Many sites were studied in almost all cities in the West Bank. Nablus, Ramallah and Albireh and Hebron were the main cities among all because they have a lot of diversity in land uses.

5.6 Thesis Outline

The thesis contains the following chapters; introduction which presents general background, problem definition, and objectives of the research. Literature review is discussed in chapter two. The methodology is presented in chapter three, while field survey and data collections are discussed in chapter four. Data analysis and outputs are presented and discussed in chapter five. In addition, conclusions and recommendations are presented in chapter six.

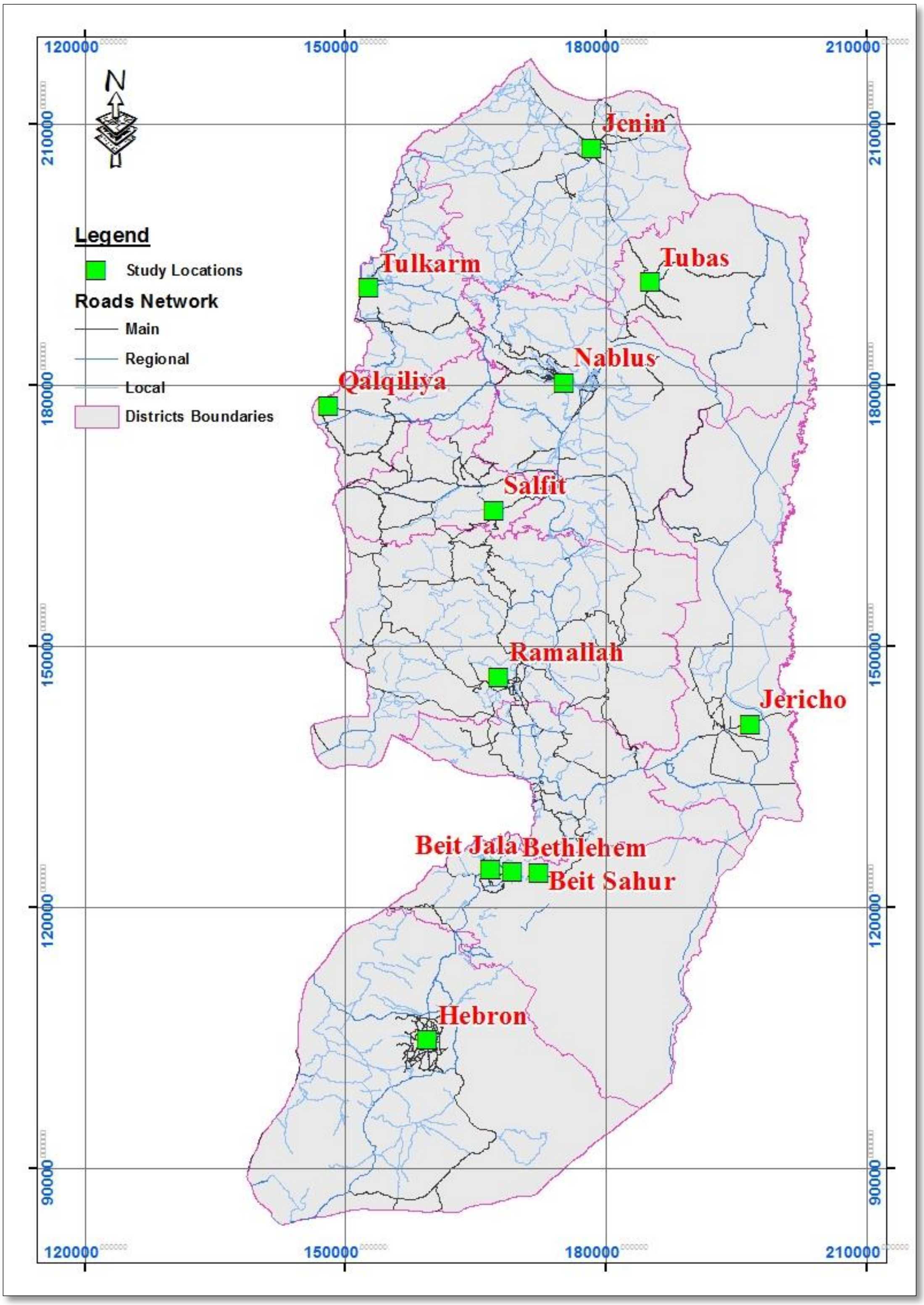

Figure 5.1: Study Area

Source: (Ministry of Local Government, 2015)

Chapter Two

Literature Review

6.1 General Overview

Parking and trip rates/equations are used in evaluating the requirements of transportation network such as the right of way adjacent to specific land use or the maximum traffic volume should not be exceeded in the adjacent street, as well as size of parking for each type of land use. Excessive on-street parking supply may affect negatively the level of service of roads network due to the generated obstructions from these parked vehicles. Furthermore, deficiency in providing sufficient off-street parking spaces for land uses such as retail and office creates negative economic impacts. On the other hand, size of parking supply might exhaust roads network and drop down the level of service to the worst. In essence, estimating parking generation for different uses absolutely contributes in specifying and controlling parking supply for each land use, and consequently avoiding congestion generated by parking.

6.2 Review of Parking Studies

This section provides a review of selected past relevant studies of parking generation that have been conducted in three levels; international, regional, and local studies. Historically, many studies around the world have been developed and used. Unfortunately, local studies as researches, manuals, books, etc. are scarce as shown in the following subsections.

6.2.1 International Studies

International studies are divided into the following sub-sections:

6.2.1.1 North America

The American Institute of Transportation Engineers (ITE) published several studies about parking generation in different format such as journals and reports. The most recent report is the 4^{th} edition of Parking Generation, which involves 106 land uses. Indeed, the 4^{th} Edition Parking Generation report represents a collection of data since 1978.

The 4^{th} Edition of Parking Generation, which will be called later as "ITE Parking Generation", involves parking demand observation, time and date of observation, and independent variables. Parking Generation demonstrates a reasonable relationship between parking demand and single independent variable. Previous editions used the average maximum parking demand ratios in predicting parking demand regardless of some important factors such as area type. On the contrary, the third and fourth editions did not use that, but it began to take more factors of estimation parking demand such as linking data to time and area type. Most of the data available in the ITE Parking Generation are from suburban sites with free parking and single use.

Parking Generation produced various levels of statistics ranging from poor to good. For example, when using the gross floor area (GFA) with parking demand it produces high coefficient of variation; however, when using number of employees it produces low coefficient of variation. The ITE concluded that homogeneous data sets or small data sets may produce low coefficient of variation and this does not mean more reliable relationship. Statistically reliable data does not cover all sites but it forms a long range goal. Indeed, average or mean parking demand has been used in Parking Generation (ITE, 2010).

ITE (2010) provides information and guidelines about site selection, permissions, procedure, background, and independent variables. The following are some variables in ITE documents that were used in predicting parking demand:

- Residential: dwelling units, persons, vehicles, acres.
- Office: employees, 1,000 square feet (sq. ft.)GFA, acres.
- Retail: employees, acres, 1,000 sq. ft. GFA, 1,000 sq. ft. occupied gross leasable area (GLA), etc.
- Shopping Center: 1,000 sq. ft. GFA, employees, % restaurant space, % entertainment space.

ITE Parking Generation provides models and rates for predicting parking demand for various land use types, for example on weekday, Low/Mid-rise Apartment generates 0.59 to 1.94 and 0.66 to 2.5 parked vehicle per dwelling unit (DU) for suburban and urban areas, respectively. Office Building generates 0.86 to 5.58 and 1.46 to 3.43 parked vehicles per 1000 sq. ft. GFA for suburban and urban areas, respectively. Shopping Center generates 1.44 to 7.37 parked vehicles per 1000 sq. ft. for non-Friday weekday (ITE, 2010).Figure 6.1exhibits an example of parking generation model/equation for Low/Mid-Rise Apartment through average peak period of weekday in urban area.

The 2nd Edition of Parking Generation covered only suburban areas, and the last two editions covered five areas: CBD, central city (not downtown), suburban center, suburban, and rural. Parking Generation showed that local conditions and area type can influence parking demand. Parking Generation introduced the importance of estimation of parking demand with respect to the ambient temperature (McCourt, 2004).

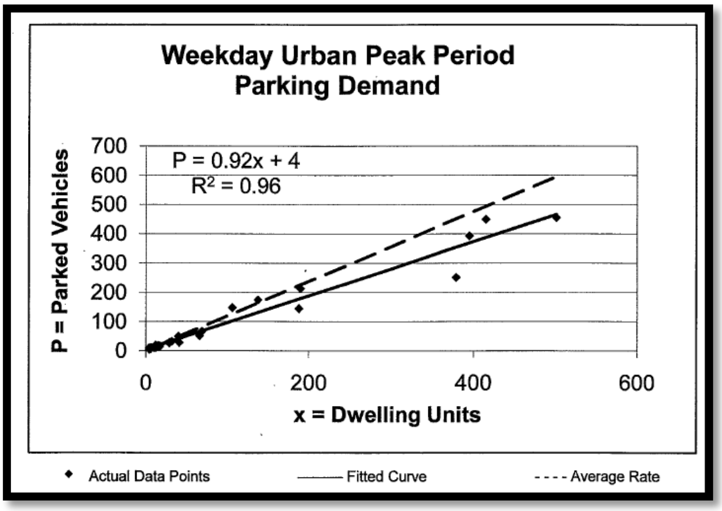

Figure 6.1: Average Peak Period Parking Demand vs. Dwelling Units (ITE, 2010).

Kuah (1991) followed a procedure for estimating parking demand in order to develop ordinances to regulate parking supply for meeting peak parking demand for a single use. The author used several factors, including project size, type of zoning, type and number of persons expected to visit the site, availability of alternative transportation modes, and the time frame of the analysis in performing the study. The author proposed a methodology for estimating parking demand for Mixed Use Developments (MXDs) planned in jurisdictions with Transportation System Management (TSM) programs ordinances. The proposed method accounted for potential parking reductions resulting from the implementation of TSM and the sharing of parking spaces for MXDS (Kuah, 1991).

The author concluded that the study not only takes into account parking reductions because of TSM programs, but it also addresses the saving of spaces because of shared parking among different land uses of the MXDs. Based on that approach, developers will be able to provide an adequate number of parking spaces that might vary from the code requirements.

Meyer (1984) published guidelines for obtaining parking generation data. These guidelines involved site selection, permission, background data, procedure, and existing data. Each one of these guidelines should be considered in performing parking generation. The study indicated that it is important to take permission from the owner/manager of prospective survey site. Procedure for conducting parking occupancy count at each site should be counted at the time of peak parking demand, and variation of peak parking demand throughout the time horizon should be studied as well (Meyer, 1984). In addition, the author provided guidelines, and these were taken into consideration in second, third, and fourth edition of the ITE Parking Generation.

Gattis et al (1995) studied parking generation at a selected type of schools, which were elementary schools. The authors addressed the issues accompanying the generated traffic congestion that occurred on the surrounding streets at school's beginning and dismissal. The authors presented methods to predict the parking demand during this "school rush-hour". Therefore, several factors were studied such as location of school with respect to different types of roads classes (i.e. collector, local, etc.).

Predictive models were developed based on variables that local officials could easily estimate or find in common documents, such as census data. The author concluded, the provision of adequate parking spaces can reduce school traffic congestion and enhance traffic safety (Gattis et al., 1995).

Smith (1990) prepared a report to guide users of the second edition of ITE Parking Generation. The author used factors that contribute to parking demand, which are related to the characteristics of the sites themselves and others that are related to the way in which each individual study was conducted such as availability of transit and time of year. In addition, possible methods for estimating design level parking demand for rates, equations, and cumulative distributions were addressed. Some of these methods are parking generation rates and standard deviations, regression equations, and cumulative distributions.

Moreover, Smith (1990) provided precautions when using ITE Parking Generation, such as care should be taken in using the data where sample sizes are small. The regression line is used to estimate total peak parking occupancy, not the generation rate.

In addition, Smith (1990) provided several tips for users when using the data from the second edition of Parking Generation such as:

- The regression line should not be used for sites where the independent variable is outside the limits of the data available.
- Possible choices include using the generation rate or using the generation rate computed from the high or low limits of the regression line.
- The occupancy computed from the mean rate can be plotted on the same graph as the regression line for the purpose of comparison.
- When sample sizes are small, little confidence can be placed.

Smith study (1990) investigated two area types, which were suburban activity centers and downtown sites. The study found that application of the output rates/equations can be applied on activity center requires appropriate allowances for time-of-day variations, multiple stops, etc. The author concluded that this would normally be done only for new development and where more direct studies and data are unavailable.

Rugger and Gorys (1989) studied the impact of a 90-room hotel to be added to an existing banquet hall in the City of North York, Ontario, Canada, focusing primarily on the implications of the project with respect to its parking requirement.

The authors conducted surveys on five sites, including the subject site. Two of the sites were major hotels in close proximity to the subject site, while the other two were industrial/ commercial sites adjacent to the subject site. The degree of certainty that one can put on these values was calculated through the 95% confidence of the mean.

Analysis of collected data showed the demand for parking at the two hotels did not, in any instance during the survey period, ever exceed 75% of the supply. The present parking capacity at the subject site can accommodate a hotel operation for 94% of the time; the exception being Saturday evenings because of the banquet functions. However, this problem already existed and the owners of the subject site made arrangements with neighbors to share parking spaces (Ruggero et al., 1989).

Hain et al. (1987) studied parking generation rates developed from recreational land uses. The authors focused on four recreational land uses in Colorado: golf courses, athletic clubs, bowling alleys, and ski areas. To simplify the data collection effort, site managers for each land use were contacted prior to the survey to identify the peak parking demand period.

Several statistics were included in the study such as mean, range, standard deviation, linear regression equations, and coefficient of determination (R^2),which ranged from (no fit) to 1 (perfect fit). The authors recommended that additional study of this land use is needed to get more accurate and reliable estimates (Hain et al., 1987).

Fitzgerald and Halliday (2002) prepared a study for the Northwest Connecticut regarding parking. Forty two locations were surveyed and each location was counted twice in two different dates after specifying the peak period of each location.

Parking occupancy was counted in 10 minutes interval, and area types were distinguished. Comparison was undertaken between regulations and actual number of spaces available, and the occupied spaces observed. Square footage of building space was based on evaluating the number of space required for specific land use. The study showed that many of parking areas were underutilized; for example, 11 existing spaces per 1000 sq. ft. of building area were provided at a general office, and the 3 occupied spaces were observed, but the national standards set out 5 to 10 spaces per 1000 sq. ft. Therefore, using strategies to reduce the amount of provided parking in zoning regulations is useful because the results showed the average percentage of occupied parking spaces was less than 50%, and this percent is smaller than desirable percentage (85 percent to 95 percent). Several strategies should be followed such making modifications on the existing standards, and promoting shared parking (Fitzgerald and Halliday, 2002).

Small Office Complexes were not included in ITE Parking Generation. Therefore, the Montana State University Institute of Transportation Engineers gathered information on Nopper Technology Building, which is located in Montana. Traffic tubes were used to collect traffic data on this development. Estimation of both employees and occupancy in the development was used. The study was based on the ITE basic forms in conducting surveys. In three separate times or dates the traffic data were collected. Square footage was used as independent variable in estimating parking demand. Different types of modes were included in the results of this study like trucks, pedestrian, vehicle, and bicycles. Parking rate of 1.67 on average is required for every 1000 sq. ft. GFA (MSU-ITE, 2009).

Rowe et al. (2013) studied the importance of investment in parking provision. Misunderstanding of variation in parking demand for different areas (urban, suburban, etc.) leads to overprovision of parking and increased cost to users that have no need for these facilities.

The author studied the effects of decrease in auto ownership, licensed drivers, and vehicle miles traveled, especially among young people in United States. The design of multifamily housing for low rates of vehicle ownership is equally as important as design for suburban conditions where higher rates of vehicle access are found.

Socio-demographic, housing, and built environment variables have all been shown to have an impact on residential parking and vehicle availability. More than 100 factors were developed for data collection and analysis such as supply and price, property/development characteristics, neighborhood household characteristics, accessibility, and built form/development patterns. Sample sizes of 208 sites were assembled, representing various types of multifamily development around urbanized King County Metro in the Seattle region. The parking utilization data was correlated with the 100 factors. Factors with higher correlations to parking utilization include the supply of parking, transit access, walk score, concentrations of people and jobs, block size transit service, good walk access, and shorter block spacing have a reasonable potential to provide lower parking supply for a multifamily residential project (Rowe et al., 2013).

Although each of these factors individually did not exhibit strong correlation ($R^2 > 0.7$), relationships plots were conducted between supply, transit access, concentration of people and jobs, walk score, and block size versus observed parking. CBD multifamily parking utilization of 0.51 vehicles per occupied dwelling unit in the sites studied, compared with suburban 1.18 vehicles per occupied dwelling unit, indicates that better accommodations/ environment for low- and zero-auto-ownership households correlates with reduced need for parking. Most important, the research demonstrates that higher supply of parking appears to consistently correlate with greater parking demand (Rowe et al., 2013).

Rowe et al. (2011) studied the effects of transit availability on the provision of parking spaces in urban areas. The author examined the relationship of parking demand and transit service in First Hill– Capitol Hill (FHCH) and Redmond; two urban centers in King County, Washington. The results showed a strong relationship between transit service and parking demand. Parking demand in FHCH was observed to be 0.52 parking spaces per dwelling unit, which was about 50% less than parking demand observed in Redmond, a growing mixed-use suburban center, and 50% less than data reported by the ITE.

Two centers were chosen and they represent two contrasting types of development, an urban and a suburban environment, yet they have the highest number of multifamily apartment buildings available to study among all centers in King County Metro in Seattle. To assess parking demand, eight apartment buildings (four in each urban center) were selected to conduct parking utilization counts. Property managers at each development site were contacted to gain permission to use their sites for this research (Rowe et al., 2011).

Specific criteria were based on filtering and selection of sites such as permissions from manger or owner of site and occupancy is at least 85 percent. Parking counts were completed during midweek days (Tuesday through Thursday) at the peak parking demand hours for residential land uses (i.e., from 12:00 to 5:00 a.m.). The results show that parking demand is lower than the amount supplied in both urban centers, a finding which suggests that parking is overbuilt. The observed parking demand found in this study is less than the parking demand data presented in the ITE report in both urban centers (Rowe et al., 2011).

Gabriel (2010) provided trip generation and parking statistics for Oxford Plaza in California. This development is categorized as residential land use. This development is close to commercial area and dozen transit line. Data collection was done during three weekdays. Person trips and vehicle trips were identified in the study. Specific parking pricing strategy in area of development was reflected in this study.

The author concluded the Oxford Plaza does not provide sufficient parking to encourage using other modes of travel, and despite of that there were a lot of vehicles parked outside of development (off-street). Therefore, parking demand is larger than parking supply (Gabriel, 2010).

Fehr and Peers (2008) provided an assessment of the expected parking demand and peak hour trip generation of the proposed Stanford Hospitals and Clinics (SHC)/Lucile Packard Children’s Hospital (LPCH) projects. The study utilize traffic counts and parking occupancy surveys to define unique trip generation and parking demand rates for the hospitals as a whole (inpatient and clinic space) and for certain Welch Road medical office buildings. These rates were applied to the growth plans for the hospitals, including new inpatient and clinic space, and for a new medical office building to be located on the Hoover Pavilion site.

The survey data indicated that the hospitals generate traffic and parking demand at rates that are generally consistent with rates observed at other large medical centers. The rates were based on the total floor area for inpatient space and clinics.

Parking industry publications such as “Parking,” published by the ENO Foundation, recommend that a vacancy factor of 10 to 15 percent be applied to the calculated parking demand to quantify the needed parking spaces to meet parking demand. The vacancy factor is needed to ensure that drivers are able to locate an available parking space without re-circulating through the parking areas (Le Craw et al., 1946).

The authors conducted traffic counts during the morning (7:00 to 9:00 AM) and evening (4:00 to 6:00 PM) peak periods for 20 parking areas. These counts were conducted using either machine counts or tubes (6 driveways) and manual/person counts (15 driveways). In addition to driveway counts, peak period occupancy and parking permit surveys were conducted for the 20 parking areas and three on-street locations. Fehr and Peers also determined the peak hospital parking occupancy, or ‘demand’, during both the mid-morning and mid-afternoon periods. Parking occupancy or demand is the number of spaces in which vehicles are parked. As a result, the recommended parking demand rates for the hospitals and medical office space were determined (Fehr, 2008).

Ornstein (1966) indicated that in residential area there are two points that should be considered; providing adequate parking spaces plus the place of parking with respect to developments such as on street. The author studied the parking demand for the inhabitants' vehicles ownership rather than all users of parking spaces; for example, visitors, customers, and employees. Ornstein concluded the availability of mass transit in residential area does not affect the parking spaces. The author presented three factors to alleviate the problems associated with provision of parking spaces in residential areas. Zoning ordinances, public power, and providing off-street parking are factors that could be used as a remedial tools in solving parking provision problems in existing developments. The author concluded that in the new development zoning ordinance is the key solution of parking problem, while in existing developments off-street facilities can be effective solution for alleviating parking problem (Ornstein, 1966).

6.2.1.2 South America

A new type of land use was discovered in the Portland area, and as a result, Students in Transportation Engineering and Planning (STEP) (2009) conducted study in order to include this new type of land use in the ITE documents. The IKEA is an international, home products retailer with stores in many countries, and indeed, it is a discount big store. This development has large area store, shopping center, and large parking spaces for vehicles and bicycles. Pedestrian and bicycle movements were counted since there was a light rail 500 ft. away from the developments. This development has its internal trips that prevented distinguishing people modes of choice. Three separate dates were used to conduct survey counts. Peaks were identified and documented since the estimation of parking demand relied on it. Parking accumulation was drawn then the average was taken as representative one. ITE survey forms were used for conducting the study (Students in Transportation Engineering and Planning, 2009).

6.2.1.3 Australia

Douglass and Albey (2011) prepared a research study to compare New Zealand, Australia, UK, and USA information on trip and parking related to land uses, and reviewed current trip generation survey and data manuals from these four countries. The research covered surveyed trips to and from individual sites by all modes of travel, and considered observations from car park demand surveys. The research considered seasonal traffic and parking variations and identified the practical parking design demand for a whole year as the 85th percentile satisfaction, which is also the 50th highest hour. The 85th percentile was the upper design limit suggested for the site being considered. Independent variables such as GFA, gross leasable floor area (GLFA), which is commonly 80% of the GFA, site area (SA), employees, and activity units were derived from survey process.

In residential; primary factors explaining the variation in household trip generation such as topography, demography, etc. were considered. The combination of various socio-economic characteristics, student flats, etc. led to widely varying vehicle use and associated parking demand and traffic generation. In retail; traditional town center shopping areas experienced a range of vehicle and pedestrian journeys. In smaller towns and suburban areas, the proximity of retail areas to residential catchments means about 10% to 15% of shopping trips are made on foot or by bicycle. The most practicable unit for most district plans is still spaces per 100 m^2 GFA (Douglass and Albey, 2011).

Douglass and Abley (2011) concluded that the designer and planner must appreciate both the direct effect of the physical features of a site and the indirect factors such as catchment, competition, and surrounding transportation systems.

The Roads and Traffic Authority (2002) established a guide that outlined all aspects of traffic generation considerations relating to developments. This guide sets out the range of parking demands likely to occur at an isolated site, recognizing the impact it may have on transport policy and travel demand. Parking provision should be viewed as the minimum desirable requirement, while Councils' parking codes are considered to be minimum mandatory requirements. Roads and Traffic Authority (2002) conducted traffic counts in both peak periods of which vehicular traffic occurs (peak of development itself and peak of adjacent road network).

The independent variables used were not always suitable for predicting future traffic generating characteristics of a proposed development. For example, using employees can be useful for operation studies; not for future planning studies. The parking provisions recommended are based, wherever possible, on physical characteristics of the proposed development, particularly the gross floor area (Roads and Traffic Authority, 2002).

The Roads and Authority (2002) used 85th percentile level of demand in parking demand estimation. For examples, one parking space is required for each one dwelling unit, and the recommended minimum number of off-street visitor parking spaces is one space for every 5 to 7 dwellings for residential land use. About 6.1 parking spaces per 100 sq. m. are required for GLFA ranging from 0 to 10000 sq. m. In off-street parking GLFA is preferred to GFA for the shopping center land use category because it refers most specifically to the factor that generates / attracts trips. As a guide, about 75% of the GFA is deemed GFLA. However, this percentage can vary substantially between developments.

Clark (2007) studied trips and parking generation in New Zealand (NZ) and Australia for the purpose of promotion of practices for sources of surveyed data that was used in New Zealand and Australia. The study was undertaken to show the differences, correlations, and similarities in traffic conditions in UK and NZ land use types. Therefore, a simple system of site lists linked to data for individual sites was developed in both countries (UK and NZ). Variation through years such as seasonal, weekly, daily, and hourly factors were included in this study in order to identifying 85% design hour. Some differences between individual sites within a land use class were noticed.

However, taking the averages, or more importantly the 85th percentile to get UK, New Zealand, and probably Australia in the same order is oriented. Finally; The New Zealand Trips and Parking Database (NZTPD) is being upgraded and detailed comparisons are being made with Trip Rate Information Computer System (TRICS) (JMP Consultants Limited., 2013) to develop the database as well as accuracy and coverage of data (Clark, 2007).

6.2.1.4 Europe

JMP Consultants Limited (1995) studied the provision of parking at food retailing in order to reduce the trips distance and alleviate the reliance on car, in addition to providing safe environment through alleviating the impacts of transportation. Maximum parking demand was recorder for selected sites of retail in and out of town center. The results indicated the demand in town center is larger than out of center. Moreover, parking rates in terms of GFA and retail floor area were computed during three weekdays which represent the maximum regime. The author also noticed that there is a relationship between customer visits and maximum parking demand (JMP Consultants Limited, 1995).

JMP Consultants Limited (1995) assessed parking demand in terms of comparison of existing database of parking demand with existing parking standards. Six land uses were studied to achieve that comparison. The 85th percentile was taken as a high value and this value is not rigid; the 50th percentile and more is suggested. Maximum hourly accumulation of each site was noted. Base on the gross floor area parking demand ratios were calculated. The survey was designed to undertake the typical days rather than peak days to avoid adaptation of peak parking demand. Confidence level of one standard deviation (std.) from the mean (68%) and two std. from the mean (94%) were used in data analysis. Seasonal, operational, and growth in demand factors affected the resultants demand. These factors were reflected in the 85th percentile but the results in some instances were over provision of parking space. Therefore, using lower value to reflect previous factors was adopted. Comparison of parking demand with existing standards showed there are many up and down variation values especially in retail land use.

6.2.1.5 Other Countries

Regidor and Regin (2010) assessed some issues and concerns pertaining to local trip and parking rates in Philippine. Parking generation in Philippines used a number of relevant laws pertaining to the provision of off-street parking for different types of developments, and among these is the National Building Code (P.D. 1096) of the Republic of the Philippines, which stipulates the minimum requirements in the number of parking slots per type of development. In this law, developments are classified into groups and divisions ranging from Group A to Group J; these divisions summarize several types of land uses such as hotel, residential, industrial, etc. The study identified several parameters for parking requirements for such developments such as gross floor area, gross saleable area, floor area ratio (density), parking slot cost, and distance from the CBD.

However, it is also necessary to point out the importance of estimating local trip and parking generation rate because ITE trip and parking generation does not incorporate public transport trips, and it is limited to vehicle trips that are interpreted as private trips (Regidor et al., 2010).

6.2.2 Regional Studies

The Department of Transport of Abu Dhabi (2012) prepared a manual for assisting planners, engineers, and developers in estimating the parking and trip generation rates for several local land uses. These rates have been obtained through the survey and analysis on nearly 400 different sites throughout the Emirate.

To ensure sufficient parking with respect to size and location of development, a specialized process was undertaken in publishing this manual, which includes site selection, surveys, data analysis and validation. Parking generation rates that was developed in this manual covered all types of predominated land uses in Abu Dhabi (Department of Transportation, 2012).

Regional shopping center/mall generates 0.204 resident or employee parked vehicle, and 2.433 visitor parked vehicle, 0.013 parked school/company/trucks per 100 sq. m. These rates are based on 4 selected sites that are well distributed around the study area. Local shopping center generates 0.107 resident or employee parked vehicle, and 1.204 visitor parked vehicle, 0.007 parked vehicle school/company/trucks per 100 sq. m. These rates are based on 5 selected sites that are well distributed around the study area. In addition, supermarket generates in non-CBD area of Abu Dhabi 0.949 resident or employee vehicle, and 6.371 visitor parked vehicle, 0.214 school/company/trucks per 100 sq. m. These rates are based on 15 selected sites that are well distributed around the study area. Local government office generates parking rate in Abu Dhabi City of 1.982 vehicles per 100 sq. m. based on sample size of 3. On the other hand, residential land use was covered in this manual and it was based on the number of bedroom as an independent variable (Department of Transportation, 2012).

Al-Masaeid et al. (1999) developed statistical models for estimating vehicle parking demands of different land uses in Jordan. These land uses include 53 hospitals, 40 hotels, 42 office buildings, 35 apartment buildings, 21 restaurants, and 17 shopping centers, for a total of 208 sites. The sites were located in different cities in Jordan, including Amman, Zarqa, and Irbid. Three criteria were adopted in the selection process. First, each selected site must have a well-defined parking lot and the parking is not permitted to be used by adjacent land uses. This criterion is important to determine the peak parking need accurately for the selected land uses only. Second, the sites of each land use should be located in different cities. Clearly, this criterion was adopted to increase the domain of inferences. Third, the parking lot for each site should have an adequate parking supply. The availability of a sufficient parking supply was judged through field survey. All selected sites were located outside the CBD's. A statistical model for estimating vehicle parking demand of various land uses in Jordan was developed.

The developed models had an exponential form, except for models for restaurants and shopping centers, which had a linear form. The researchers concluded that compared with the standard values for developed countries, the parking demands for the investigated land uses in Jordan had lower rates (Al-Masaeid et al., 1999).

6.2.3 Local Studies

Ordinances were developed and used by the Ministry of Local Government (MoLG) and municipalities in Palestinian localities regarding provision of parking supply.

Local small scale studies were conducted by several agencies/ organizations in specific sites in the West Bank such as Traffic Analysis and Simulation of Al-Ersal Center Project (Al-Sahili, 2010).

Al-Sahili (2010) performed parking and traffic counts adjacent to residential, hotel, office, and shopping / retail center land uses to capture trips and parking associated with the particular land use. Five sites (land uses) were surveyed during the AM peak and PM peak periods of atypical workday. This study provides local trip generation rates and parking generation rates for the selected developments in the study area. In addition, the study evaluated the proposed parking supply against the parking requirements established by MoLG in Palestine. The study concluded that the local parking requirements may not be suitable for mix land uses, such as the project of Al-Ersal Center.

Palestinian Buildings Laws and Regulations for Local Government Units (LGU's) (Ministry of Local Government, 2011)is the only system used locally by planners, and LGU's for estimating parking requirements for various land uses. For residential land use class (A, B, and high rise buildings) one space for each dwelling unit is required. While for Class C, D, and old city one space for each two dwelling units is required. Retail land use should provide one space for each 50 square meter of stores and exhibits one additional space for other uses (other than stores). For each 70 square meter (sq. m.) of office land use one space should be provided. Appendix (F) shows an extracted table from the Palestinian regulation of parking spaces provision.

6.3 Summary and Discussion

Different studies, reports, and projects were conducted to find parking generation for various land uses. In summary, the variables used in these efforts overlap and some of these variables are used in operational purposes while the others in future or new developments. Types of land uses not only define what variable should be used in developing parking generation, but also the case study and the nature participate in defining the variables. The outputs of some studies were appended by limitations and precautions when using the developed parking demand generation. Some studies take different area types but mainly suburban area occupied the main concern of most of them. Survey tools used in developing parking generation were interviews, manual counting, and automatic counting (pneumatic). Some agencies or researchers developed parking generation rates and compared these with used regulations and codes of their areas. Parking accumulation of each land use was counted for peak period of adjacent street, for AM peak, and for PM peak, and this depends upon the objective of each study.

Linear Regression analysis and the average maximum parking demand ratio were the major tool in developing parking generation. In addition, sample size limits the accuracy and power of the output rate or equation and some studies mentioned that the accuracy developed will be enhanced in the future by expanding the sample size.

In summary, the level of efforts and details were different from one study to another based on several factors such as time of study, budget, availability of resources, and the condition of studied area.

The most common independent variables among the reviewed studies will be investigated. The ITE survey methodology, which is the most common among these studies, and the time horizons for conducting surveys will be taken into consideration in this research; specifics of the ITE used in this research will be presented in later chapters. Furthermore, non-CBD sites or peripherals of cities will be adopted in the survey in this study.

Chapter Three

Methodology

7.1 Background

This thesis covers several Palestinian cities in the West Bank. The nature of cities in the West Bank is different from other cities abroad. The differences are in terms of size, economic conditions, travel habits, and so on. These differences lead to the conclusion that the used methodology may differ a little bit from other research conducted abroad.

Literature review presented that almost all published studies counted accumulation of parking at different periods of time depending on the purpose of the study. The ITE has established guidelines for conducting parking occupancy counts (ITE, 2010). Estimating parking accumulation of each site by counting parked vehicles at specified intervals and at specific periods of time is the main purpose of surveying works.

The following sub sections show how the research was conducted.

7.2 Data Collection Procedure

For the purpose of preparing parking generation rates/equations, several parameters are required at the initial stage in order to get ready for preparing good data survey forms and traffic counting sheets. The following subsections provide details about main items in the data collection process:

7.2.1 Desk Review

This process intended for reviewing previous studies related to parking generation for different types of land uses. Literature review related to parking generation models or rates was reviewed.

7.2.2 Selection of Variables

Developing of parking generation rates or equations required gathering information about dependent and independent variables. Therefore, the selection of independent variables (parameters) depends on the nature of each land use such as residential land use patterns might use dwelling units, while retail land use might use number of employees and the same for office land use patterns. These variables are very important because parking generation is used to predict parking demand of specific land use in the form of equations or rates that will be built based on parameters (independent variables). Therefore, desk review provides several proposed variables that assist in designing survey form.

7.2.3 Sample Size Determination

Sample size was determined based on the ITE guide, statistical considerations (example; population size, ranges of data etc.) as well as some significance levels, and the available resources. Therefore, a minimum of four sites should be provided to conduct analysis and get useful information as stated by ITE (2010). The higher the sample size, the better reliability can be reached.

7.2.4 Sites Selection

Searching for suitable sites in each city was done using 2012and 2014 aerial photo of the West Bank. Moreover, the internet websites were helpful for getting useful information about some sites such as working days and hours, surrounding areas, nature of its services, location of site, and so on.

The researcher visited many sites in order to investigate and evaluate whether the proposed sites are appropriate and meet the set criteria, such as classification of area (urban, suburban, and rural). ITE (2010) suggested some guided criteria for selecting sites that enhance the outputs of study, these are:

- Site should be mature (i.e., at least two years old).
- Occupancy (i.e., at least 85 percent).
- Sites should be clear for the purpose of controlling parking counts on it.
- No abnormal condition besides selected site such as constructions.
- Accessible by the surveyors for collecting whole information.

ITE stated that sample size of at least four should be analyzed to develop regression model (McCourt, 2004). This would be appropriate for some land uses with limited availability.

In addition, evaluation of each site was undertaken in terms of how many persons (surveyors) are needed to conduct a traffic count, and at what location they should be. Moreover, meeting and coordinating with the responsible person of the site and meeting surveyors were conducted through site visits. In addition, access of site and ability of surveyor to conduct and control vehicular traffic in and out of the development were also taken into consideration in the selection process.

Furthermore, selected developments should have single land use because this research focuses on single land use rather mixed land uses.

7.2.5 Classification of Land Uses

Investigation about the residential, retail, and office land use, and taking into consideration the local experience and the existing environment in Palestinian cities, lead to the conclusion that these land uses can be classified into types, and types could be classified into classes. Residential land use type can be classified into different classes as attached housing (AH), detached housing (DH), and apartments (APH). While office land use was classified based on its nature and services they provided as general, institutional, and government land use classes. Retail land use was classified to three classes; strip, shopping center, medium to large supermarket, which is called later supermarket.

7.2.6 Data Collection Forms Design

The type of needed data was determined based on local experience and international and regional references. Special forms were prepared to collect necessary information of each selected site and to fulfill the need of estimating parking generation in terms of the required variables needed (See Appendix A). Moreover, special counting form was prepared for the purpose of the parking count survey (Appendix B).

7.2.7 Interviews

Interviews were held with people who have the merit to provide information about the surveyed development/site. Special interviews were made with large developments such as Plaza Mall and Jawwal Company to discuss the research and its objectives. Feedback from these developments about their requirements to conduct traffic count was taken into consideration such as coordination with the developments before conducting the survey.

Permission for conducting the traffic count during specific peak periods of each site was obtained. Some sites needed two types of permissions; one of them was local permission, which was requested from the owner/manager and the other permission was security permission from police centers, ministries, and associations.

Therefore, the communication tools used in getting full information about sites were: telephone, email, fax, mail, personal interviews, and social media. These tools were effectively used to improve the accuracy of counting and getting any future information about sites.

7.2.8 Count Periods and Durations

As stated by ITE, time of counting is connected to the purpose of the study; from the objectives and outcomes of this research, it is finding peak periods parking demand of each site during weekdays for the periods of AM and PM. In addition, time of day in which the adjacent streets of each site exposed to the highest volume of traffic is recorded in this study. Therefore, during data collection process information about the peak movements of vehicles in and out of site was recorded to minimize and restrict the period of parking count. As a result, two peak periods were developed, and counts based on 15-minute time interval was used. Time counting interval is appropriate since ITE used larger interval (I hour) in order to capture the variation during the whole day (ITE, 2010). Therefore, as counting interval decreases the probability of detecting the maximum accumulation increases, especially when the stay duration of parked vehicle is small.

Furthermore, this study covers only the weekdays (Monday, Tuesday, and Wednesday), and it does not take into account the weekends, holidays, and any abnormal day through the week.

7.2.9 Filtering/Screening

From among large number of visits for proposed sites; only specific number of sites for each land use was selected based on obvious and predefined criteria (ITE guides). The criteria as presented in the Methodology Chapter (section 3.2.4) were used to judge about the suitability of a site for conducting the study. Preliminary selection of sites was based on visual and not professional experience; therefore, after visits and interviews several preselected sites were excluded and replaced.

7.2.10 Parking Accumulation Survey Counts

Parking counts for each selected sites were conducted. Communications with surveyors throughout counting times were tedious; however, it was important to ensure good quality of data and in solving problems appeared during counts. Different numbers of surveyors (1 to 4 persons) were assigned to each site for the purpose of counting, based on the characteristics of each site and its surrounding area. Furthermore, communicating with police centers in some areas to facilitate the works of traffic parking surveyors was made before counting.

7.2.11 Data Aggregation

Collection of parking counts from surveyors with the data of the selected sites was organized. Therefore, two parking accumulations data per site were collected. Moreover, variables and descriptive information of each site were also collected. Figure 7.1 summarizes the data collection processes.

7.3 Data Analysis Process

The following sub-sections contain information about the process of data analysis that were used for developing parking generation models and rates.

7.3.1 Maximum Average Parking Accumulation

Parking accumulation is the number of parked vehicle at a specified time (Garber et al., 2010). It provides maximum parked vehicles during counting periods (AM, PM, and both).

Parking accumulation was used to predict the maximum parked vehicles during weekdays throughout conducting survey counts during different peak periods for each development. In order to identify the time of maximum accumulation; inventory study was conducted to minimize counting duration, and consequently, saving efforts. Average maximum parking accumulation represents the average maximum parked vehicles during two days of counts.

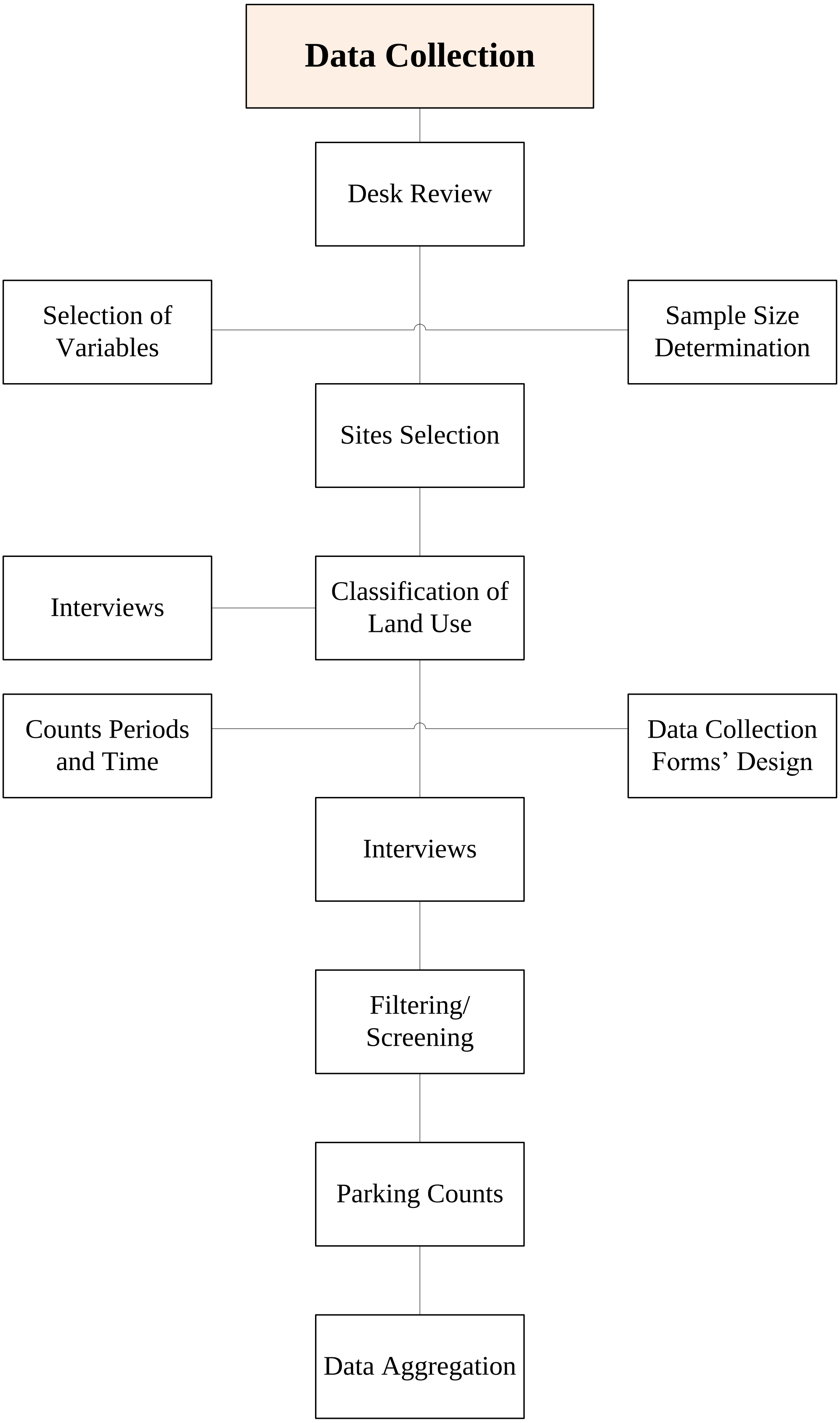

Figure 7.1: Flow Chart of Data Collection Process

7.3.2 Test of Normality

Normality plot with test was used to check the normality distribution of variables and residuals. Some studies showed that there are no need to check the normality of variables but the normality test of residuals are important (David, 2008). Thus, this study focused on the normality of residuals rather than variables.

The Shapiro-Wilk Test is more appropriate for small sample sizes (< 50 samples), but can also handle sample sizes as large as 2000. For this reason using the Shapiro-Wilk test is used as numerical means of assessing normality (Gray et al., 2012). Some researchers recommend the Shapiro-Wilk test as the best choice for testing the normality of data(Lillis, 2008).

The following is the hypothesis that was used in interpreting the normality tests. The null hypothesis is accepted if significant Shapiro-Wilk (Sig. W) is larger than 0.05 (assume 95% confidence level), otherwise the null hypothesis is rejected. For small sample sizes, normality tests have little power to reject the null hypothesis, therefore, small samples most often pass normality tests.

H0: Normal Distribution

H1: Not Normal Distribution

P value is the probability of type one error, and if this value is smaller than certain predefined value, the results will be significant and this means rejection of null hypotheses. Small sample size is misleading, so the previous conclusion is not correct about rejection or acceptation of null hypothesis for small sample size (Noru, 2012).

As a result, normality test of residuals (i.e. the difference between the obtained results from observation and a model/rate) in regression analysis is important and should be checked to avoid incorrect estimate for dependent variable; therefore, it was used in this study, and it is called validation.

7.3.3 Overview of Simple Linear Regression

Developing parking generation equations or rates requires statistical analysis in order to assure robust model and meaningful outputs. Relationship between dependent variable and single independent is called simple linear regression, and correlation between them known as bivariate Correlations.

The mathematical complexity of the model and the degree to which it is a realistic model depends on how much is known about the process being studied and on the purpose of the modeling exercise. Estimating parking demand is the main output of this study, so linear regression model method is used when the prediction forms problem objective of study (Rawlings et al., 1998).

A linear regression model consists of a dependent variable, independent variables, coefficients, and a constant. The dependent variable represents the Parking Demand (P) and independent variables (parameters) vary, and depend upon the type of each land use pattern. For example, retail used gross floor area (GFA), gross leasable area (GLA), and number of employees as independent variables. Simple regression used only one independent variable in developing the model. Simple linear regression model minimizes the least square error of the model and can be formulated in general as:

$$\mathbf{P = \beta_1 * X_1} + B_0 + \epsilon_i$$

P: Parking Demand

B_1: Slope (Coefficient)

B_0: intercept (constant)

X_1: Independent Variable

$\epsilon_{i:}$**:** Random error

Evaluation of regression analysis with intercept is based mainly on the graph, confidence interval, coefficient of determination, root mean square error (RMSE), and residuals plots (Shacham et al., 1996).

7.3.4 Rates

Average weighted mean, which is predominately used in several locations around the worlds, for example, UAE, Australia, and USA for estimating parking demand of different land uses. Rates could be used when the developed model does not have power to predict.

7.3.5 Goodness of Fit: Coefficient of Determination (R Square)

Best fit or regression line, which stands for the line that matches largest number of points or close enough from them. Distances between points and line should be minimized for regression line and these distances are called residuals (the difference between observed value and the predicted value).

R^2 or adjusted R^2 measures the goodness of fit of the developed model. The adjusted R^2 adjusts the values of R^2 when sample size is small because the estimated R^2 of small sample size tends to be higher than actual R^2 for population. Adjuster R^2 is used when it differs by large amount from R^2 (Green et al., 2010).

As R^2 is close to 1, this means that there is high correlation between associated variables in the model. R^2 is used to express the variation in the percentage of number of parked vehicles associated with the variance in the sample size of independent variable (McCourt, 2004). As stated before, this coefficient is strongly used for comparison among different regression with intercept models. And as stated and guided by ITE, it is preferable to use R^2 when there is sufficient sites and R^2 is larger than 0.5 (ITE 2010).

$$R^2=1-\frac{\text{Sum of Squares of Residual (SS Residual)}}{\text{Sum of Squares Total (SS Total)}}$$

7.3.6 Statistical Tests

When parking generation is developed, some tests should be performed to estimate the accuracy of these developed models. Two types of tests involved in regression analysis, these are:

7.3.6.1 Significance of Overall Model: F- Test

Analysis of Variance (ANOVA) provides information on how the regression equation accounts for variability in the independent variable. F-Test is used to test the significance of the generated model at predefined confidence level. The reliability of the developed models depends on this test (Montgomery et al., 2002).

7.3.6.2 Testing the Significance of Coefficients in Model: T- Test

T-Test was used to test the hypothesis about coefficients included in the generated model by checking the significance of coefficients included in the developed model. Test of hypotheses can be done using the T-test null hypothesis (H0), which is whenever a coefficient is not significant and does not impact the model at predefined confidence level. On the other hand, alternative hypothesis (H1) shows that the coefficient is significant and affects the model (Montgomery et al., 2002). Figure 7.2summarizes data analysis processes, as shown below.

7.4 Software

Statistical software packages were used to analyze the collected data such Statistical Package for the Social Sciences (SPSS).

7.5 Developing Parking Generation Model

The most important step in developing parking generation is the selection of appropriate parameters and this could be done using statistical analysis.

Parking generation model based on single parameters such as how many parked vehicles are presented if there are X-dwelling units, employees, GFA, GLA, inhabitants, etc. In addition, parking rates were developed in terms of different variables (parameters) for each class of the selected types of land uses. Simple regression analysis forms the best way for developing their models.

7.6 Models Verification and Validation

Validation process is used to test the accuracy of developed model. Coefficient of determination and square errors are not enough to support the produced model. Residuals should show a random distribution in order to represent the data in suitable fit. Moreover, residual sum should be zero. Residuals are plotted in y- axis while independent variable in X-axis, and if

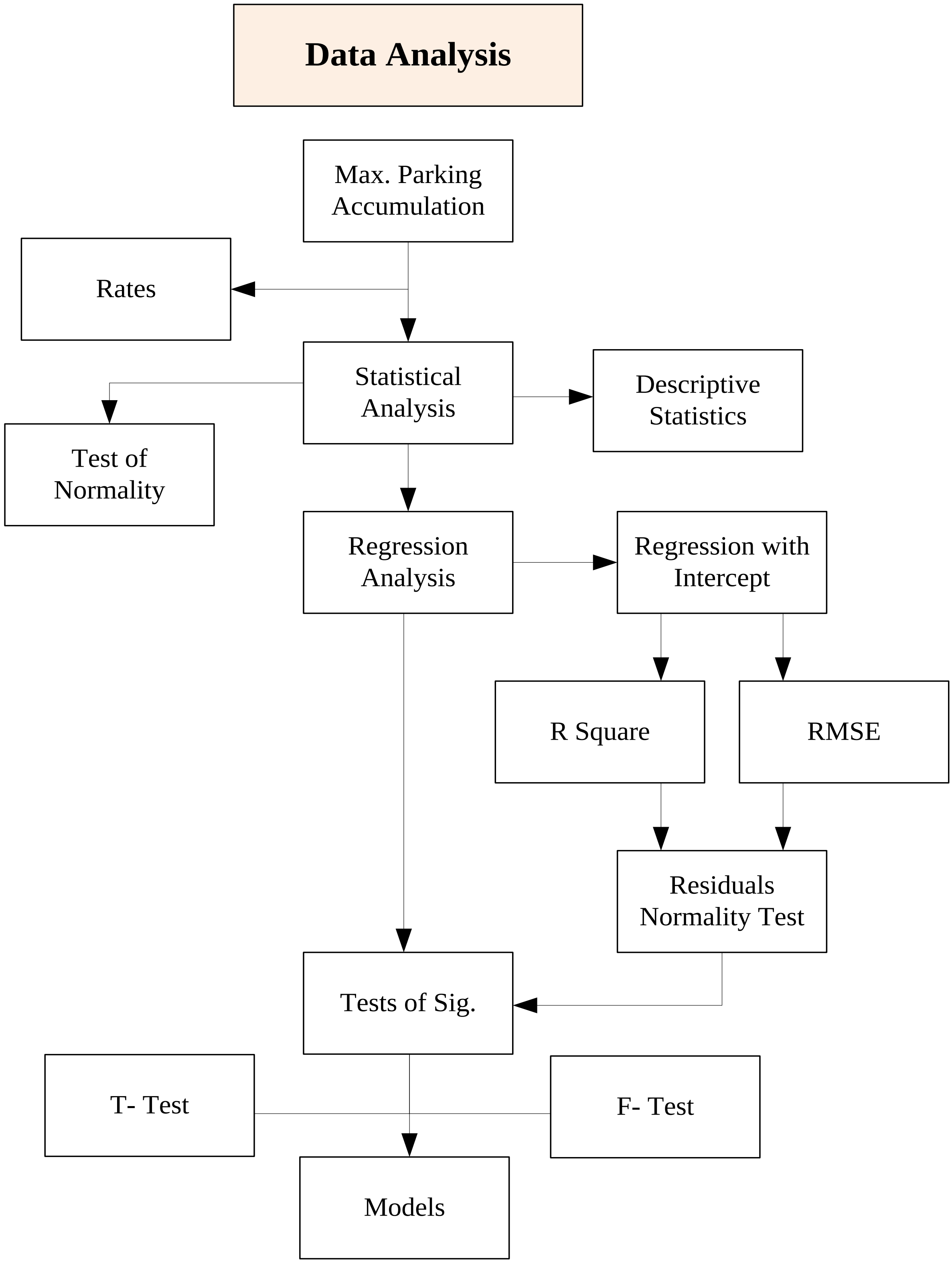

Figure 7.2: Flow chart of Data Analysis Process

the data are distributed randomly around X-axis the linear regression is appropriate to represent (Minitab, 2015).

Model verification is important to see the error between the results of the model and the observed value. Verification generally comes first-done before validation. Furthermore, model verification is important to see the ability of model in predication in the future.

Therefore, a random sample was selected from some classes, which have sufficient sample size, in order to verify the model (about 15% of sample size).

7.7 Selection of Study Area and its Characteristics

Retail, Office, and Residential land use types have already been identified as the focus of this study for the initial stage of building database (local parking generation rates or equations) for Palestinian cities. These developments represent some of the main types of major developments in Palestinian cities locating mainly in the suburban areas.

The number of surveyed sites depends on the availability of appropriate developments and sites, the possibility of conducting the survey, budget, and expected reliability of such survey results.

Chapter Four

Field Survey and Data Collection

8.1 Study Area

In this research, the collected data are distributed in the West Bank; and mainly in West Bank cities (Hebron, Ramallah, Albireh, Bethlehem, Jenin, Tulkarem, Nablus, Qalqilia, and Jericho). Residential, office, and retail sites were studied in this research that were located in suburb areas and isolated from overlapping activities with other land uses.

8.2 Sample Size

According to the ITE (2004 and 2010) a minimum of 4 points are required in order to undertake statistical analysis and generating simple regression model. In this research, more than 4 sites for each of residential, retail, and office were selected to the conduct parking generation study.

Seventy three sites were selected and distributed among the three types of land uses. Each land use type has several sites that were distributed in several main cities in the West Bank. There are 23 sites of residential land use, 26 sites of office land use, and 24 sites of retail land use types in this study. The residential land use consists of 8 DH, 5 AH, and 10 APH. Office land use consists of 14 sites of government office, 7 sites of institutional office, and 5 sites of general office. Retail land use consists of 15 sites of supermarket class, 8 sites of strip retails land use, and only one shopping center land uses. Additional sites for some land use classes were selected for the verification purposes.

All above land uses and their classes are shown in tables hereafter.

8.3 Types of Data Collection

Collected data contains information about independent variables such as gross floor area (GFA), number of employees, or number of dwelling units in apartment buildings. In addition, brief information about each site and surrounding area to avoid misunderstanding the selected sites was collected.

Access of public transportation to the selected sites is included in the survey forms as shown in this chapter. The nature of the selected sites and the reliability of available public transportation are factors that might not affect parking generation in this study area. Therefore, public transportation factor is not included in the analysis chapter.

The following two points summarized the nature of data acquired from the selected sites:

Development/Site's Characteristics

- Descriptive Data: it depicts the site location and its relationship with surrounding main features such as adjacent streets or neighborhood.

- Statistical Data: it involves some statistics about the population in each site, and some engineering calculations.

Parking Accumulation Survey Count

Manual parking occupancy counts, which represent the number of parked vehicle at specific time during two peak periods of a day, was conducted at each site for two weekdays.

8.4 Survey Forms

Special forms were used for the purpose of data collection process, which include descriptive and statistics. Useful information of each type of land uses was involved in separate form (i.e., residential form, retail form, and office form). The recorded information in the prepared forms is description of each site, time of data acquisition, day, operational time, etc. (see Appendix A). The dependent variable is the measured variable and it is the response of the independent variable. Independent variables are called repressors, explanatory variables, and predictors (Montgomery et al., 2002). Dependent and independent variables form the major items in the forms because they are the base for developing parking generation. The prepared parking accumulation sheets were used for collecting information about the parking demand for each land use.

8.5 Field Survey

This presents information about the survey process of collecting parking counts. Number of vehicles parked at each site during 10 minutes interval during the rush hour and peak of the adjacent street. Survey forms and sheets were used in conducting data collection. In addition, data aggregation of parking accumulation and the characteristics of each site, as shown in the following sections, are conducted as well.

8.6 Data Aggregation

Acquired data includes collection of information about each site such as descriptive and statistical information. The following points summarized the aggregated data of each type of land use and their classifications. This process included office work, interviews, and field visits.

The attained information from survey forms are descriptive data and proposed variables, which are classified to dependent and independent. Different independent variables were selected in order to build good estimates of the dependent variable. Independent variables were derived from several resources and local experience.

8.6.1 Residential Land Use

The independent variables are number of inhabitants, number of occupied units, and number of unoccupied units in each development.

8.6.1.1 Attached Housing Class (AH)

Attached housing forms one of the predominant land use patterns of residential land use in Palestinian cities. Table 8-1summarizes the collected data of this class of land use in terms of name of development, number of inhabitants, number of occupied, total dwelling units, number of vehicles that inhabitants have, and occupancy of development.

Only five sites/developments were studied because there are a few developments found in the study area (among the explored sites) that comply with almost all the predefined specific criteria (ITE, 2010).

8.6.1.2 Detached Housing Class (DH)

Detached housing or villas are a common type of building in all cities in the West Bank. This class is a single house over a single parcel. Eight sites were studied, and the results as shown in

Table 8-2. There are three sites that are far away from public transport source (more than 400 m), however, this does not affect the parking generation nature.

8.6.1.3 Apartment Housing Class (APH)

Table 8-3 shows the data collection of APH which contains 10 sites distributed in the study area. These sites have been serviced by public transportation except one site, which is Al Ajlouni Housing site.

Table 8-1: Collected Data about Attached Housing Land Use (AH)

No.	Name of Development/s	Location/City	No. of Inhabitants	No. of Occupied AH Units	Total No. of AH Units	No. of Owned Vehicles	Occupancy (%)
1	Doctors' Housing - Al Jabriat	Jenin	108	24	36	25	67
2	Doctors' Housing	Nablus	180	36	52	30	69
3	Al Ata'ot Housing	Qalqilia	59	13	14	10	93
4	An Najmeh Housing - Abu Qash	Ramallah and Albireh	115	23	48	28	48
5	Education Housing	Tulkarem	80	23	31	11	74

Table 8-2: Collected Data about Detached Housing Land Use (DH)

No.	Name of Development/s	Location/City	No. of Inhabitant	No. of Occupied Dwelling Units	Total No. of Dwelling Units	No. of Owned Vehicles	Occupancy (%)
1	Engineers Housing - Beit Sahour	Bethlehem	158	45	45	44	100
2	Az Zaytona Housing	Hebron	308	76	76	141	100
3	Al Khedawi Housing	Jericho	28	7	7	9	100
4	Engineers Housing - Al Makhfeya	Nablus	225	45	81	100	55
5	Tayba Housing	Nablus	66	16	17	27	94
6	Swaileh Villas	Qalqilia	38	8	8	9	100
7	Al Dawha Housing- Bir Zeit	Ramallah and Albireh	187	36	51	48	70
8	Social Affairs Housing	Tulkarem	142	45	54	45	83

Table 8-3: Collected Data about Apartment Housing Land Use (APH)

No.	Name of Development/s	Location/ City	Total GFA (m²)	Average Apartment Area (m²)	No. of Inhabitant	No. of Occupied Dwelling Units	Total No. of Dwelling Units	No. of Owned Vehicles	Occupancy (%)
1	Yasso' Child Housing	Bethlehem	2800	105	220	24	24	24	100
2	Al Mohtaseb Building	Hebron	2320	125	87	18	23	11	78
3	Palestinian Housing	Jenin	7600	115	384	64	64	12	100
4	Al Ajlouni Housing	Jericho	3150	115	120	25	40	4	63
5	ANNU Housing - Al Ma'jeen	Nablus	11648	150	382	61	77	39	79
6	An Noor Building	Nablus	4400	140	135	26	32	6	81
7	Old Qalqilia Housing	Qalqilia	2340	160	70	14	16	13	88
8	New Qalqilia Housing	Qalqilia	6200	105	315	58	72	26	81
9	BirZeit University Housing	Ramallah and Albireh	5250	170	120	30	30	30	100
10	Al Jawhara Tower	Tulkarem	5250	135	126	29	33	19	88

8.6.2 Office Land Use Class

Public transportation routes serviced all sites in this type of land use and this was derived from the survey form. Representative sample size of general, institutional, and government office were selected as shown in the next subsections. Several independent variables were included in the survey forms such as GLA, GFA, number of workers/employees (including owners who are working), and number of vehicles. General Office Class

Standalone General Office land use class was hard to find because there were conflicts with other land uses types. Therefore, only 5 sites were studied that have a single land use or the general office predominant use (95%).

Table 4-4, Table 4-5, and Table 4-6 present the collected information about the three classes of office land use.

Table 4-4 summarizes the collected information about each site of office land use, as shown below. There is an access of public transportation in each site within 400 m.

8.6.2.1 Institutional Office Class

Institutional land use class is a land use, which takes the office style with great capability such as private garage, large building, etc. Seven sites were studied as shown in Table 8-5. There is an access of public transportation in each site within 400 m.

Table 8-4: Collected Data about General Office Land Use Class

No.	Name of Development/s	Location/ City	No. of Workers	Total GFA (m^2)	Total GLA (m^2)	No. of Owned Vehicles
1	Aabdeh Building - Morra Intersection	Hebron	42	1655	1160	21
2	Al Isra' Building - Faisal Str.	Nablus	35	540	380	10
3	Jawwal Building - Rafidia Main Str.	Nablus	45	1000	900	15
4	Ugarit Building - Near Al Ersal Str.	Ramallah and Albireh	25	1000	1000	20
5	Bdran Complex	Tulkarem	23	1425	1425	15

Table 8-5: Collected Data about Institutional Office Land Use Class

No.	Name of Development/s	Location/ City	No. of Workers	Total GFA (m^2)	Total GLA (m^2)	No. of Owned Vehicles
1	Palestinian Insurance Company	Bethlehem	12	250	250	8
2	Telecommunication Company - Paltel	Jenin	25	1000	1000	20
3	Telecommunication Company - Paltel	Nablus	390	7200	7200	196
4	Al Mashriq Insurance Company	Ramallah and Albireh	99	3130	3130	55
5	Alwatanya Company	Ramallah and Albireh	300	4067	3246	150
6	Jawwal Company - Main Headquarter	Ramallah and Albireh	600	12500	12500	275
7	Telecommunication Copmany - Paltel	Tulkarem	43	900	700	24

8.6.2.2 Government Office Class

Government office facilities are available in each city. Fifteen sites were studied based on the predefined site selection criteria or guides and the location of each site is out of city center. There is an access to public transportation for each site within 400 m. Table 8-6 summarizes necessary information for developing parking generation.

Table 8-6: Collected Data about Government Office Land Use Class

No.	Name of Development/s	Location /City	No. of Workers	Total GFA (m^2)	Total GLA (m^2)	No. of Owned Vehicles
1	Directorate of Religious Endowments	Bethlehem	36	400	400	21
2	Educational Guidance Office	Bethlehem	22	600	300	6
3	Directorate of Public Works	Hebron	30	400	400	15
4	Governorate Building	Hebron	63	2000	2000	25
5	Directorate of Education	Jenin	110	1100	950	40
6	Directorate of Education	Jericho	75	850	850	12
7	Directorate of Education	Nablus	54	1000	1000	29
8	Governorate Building	Qalqilia	43	1208	690	14
9	Ministry of Agriculture	Ramallah and Albireh	190	3950	3950	35
10	Ministry of State	Ramallah and Albireh	80	2000	2000	27
11	Governorate Building	Salfit	41	1823	1373	15
12	Directorate of Education	Tubas	81	1200	1200	26
13	Directorate of Education	Tulkarem	123	1570	1440	45
14	Governorate Building	Tulkarem	43	1500	1500	21

8.6.3 Retail Land Use

As noted in the methodology chapter, many sites were selected within the study area that fulfills the predefined criteria. The studied sites were 17 supermarket land use class and 8 strip retail. In addition, one shopping center was studied, which is the only one in the West Bank that complies to the criteria. GLA, GFA, and number of workers are the main independent variables of retail land use. Table 8-7, Table 4-8, and Table 4-9 present the collected information of retail land use classes.

8.6.3.1 Supermarket Class

Supermarket covers almost large percent of retail. The selected sites for the purpose of developing parking generation were selected based on being in the peripheral area and fulfilling the predefined criteria of ITE for site selection step. The selected sites shared high percentage of similar characteristics and scale. Small shops were excluded, supermarket sites without acceptable surrounding environments were also excluded, and variations among cities were also included.

8.6.3.2 Strip Retail Class

The selection of strip retail land use class was difficult because there were obstacles facing the researcher such as almost all strip retail are close to urban areas and the existence of other land use types besides strip retail leads to excluding the site. Public transportation routes serviced all sites of this type of land use. Shopping Center Class

Shopping center represents the largest size market in terms of area, diversity of available goods, etc. The only shopping center available in the West Bank cities that complies with the site selection criteria is Plaza Mall, in Albireh City as shown in Table 4-9. Access of public transportation is available at this site.

Table 8-8 shows the collected information about strip retail classes in terms of number of workers, GFA, gross leasable area (GLA), and number of vehicles owned by workers and development.

Table 8-7: Collected Data about Supermarket Land Use Class

No.	Name of Development/s	Location/ City	No. of Workers	Total GFA (m^2)	Total GLA (m^2)	No. of Owned Vehicles
1	Al Moghrabee Supermarket	Bethlehem	5	240	240	5
2	Khater Supermarket	Bethlehem	5	200	200	3
3	Al Yazan Supermarket	Hebron	5	170	170	7
4	Supermarket and Coffee of Abu Mazin	Hebron	5	520	520	2
5	Saif Side Supermarket	Jenin	3	300	300	2
6	Ar Rjoub Supermarket	Jericho	2	113	113	1
7	Bravo Supermarket - Rafidia Main Str.	Nablus	15	650	650	2
8	Wahet Al Makhfeya	Nablus	6	320	320	2
9	Al Karmel Supermarket	Qalqilia	14	700	700	2
10	Bravo Supermarket - Al Masyoun	Ramallah and Albireh	12	1000	1000	1
11	Bravo Supermarket - Al Tyreh	Ramallah and Albireh	15	1200	1200	2
12	Green Land Supermarket - Al Tyreh	Ramallah and Albireh	3	300	300	1
13	Almadina Supermarket	Tubas	2	110	110	1

No.	Name of Development/s	Location/ City	No. of Workers	Total GFA (m^2)	Total GLA (m^2)	No. of Owned Vehicles
14	Al Islameya Supermarket	Tulkarem	12	490	490	5
15	Dallas Supermarket	Tulkarem	4	420	420	2

8.6.3.3 Shopping Center Class

Shopping center represents the largest size market in terms of area, diversity of available goods, etc. The only shopping center available in the West Bank cities that complies with the site selection criteria is Plaza Mall, in Albireh City as shown in Table 4-9. Access of public transportation is available at this site.

Table 8-8: Collected Data about Strip Retail Land Use Class

No.	Name of Development/s	Location/ City	No. of Workers	Total GFA (m^2)	Total GLA (m^2)	No. of Owned Vehicles
1	Alkarkafah Strip Retail	Bethlehem	9	210	210	6
2	Ras Aljora Area Strip Retail	Hebron	28	980	980	17
3	Asira Ash Shamalieh Main Street Strip Retail	Nablus	11	275	275	9
4	Ishtar Shops Strip Retail	Nablus	6	200	200	4
5	Near Fehmi Gas Station Strip Retail	Qalqilia	8	196	196	6
6	Al Masyoun Strip Retail	Ramallah and Albireh	14	1200	1200	4
7	Near Al Quds Street Strip Retail	Ramallah and Albireh	5	180	180	3
8	Near Telecommunica-tions Company Strip Retail - Paltel	Tulkarem	11	265	265	5

Table 8-9: Collected Data about Shopping Center Land Use Class

No.	Name of Development/s	Location/ City	No. of Workers	Total GFA (m^2)	Total GLA (m^2)	No. of Owned Vehicles
1	Plaza Mall	Albireh	37	5500	4200	20

8.7 Parking Accumulation

Two days from among the three typical weekdays (Monday, Tuesday, and Wednesday) were used to conduct traffic survey count for each site. The peak periods of adjacent streets of some sites coincided with the peaks of the studied sites during AM and PM periods, and this was noticed forall sites of office land use type. In office land use, three periods were analyzed which are: AM, PM (which represent the peaks of the sites and adjacent streets during morning and evening), and the peak of the development, which represents the maximum recorded value during all periods, and this should be used for design purposes.

Different time periods during the day are used for conducting the parking accumulation. The difference in counting times was due to the nature of the surveyed sites, as well as the surrounding conditions. Parking accumulation is conducted during the following hours: 7:00-9:00 AM and 14:00-17:00 PM for residential land use, 7:00-10:45 AM and 12:00-17:00 PM for office land use, and 7:00 AM to 21:00 PM for retail land use.

8.7.1 Residential Land Use

Parking accumulation of residential land use was counted manually for two days, and two peak periods with different hours of the adjacent streets in each day (AM and PM). Table 4-10, Table 4-11, and Table 4-12 show the average peak parking accumulation for the two periods which represents the average maximum peak of the two-day count (Parking Demand).

Table 8-10: Attached Housing Land Use Class Parking Accumulation

No.	Name of Development/s	Location/City	Parking Demand (AM)	Parking Demand (PM)
1	Doctors' Housing - Al Jabriat	Jenin	17	13
2	Doctors' Housing	Nablus	36	12
3	Al Ata'ot Housing	Qalqilia	15	10
4	An Najmeh Housing - Abu Qash	Ramallah and Albireh	35	21
5	Education Housing	Tulakrem	12	9

Table 8-11: Detached Housing Land Use Class Parking Accumulation

No.	Name of Development/s	Location/City	Parking Demand (AM)	Parking Demand (PM)
1	Engineers Housing - Beit Sahour	Bethlehem	40	47
2	Az Zaytona Housing	Hebron	49	45
3	Al Khedawi Housing	Jericho	4	6
4	Engineers Housing - Al Makhfeya	Nablus	68	45
5	Tayba Housing	Nablus	12	14
6	Swaileh Villas	Qalqilia	12	18
7	Al Dawha Housing - Bir Zeit	Ramallah and Albireh	48	43
8	Social Affairs Housing	Tulkarem	26	12

Table 8-12: Apartments Housing Land Use Class Parking Accumulation

No.	Name of Development/s	Location/City	Parking Demand (AM)	Parking Demand (PM)
1	Yasso' Child Housing	Bethlehem	23	13
2	Al Mohtaseb Building	Hebron	5	5
3	Palestinian Housing	Jenin	12	13
4	Al Ajlouni Housing	Jericho	3	4
5	ANNU Housing - Al Ma'jeen	Nablus	26	23
6	An Noor Building	Nablus	9	8
7	Old Qalqilia Housing	Qalqilia	13	24
8	New Qalqilia Housing	Qalqilia	24	38
9	BirZeit University Housing	Ramallah and Albireh	27	23
10	Al Jawhara Tower	Tulkarem	11	9

8.7.1 Office Land Use

The same counting methods of residential land use and periods were used for developing average maximum accumulation of parked vehicles for office land use. Table 4-13, Table 4-14, and Table 4-15 show the outputs of survey process. Parking demand herein and after represents the average peak value of the two-day parking counts. Whilst, maximum parking demand is the maximum parking demand of the development.

Table 8-13: General Office Class Parking Accumulation

No.	Name of Development/s	Location/City	Parking Demand (AM)	Parking Demand (PM)	Max. Parking Demand
1	Aabdeh Building - Morra Intersection	Hebron	9	8	9
2	Al Isra' Building - Faisal Str.	Nablus	21	34	34
3	Jawwal Building - Rafidia Main Str.	Nablus	8	15	15
4	Ugarit Building - Near Al Ersal Str.	Ramallah and Albireh	16	18	18
5	Bdran Complex	Tulkarem	14	13	14

Table 8-14: Institutional Office Class Parking Accumulation

No.	Name of Development/s	Location/City	Parking Demand (AM)	Parking Demand (PM)	Max. Parking Demand
1	Palestinian Insurance Company	Bethlehem	17	12	17
2	Telecommunication Company - Paltel	Jenin	21	14	21
3	Telecommunication Company - Paltel	Nablus	159	153	159
4	Al Mashriq Insurance Company	Ramallah and Albireh	31	48	48
5	Alwatanya Company	Ramallah and Albireh	112	127	127
6	Jawwal Company - Main Headquarter	Ramallah and Albireh	310	313	313
7	Telecommunication Copmany - Paltel	Tulkarem	16	11	16

Table 8-15: Government Office Class Parking Accumulation

No.	Name of Development/s	Location/City	Parking Demand (AM)	Parking Demand (PM)	Max. Parking Demand
1	Directorate of Education	Bethlehem	8.5	8	10
2	Directorate of Religious Endowments	Bethlehem	7	6	8
3	Educational Guidance Office	Bethlehem	7	6	7
4	Directorate of Public Works	Hebron	19	17	21
5	Governorate Building	Hebron	26	22.5	27
6	Directorate of Education	Jenin	30.5	29	32
7	Directorate of Education	Jericho	15	13.5	18
8	Directorate of Education	Nablus	26.5	30	30
9	Governorate Building	Nablus	15.5	19.5	21
10	Ministry of Agriculture	Ramallah and Albireh	38	33.5	40
11	Ministry of State	Ramallah and Albireh	19.5	22.5	25
12	Governorate Building	Salfit	23.5	34.5	39
13	Directorate of Education	Tubas	24.5	26	28
14	Directorate of Education	Tulkarem	30.5	24	33
15	Governorate Building	Tulkarem	22	23.5	29

8.7.2 Retail Land Use

Medium to large Supermarket, Strip, and Shopping Center Retail land use classes were counted for two days in two peak periods to capture the highest peak. There is no AM and PM unified parking accumulation for all sites because the peak periods of each site are different from another. Therefore, parking counts of two peaks were conducted in order to capture the maximum parking demand of the facility.

Table 4-16, Table 4-17, and Table 4-18 show the average maximum parking accumulation of each development during the two weekdays.

Table 8-16: Supermarket Parking Accumultation

No.	Name of Development/s	Location /City	Parking Demand (First Peak)	Parking Demand (Second Peak)	Max. Parking Demand
1	Al Moghrabee Supermarket	Bethlehem	5	5	5
2	Khater Supermarket	Bethlehem	7	7	7
3	Al Yazan Supermarket	Hebron	6	10	10
4	Plaza Supermarket - Bravo	Hebron	12	10	12
5	Supermarket and Coffee of Abu Mazin	Hebron	3	8	8
6	Saif Side Supermarket	Jenin	6	7	7
7	Ar Rjoub Supermarket	Bethlehem	9	6	9
8	Bravo Supermarket - Rafidia Main Str.	Nablus	16	19	19
9	Wahet Al Makhfeya	Nablus	3	4	4
10	Al Karmel Supermarket	Qalqilia	8	7	8
11	Bravo Supermarket - Al Masyoun	Ramallah and Albireh	19	15	19
12	Bravo Supermarket - Al Tyreh	Ramallah and Albireh	24	23	24
13	Green Land Supermarket - Al Tyreh	Ramallah and Albireh	10	18	18
14	Max Mar Supermarket - Al Ersal Main Str.	Ramallah and Albireh	59	40	59
15	Almadina Supermarket	Tubas	3	4	4
16	Al Islameya Supermarket	Tulkarem	5	7	7
17	Dallas Supermarket	Tulkarem	4	4	4

Table 8-17: Strip Class Parking Accumulation

No.	Location of Strip	Location/ City	Parking Demand (First Peak)	Parking Demand (Second Peak)	Max. Parking Demand
1	Alkarkafah Strip Retail	Bethlehem	6	7	7
2	Ras Aljora Area Strip Retail	Hebron	19	19	19
3	Asira Ash Shamalieh Main Street Strip Retail	Nablus	6	9	9
4	Ishtar Shops Strip Retail	Nablus	6	8	8
5	Near Fehmi Gas Station Strip Retail	Qalqilia	8	7	8
6	Al Masyoun Strip Retail	Ramallah and Albireh	15	14	15
7	Near Al Quds Street Strip Retail	Ramallah and Albireh	11	9	11
8	Near Telecommunication Company Strip Retail - Paltel	Tulkarem	6	7	7

Table 8-18: Shopping Center Class Parking Accumulation

No.	Name of Development/s	Location /City	Parking Demand (First Peak)	Parking Demand (Second Peak)	Max. Parking Demand
1	Plaza Mall	Ramallah and Albireh	120	124	124

Chapter Five

Data Analysis and Outputs

9.1 Introduction

This chapter analyzes collected data and provides discussion of the outputs. Statistical tools are used to estimate parking demand for morning, evening, and peak periods.

The following sections summarize the outputs of data analysis of each class of land use using SPPS.

9.2 Simple Regression Analysis

Neither regression nor correlation analyses can be interpreted as estimating cause-and-effect relationships. They can indicate only how or to what extent variables are associated with each other. Confidence interval of 95% is used when there are more than 20 sites available as noted by the Institute of Transportation Engineers (ITE, 2010). Low confidence level could be considered for small sample size such as 68% (one std. from the mean) and 95% (approximately two std. from the mean) (Smith, 1990). Higher confidence level is recommended to ensure high percentage of reliability.

9.2.1 General Form of Parking Generation Models/ Equations

The collected data are analyzed using regression analysis as follow:

Simple Regression with Intercept

The following equations represent the formulas of produced parking generation model.

$$P = \beta_1 * X_1 + C \rightarrow \textbf{Linear}$$

$$Ln(P) = \beta_1 * Ln(X) + C \rightarrow \textbf{Power}$$

$$Ln(P) = \beta_1 * X + C \rightarrow \textbf{Exponential}$$

$$P = \beta_1 * Ln(X) + C \rightarrow \textbf{Logarithmic}$$

P: Parking Demand (Dependent Variable)

X: Independent Variable

β_1: Variable Coefficient (Slope)

C: Constant (Intercept)

Note: The above equations have an estimation error (ϵ_i) as shown in Methodology Chapter (sub-section 3.3.3)

9.3 Data Analysis

Linear and nonlinear regression analysis produced models, which are used in predicting parking demand. Logarithmic, power, exponential and linear regression models are conducted in the collected data and the best fit model is included. These developed models have various powers of prediction; therefore, comparison among models of same independent variable should be based on the residuals plot, confidence level, R^2, and RMSE (standard error of the estimate) (Shacham et al., 1996). Furthermore, validation of models and verification of models/rates are good indicators for their accuracy in prediction.

The following subsections present the analysis of collected data associated with the three land uses and their classes. The most appropriate form of the model for each independent variable is provided. Other forms were investigated; however, not presented.

Analysis of one example is presented in details (AH class), and only the main outputs of others classes are presented in tables.

The final outputs of this chapter is summarized in Appendix (D) and sample form is shown in Table 5-1, which contains the produced models and rates, and their associated parameters such as average size of data, standard deviation, confidence interval, data plot, equation, R^2, residuals plot, test of normality of residuals, mean, range, minimum, maximum, and coefficient of variation (CV).

Table 9-1: Parking Generation Sheet Form

Average Peak Parking Demand vs. Number of Inhabitants
Survey Time Range
Number of Sites
Average Size
Standard Deviation
Coefficient of Variation (CV)
Range
Rate
85th Percentile
33rd Percentile
Model
Model Confidence Interval
Coefficient of Determination (R^2)

9.3.1 Descriptive Statistics

This section represents descriptive statistics that is used to organize, interpret, and clarify the collected data in a meaningful form. Descriptive statistics of variables are presented in Appendix (C). These statistics should be used for interpreting the results of analysis and ease of understanding the data and the models such as mean, standard deviation, range, and skewness, which is used to indicate degree of asymmetry of the probability distribution of a random variable about its mean (MacGillivray et al., 1988). In addition, Coefficient of Variation (CV) shows the variation of data around the mean and measures the concentration of data. This coefficient is computed by dividing the standard deviation by the mean and it is expressed as percentage. Importance of this coefficient is to remove the misunderstanding of variance when it has small value because this coefficient gives percentage with respect to mean. There are no specific limits for CV but a value of 10% could be the acceptable upper limit (Wesrgard, 1999).

9.3.2 Residential Land Use

Parking accumulation during AM and PM peak periods of the adjacent streets are analyzed. Indeed, some agencies or references use vehicle ownerships as parking demand and add small percentage of 10% and 5% for circulation and visitors, respectively (Willson, 2005).

Table 9-2 and Table 9-3, which are examples of descriptive statistics of independent variables, they will be shown in the final outputs of parking generation models.

Table 9-2: Descriptive Statistics for No. of Inhabitants of AH

Mean	Std. Deviation	CV	Minimum	Maximum	Range
108.40	45.87	42%	59	180	121

It is obvious from Table 9-2 that the average number of inhabitants is 108.4. The maximum value in the collected data of AH is 180 inhabitants whereas the minimum is 59 inhabitants.

Table 9-3: Descriptive Statistics for No. of Occupied AH Units

Mean	Std. Deviation	CV	Minimum	Maximum	Range
23.8	8.17	34%	13	36	23

The average number of occupied houses is 23.8 as shown in Table 9-3. The range of values is 23 and the CV is 34%.

Therefore, good inferences about the produced model or rate could be done when descriptive statistics of parking demand are provided.

The following subsections summarize the process of statistical analysis of each one of three classes of residential land use.

9.3.2.1 Regression Analysis

AH, DH, and APH classes are analyzed in this section. It is noted that almost all selected sites have an occupancy value more than 85% as shown previously in the data collection chapter, which consistent with the set criteria.

Parking generation is analyzed using regression analysis, as shown below.

- **Regression Analysis with Intercept**

Table 9-4 presents the main outputs of regression analysis, which includes the relationship between dependent variable and single independent variable (number of occupied houses and number of inhabitants).

Furthermore, it provides an indication about the power or accuracy of the attained model in prediction.

Table 9-4: AH Land Use Class Regression Analysis Parameters

Parking Demand (AM) vs. Number of Occupied AH Units		
R	R^2	Std. Error of the Estimate
0.644	0.414	10.209
Parking Demand (AM) vs. Number of Inhabitants		
R	R^2	Std. Error of the Estimate
0.811	0.658	7.800

The following points are interpretation of the results of regression analysis that were included in the summary tables.

– Goodness of Fit: Coefficient of Determination R^2

Assessing the accuracy of prediction is achieved by studying R^2. From Table 9-4, about 40% and 65% of variation in parking demand in the AM period is explained by number of occupied houses and number of inhabitants, respectively.

– Significance of Model: F- Test

Table 5-5 shows Analysis of Variance (ANOVA) results, which are used to test the significance of R and R^2 using F-test. In conclusion, at 95% confidence interval, all independent variables that were used in developing the parking demand model in the AM period are not good predictors because the 0.241 and 0.96 are larger than 0.05. Decreasing the confidence interval will be appropriate here due to small sample size, for example, 68% is appropriate here.

Table 9-5: AH Simple Linear Regression ANOVA Table

Parking Demand (AM) vs. Number of Occupied AH Units				
	Sum of Squares	Mean Square	F	Sig.
Regression	221.323	221.323	2.123	0.241
Parking Demand (AM) vs. Number of Inhabitants				
	Sum of Squares	Mean Square	F	Sig.
Regression	351.471	351.471	5.777	0.096

–Model Coefficient Significance (Constant): T- Test

Coefficients in Table 9-6 are used to build the model by providing the coefficients of independent variable and the constant (β and c). Therefore, at 95% the t- test showed that H0 is correct (0.937 and 0.938>0.05) for both models, respectively.

Table 9-6: AH Simple Linear Regression Coefficients

Parking Demand (AM) vs. Number of Occupied AH Units					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.323	15.560		0.085	0.938
Number of Occupied AH Units	0.911	0.625	0.644	1.457	0.241
Parking Demand (AM) vs. Number of Inhabitants					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.849	9.854		0.086	0.937
Number of Inhabitants	0.204	0.085	0.811	2.403	0.096

From Table 9-6, the Parking Generation Model for AH class during AM period based on number of occupied AH unit is:

$$P = 0.911 * X + 1.323 \quad \text{-------------} \quad (1)$$

P: Parking Demand (AM) (Passenger Car)

X: Number of Occupied AH Units

Figure 9.1 shows the data plot of AH land use class and the regression line in association with the coefficient of determination.

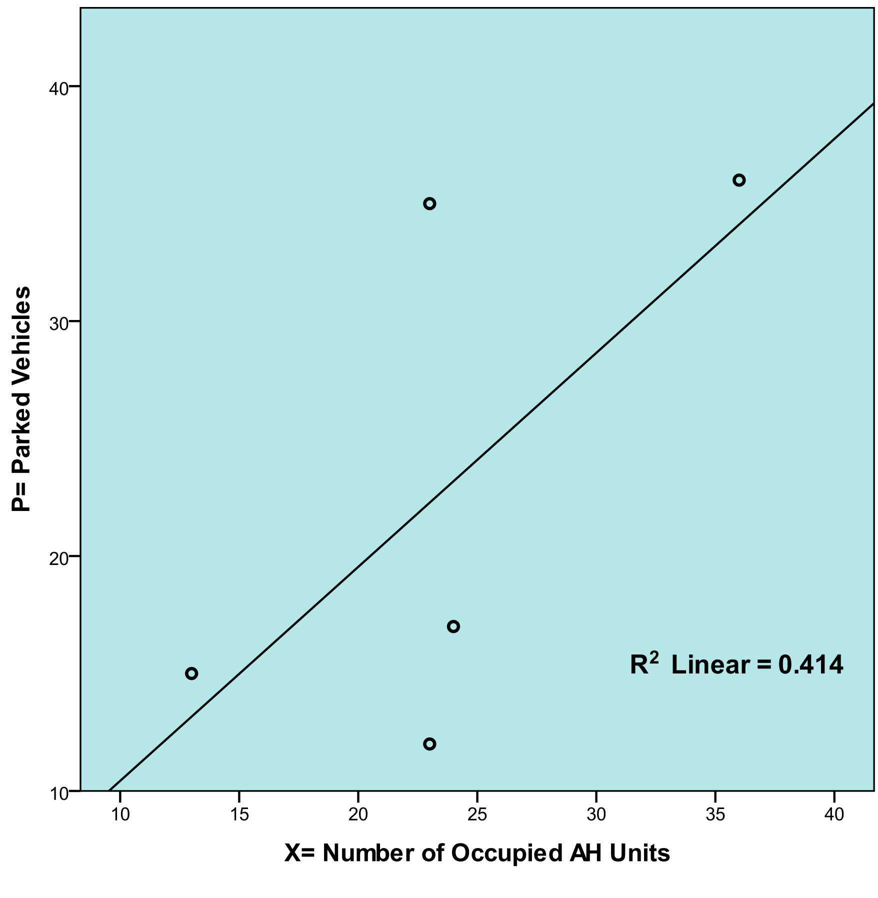

Figure 9.1: Model Plot of Parking Demand (AM) vs. No. of Occupied Houses

Note: number of occupied attached housing units means the total number of units in development (each one AH contains two units).

From Table 9-6, Parking Generation Models for the AH class during AM period based on number of inhabitants is:

$$P = 0.204*X + 0.849 \quad \text{--------------(2)}$$

P: Parking Demand (AM) (Passenger Car)

X: No. of Inhabitants

In addition, the model plot presents the relationship of parking demand with number of inhabitants is shown in Figure 9.2.

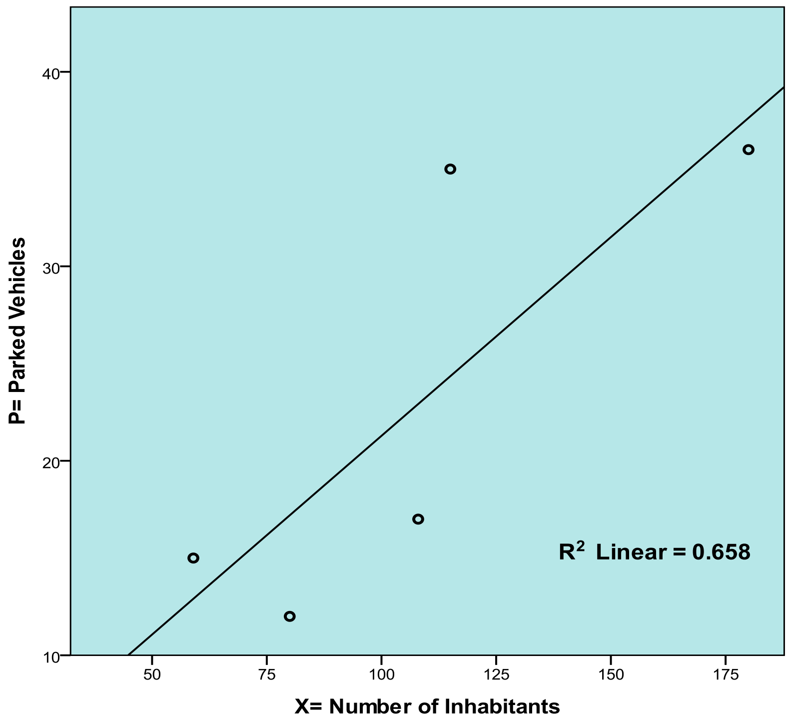

Figure 9.2: Model Plot of Parking Demnd (AM) vs. No. of Inhabitants

Indeed, the models (1 and 2) of AH land use class do not have a good power because the significance of intercept is not significant, since P value for both parameters is very high (>>0.05).

A significant intercept (<0.05) in a model only means that there is also a constant in the model. As a result, using intercept as zero generally increases prediction error and hence should be avoided, if possible.

Therefore, the attained R^2 for the number of occupied AH units predictor is a small value (less than 0.5). Therefore, aborting any points will affect the model because the sample size is small. The CV showed that the variation in data points in the first independent variable is larger than others and this can interpret the value of R^2. In essence, the minimum acceptable value of R^2 is 0.5, and models of R^2 smaller than 0.5 should not be considered and used (ITE, 2010).

– **Test the Normality of Residuals**

The normality of residuals is essential to ensure the accuracy of the developed model. Figure 9.3 shows the scatter plot of the data. In this figure, the points are close to a diagonal line; therefore, the residuals appear to be approximately normally distributed without considering the sample size. The deviations of points from diagonal line weaken the produced model in prediction, and at the same time affect the strength of model.

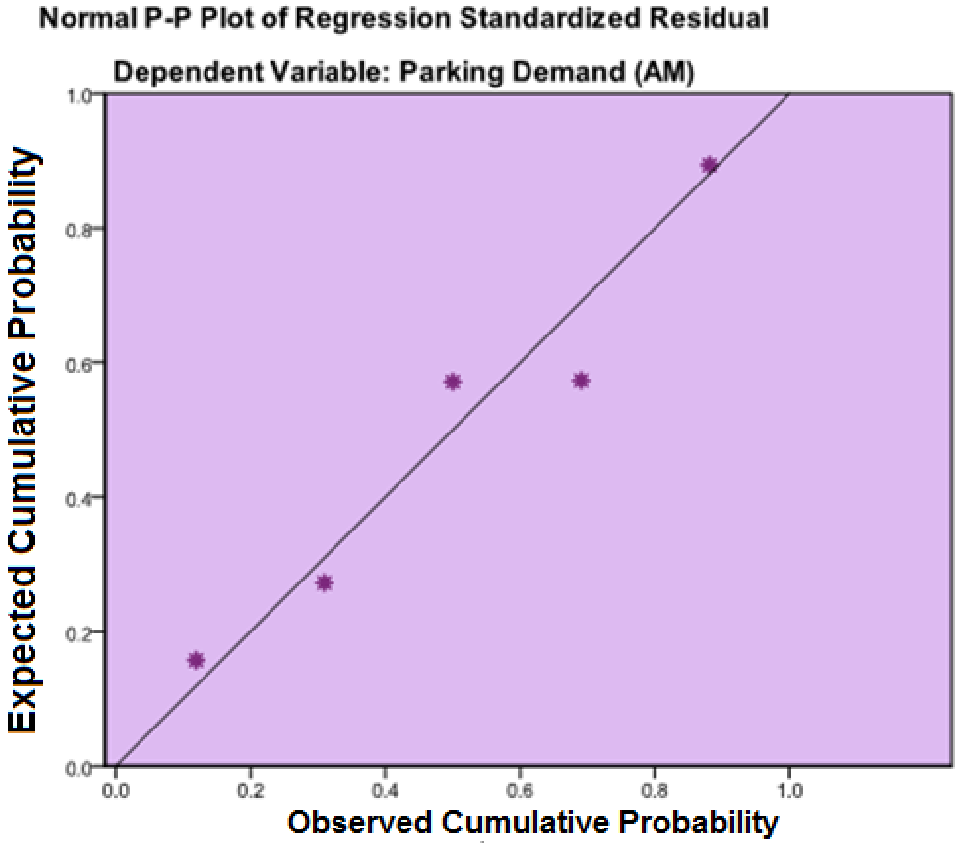

Figure 9.3: Residual Normality Plot

The summation of residuals is preferred to be zero value in order to ensure accurate prediction of parking demand. Figure 9.4 shows that there is an asymmetry distribution around the mean. Thus, using the model carefully in prediction is important to avoid erroneous prediction because this deviation weakens the model in prediction.

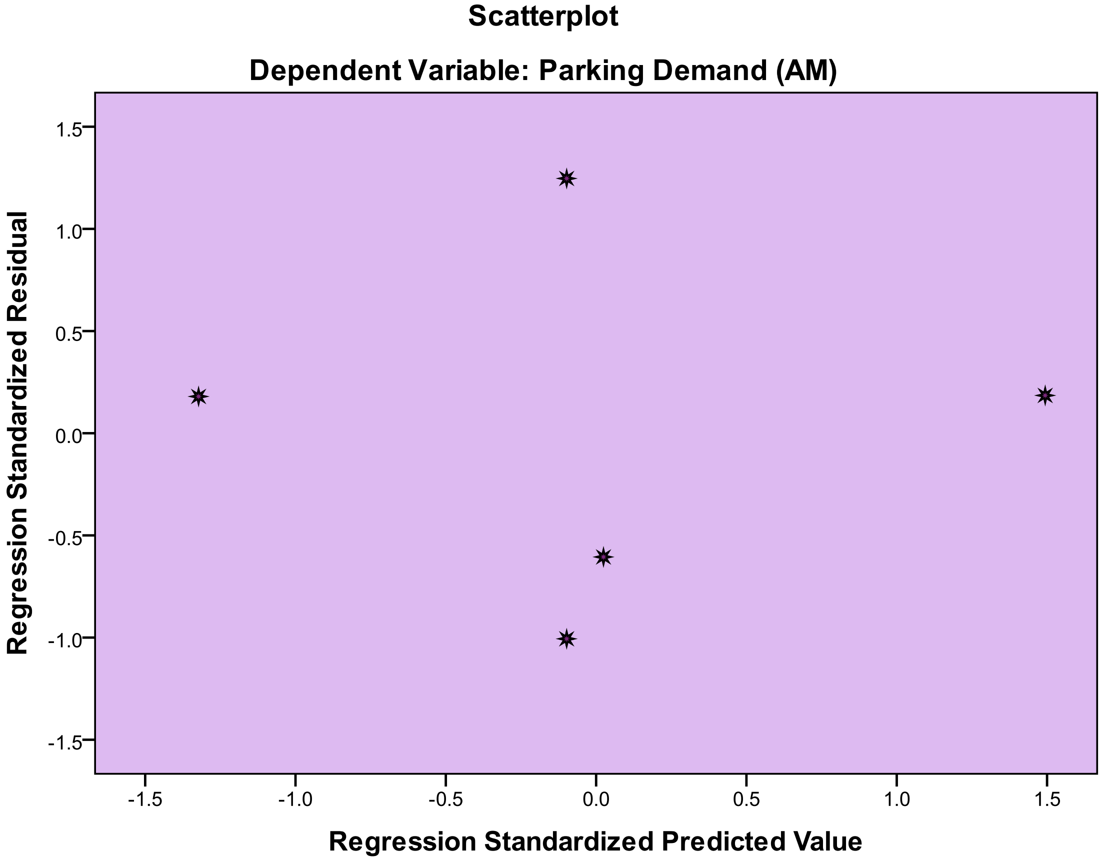

Figure 9.4: Distribution of Residuals around Mean

- **Confidence Interval Bounds**

Table 9-7 presents some statistics values of the t-Student distribution. These values are used in calculating the confidence interval. Lower and upper bounds, which form the range of predictions (rates), can be computed using the following formulas:

Lower/Upper Bound=

Coefficient of Variable ± Z* Standard Error.

Z: Based on number of degree of freedom (df) = N-1 (N: sample Size).T-Distribution is used in the analysis.

Table 9-7: Critical Values of the t - Distribution (Z)

df`	Confidence Level (%)		
	90	**95**	**99**
2	2.920	4.303	9.925
3	2.353	3.182	5.841
4	2.132	2.776	4.604
5	2.015	2.571	4.032
8	1.943	2.306	3.355
10	1.812	2.228	3.169
15	1.753	2.086	2.845
20	1.725	2.009	2.678

Source: (Montgomery et al., 2002)

Table 9-7 is used to compute confidence interval bounds for every model.

Parking generation models of AH Residential Land Use class are shown in Table 9-8 and Table 9-9. These tables present the models and rates with their associated statistics during the AM and PM periods.

Table 9-8: Parking Generation Models for AH Residential Land Use Class in AM and PM Periods

No.	Period	Regression Model	Type	R^2	R^2 adj.	F-test		MS	t- test		Std. Error of the Estimate	Independent Variable
						F	Sig.		t	Sig.		
1	AM	P= 0.911*X+ 1.323	Linear	0.41	0.22	2.12	0.241	104	0.085	0.938	10.2	Number of Occupied AH Units
2		P= 0.204*X+ 0.849	Linear	0.66	0.54	5.78	0.096	61	0.086	0.937	7.8	Number of Inhabitants
3	PM	$P= 2.66 * X^{0.516}$	Power	0.28	0.04	1.159	0.361	0.12	0.651	0.561	0.35	Number of Occupied AH Units
4		$P= 0.708 * X^{0.635}$	Power	0.56	0.41	3.83	0.145	0.07	-0.229	0.833	0.27	Number of Inhabitants

Table 9-9: Parking Generation Rates for AH Residential Land Use Class in AM and PM Periods

No.	Period	Rate	Std. Deviation	CV (%)	Range
1	AM	0.95 space per occupied AH unit	0.39	41	1.02
2		0.21 space per inhabitant	0.07	32	0.16
3	PM	0.55 space per occupied AH unit	0.25	45	0.58
4		0.12 space per inhabitant	0.05	39	0.12

The produced models' forms of AH class for both AM and PM periods were linear and power, respectively.

Table 9-8 shows that all regression models are not significant at 95% confidence interval.

From Table 9-8, the produced models for PM period and the first model in AM period are not strong models for prediction, because they have low values of R^2. Therefore, it is preferable to use the rates in Table 9-9.Std. Error of the Estimate also gives an indication about the concentration of the data around the fitted equation. Values of 10.2 and 7.8 are the RMSE of the linear regression model based on the predictive variables number of occupied houses and number of inhabitants, respectively. On the other hand, 0.35 and 0.27 are the RMSE of the power regression models based on the number of occupied houses and number of inhabitants, respectively. Therefore, the best fit model means highest R^2 and lowest RMSE.

Therefore, the small sample size affected the strength of all produced models either rates or models. Rates are recommended to use for AH land use class because the produced models are poor.

In essence, prediction points should be within the plot area in order to get the level of accuracy for the used model. Extrapolation should be used carefully especially when the model is week in prediction to ensure minimal error. Confidence level could affect the use of produced models; for example at confidence interval 90%, the produced model of $R^2$0.66 is recommended to use.

DH and APH Land Use classes are similarly analyzed. As in the previous analysis of AH class, different types of transformation (linear, logarithmic, exponential, and power) are checked, and only models that have the best fit are recorded.

Table 9-10 and Table 9-11 summarize the results of regression analysis for DH land use class. These tables include parking generation models and rates for both AM and PM periods.

Table 9-10: Parking Generation Models for DH Residential Land Use Class in AM and PM Periods

No.	Period	Regression Model	Type	R^2	R^2 adj.	F-test		MS	t-test		RMSE	Independent Variable
						F	Sig.		t	Sig		
1	AM	$P= 0.914*X^{0.911}$	Power	0.82	0.79	26.92	0.002	0.2	-0.14	0.894	0.448	Number of Occupied DH Units
2		$P= 0.157* X^{1.065}$	Power	0.91	0.90	61.06	0	0.1	-2.89	0.029	0.314	Number of Inhabitants
3	PM	P= 14.951*ln (x)-20.34	Log*	0.55	0.48	7.38	0.035	167	-1.09	0.315	12.918	Number of Occupied DH Units
4		P= 16.781*ln (x)-50.38	Log*	0.67	0.62	12.20	0.013	123	-2.19	0.07	11.075	Number of Inhabitants

* log: Logarithmic

Table 9-11: Parking Generation Rates for DH Residential Land Use Class in AM and PM Periods

No.	Period	Rate	Std. Deviation	CV (%)	Range
1	AM	0.93 space per occupied DH unit	0.40	43	0.94
2		0.22 space per inhabitant	0.06	29	0.16
3	PM	0.82 space per occupied DH unit	0.56	69	1.93
4		0.20 space per inhabitant	0.11	57	0.16

In Table 9-10, the produced models in AM period are good estimators for parking generation; because they produced good values of R^2, RMSE, confidence level, and residuals plot. Furthermore, the produced models for AM period are significant at 95% confidence interval. Thus, these models are recommended to be used in prediction.

In the PM period, the developed models in Table 9-10 are fair to good in prediction with respect to the associated statistical parameters of each model. Therefore, using rates included in Table 9-11are recommended, but the model which used the number of inhabitants as independent variable could be used because it has an acceptable R^2.

Independent variable should be within the range of data when using rates and models to ensure good level of accuracy.

Table 9-12 and Table 9-13 summarize the results of regression analysis for APH land use class for both AM and PM periods.

Logarithmic models are the best fit models in AM period whereas power and exponential models are the best fit models of PM period. From the results in Table 9-12, it is not recommended to use any model in both AM and PM periods, because the produced regression models are poor models in prediction based on the attained R^2, F-test, and other supporting statistical parameters. Therefore, using the produced rates included in Table 9-13 instead of models is recommended.

Table 9-12: Parking Generation Models for APH Residential Land Use Class on AM and PM Periods

No.	Period	Regression Model	Type	R^2	R^2 adj.	F-test		MS	t-test		Std. Error of the Estimate	Independent Variable
						F	Sig.		t	Sig.		
1	AM	P= 11.379*ln(x)-40.97	Log	0.44	0.37	6.38	0.035	53	-1.8	0.11	7.3	Number of Inhabitants
2		P= 11.035*ln(x)-76.032	Log	0.36	0.28	4.54	0.066	61	-1.75	0.118	7.8	GFA (sq. m.)
3		P= 12.534*ln(x)-25.925	Log	0.39	0.31	5.11	0.054	58	-1.38	0.206	7.6	Number of Occupied Dwelling Units (DU's).
4	PM	$P= e^{1.816*X}$	Exp*	0.28	0.18	3.03	0.12	0.50	3.93	0.004	0.703	Number of Inhabitants
5		$P= 0.025*X^{0.741}$	Power	0.23	0.13	2.37	0.162	0.53	-0.91	0.388	0.725	GFA (sq. m.)
6		P= 0.424*X+ 2.278	Linear	0.38	0.30	4.89	0.058	81	0.34	0.745	9	Number of Occupied DU's.

*Exp: Exponential

Table 9-13: Parking Generation Rates for APH Residential Land Use Class on AM and PM Periods

No.	Period	Rate	Std. Deviation	CV (%)	Range
1	AM	0.09 space per Inhabitant	0.06	66	0.20
2		0.33 space per 100 sq. m. of GFA	0.22	65	0.71
3		0.51 space per occupied DU	0.30	59	0.82
4	PM	0.09 space per Inhabitant	0.10	106	0.31
5		0.33 space per 100 sq. m. of GFA	0.28	87	0.91
6		0.49 space per occupied DU	0.45	92	1.57

9.3.2.2 The Best Models and Rates for Residential Land Use

Table 9-14 summarizes the produced models (R^2>0.6) or rates for each class based on number of inhabitants and occupied units, while

Table 9-15 summarizes the applicable and recommended models and rates of parking generation during AM and PM periods of residential land use for the most appropriate independent variable.

The recommended models/rates are the most powerful ones among others based on statistical parameters (R^2>0.6) and the predominant used independent variable, as applicable.

Table 9-14: Parking Generation Models/Rates of Resdential Land Use

Class	Period	Independent Variable	Model	R^2	Rate
AH	AM	Number of Occupied AH Units	-	-	0.95 space per Occupied AH unit
		Number of Inhabitants	P= 0.204*X+ 0.849	0.66	-
	PM	No. of Occupied AH units	-	-	0.55 space per Occupied AH unit
		Number of Inhabitants	-	-	0.12 space per inhabitant
DH	AM	Number of Occupied DH Units	$P= 0.914*X^{0.911}$	0.82	-
		Number of Inhabitants	$P= 0.157* X^{1.065}$	0.91	-
	PM	Number of Occupied DH Units	-	-	0.82 space per Occupied AH unit
		Number of Inhabitants	P= 16.781*ln(x)-50.38	0.67	-
APH	AM	Number of Inhabitants	-	-	0.09 space per inhabitant
		GFA (100 sq. m.)	-	-	0.33 space per 100 GFA
		Number of Occupied DU's.	-	-	0.51 space per Occupied DU
	PM	Number of Inhabitants	-	-	0.09 space per inhabitant
		GFA (sq. m.)	-	-	0.33 space per 100 GFA
		Number of Occupied DU's.	-	-	0.49 space per Occupied DU

Table 9-15: Recommended Parking Generation Models/Rates of Resdential Land Use

Class	Period	Independent Variable	Model	R^2	Rate	Recommended
AH	AM	Number of Inhabitants	P= 0.204*X+ 0.849	0.66	0.21 space per inhabitant	Model
	PM	Number of Inhabitants	$P= 0.708 * X^{0.635}$	0.56	0.12 space per inhabitant	Rate
DH	AM	Number of Inhabitants	$P= 0.157* X^{1.065}$	0.91	0.22 space per inhabitant	Model
	PM	Number of Inhabitants	P= 16.781*ln(x)-50.38	0.67	0.20 space per inhabitant	Model
APH	AM	Number of Occupied DU's.	P= 12.534*ln(x)-25.925	0.39	0.51 space per Occupied DU	Rate
	PM	Number of Occupied DU's.	P= 0.424*X+ 2.278	0.38	0.49 space per Occupied DU	Rate

Do the developed parking generation models/rates from this study differ from Palestinian regulations? Appendix F presents the needed parking spaces for residential land use regardless of its classes and surrounding environment. One space per dwelling units shall be provided, according to local regulations (Appendix F). However the produced models/rates in this study provide different values for land use type (0.51-0.95 space per DU), and these values depend on a class of residential land use.

Moreover, a comparison of the recommended models/rates of this research with the common international parking generation (ITE) is shown in Table 9-16.

Table 9-16: The Obtained Parking Generation Models/Rates of Residential Land Use vs.ITEModels/Rates *

Land use class	Period	Result of Recommended Model/Rate	ITE Model/Rate Result
AH	AM	0.30 space per Occupied DU	1.73 space per Occupied DU
DH	PM	0.30 space per Occupied DU	0.35 space per Occupied DU
APH	AM	0.51 space per Occupied DU	1.23 space per Occupied DU
	PM	0.49 space per Occupied DU	1.2 space per Occupied DU

*Source: (ITE, 2010)

The differences shown in Table 5-16 justify using local studies rather than international studies. Abu Dhabi regional study has detailed rates for many land use types and is not appropriate for similar comparison.

9.3.3 Office Land Use

Office Land uses are classified into three classes based on the local condition Chapter Four. General, Institutional, and Government Office Land use classes are analyzed in the following subsections to find models or rates of predicting parking demand. Three peaks were used in analysis: AM and PM peaks of the adjacent streets as well as the maximum peak period of development.

Table 9-17 and Table 9-18 show that the parking generation models based on the peak parking of development. These tables involve different forms of regression; exponential, linear, and power for General Office class. Linear regression models are the best fit for Institutional Office class. On the other hand, Government Office class has two types of regression model forms, which are logarithmic and power models.

As shown in Table 9-17, the produced models of General Office class based on GFA, GLA, and number of workers' vehicles are the best models, because they have high R^2, and they are significant at 95% confidence level. Therefore, using these three models in prediction is recommended, while, the number of workers as an independent variable for parking generation rate shown in Table 9-18 should be used instead of poor model (R^2<0.6) in Table 9-17.

Table 9-17: Parking Generation Models for Office Land Use Classes Based in Peak Parking of Development

No.	Land Use Class	Regression Model	Type	R^2	R adj.	F-test		MS	t-test		RMSE	Independent Variable
						F	Sig.		t	Sig.		
1	General Office	$P= 20.88*e^{-0.008x}$	Exp	0.03	0	0.082	0.793	0.30	3.11	0.053	0.547	Number of Workers
2		$P= 27502*X^{-1.072}$	Power	0.93	0.91	40.72	0.008	0.02	8.74	0.003	0.145	GFA (sq. m.)
3		P=-17.62*ln(x) + 137.32	Log	0.88	0.83	21.11	0.019	15	5.26	0.013	3.892	GLA (sq. m.)
4		P= -28.51*ln(x) + 96.07	Log	0.78	0.71	10.71	0.047	27	3.98	0.028	5.162	Number of Workers' Vehicles
1	Institutional Office	P= 0.48*X-0.57	Linear	0.97	0.97	182.17	0.000	387	-0.05	0.959	19.677	Number of Workers
2		P= 0.025*X-2.18	Linear	0.97	0.97	170.25	0.000	414	-0.20	0.850	20.335	GFA (sq. m.)
3		P= 0.024*X+ 3.26	Linear	0.95	0.94	98.04	0.000	703	0.23	0.825	26.519	GLA (sq. m.)
4		P= 1.03*X-7.17	Linear	0.95	0.94	102.62	0.000	673	-0.49	0.640	25.949	Number of Workers' Vehicles
1	Government Office	P=10.79*ln(x)-20.99	Log	0.46	0.42	10.38	0.007	51	-1.49	0.163	7.196	Number of Workers
2		P=11.38*ln(x)-56.91	Log	0.61	0.57	18.43	0.001	38	-3.03	0.010	6.171	GFA (sq. m.)
3		P=10.62*ln(x)-49.92	Log	0.64	0.61	21.15	0.001	35	-3.10	0.009	5.912	GLA (sq. m.)
4		$P= 2.8*X^{0.664}$	Power	0.45	0.38	9.11	0.008	0.17	0.79	0.140	0.418	Number of Workers' Vehicles

Table 9-18: Parking Generation Rates for Office Land Use Classes Based in Peak Parking of Development

No.	Land Use Class	Rate	Std. Deviation	CV (%)	Range
1	General Office	P= 0.52 space per worker	0.31	59	0.77
2		P= 1.57 space per 100 sq. m. of GFA	2.34	150	5.78
3		P= 1.81 space per 100 sq. m. of GLA	3.46	192	8.21
4		P= 1.09 space per worker vehicle	1.19	110	3
5	Institutional Office	P= 0.48 space per worker	0.38	79	1.04
6		P= 2.41 space per 100 sq. m. of GFA	1.82	75	5.28
7		P= 2.50 space per 100 sq. m. of GLA	1.81	73	5.28
8		P= 0.96 space per worker vehicle	0.49	51	1.46
9	Government Office	P= 0.33 space per worker	0.19	58	0.65
10		P= 1.68 space per 100 sq. m. of GFA	0.01	59	3.79
11		P= 1.82 space per 100 sq. m. of GLA	0.01	55	3.79
12		P= 1.17 space per worker vehicle	0.61	52	2.57

Furthermore, Institutional Office class has strong models and rates as shown in Table 9-17 and Table 9-18. Thus, using either models or rates in prediction is applicable, but models are recommended to be used because they are preferred statistically. Coefficient of Variation is high enough to conclude that the data has high variance, and this means the distribution of data does not follow the normal distribution (test of normality).

Government Office land use class showed fair and poor parking generation models as shown in Table 9-17. The produced models that used GFA and GLA as independent variables could be used because they produced acceptable R^2 (> 60%). As a result, the produced rates in Table 9-18 for Government Office class are recommended to use instead of models, especially for number of workers and number of workers vehicles independent variables.

Table 9-19 and Table 9-20 show the developed models and rates of office land use for the peak of adjacent streets during the AM period.

As shown in Table 9-19, General Office class produced poor parking generation models. In addition, Institutional Office class models or rates are strong predictor at high level of confidence. As aforementioned, the models are better than rates. Thus, Institutional Office models presented in Table 9-19 are recommended to use.

Finally, Government Office class produced fair to good models as shown in Table 9-19. Therefore, using the statistically good models is recommended.

The peak parking accumulation during the PM was also studied as shown in Table 9-21 and Table 9-22.

Table 9-19: Parking Generation Models for Office Land Use Classes Based in AM Peak Accumulation

No.	Land Use Class	Regression Model	Type	R^2	R adj.	F-test		MS	t-test		RMSE	Independent Variable
						F	Sig.		t	Sig.		
1	General Office	$33.148*e^{-0.029x}$	Exp	0.44	0.25	2.33	0.224	0.14	5.26	0.013	0.3736	Number of Workers
2		P=-9.49*ln(x)+79.32	Log	0.55	0.40	3.61	0.154	19	2.28	0.107	4.320	GFA (sq. m.)
3		P=-7.27*ln(x)+62.66	Log	0.44	0.25	2.36	0.222	23	1.95	0.147	4.794	GLA (sq. m.)
4		P= -11.29*ln(x)+ 44.37	Log	0.36	0.15	1.71	0.283	26.2	1.86	0.160	5.118	Number of Workers' Vehicles
1	Institutional Office	P= 0.478* X-5.269	Linear	0.97	0.96	136.16	0.000	514	-0.434	0.682	22.676	Number of Workers
2		P= 0.025* X-7.082	Linear	0.97	0.96	144.86	0.000	484	-0.59	0.577	22.008	GFA (sq. m.)
3		P= 0.024* X-1.882	Linear	0.95	0.94	98.08	0.000	27	-0.134	0.898	26.536	GLA (sq. m.)
4		$P= 15.502*e^{0.012x}$	Exp	0.98	0.98	265.28	0.000	0.03	27.31	0.00	0.1804	Number of Workers' Vehicles
1	Government Office	P=11.89*ln(x)-26.93	Log	0.65	0.62	21.79	0.001	30	-2.56	0.025	5.442	Number of Workers
2		P=10.15*ln(x)-49.96	Log	0.54	0.51	14.32	0.003	38	-2.63	0.022	6.167	GFA (sq. m.)
3		P=9.88*ln(x)-46.77	Log	0.64	0.61	21.30	0.001	30	-3.14	0.009	5.482	GLA (sq. m.)
4		P= -0.312*X+ 23.903	Linear	0.78	0.61	18.91	0.001	32	1.94	0.077	5.691	Number of Workers' Vehicles

Table 9-20: Parking Generation Rates for Office Land Use Classes Based on AM Peak Accumulation

No.	Land Use Class	Rate	Std. Deviation	CV (%)	Range
1	General Office	P= 0.39 space per worker	0.23	60	0.47
2		P= 1.18 space per 100 sq. m. of GFA	1.37	116	3.38
3		P= 1.37 space per 100 sq. m. of GLA	2.04	149	4.79
4		P= 0.82 space per worker vehicle	0.68	0.83	1.70
5	Institutional Office	P= 0.45 space per worker	0.40	88	1.10
6		P= 2.29 space per 100 sq. m. of GFA	1.88	82	5.81
7		P= 2.37 space per 100 sq. m. of GLA	1.87	79	5.81
8		P= 0.91 space per worker vehicle	0.53	58	1.56
9	Government Office	P= 0.31 space per worker	0.15	48	0.44
10		P= 1.55 space per 100 sq. m. of GFA	1.00	65	3.79
11		P= 1.69 space per 100 sq. m. of GLA	0.99	58	3.79
12		P= 0.92 space per worker vehicle	0.30	33	1.23

Table 9-21: Parking Generation Models for Office Land Use Classes Based on PM Peak Accumulation

No.	Land Use Class	Regression Model	Type	R^2	R adj.	F-test		MS	t-test		RMSE	Independent Variable
						F	Sig.		t	Sig.		
1	General Office	$P= 21.78*e^{-0.010x}$	Exp	0.04	0	0.133	0.759	0.36	2.88	0.063	0.60	Number of Workers
2		$P= 61945*X^{-1.193}$	Power	0.95	0.93	57.34	0.005	0.02	10.05	0.002	0.136	GFA (sq. m.)
3		P= -18.4*ln(x)+142.28	Log	0.88	0.84	21.88	0.018	15.9	5.31	0.013	3.991	GLA (sq. m.)
4		P= -28.06*ln(x)+94.51	Log	0.70	0.60	6.90	0.079	40	3.20	0.049	8.328	Number of Workers' Vehicles
5	Institutional Office	P=0.486* X-5.449	Linear	0.97	0.97	173.10	0.000	418	-0.50	0.640	20.448	Number of Workers
6		P=0.025* X-7.057	Linear	0.97	0.96	159.44	0.000	453	-0.61	0.566	21.280	GFA (sq. m.)
7		P=0.024* X-1.449	Linear	0.95	0.94	91.05	0.000	775	-0.10	0.925	27.844	GLA (sq. m.)
8		P=1.045* X-12.121	Linear	0.95	0.94	98.93	0.000	716	-0.81	0.453	26.768	Number of Workers' Vehicles
9	Government Office	$P= 1.86*X^{0.574}$	Power	0.37	0.32	6.98	0.022	0.22	0.69	0.502	0.465	Number of Workers
10		P= 10.47*ln(x)-51.99	Log	0.56	0.52	15.08	0.002	38	-2.72	0.019	6.196	GFA (sq. m.)
11		$P= 0.289*X^{0.608}$	Power	0.59	0.56	17.42	0.001	0.14	-1.23	0.244	0.373	GLA (sq. m.)
12		$P= 2.63*X^{0.659}$	Power	0.40	0.35	8.02	0.015	0.21	1.35	0.204	0.452	Number of Workers' Vehicles

Table 9-22: Parking Generation Rates for Office Land Use Classes Based on PM Peak Accumulation

No.	Land Use Class	Rate	Std. Deviation	CV (%)	Range
1	General Office	P= 0.51 space per worker	0.31	61	0.78
2		P= 1.54 space per 100 sq. m. of GFA	2.36	153	5.81
3		P= 1.78 space per 100 sq. m. of GLA	3.48	196	8.26
4		P= 1.07 space per worker vehicle	1.20	112	3.02
5	Institutional Office	P= 0.46 space per worker	0.22	48	0.70
6		P= 2.33 space per 100 sq. m. of GFA	1.20	51	3.38
7		P= 2.41 space per 100 sq. m. of GLA	1.26	52	3.2
8		P= 0.93 space per worker vehicle	0.32	34	0.98
9	Government Office	P= 0.31 space per worker	0.20	64	0.67
10		P= 1.57 space per 100 sq. m. of GFA	0.01	59	3.40
11		P= 1.70 space per 100 sq. m. of GLA	0.01	55	3.40
12		P= 0.93 space per worker vehicle	0.46	49	2.01

As shown in Table 9-21, number of workers independent variable of General Office class shall not be used in prediction because the analysis showed there is a weak relationship between dependent and independent variables. On the other hand, GFA and GLA at 95% confidence level independent variables are good models in prediction based on the F-test. On the other hand, the model that used number of workers vehicles as repressor is good model at 90% confidence level based on the F-test. Thus, using rates that were included in Table 9-22 are recommended for number of workers and number of workers vehicles repressors.

The analysis of Institutional Office class produced good prediction models and rates as shown in Table 9-21 and Table 9-22. Parking generation models in Table 9-21 are better than rates included in Table 9-22, and this was justified statistically.

The developed parking generation models for Government Office class in Table 9-21 are poor models. Rates that are presented in Table 9-22 are recommended in prediction of parking demand for Government Office.

9.3.3.1 The Best Models and Rates for Office Land Use

Table 9-23 and Table 9-24 summarize the applicable and recommended models (R^2>0.6) and rates of parking generation during periods of AM, PM, and peak of development of office land use.

Appendix F presents the required parking spaces for office land use based on the Palestinian MoLG regulations regardless of its classes. One space per 70 sq. m. shall be provided according to local regulations. However, the produced models/rates in this study provide higher values. The developed models/rates provide different values for three classes of office land use, while MoLG regulations provide one value for all office types.

Comparison with the ITE parking generation provides large differences. For example, this study produces 1.5 spaces per 100 sq. m. GFA for general office class, while the ITE provides 2.74 spaces per 100 sq. m. GFA for office building land use. Again, this large difference justifies using local parking generation.

Table 9-23: Parking Generation Models/Rates of Office Land Use

Class	Period	Independent Variable	Model	R^2	Rate
	Peak	GFA (sq. m.)	$P= 27502*X^{-1.072}$	0.93	-
		GLA (sq. m.)	P=-17.62*ln(x)+137.32	0.88	-
		Number of Workers' Vehicles	P=-28.51*ln(x)+96.07	0.78	-
	AM	GFA (sq. m.)	-	-	1.18 space per 100 sq. m. GFA
		GLA (sq. m.)	-	-	1.37 space per 100 sq. m. GLA
		Number of Workers' Vehicles	-	-	0.82 space per worker's vehicle
	PM	GFA (sq. m.)	$P= 61945*X^{-1.193}$	0.98	-
		GLA (sq. m.)	P=-18.40*ln(x)+142.28	0.88	-
		Number of Workers' Vehicles	P=-28.06*ln(x)+94.51	0.70	-
Institutional Office	Peak	Number of Workers	P= 0.48*X-0.57	0.97	-
		GFA (sq. m.)	P= 0.025*X-2.18	0.97	-
		GLA (sq. m.)	P= 0.024*X+ 3.26	0.95	-
		Number of Workers' Vehicles	P= 1.03*X-7.17	0.95	-
	AM	Number of Workers	$P= 0.478* X_1-5.269$	0.97	-
		GFA (sq. m.)	P= 0.025* X-7.082	0.97	-
		GLA (sq. m.)	P= 0.024* X-1.882	0.95	-
		Number of Workers' Vehicles	$P= 15.502*e^{0.012x}$	0.98	-
	PM	Number of Workers	P=0.486* X-5.449	0.97	-
		GFA (sq. m.)	P=0.025* X-7.057	0.97	-
		GLA (sq. m.)	P=0.024* X-1.449	0.95	-
		Number of Workers' Vehicles	P=1.045* X-12.121	0.95	-
Government Office	Peak	Number of Workers	-	-	0.33 space per worker
		GFA (sq. m.)	P=11.53*ln(x)-57.71	0.61	-
		GLA (sq. m.)	P=10.62*ln(x)-49.92	0.64	-
		Number of Workers' Vehicles	-	-	1.17 space per worker's vehicle

Class	Period	Independent Variable	Model	R^2	Rate
	AM	Number of Workers	P=11.89*ln(x)-26.93	0.65	-
		GFA (sq. m.)	-	-	1.55 space per 100 sq. m. GFA
		GLA (sq. m.)	P=9.88*ln(x)-46.77	0.64	1.69 space per 100 sq. m. GLA
		Number of Workers' Vehicles	P= $-0.312*X_1+ 23.903$	0.78	0.92 space per worker's vehicle
	PM	Number of Workers	-	-	0.31 space per worker
		GFA (sq. m.)	-	-	1.57 space per 100 sq. m. GFA
		GLA (sq. m.)	-	-	1.70 space per 100 sq. m. GLA
		Number of Workers' Vehicles	-	-	0.93 space per worker's vehicle

Table 9-24: Recommended Parking Generation Models/Rates of Office Land Use

Class	Period	Independent Variable	Model	R^2	Rate	Recommended
General Office	Peak	GFA (sq. m.)	P= $27502*X^{-1.072}$	0.93	P= 1.57 space per 100 sq. m. of GFA	Model
	AM	GFA (sq. m.)	P=-9.49*ln(x)+79.32	0.55	1.18 space per 100 sq. m. GFA	Rate
	PM	GFA (sq. m.)	P= $61945*X^{-1.193}$	0.98	P= 1.54 space per 100 sq. m. of GFA	Model
Institutional Office	Peak	GFA (sq. m.)	P= 0.025*X-2.18	0.97	P= 2.41 space per 100 sq. m. of GFA	Model
	AM	GFA (sq. m.)	P= 0.025* X-7.082	0.97	P= 2.29 space per 100 sq. m. of GFA	Model
	PM	GFA (sq. m.)	P=0.025* X-7.057	0.97	P= 2.33 space per 100 sq. m. of GFA	Model
Government Office	Peak	GLA (sq. m.)	P=10.62*ln(x)-49.92	0.64	1.82 space per 100 sq. m. GLA	Model
	AM	GLA (sq. m.)	P=9.88*ln(x)-46.77	0.64	1.69 space per 100 sq. m. GLA	Model
	PM	GLA (sq. m.)	P= $0.289*X^{0.608}$	0.59	1.70 space per 100 sq. m. GLA	Rate

9.3.4 Retail Land Use

Supermarket, Strip, and Shopping Center Retail Land use classes were analyzed.

The analysis of the collected data regarding retail land use showed there are two peak periods (not necessary AM or PM) of parking demand. For example, supermarket development has two peak periods from 14:00 to 16:00 and 19:00 to 21:00, so the two peaks are in PM periods. Only the maximum peak value for each development was analyzed, because it represents the maximum parking demand of each development.

Data collection indicated that the GFA and GLA independent variables are the same in Strip and Supermarket Retail classes. Therefore, only one of them was used in the analysis, which is GLA.

Table 9-25 and Table 9-26 are summary tables of the regression analysis of retail land use type.

Table 9-25 shows poor models for supermarket retail class, and fair to good models for strip retail class. The produced models of supermarket class provide low level of accuracy in prediction. Therefore, using rates included in Table 9-26 is preferable. Whereas, the developed rates of strip class should be used except the derived model from number of workers' vehicles independent variable.

Table 9-25: Parking Generation Models for Retail Land Use Classes Based on Peak Demand of Development

No.	Land Use Class	Regression Model	Type	R^2	R adj.	F-test		MS	t-test		RMSE	Independent Variable
						F	Sig.		t	Sig.		
1	Supermarket Retail	P= 0.773*X+ 4.636	Linear	0.34	0.287	6.34	0.023	30	1.80	0.096	5.482	Number of Workers
2		P= 0.014*X+ 3.74	Linear	0.51	0.471	13.47	0.003	22	1.75	0.104	4.722	GLA (sq. m.)
3		P= -2.947*ln(x)+ 12.384	Log	0.08	0.007	1.10	0.313	42	4.64	0.000	6.471	Number of Workers' Vehicles
4	Strip Retail	P= 0.492*X+ 4.843	Linear	0.68	0.625	12.65	0.012	7	2.62	0.040	2.661	Number of Workers
5		P= 0.009*X+ 6.453	Linear	0.75	0.711	18.23	0.005	5	5.14	0.002	2.334	GLA (sq. m.)
6		P= 0.606*X+ 6.408	Linear	0.40	0.300	3.99	0.093	13	2.65	0.038	3.634	Number of Workers' Vehicles

Table 9-26: Parking Generation Rates for Retail Land Use Classes Based on Peak Demand of Development

No.	Land Use Class	Rate	Std. Deviation	CV (%)	Range
1	Supermarket Retail	P= 1.15 space per worker	1.05	92	3.83
2		P= 2.08 space per 100 sq. m. of GLA	1.74	83	5.17
3		P= 3.91 space per worker vehicle	5.93	1.52	17.60
5	Strip Retail	P= 0.82 space per worker	0.51	63	1.60
7		P= 2.22 space per 100 sq. m. of GLA	1.13	51	3.56
8		P= 1.52 space per worker vehicle	1.08	71	2.63

Shopping Center class was studied. Only one site is available in the study area that has the characteristics of shopping center land use class as noted before. Therefore, the rate is applicable to use in predicting parking generation (see Table 9-27).

Table 9-27: Parking Generation Rates for Shopping Center Land Use Class

Period	Max. Average Parking Peak Demand
Total GFA (per 100 sq. m.)	2.25
Total GLA (per 100 sq. m.)	2.94

9.3.4.1 The Best Models and Rates for Retail Land Use

Table 9-28 and Table 9-29 summarize the applicable and recommended models (R^2>0.6) and rates of parking generation during AM and PM periods of Retail land use.

Table 9-28: Parking Generation Models/Rates of Retail Land Use

Class	Independent Variable (X)	Model	R^2	Rate
Supermarket Retail	Number of Workers	-	-	1.15 space per worker
	GFA (100 sq. m.)	-	-	2.08 space per 100 sq. m. GFA
	Number of Workers Vehicle	-	-	3.91 space per worker's vehicle
Strip Retail	Number of Workers	P= 0.492*X+ 4.843	0.68	0.82 space per worker
	GFA (sq. m.)	P= 0.009*X+ 6.453	0.75	2.22 space per 100 sq. m. GFA
	Number of Workers Vehicle	-	-	1.52 space per worker's vehicle

Table 9-29: Recommended Parking Generation Models/Rates of Retail Land Use

Class	Independent Variable (X)	Model	R^2	Rate	Recommended
Supermarket Retail	GFA (100 sq. m.)	P= 0.014*X+ 3.74	0.51	2.08 space per 100 sq. m. GFA	Rate
Strip Retail	GFA (sq. m.)	P= 0.009*X+ 6.453	0.75	2.22 space per 100 sq. m. GFA	Model

One space per 50 sq. m. shall be provided according to Palestinian MOLG regulations (Appendix F).However, the produced models/rates in this study provide higher values for parking generations such a land use type. The developed models/rates provide different values for three classes of retail land use, while the local regulations provide one value for all retail land use types.

9.4 Models Verification and Validation

Residual plots presented in Appendix (E) show the difference between regression lines and field measurement. All resulted models have points that deviate from regression lines. These deviations vary from one model to another. Therefore, as the points are close to the regression line the model is better.

Validation and verification are used to test the ability of developed models/equations in prediction. Indeed, the small simple size of some classes weakens the validation and verification accuracy.

Model Validation

The validation of developed models are studied based on some statistical parameters that are used to test the power of model such as R^2 and residual plots as shown in the aforementioned tables for each land use type, and in Appendix (E). Validation is used to test the quality of used methodology in producing models/equations.

Model/Rate Verification

Verification of the attained models and rates are checked based on random samples; this sample was selected for studied land use classes to estimate the parking demand, and make inferences about the differences between the observations and the model estimation. If the estimated values from models coincide or close to the observed values, the models can be considered verified. For the purpose of this research and according to the studied sample sizes, 25% of difference is acceptable as an average.

Table 9-30 shows that not all the models are verified in DH class, particularly in the PM period. Other new sites are required to test the model verified and make inferences.

Table 9-30: Models Verification of DH Class

Period	Independent Variable	Model	Sample No.	Model	Observed	Difference
AM	Number of Occupied DH Units	$P= 0.911 *X^{0.911}$	1	29	35	-17%
			2	33	37	-11%
	Number of Inhabitants	$P=0.157* X^{1.065}$	1	34	35	-3%
			2	40	37	8%
PM	Number of Inhabitants	$P= 16.781*\ln(x)-502.77$	1	35	47	-26%
			2	37	36	3%

Only Government office land use class is verified among the three classes of office land use because the sample size is large enough. The other two classes are not verified here because the sample size of each is small.

Table 9-31 presents the estimated parking demand from previous models (regression with intercept) for government office classes during three count periods and the observed values.

It is obvious from Table 9-31 that almost all the developed models have low differences (<25%).

Table 9-31: Models Verification of Government Office Class

Period	Independent Variable	Model	Sample No.	Model	Observed	Difference
Peak	GFA (sq. m.)	P=11.53*ln(x)-57.71	1	19	18	6%
			2	37	45	-18%
			3	6	6	0%
	GLA (sq. m.)	P=10.62*ln(x)-49.92	1	21	18	17%
			2	38	45	-16%
AM	Number of Workers	P=11.89*ln(x)-26.93	1	19	18	6%
			2	35	45	-22%
	GLA (sq. m.)	P=9.88*ln(x)-46.77	1	19	18	6%
			2	35	45	-22%
	Number of Workers Vehicles	P= -0.312*X+ 23.903	1	18	18	0%
			2	7	45	-84%
PM	GLA (sq. m.)	$P= 0.289*X^{0.608}$	1	17	14	21%
			2	43	43	0%

For strip retail class, Table 9-32 shows that the observed values are close to the estimated values of developed models. Thus, almost all the models are verified (<25%).

Table 9-32: Models Verification of Strip Retail Class

Period	Independent Variable	Model	Sample No.	Model	Observed	Difference
Peak	Number of Workers	$P= 0.492*X_1+ 4.843$	1	13	14	-7%
			2	9	9	0%
			3	15	15	0%
	GLA (sq. m.)	$P= 0.009*X_1+ 6.453$	1	11	14	-21%
			2	8	9	-11%
			3	15	15	0%

Rates Verification

Table 9-33 presents the validation of Detached and Apartment Housing classes. The table shows that the values of observed data are close to the rate values in almost all samples. High value of the difference (true value minus estimated value) means that the rate has weak power in prediction.

Table 9-33: Rates Verification of APH and DH Classes

Land Use Class	Period	Independent Variable	Rate	Sample No.	Rate	Observed	Difference
APH	AM	Number of Inhabitants	0.09 space per Inhabitant	1	23	28	18%
				2	48	51	-6%
				3	17	18	-6%
		GFA (100 sq. m.)	0.33 space per 100 sq. m. of GFA	1	24	28	-14%
				2	41	51	-20%
				3	13	18	-28%
		Number of DU's	0.51 space per occupied DU	1	16	28	-43%
				2	68	51	33%
				3	24	18	33%
	PM	Number of Inhabitants	0.09 space per Inhabitant	1	23	26	-12%
				2	54	55	-2%
				3	17	19	-11%
		GFA (100 sq. m.)	0.33 space per 100 sq. m. of GFA	1	25	26	-4%
				2	61	55	11%
				3	13	19	-32%
		Number of DU's	0.49 space per occupied DU	1	25	26	-4%
				2	66	55	20%
				3	23	19	21%
DH	PM	Number of Inhabitants	0.20 space per inhabitant	1	47	32	47%
				2	18	26	-31%
				3	36	36	0%
		Number of occupied DH Units	0.82 space per Occupied DH unit	1	47	37	27%
				2	18	18	0%
				3	36	43	-16%

Government Office class rates are also verified as shown in Table 9-34. Almost all the developed rates are verified based on the differences attained. Some high difference values showed that the rates are poor, but this result does not have poor because the sample size that was used in verification is small.

Table 9-34: Rates Verification of Government Office Class

Period	Independent Variable	Rate	Sample No.	Rate	Observed	Difference
Peak	Number of Workers	0.33 space per worker	1	17	18	6%
			2	47	45	4%
			3	10	6	67%
	GFA (sq. m.)	1.68 space per 100 sq. m. GFA	1	13	18	-28%
			2	64	45	42%
			3	4	6	-33%
	GLA (sq. m.)	1.82 space per 100 sq. m. GLA	1	15	18	-17%
			2	69	45	53%
			3	5	6	-17%
	Number of Workers' Vehicles	1.17 space per worker's vehicle	1	23	18	28%
			2	64	45	42%
			3	12	6	100%
AM	Number of Workers	0.31 space per worker	1	16	18	-11%
			2	44	45	-2%
			3	7	6	17%
	GFA (sq. m.)	1.55 space per 100 sq. m. GFA	1	12	18	-33%
			2	59	45	31%
			3	4	6	-33%
	GLA (sq. m.)	1.69 space per 100 sq. m. GLA	1	14	18	-22%
			2	64	45	42%
			3	4	6	-33%
	Number of Workers' Vehicles	0.92 space per worker's vehicle	1	18	18	0%
			2	51	45	13%
			3	9	6	50%
PM	Number of Workers	0.31 space per worker	1	16	14	14%
			2	44	43	2%
			3	7	5	40%
	GFA (sq. m.)	1.57 space per 100 sq. m. GFA	1	13	14	-7%
			2	60	43	40%
			3	4	5	-20%
	GLA (sq. m.)	1.70 space per 100 sq. m. GLA	1	14	14	0%
			2	65	43	51%
			3	4	5	-20%
	Number of Workers' Vehicles	0.93 space per worker's vehicle	1	19	14	36%
			2	51	43	19%
			3	9	5	80%

Table 9-35 presents rates verification of strip retail class, which is verified because the observed values are close to the rate values in two out of three points (<25%).

Table 9-35: Rates Verification of Strip Retail Class

Period	Independent Variable	Rate	Sample No.	Rate	Observed	Difference
Peak	Number of Workers' Vehicles	1.52 space per worker's vehicle	1	12.2	14	13%
			2	10.6	9	-18%
			3	10.6	15	29%

Chapter Six

Conclusions and Recommendations

10.1 Introduction

Estimating parking Generation is important because it has major effects on developing, design, planning, and managing real estate and road network. Providing parking spaces more than required will affect the price of the real estate. On the other hand, providing parking spaces less than required will negatively affect the road network capacity and affect the real estate itself. Therefore, estimating parking generation will help the decision makers in traffic management and planning.

Palestine does not have complete and specialized documents that provide engineers and planners the necessary parking demand estimation for current and new developments. The only available regulations need updating to meet the current and future needs. Moreover, they are not based on reliable studies. This research established the first step towards a comprehensive parking generation document that will be used for all stakeholders in preparing parking regulations. The research studied the parking demand for three selected land uses, which are residential, office, and retail. These selected land uses represent the main and predominated land uses in Palestine. The research covers all main cities in the West Bank. The cities peripheries are the domain of this research.

Extensive efforts are made to investigate and select appropriate sample size for each land use type. The three aforementioned land uses were subdivided into classes based on the nature of the collected data in order to increase the relevance and accuracy of the study. Attached housing, detached housing, apartment housing classes are the residential land use classes. General, institutional, and government classes represent the office land use classes. On the other hand, supermarket, strip and shopping center classes are the Retail land use classes.

Different models and rates are produced to be used in predicting the parking demand of each land use and its class. Each model or rate has its own statistical characteristics that justify using it and shows its power in predicting parking demand.

10.2 Conclusions

The following inferences are the main conclusions about the outputs of this thesis. These points provide the reader with information and instructions about the produced models and rates:

- Twenty six sites of office land use, 23 sites of residential land use, and 24 sites of retail land use were studied.
- The most predominant independent variables are number of dwelling units and number of inhabitants for residential land use. Gross floor area, gross leasable area, and number of vehicles owned by workers are the predominant independent variables for office land use. While

gross leasable area and number of workers are the predominant independent variables for retail land use.

- Simple regression analysis, which is the most common method to develop models and rates for parking generation, was used. SPSS and Excel tools were used to develop the models.
- Two or three periods of analysis were studied (AM, PM, and the Peak of facility) depends on the nature of the land use. AM and PM represent the peak of adjacent streets during morning and evening hours. The peak of facility represents the peak period of parking occupancy, and it was derived from the AM and PM periods of the adjacent streets. Sometimes, the peak of adjacent streets coincides with the peak period of facility such as for office land use.
- Models and rates were developed for all land use types. Both strong to poor models and rates were investigated. Therefore, summaries of the best models and rates were summarized for each type of land use.
- All land use classes' models and rates were built but with different reliability due to some statistical factors. Furthermore, the socioeconomic differences among cities, for example, vehicles ownership, availability of public services, etc., have produced models with various statistical significance levels.
- For certain land uses, the sample size was small (such as AH which has only five sites), as these were the available facilities that satisfy the field survey criteria. This was the case for attached housing and

general office classes. Therefore, caution should be taken when using the developed models or rates for these classes.

- In general, models are recommended to be used over rates. Models with coefficient of variation (R^2) larger than 0.5 are classified as fair to good models; confidence interval should not be less than 95% for the model to get realistic information. The produced models will have higher power when the size of the facility is within the range of data set of the model.
- Validation and Verification of models and rates show that, in general, observed values are close to the models' or rates' value. Few samples show high differences between the models' and observed values; this could be statistical justified.

In summary, statistical models and rates for estimating parking demand for residential, office, and retail land use types are developed. The developed models have power, linear, logarithmic, and exponential forms.

10.3 Recommendations

The results of this research are valuable and can be developed to be comprehensive and highly reliable to be used in Palestine. The following points will enrich the study and open new opportunities for forthcoming researchers:

- The thesis covers only three types of land uses. It is recommended to expand this study to cover all available land uses in Palestinian cities.
- Location of developments with respect to the urban morphology of city affects the parking demand. Therefore, it is recommended to study the other areas, which are the central business district and rural areas.
- The thesis provides the users with parking demand, but it is recommended to add a vacancy factor for the calculated parking demand as stated in the literature.
- This study was built based on available resources; for example, availability of sites, time, and budget. In addition, while preparing this study, there are many developments that are under construction that fulfill the study criteria (such as attached housing). It is recommended to increase the reliability of the produced models from this research by increasing the sample size of each land use class. Furthermore, covering high range of variation in each class of land use could be done by increasing sample size, thus achieving higher reliability.
- The study established parking rates for weekdays, and this forms the starting point. Therefore, it is recommended to study the weekend and special events, as applicable, and develop regression models/rates for these periods.

- The outputs of this research are recommended to be adopted locally by government institutions (MOLG and municipalities) to improve the development and planning process in Palestine.
- Finally, this is the first study of its kind in the Palestinian area and it covers only three land uses. Therefore, as this is envisioned to be the core of the future “Palestinian Parking Generation Manual”, similar studies should be conducted additional land uses and to cover Gaza Strip cities as well.

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Appendix (A): Data Collection Form

Parking Survey Form

1. Offices & Retail

City/Town		
Site Name		
Land Use Code		
Location		
Classification of Site	Urban Suburb Rural	
Topography Class	Mountainous Rolling Level	
Working Hours		
Parking Peak Period (AM & PM)		
Description of Site		
<u>Parking Properties</u>		
Area of Site/Land		Actual Approx.
Total Gross Floor Area of Building/s (m^2)		Actual Approx.
Total Leasable Area of Building/s (m^2)		Actual Approx.
Number of Employees/Workers		Actual Approx.
No. of vehicles owned by employees or workers		Actual Approx.
No. of vehicles owned by development		Actual Approx.
Location of Parking	Garage: One Floor Garage: More than One Floor Parking Lot On street Inside the border of building	
No. of parking spaces used for parking or total area (m^2)		Actual Approx.
Is the parking area used by another building/site	Yes No	
Is there parking delineated for customers use only? Yes No **If answer above is yes; how many spaces are delineated for customers?** **Is there a fee required for parking? If yes; what is the rate (NIS)?**		
<u>Public Transportation</u>		
Does public transportation arrive to site directly?		
Is there any public transportation within 400m away from the site?		
<u>Additional Information</u>		
Name of contact person for more information:		
Occupation:	**Tel/Mob.**	
Email:		
Written By:		
Tel/Mob.	**Date:**	

2. Residential (Apartment, Detached, and Attached Housing)

City/Town:		
Site Name:		
Land Use Code:		
Location:		
Classification of Site:	Urban Suburb Rural	
Topography Class:	Mountainous Rolling Level	
Description of Site		
Parking Properties		
Location of Parking	Garage: One floor Garage: More than one floor Parking Lot On street Inside the border of building	
Is the parking area used from outside properties	Yes No	
Total no. of apartments /villas in the selected site		Actual Approx.
Total no. of usable apartments /villas in the selected site		Actual Approx.
Average area of apartment in the selected site (m^2)		Actual Approx.
Total Gross Floor Area of Building/s (m^2)		Actual Approx.
Total Leasable Area of Building/s (m^2)		Actual Approx.
Number of inhabitant inside the site		Actual Approx.
No. of vehicles owned by inhabitants		Actual Approx.
No. of parking spaces used for parking / total area (m^2)		Actual Approx.
Is the Parking Area Used from outside properties	Yes No	
Public Transportation		
Does public transportation arrive to site directly?	Yes No	
If the answer above is number Is there any public transportation within 400m away from the site?	Yes No	
Additional Information		
Name of contact person for more information:		
Occupation:	**Tel/Mob.**	
Email:		
Written By:		
Tel/Mob.	**Date:**	

Appendix (B): Parking Count Sheet

Parking Accumulation Survey Count Sheet

Land Use Type: **Name of**
Development/Site: **Duration of Count:**
Adjacent Street Name: **Weather:** Cloudy,
Sunny, Rainy, Windy, Cold **Block/City:**
Surveyor Name: **Surveyor**
Mobile: **Day:** **Date:**

Time of Count (Start of each 15 minutes)	**Morning/Evening Total number of Parked Vehicles**				**Time of Count (Start of each 15 minutes)**	**Morning/Evening Total number of Parked Vehicles**			
	Passenger) (Car	Shared) (Taxi	(Van)	Trucks		Passenger) (Car	Shared) (Taxi	(Van)	Trucks

Notes:

Appendix (C): Descriptive Statistic

1. Residential Land Use

Table 36: Descriptive Statistics of AH Residential Land Use Class

	N	Range	Min.	Max.	Mean	Std. Deviation	Variance	Skewness		CV
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	%
Independent Variables										
a. No of Houses	5	23	13	36	23.80	8.167	66.700	0.425	0.913	34.32
b. No of Inhabitants	5	121	59	180	108.40	45.873	2104.300	0.966	.913	42.32
c. No of Persons' Vehicles	5	20	10	30	20.80	9.576	91.700	-0.463	0.913	46.04
Dependent Variables										
a. APP Parking Demand AM	5	24	12	36	23.00	11.554	133.500	0.504	0.913	50.23
b. APP Parking Demand PM	5	12	9	21	14.00	5.000	25.000	0.600	0.913	35.71
c. Max. APP Parking Demand	5	26	12	38	23.60	12.381	153.300	0.529	0.913	52.46
Valid N (listwise)	5									

APP: Average peak period

Table 37: Descriptive Statistics of DH Residential Land Use Class

	N	Range	Min.	Max.	Mean	Std. Deviation	Variance	Skewness		CV
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	%
Independent Variables										
a. No of Houses	8	69	7	76	34.75	23.469	550.786	.388	.752	67.54
b. No of Inhabitants	8	280	28	308	144.00	97.308	9468.857	.372	.752	67.58
c. No of Persons' Vehicles	8	132	9	141	52.88	45.780	2095.839	1.194	.752	86.57
Dependent Variables										
a. Max Parked Vehicles (AM)	8	64	4	68	32.19	22.544	508.210	.244	.752	70.03
b. Max Parked Vehicles (PM)	8	42	6	47	28.50	17.857	318.857	-.114	.752	62.66
c. Max Parked Vehicles (AVG)	8	69	6	75	36.75	23.113	534.214	.308	.752	62.89
Valid N (listwise)	8									

Table 38: Descriptive Statistics of APH Residential Land Use Class

	N	Range	Min.	Max.	Mean	Std. Deviation	Variance	Skewness		CV
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	%
Independent Variables										
a. Gross Floor Area	10	9328	2320	11648	5095.80	2892.704	8367736.40	1.355	0.687	56.77
b. No of Persons Occupied	10	314	70	384	195.90	121.384	14734.100	0.782	0.687	61.96
c. No of Persons' Vehicles	10	35	4	39	18.40	11.227	126.044	0.510	0.687	61.02
d. Total No. of Apartments	10	61	16.00	77.00	41.1000	21.83499	476.767	0.779	0.687	53.13
e. No of Apartment	10	50	14	64	34.90	18.675	348.767	0.800	0.687	53.51
Dependent Variables										
a. Max Parked Vehicles (AM)	10	24	3	27	15.10	8.881	78.878	0.131	0.687	58.81
b. Max Parked Vehicles (PM)	10	34	4	38	15.60	10.839	117.489	0.844	0.687	69.48
c. Max Parked Vehicles (AVG)	10	39	4	43	19.00	12.055	145.333	0.656	0.687	63.45
Valid N (listwise)	10									

1. Offices Land Use

Table 39: Descriptive Statistics of General Offices Land Use Class

	N	Range	Min.	Max.	Mean	Std. Deviation	Variance	Skewness		CV
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	%
Independent Variables										
a. No of Workers	5	22	23	45	34.00	9.849	97.000	-.094	.913	28.97
b. Gross Floor Area (m^2)	5	1115	540	1655	1124.00	431.384	186092.500	-.135	.913	38.38
c. Gross Leasable Area (m^2)	5	1045	380	1425	973.00	386.322	149245.000	-.795	.913	39.70
d. No. of Workers' Vehicles	5	11	10	21	16.20	4.438	19.700	-.364	.913	27.40
Dependent Variables										
a. Max Parked Vehicles (AM)	5	14	8	21	13.30	5.552	30.825	.415	.913	41.74
b. Max Parked Vehicles (PM)	5	26	8	34	17.30	9.954	99.075	1.572	.913	57.54
c. Max Average Peak Parked Vehicles	5	25	9	34	17.60	9.555	91.300	1.770	.913	54.29
Valid N (listwise)	5									

Table 40: Descriptive Statistics of Government Offices Land Use Class

	N	Range	Min.	Max.	Mean	Std. Deviation	Variance	Skewness		CV
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	%
Independent Variables										
a. No of Workers	14	168	22	190	70.79	45.328	2054.643	1.540	.597	64
b. Gross Floor Area (m^2)	14	3550	400	3950	1400.07	907.647	823822.533	1.717	.597	65
c. Gross Leasable Area (m^2)	14	3650	300	3950	1289.50	939.844	883306.577	1.818	.597	73
d. No. of Workers' Vehicles	14	39	6	45	23.64	11.105	123.324	.426	.597	47
Dependent Variables										
a. Max Parked Vehicles (AM)	14	31	7	38	21.75	8.774	76.990	-.154	.597	40
b. Max Parked Vehicles (PM)	14	28.5	6.0	34.5	21.964	8.9431	79.979	-.556	.597	41
c. Max Average Peak Parked Vehicles	14	31	7	38	23.71	9.442	89.143	-.507	.597	40
Valid N (listwise)	14									

Table 41: Descriptive Statistics of Institutional Offices Land Use Class

	N	Range	Min.	Max.	Mean	Std. Deviation	Variance	Skewness		CV
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	%
Independent Variables										
a. No of Workers	7	588	12	600	209.86	225.920	51039.810	.929	.794	108
b. Gross Floor Area (m^2)	7	12250	250	12500	4149.57	4392.556	19294547.952	1.335	.794	106
c. Gross Leasable Area (m^2)	7	12250	250	12500	4003.71	4430.346	19627969.905	1.419	.794	111
d. No. of Workers' Vehicles	7	267	8	275	104.00	103.998	10815.667	.782	.794	100
Dependent Variables										
a. Max Parked Vehicles (AM)	7	294	16	310	95.07	109.986	12096.869	1.499	.794	116
b. Max Parked Vehicles (PM)	7	302	11	313	96.57	111.404	12410.786	1.409	.794	115
c. Max Average Peak Parked Vehicles	7	297	16	313	100.14	109.901	12078.143	1.417	.794	110
Valid N (listwise)	7									

2. Retail Land Use

Table 42: Descriptive Statistics of Large Super Market Land Use Class

	N	Range	Min.	Max.	Mean	Std. Deviation	Variance	Skewness		CV
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	%
Independent Variables										
a. No of Workers	15	13	2	15	7.20	4.887	23.886	.691	.580	68
b. Gross Floor Area (m^2)	15	1090	110	1200	448.87	321.931	103639.267	1.195	.580	72
c. Gross Leasable Area (m^2)	15	1090	110	1200	448.87	321.931	103639.267	1.195	.580	72
d. No. of Workers' Vehicles	15	6	1	7	2.53	1.767	3.124	1.549	.580	70
Dependent Variables										
a. Max Parked Vehicles (AM)	15	21	3	24	8.27	6.250	39.067	1.473	.580	76
b. Max Parked Vehicles (PM)	15	19	4	23	9.33	6.161	37.952	1.116	.580	66
c. Max Average Peak Parked Vehicles	15	20	4	24	10.20	6.494	42.171	1.050	.580	64
Valid N (listwise)	15									

Table 43: Descriptive Statistics of Strip Retail Land Use Class

	N	Range	Min.	Max.	Mean	Std. Deviation	Variance	Skewness		CV
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	%
Independent Variables										
a. No of Workers	8	23	5	28	11.50	7.270	52.857	1.987	.752	63
b. Gross Floor Area (m^2)	8	1020	180	1200	438.25	407.897	166380.214	1.500	.752	93
c. Gross Leasable Area (m^2)	8	1020	180	1200	438.25	407.897	166380.214	1.500	.752	93
d. No. of Workers' Vehicles	8	14	3	17	6.75	4.528	20.500	2.027	.752	67
Dependent Variables										
a. Max Parked Vehicles (AM)	8	14	6	19	9.38	4.998	24.982	1.269	.752	53
b. Max Parked Vehicles (PM)	8	13	7	19	9.81	4.415	19.496	1.666	.752	45
c. Max Average Peak Parked Vehicles	8	12	7	19	10.50	4.342	18.857	1.361	.752	41
Valid N (listwise)	8									

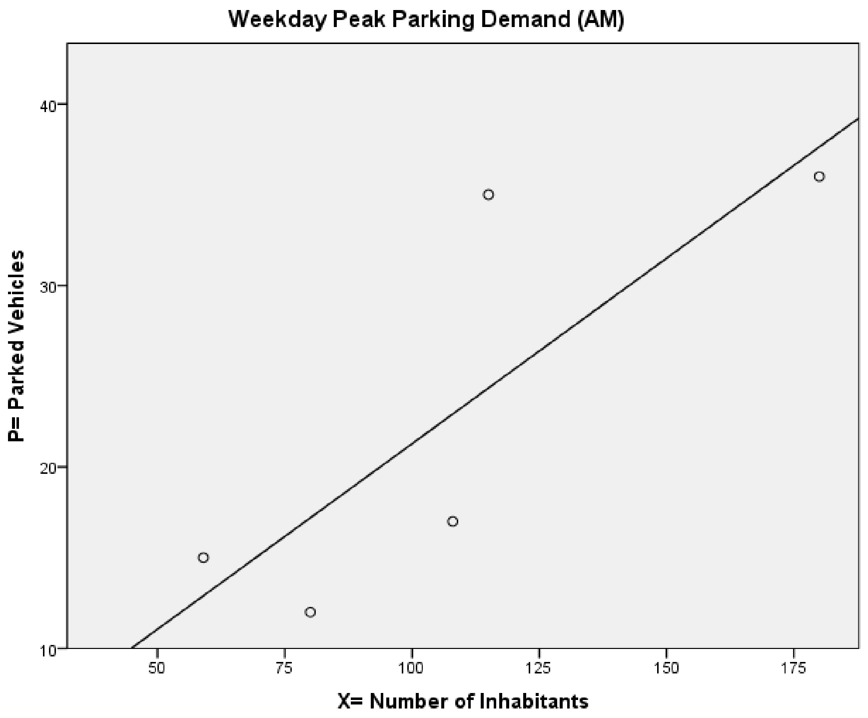
Appendix (D): Models and Rates Sheet

Parking Generation Model and Rate

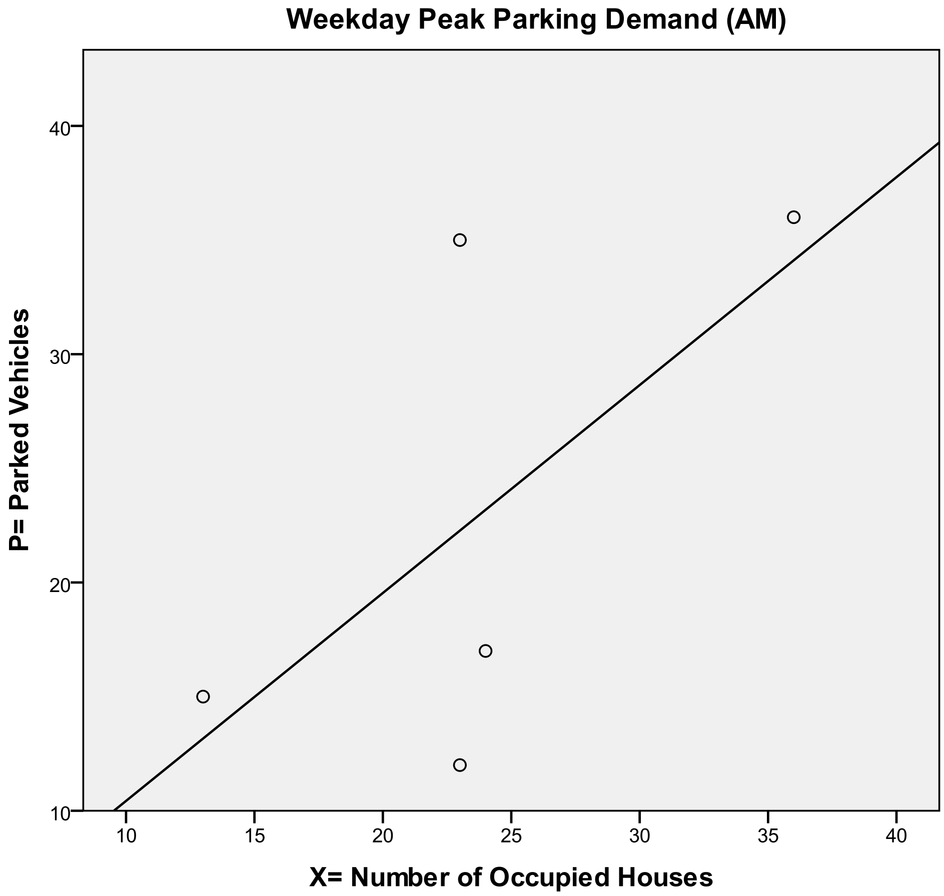
Residential Land Use

a. Attached Housing Class

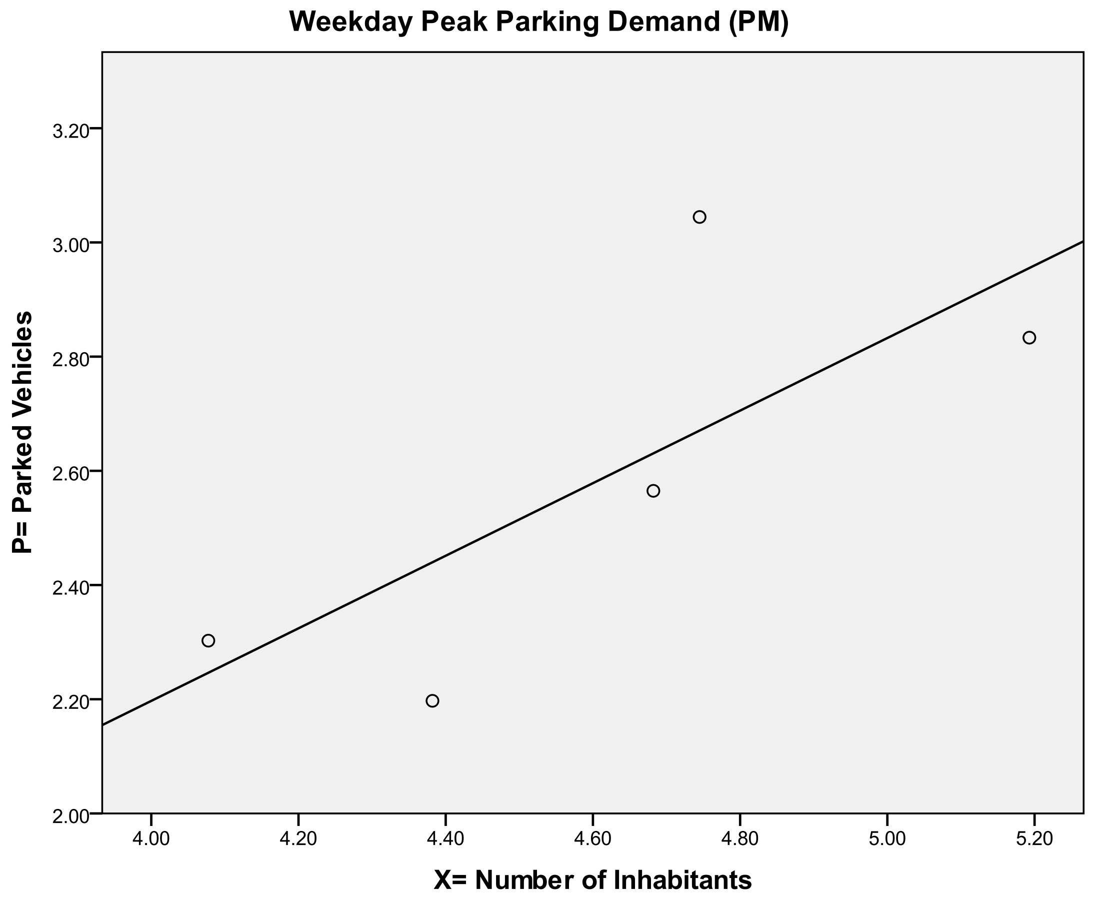
Average Peak Parking Demand vs. Number of Inhabitants	
Survey Time Range	**AM (7:00 - 9:00) on a Weekday**
Number of Sites	**5**
Average Size	**108.4**
Standard Deviation	**0.07**
Coefficient of Variation (CV)	**0.32%**
Range	**0.14-0.30 space per inhabitant**
Rate	**0.21 space per inhabitant**
85^{th} Percentile	**0.27**
33^{rd} Percentile	**0.17**
Model	**P= 0.204*X+0.849**
Model Confidence Interval	**1-0.096**
Coefficient of Determination (R^2)	**0.66**



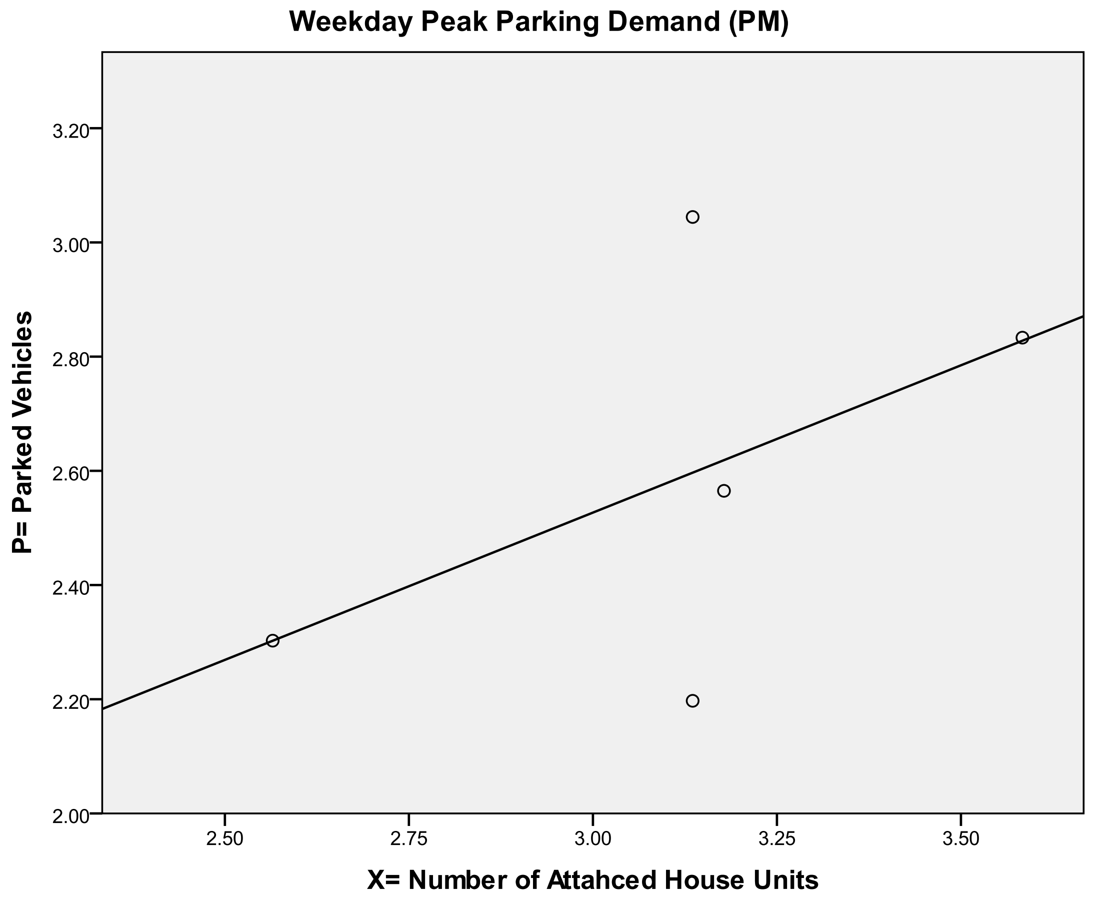
Average Peak Parking Demand vs. Number of Occupied Attached House Units	
Survey Time Range	AM (7:00 - 9:00) on a Weekday
Number of Sites	5
Average Size	23.8
Standard Deviation	0.39
Coefficient of Variation (CV)	41%
Range	0.50-1.52 space per occupied unit
Rate	0.95 space per occupied unit
85th Percentile	1.28
33rd Percentile	0.80
Model	P= 0.911*X+1.323
Model Confidence Interval	(1-0.241)
Coefficient of Determination (R^2)	0.41



Average Peak Parking Demand vs. Number of Inhabitants	
Survey Time Range	**PM (14:00 - 17:00) on a Weekday**
Number of Sites	**5**
Average Size	**108.4**
Standard Deviation	**0.05**
Coefficient of Variation (CV)	**39%**
Range	**0.07-0.18**
Rate	**0.13 space per inhabitant**
85th Percentile	**0.17**
33rd Percentile	**0.12**
Model	**P= 0.635*X-0.345**
Model Confidence Interval	**(1-0.145)**
Coefficient of Determination (R^2)	**0.56**

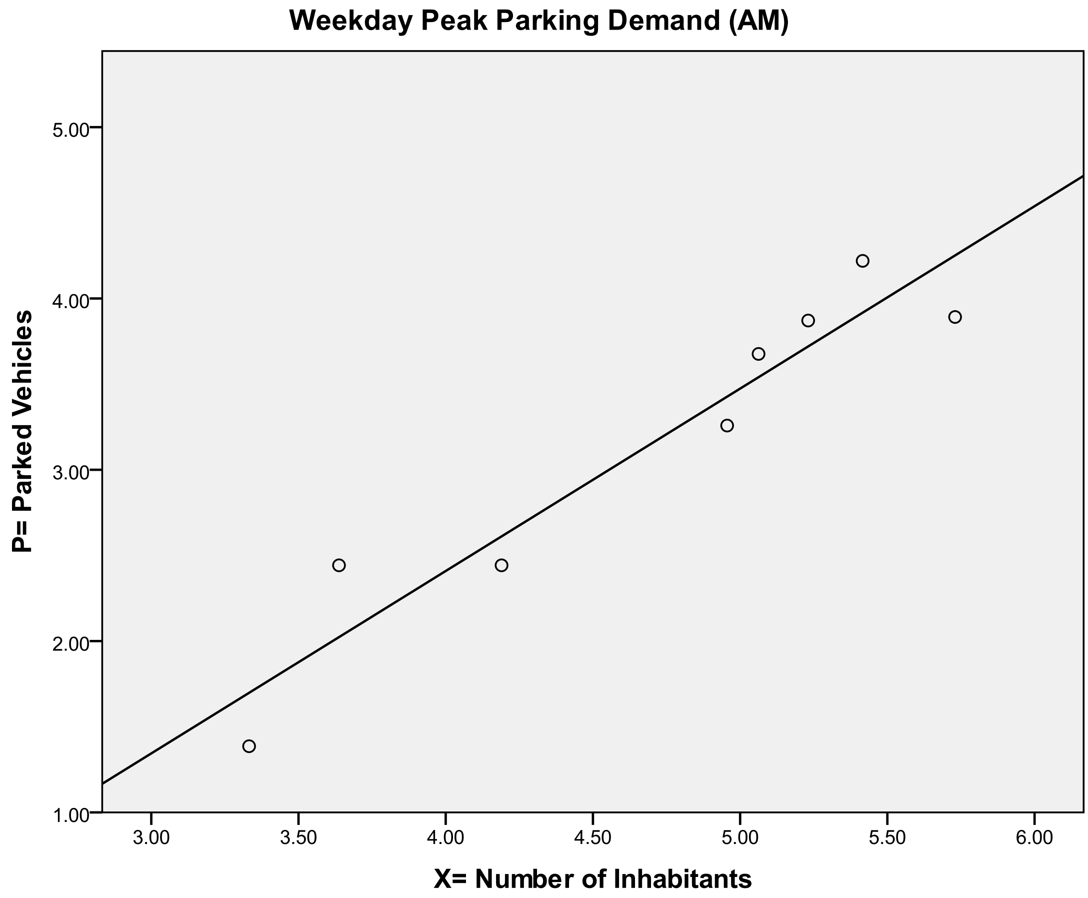


Average Peak Parking Demand vs. Number of Attached House Units	
Survey Time Range	**PM (14:00 - 17:00) on a Weekday**
Number of Sites	**5**
Average Size	**23.8**
Standard Deviation	**0.25**
Coefficient of Variation (CV)	**45%**
Range	**0.33-0.91**
Rate	**0.55**
85th Percentile	**0.83**
33rd Percentile	**0.44**
Model	**P= 0.516*X+ 0.979**
Model Confidence Interval	**(1-0.361)**
Coefficient of Determination (R^2)	**0.28**

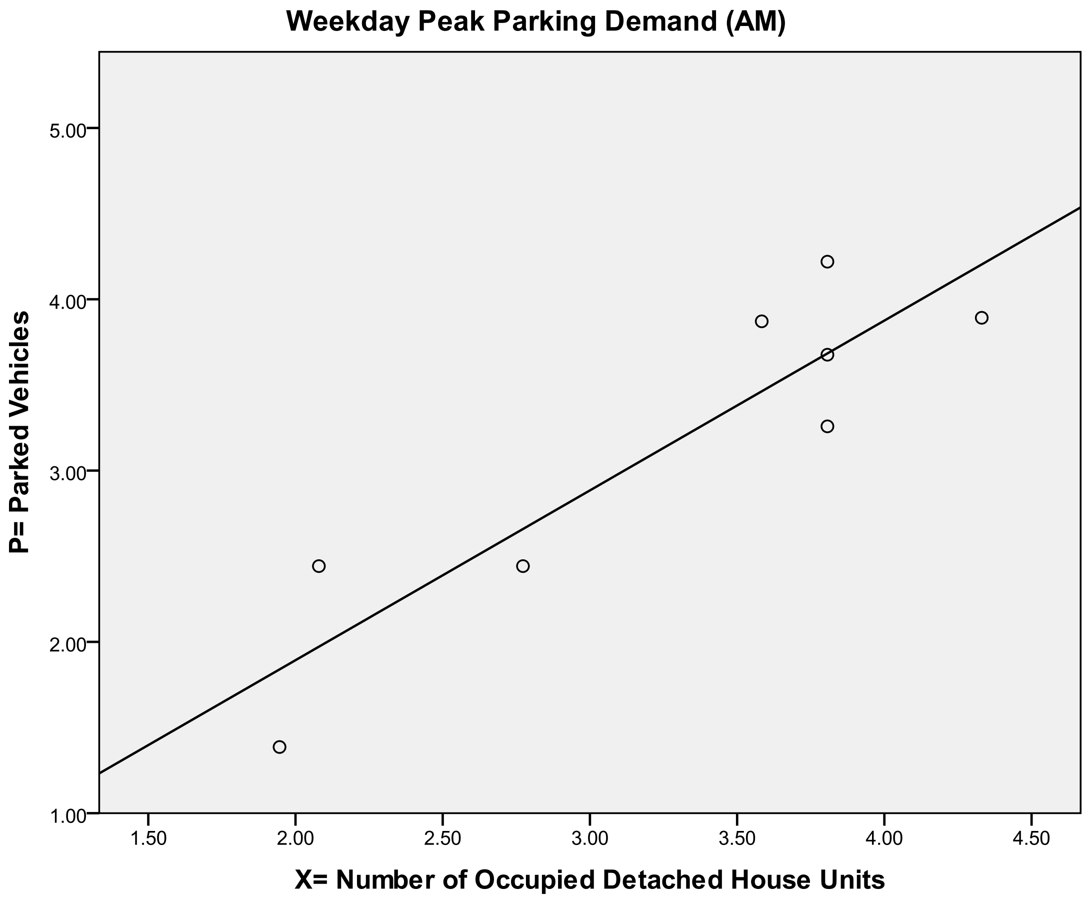


b. Detached Housing Class

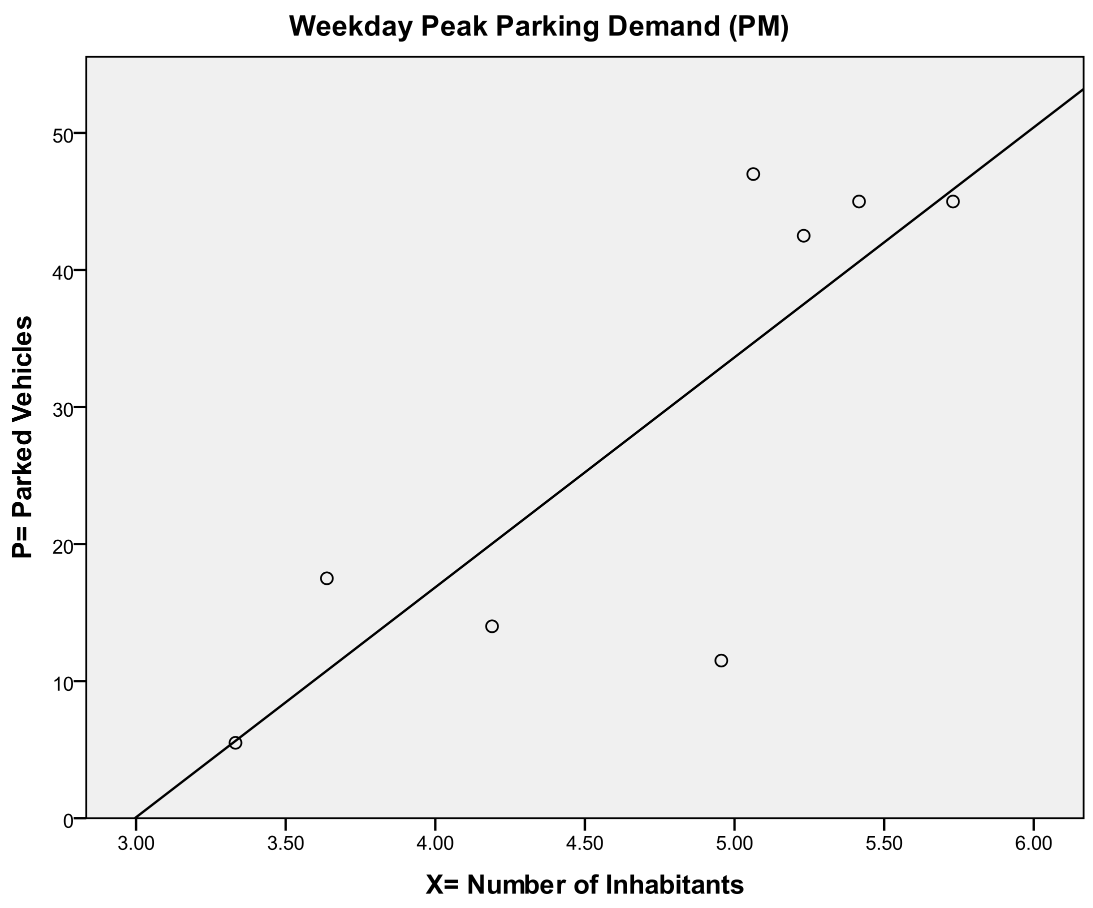
Average Peak Parking Demand vs. Number of Inhabitants	
Survey Time Range	AM (7:00 - 9:00) on a Weekday
Number of Sites	8
Average Size	144
Standard Deviation	0.06
Coefficient of Variation (CV)	29%
Range	0.14-0.30
Rate	0.22
85th Percentile	0.30
33rd Percentile	0.18
Model	$P= 0.157*X^{1.065}$
Coefficient of Determination (R^2)	0.91



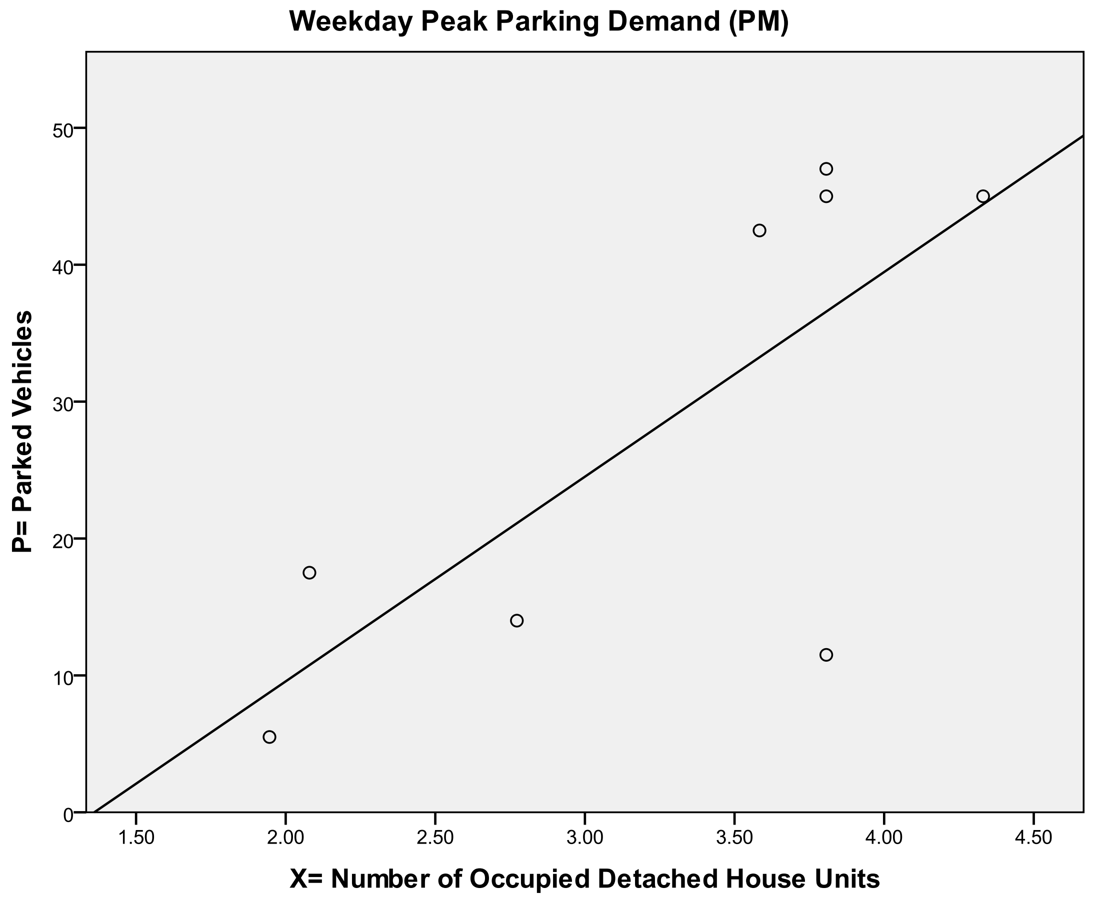
Average Peak Parking Demand vs. Number of Attached House Units	
Survey Time Range	AM (7:00 - 9:00) on a Weekday
Number of Sites	8
Average Size	34.75
Standard Deviation	0.40
Coefficient of Variation (CV)	43%
Range	0.57-1.51
Rate	0.93
85th Percentile	1.43
33rd Percentile	0.67
Model	P= 0.914*X^0.911
Coefficient of Determination (R^2)	0.82



Average Peak Parking Demand vs. Number of Inhabitants	
Survey Time Range	**PM (14:00 - 17:00) on a Weekday**
Number of Sites	**8**
Average Size	**144**
Standard Deviation	**0.11**
Coefficient of Variation (CV)	**57%**
Range	**0.08-0.46**
Rate	**0.20**
85th Percentile	**0.29**
33rd Percentile	**0.20**
Model	**P= 16.781*LN(X)-50.38**
Coefficient of Determination (R^2)	**0.67**

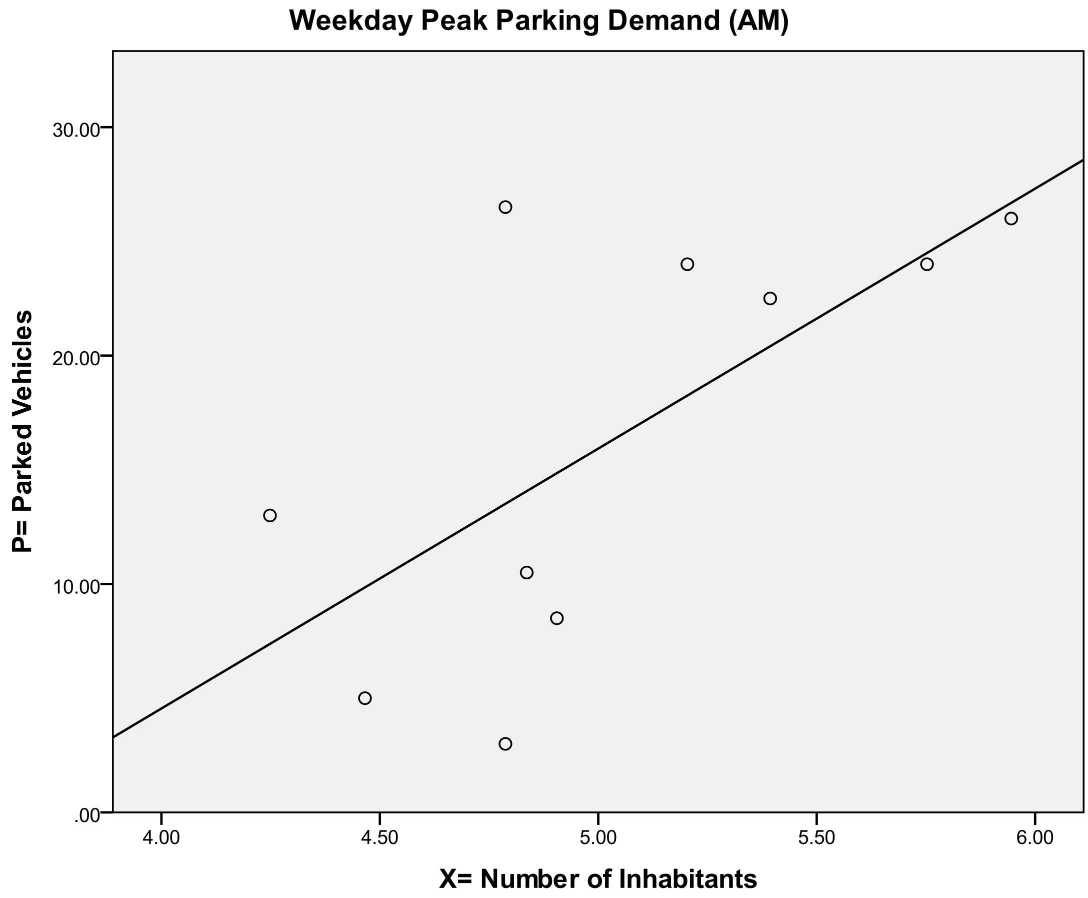


Average Peak Parking Demand vs. Number of Attached House Units	
Survey Time Range	PM (14:00 - 17:00) on a Weekday
Number of Sites	8
Average Size	34.75
Standard Deviation	0.56
Coefficient of Variation (CV)	69%
Range	0.26-2.19
Rate	0.82
85^{th} Percentile	1.17
33^{rd} Percentile	0.81
Model	P= 14.951*LN(X)-20.34
Coefficient of Determination (R^2)	0.55

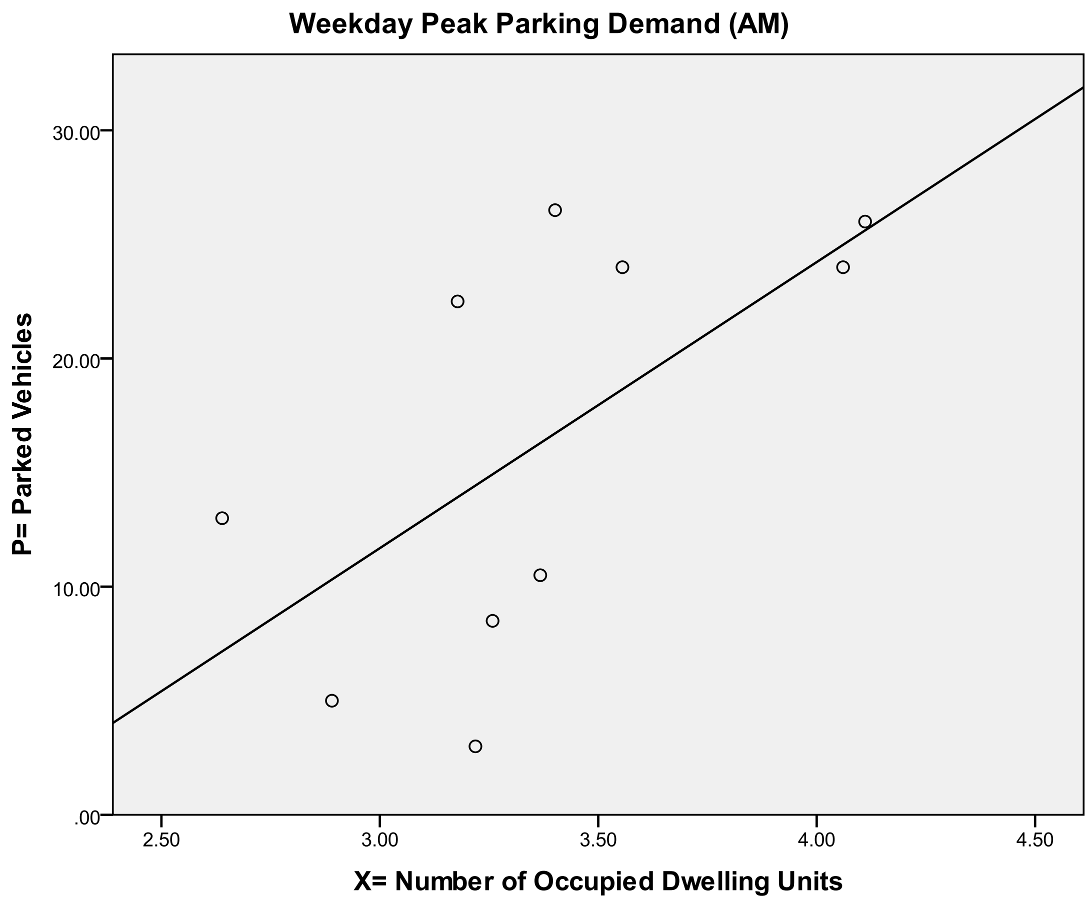


c. Apartment Housing Class

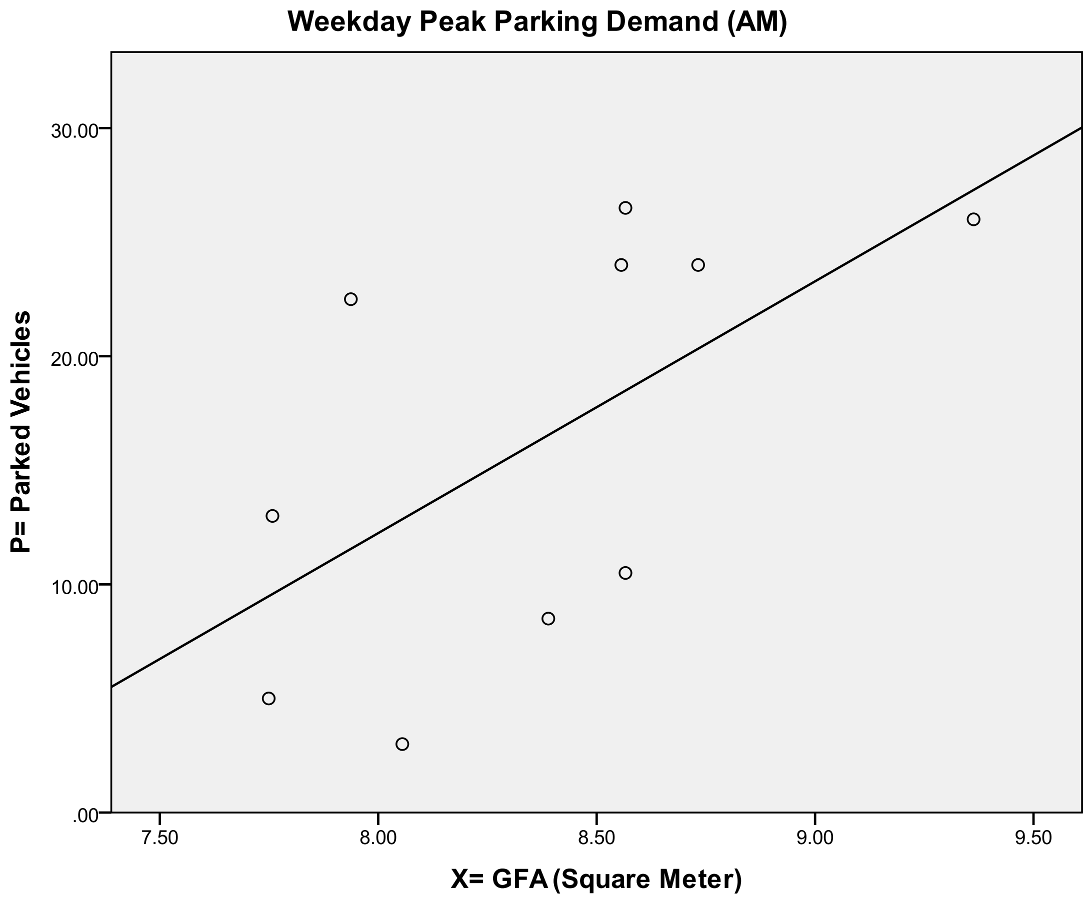
Average Peak Parking Demand vs. Number of Inhabitants	
Survey Time Range	AM (7:00 - 9:00) on a Weekday
Number of Sites	10
Average Size	175.7
Standard Deviation	0.06
Coefficient of Variation (CV)	66%
Range	0.03-0.22
Rate	0.09
85th Percentile	0.17
33rd Percentile	0.07
Model	P= 11.379*X-40.97
Coefficient of Determination (R^2)	0.44



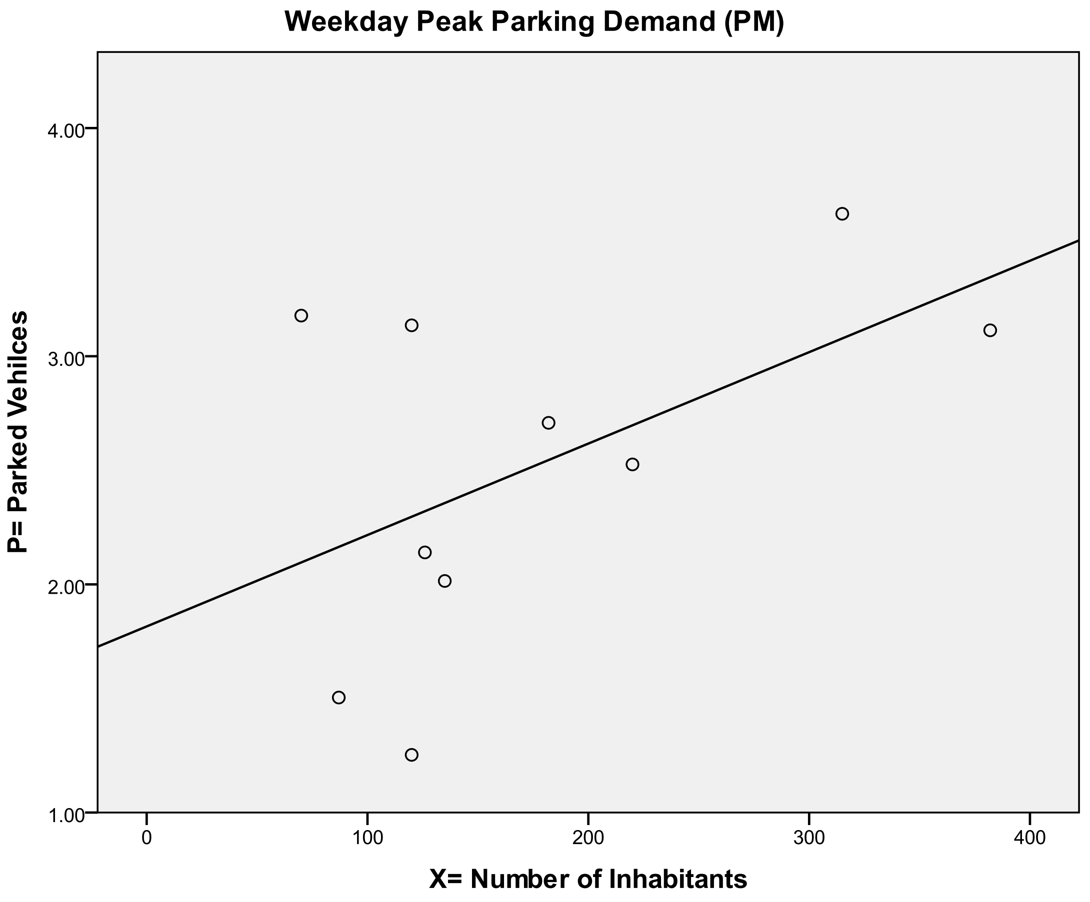
Average Peak Parking Demand vs. Number of Occupied Dwelling Units	
Survey Time Range	AM (7:00 - 9:00) on a Weekday
Number of Sites	10
Average Size	32
Standard Deviation	0.30
Coefficient of Variation (CV)	59%
Range	0.12-0.94
Rate	0.51
85th Percentile	0.91
33rd Percentile	0.36
Model	P= 12.534*LN(X-25.925
Model Confidence Interval	(1-0.054)
Coefficient of Determination (R^2)	0.39



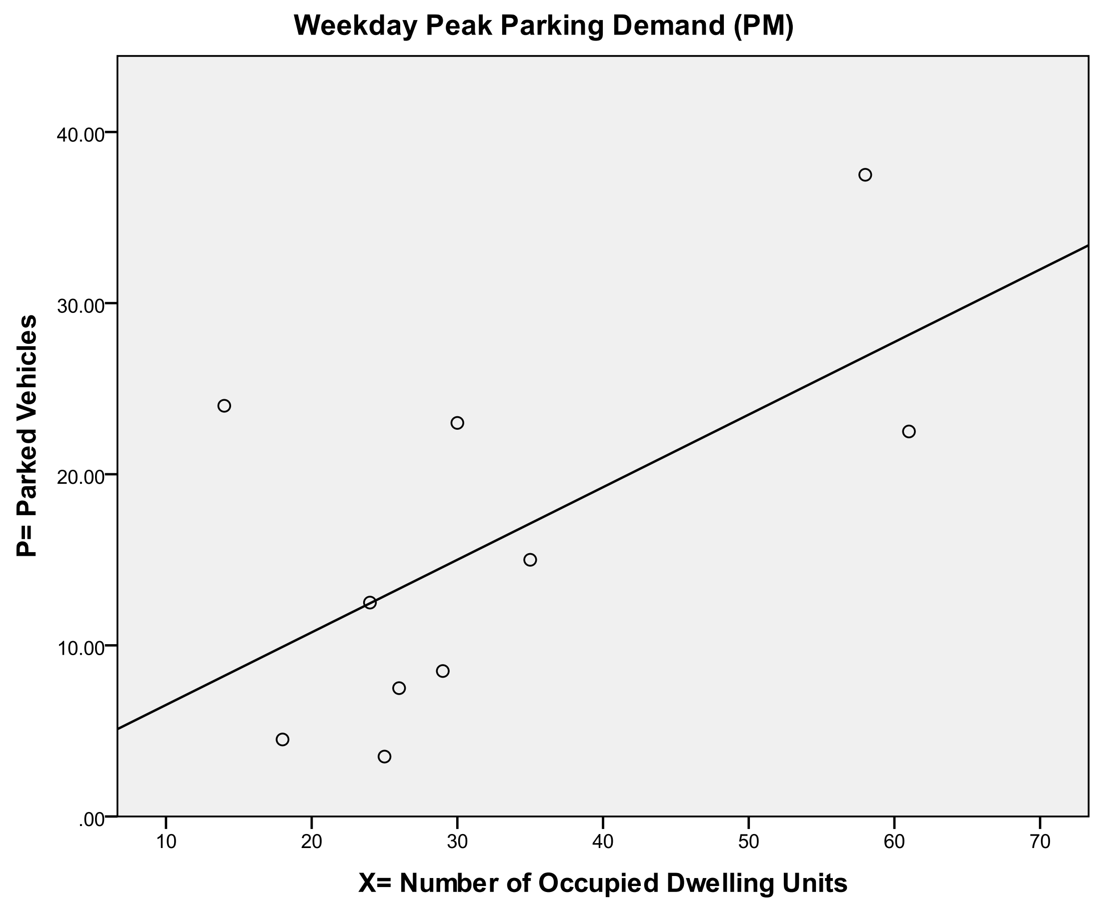
Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	**AM (7:00 - 9:00) on a Weekday**
Number of Sites	**10**
Average Size	**4855.8**
Standard Deviation	**0.22**
Coefficient of Variation (CV)	**65%**
Range	**0.1-0.80 space per 100 sq. m. GFA**
Rate	**0.33 space per 100 sq. m. GFA**
85th Percentile	**0.54**
33rd Percentile	**0.22**
Model	**P= 11.035*LN(X)-76.032**
Model Confidence Interval	**(1-0.066)**
Coefficient of Determination (R^2)	**0.36**



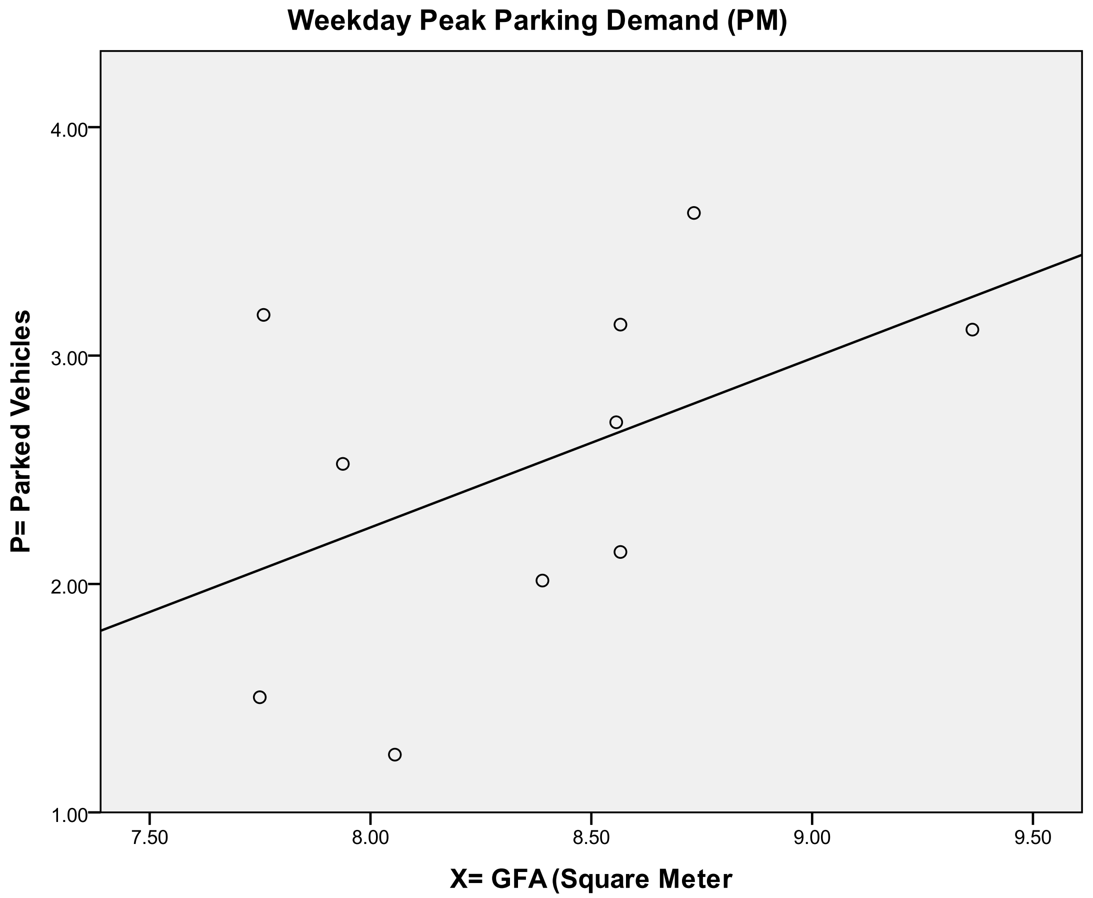
Average Peak Parking Demand vs. Number of Inhabitants	
Survey Time Range	**PM (14:00 - 17:00) on a Weekday**
Number of Sites	**10**
Average Size	**175.7**
Standard Deviation	**0.10**
Coefficient of Variation (CV)	**106%**
Range	**0.03-0.34**
Rate	**0.09**
85th Percentile	**0.17**
33rd Percentile	**0.06**
Model	**P= 1.816*X+ 0.004 EXP**
Model Confidence Interval	**(1-0.12)**
Coefficient of Determination (R^2)	**0.28**



Average Peak Parking Demand vs. Number of Occupied Dwelling Units	
Survey Time Range	PM (14:00 - 17:00) on a Weekday
Number of Sites	10
Average Size	32
Standard Deviation	0.45
Coefficient of Variation (CV)	92%
Range	0.14-1.71
Rate	0.49
85th Percentile	0.72
33rd Percentile	0.29
Model	P= 0.424*X+ 2.278
Model Confidence Interval	(1-0.058)
Coefficient of Determination (R^2)	0.38



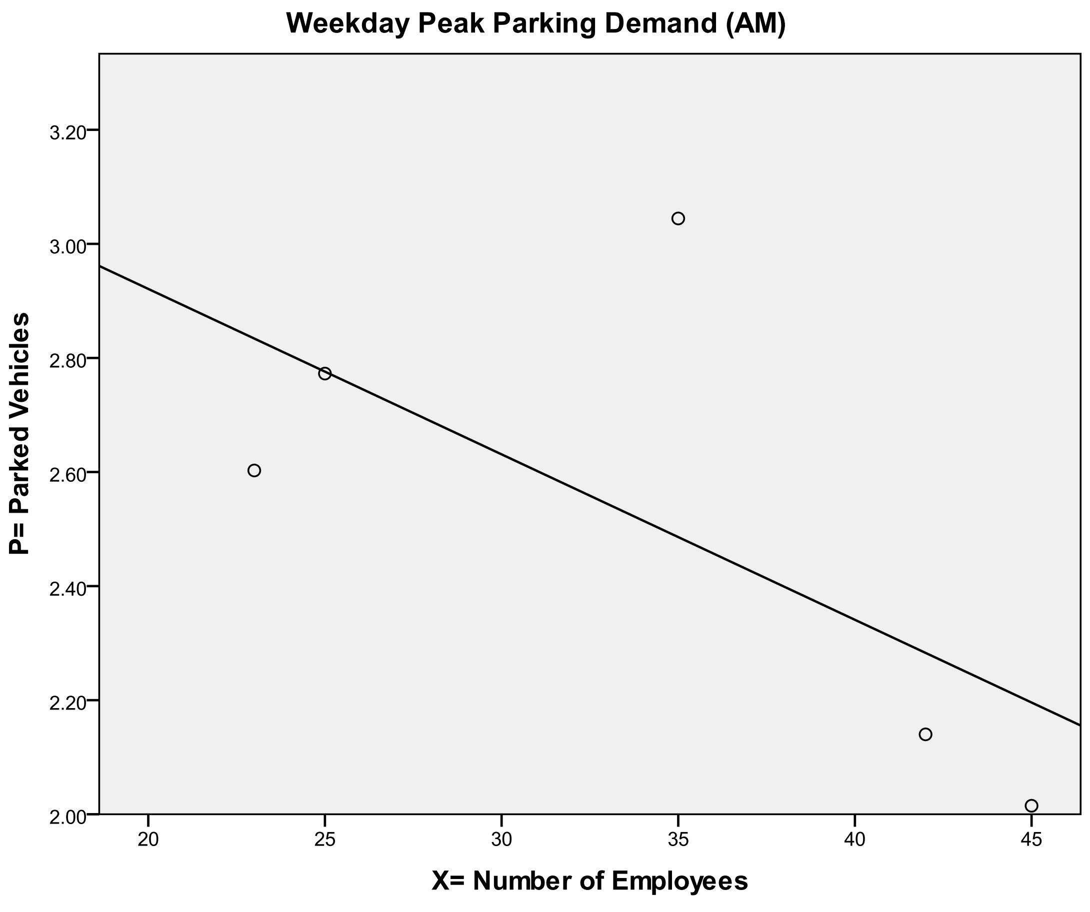
Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	PM (14:00 - 17:00) on a Weekday
Number of Sites	10
Average Size	4855.8
Standard Deviation	0.28
Coefficient of Variation (CV)	87%
Range	0.11-1.03 space per 100 sq. m. GFA
Rate	0.33 space per 100 sq. m. GFA
85th Percentile	0.55
33rd Percentile	0.19
Model	P= 0.741*X-3.678 power
Model Confidence Interval	(1-0.162)
Coefficient of Determination (R^2)	0.23



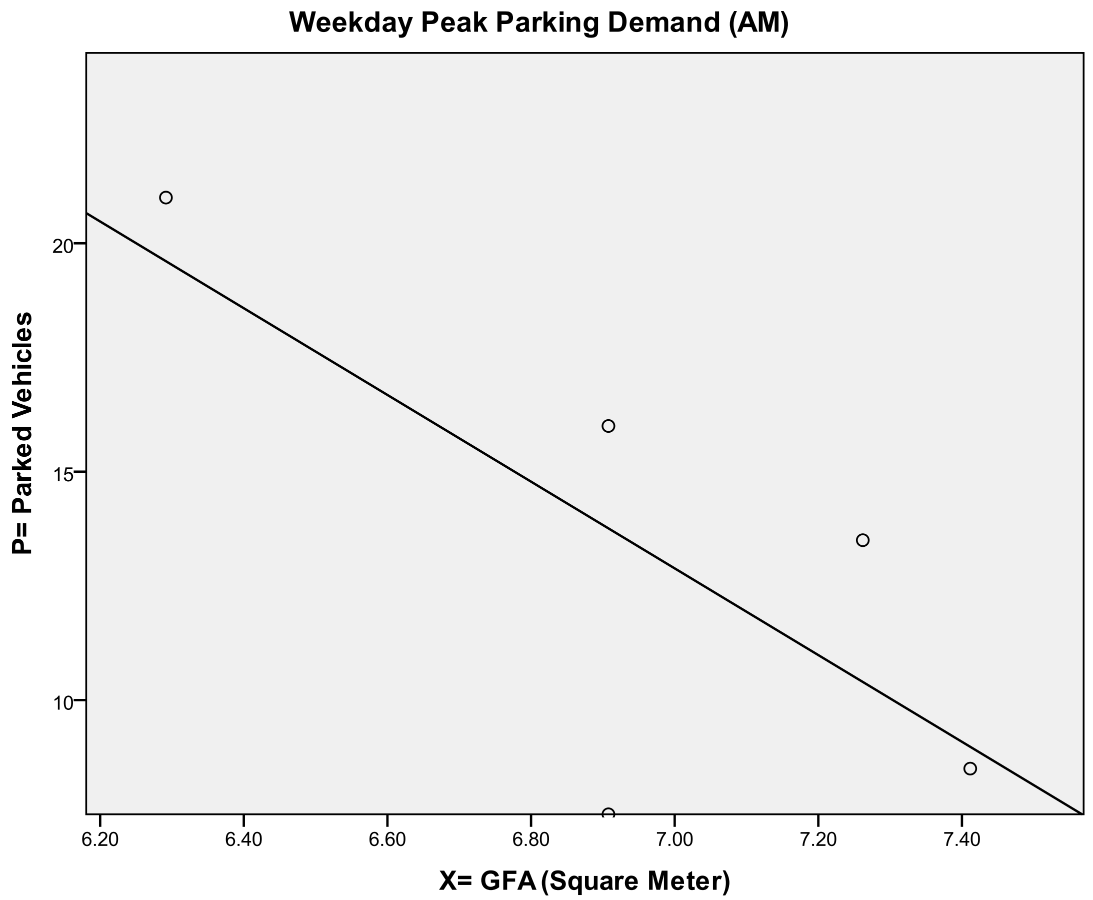
Office Land Use

a. General Office Class

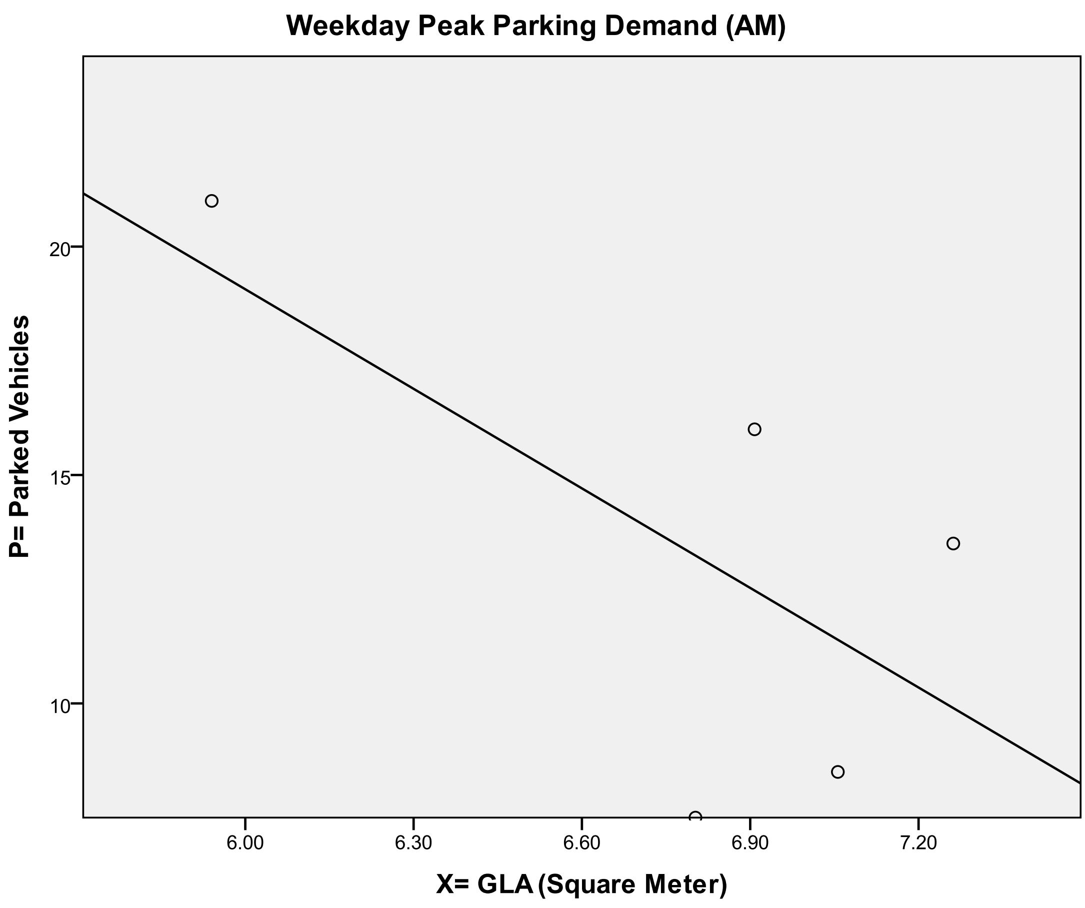
Average Peak Parking Demand vs. Number of Employees	
Survey Time Range	AM (7:00 - 10:45) on a Weekday
Number of Sites	5
Average Size	34
Standard Deviation	0.23
Coefficient of Variation (CV)	60%
Range	0.17-0.64
Rate	0.39
85^{th} Percentile	0.62
33^{rd} Percentile	0.33
Model	$33.148\ e^{-0.029\ x}$
Model Confidence Interval	(1-0.224)
Coefficient of Determination (R^2)	0.44



Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	**AM (7:00 - 10:45) on a Weekday**
Number of Sites	**5**
Average Size	**1124**
Standard Deviation	**1.37**
Coefficient of Variation (CV)	**116%**
Range	**0.51-3.89**
Rate	**1.18**
85th Percentile	**2.52**
33rd Percentile	**0.81**
Model	$\mathbf{P = -9.49ln(x) + 79.32}$
Model Confidence Interval	**(1-0.154)**
Coefficient of Determination (R^2)	**0.55**

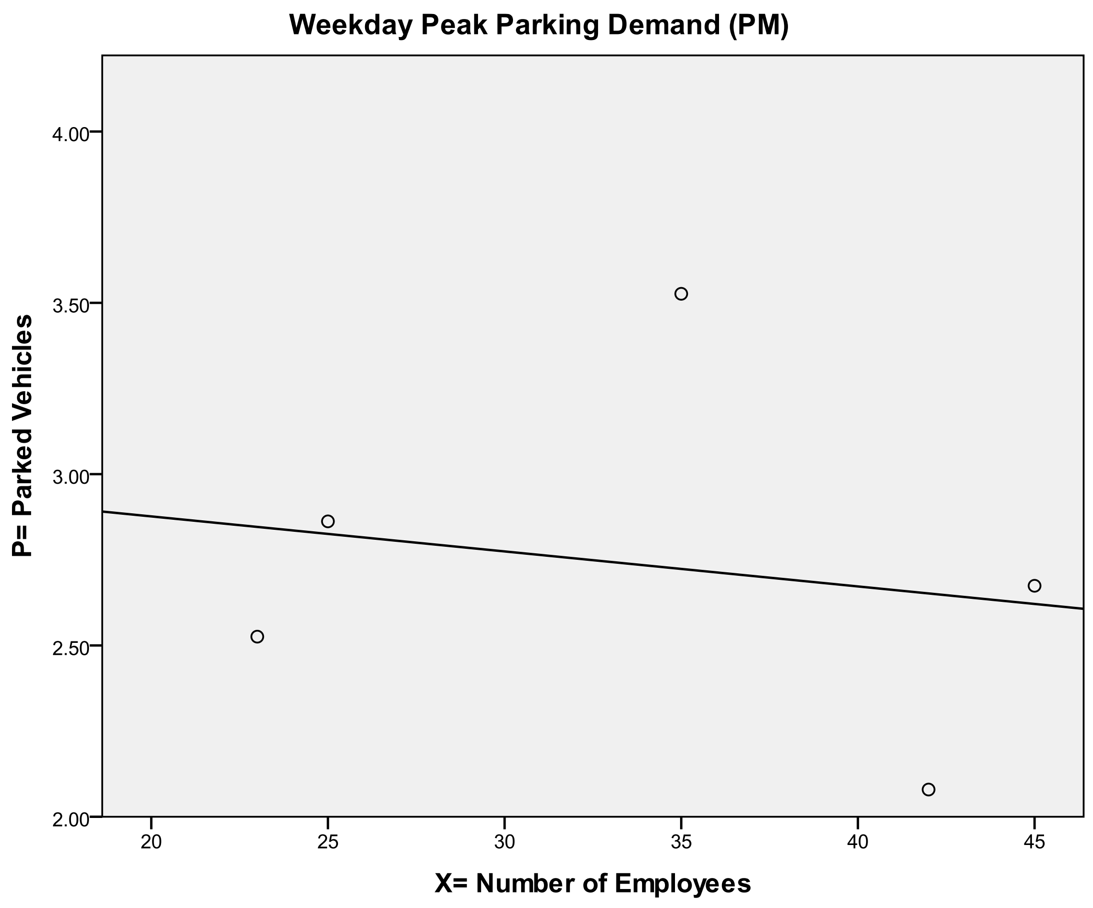


Average Peak Parking Demand vs. GLA (Square Meter)	
Survey Time Range	**AM (7:00 - 10:45) on a Weekday**
Number of Sites	**5**
Average Size	**973**
Standard Deviation	**2.04**
Coefficient of Variation (CV)	**149%**
Range	**0.73-5.53**
Rate	**1.37**
85^{th} Percentile	**3.17**
33^{rd} Percentile	**0.87**
Model	$\mathbf{P = -7.27\ln(x) + 62.66}$
Model Confidence Interval	**(1-0.222)**
Coefficient of Determination (R^2)	**0.44**

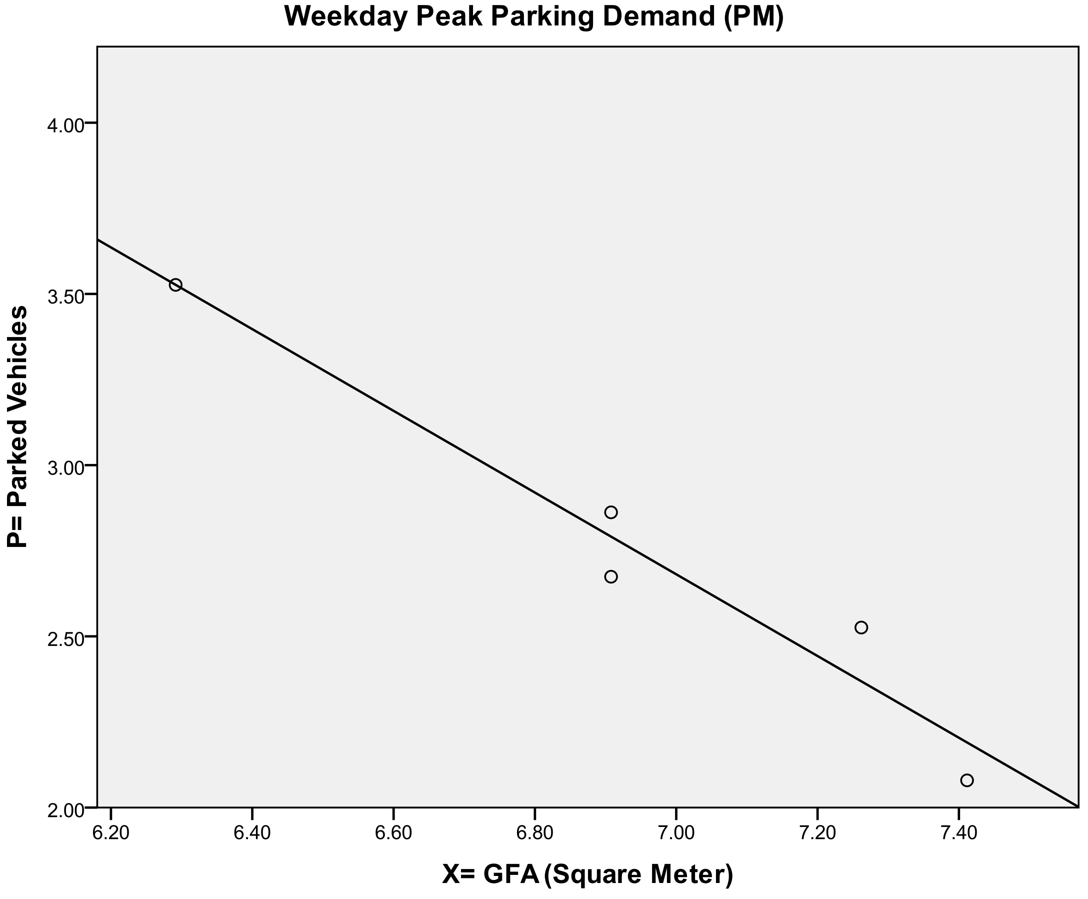


Average Peak Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**AM (7:00 - 10:45) on a Weekday**
Number of Sites	**5**
Average Size	**16.2**
Standard Deviation	**0.68**
Coefficient of Variation (CV)	**83%**
Range	**0.40-2.10**
Rate	**0.82**
85th Percentile	**1.38**
33rd Percentile	**0.60**
Model	$\mathbf{P = -11.29\ln(x) + 44.37}$
Model Confidence Interval	**(1-0.283)**
Coefficient of Determination (R^2)	**0.36**

Average Peak Parking Demand vs. Number of Employees	
Survey Time Range	**PM (11:30 - 17:00) on a Weekday**
Number of Sites	**5**
Average Size	**34**
Standard Deviation	**0.31**
Coefficient of Variation (CV)	**61%**
Range	**0.19-0.97**
Rate	**0.51**
85th Percentile	**0.81**
33rd Percentile	**0.39**
Model	**$P = 21.78\ e^{-0.010\ x}$**
Model Confidence Interval	**(1-0.759)**
Coefficient of Determination (R^2)	**0.04**

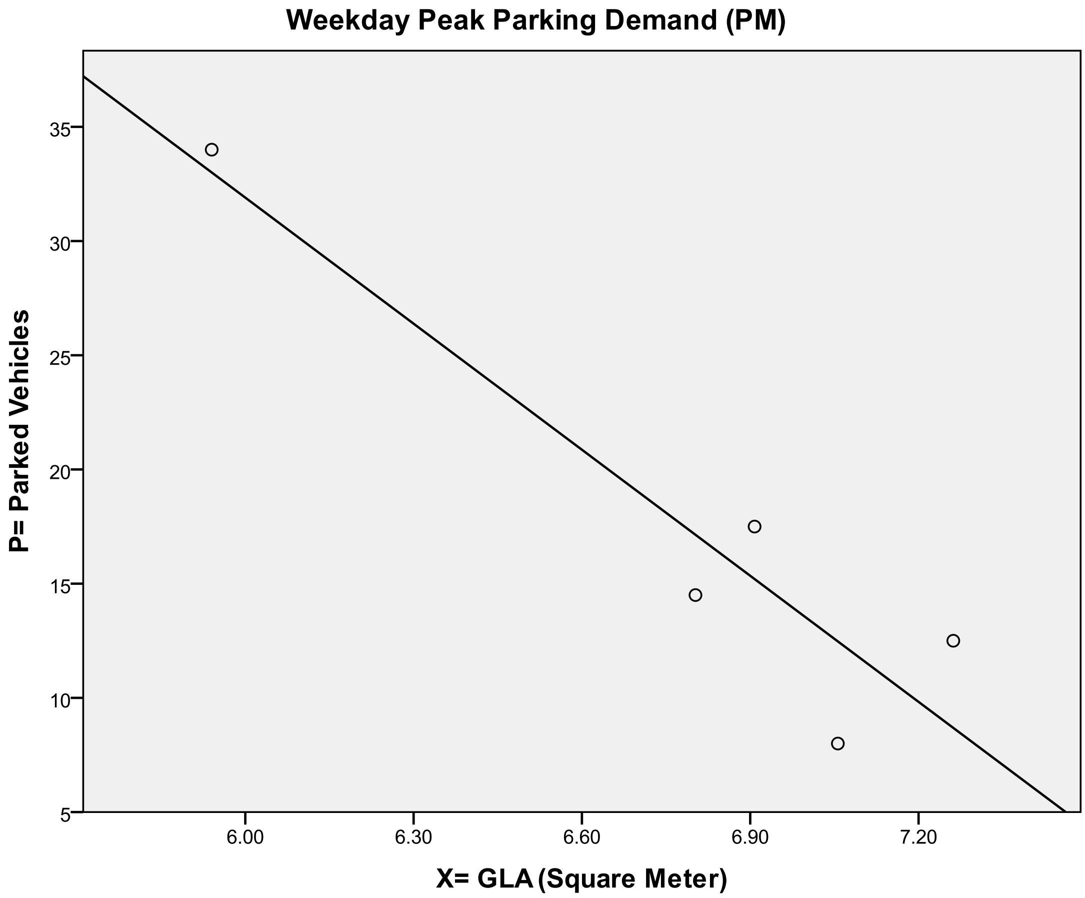


Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	PM (11:30 - 17:00) on a Weekday
Number of Sites	5
Average Size	1124
Standard Deviation	2.36
Coefficient of Variation (CV)	153%
Range	0.48-6.30
Rate	1.54
85^{th} Percentile	3.57
33^{rd} Percentile	1.06
Model	$P= 61945*X^{-1.193}$
Coefficient of Determination (R^2)	0.95

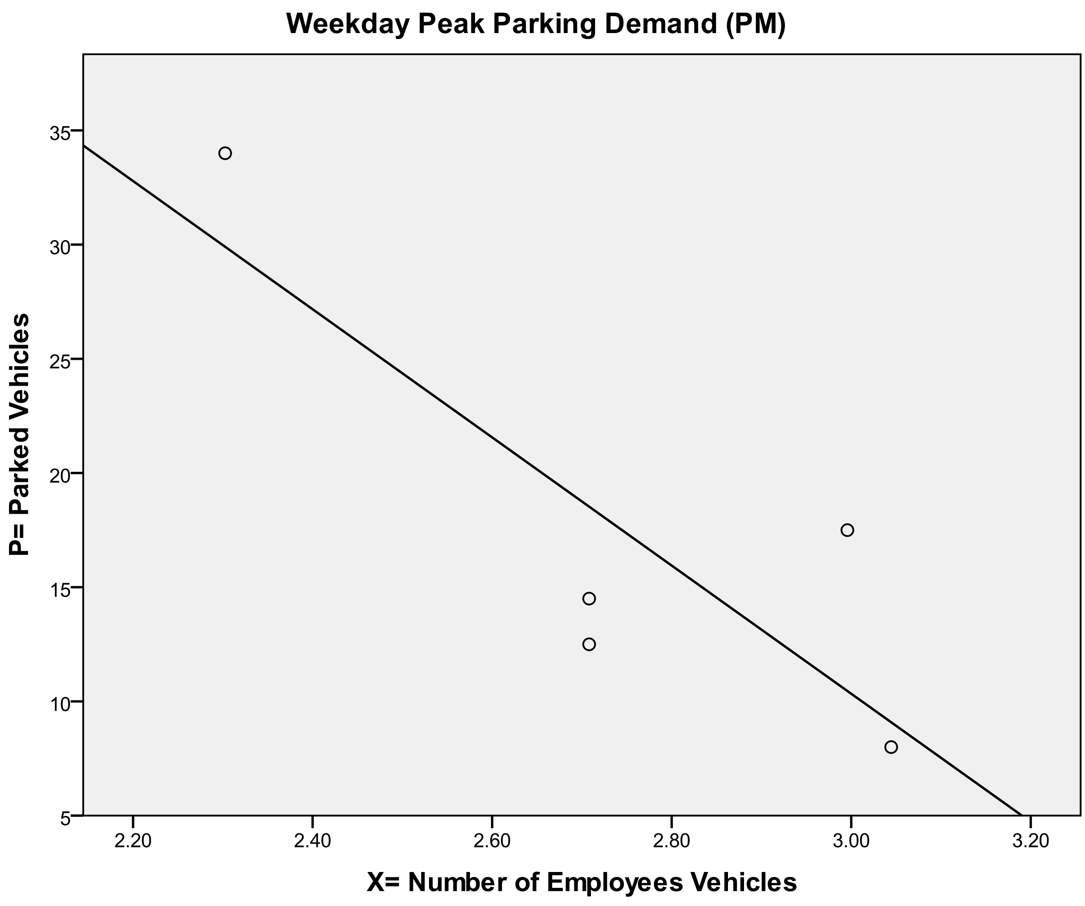


Average Peak Parking Demand vs. GLA (per 100 Square Meter)

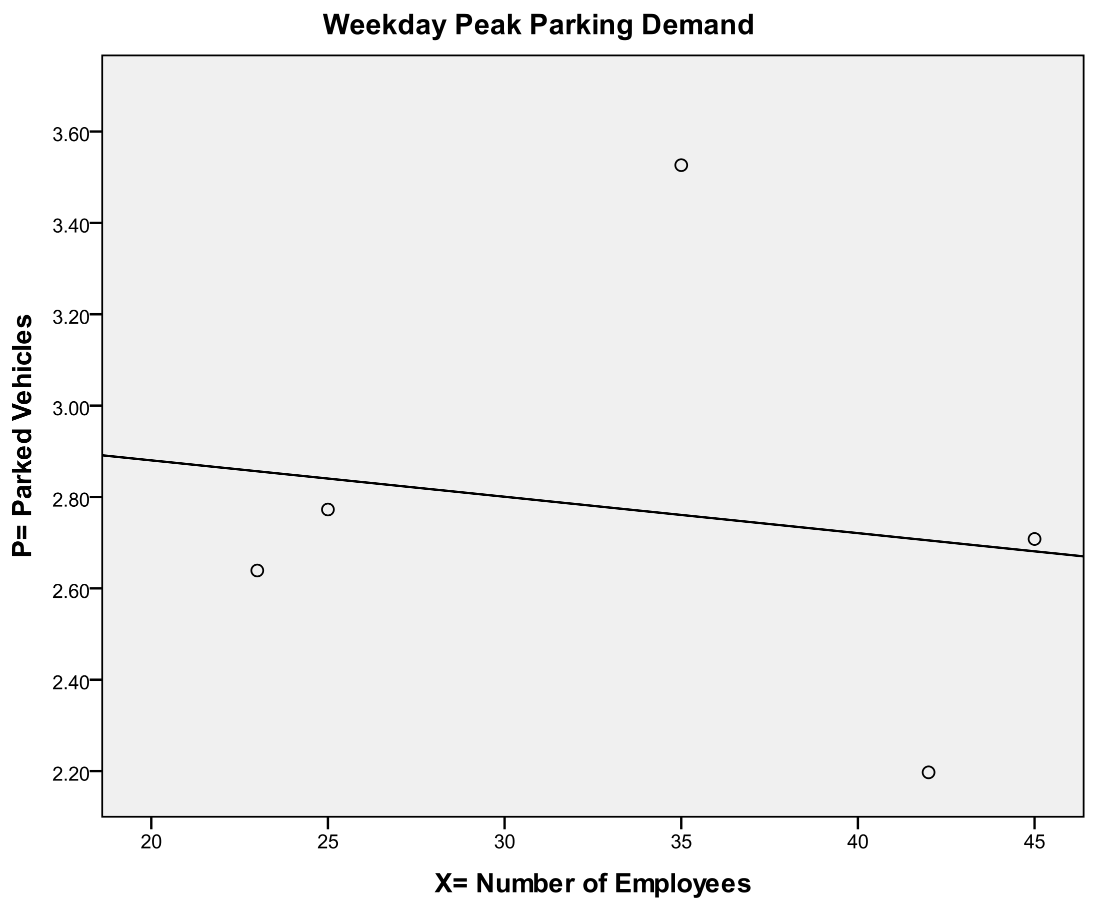
Survey Time Range	**PM (11:30 - 17:00) on a Weekday**
Number of Sites	**5**
Average Size	**973**
Standard Deviation	**3.48**
Coefficient of Variation (CV)	**196%**
Range	**0.69-8.95**
Rate	**1.78**
85th Percentile	**4.63**
33rd Percentile	**1.11**
Model	$\mathbf{P = -18.40\ln(x) + 142.28}$
Coefficient of Determination (R^2)	**0.88**



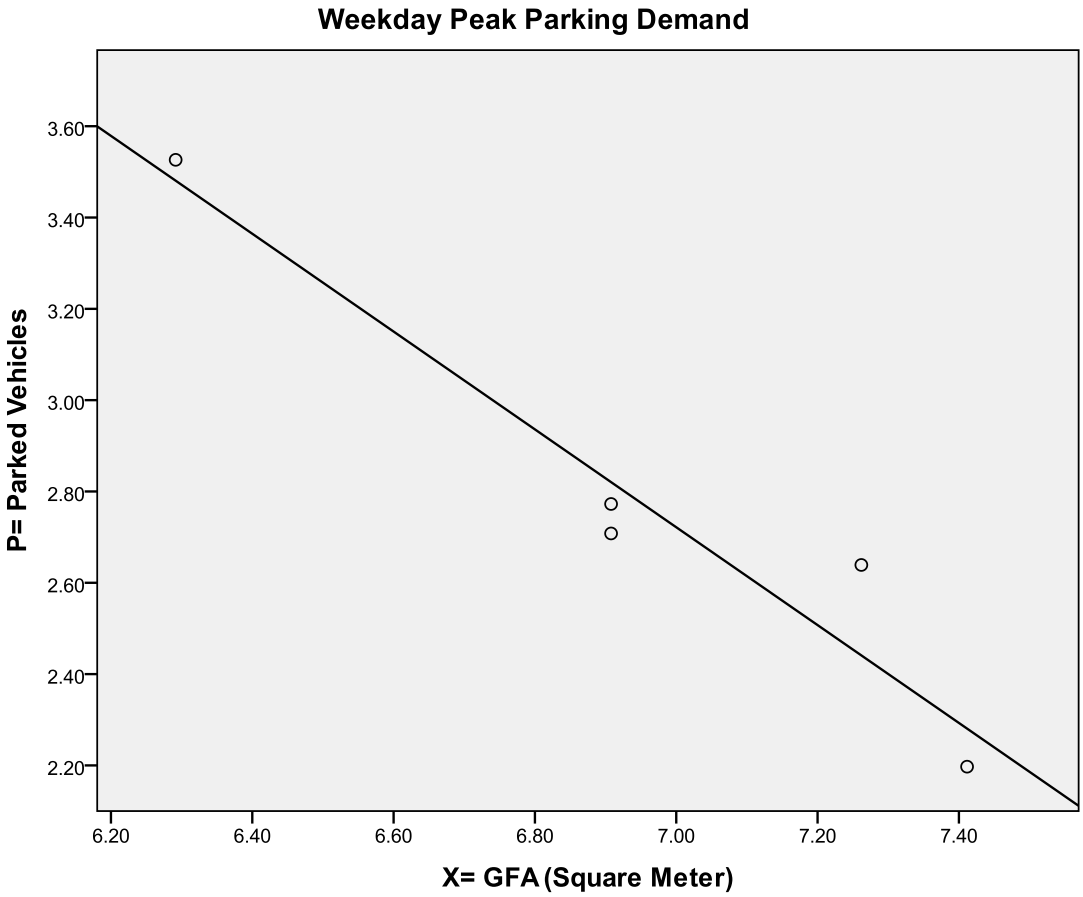
Average Peak Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**PM (11:30 - 17:00) on a Weekday**
Number of Sites	**5**
Average Size	**16.2**
Standard Deviation	**1.20**
Coefficient of Variation (CV)	**112%**
Range	**0.38-3.40**
Rate	**1.07**
85th Percentile	**1.94**
33rd Percentile	**0.85**
Model	$\mathbf{P = -28.06\ln(x) + 94.51}$
Model Confidence Interval	**(1-0.079)**
Coefficient of Determination (R^2)	**0.70**



Average Peak Parking Demand vs. Number of Employees	
Survey Time Range	**Weekday**
Number of Sites	**5**
Average Size	**34**
Standard Deviation	**0.31**
Coefficient of Variation (CV)	**59%**
Range	**0.20-0.97**
Rate	**0.52**
85^{th} Percentile	**0.81**
33^{rd} Percentile	**0.41**
Model	**$P= 20.88*e^{-.008x}$**
Model Confidence Interval	**(1-0.793)**
Coefficient of Determination (R^2)	**0.03**

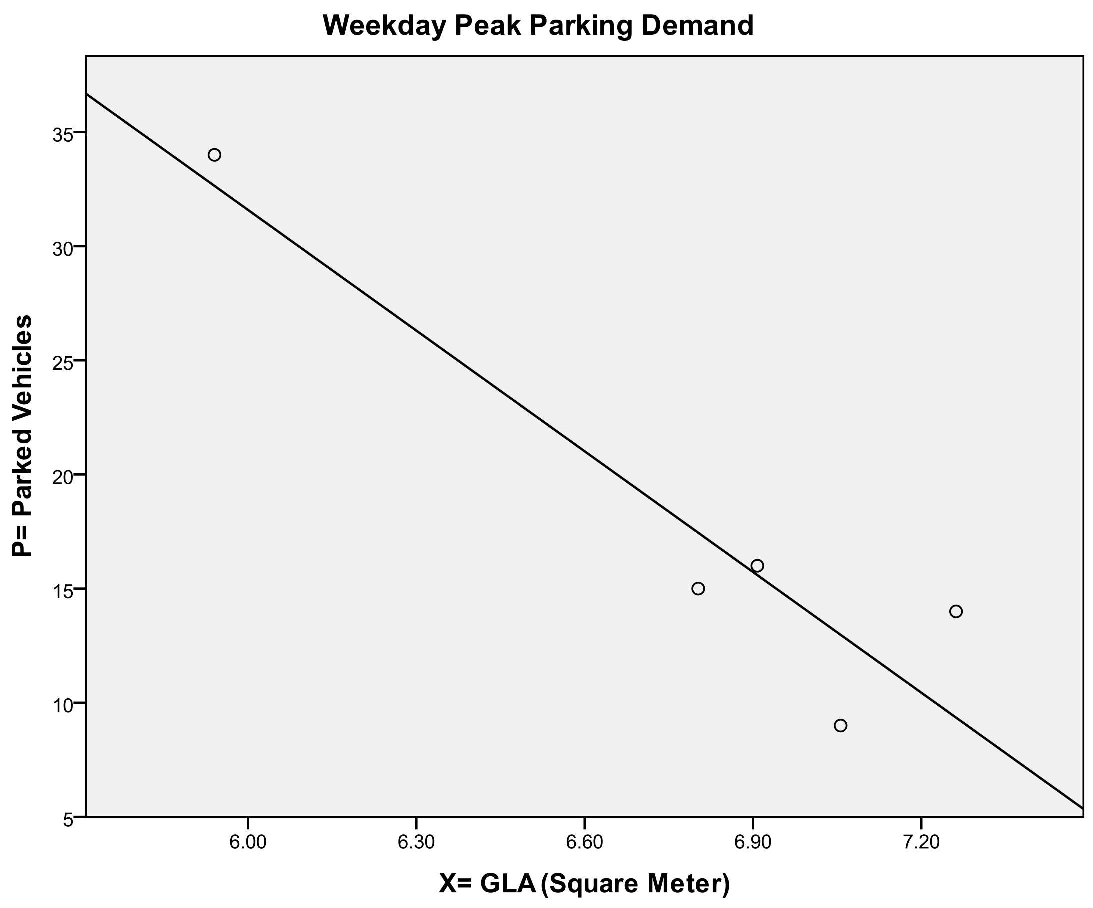


Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	**Weekday**
Number of Sites	**5**
Average Size	**1124**
Standard Deviation	**2.34**
Coefficient of Variation (CV)	**150%**
Range	**0.51-6.30**
Rate	**1.57**
85^{th} Percentile	**3.57**
33^{rd} Percentile	**1.11**
Model	**$P= 27502*X^{-1.072}$**
Coefficient of Determination (R^2)	**0.93**



Average Peak Parking Demand vs. GLA (per 100 Square Meter)

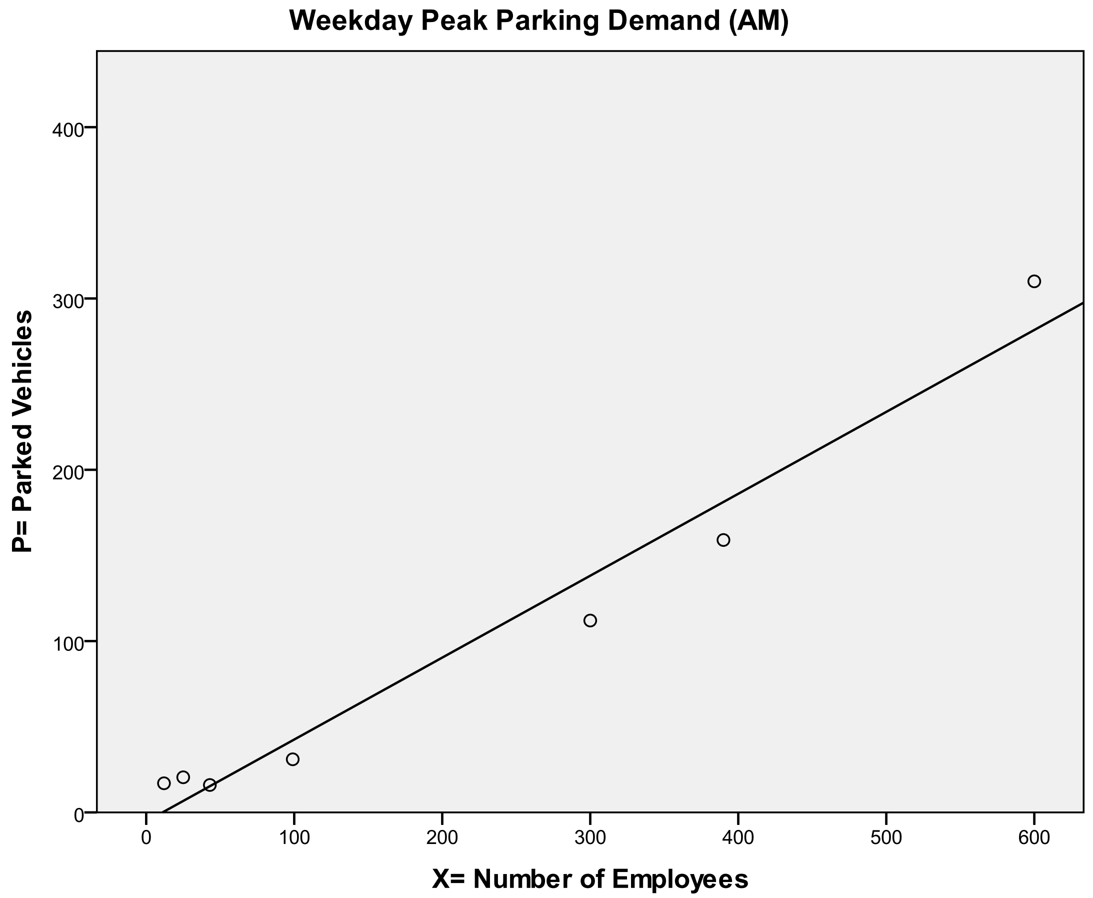
Survey Time Range	Weekday
Number of Sites	5
Average Size	973
Standard Deviation	3.46
Coefficient of Variation (CV)	192%
Range	0.73-8.95
Rate	1.81
85th Percentile	4.63
33rd Percentile	1.16
Model	$P = -17.62\ln(x) + 137.32$
Coefficient of Determination (R^2)	0.88



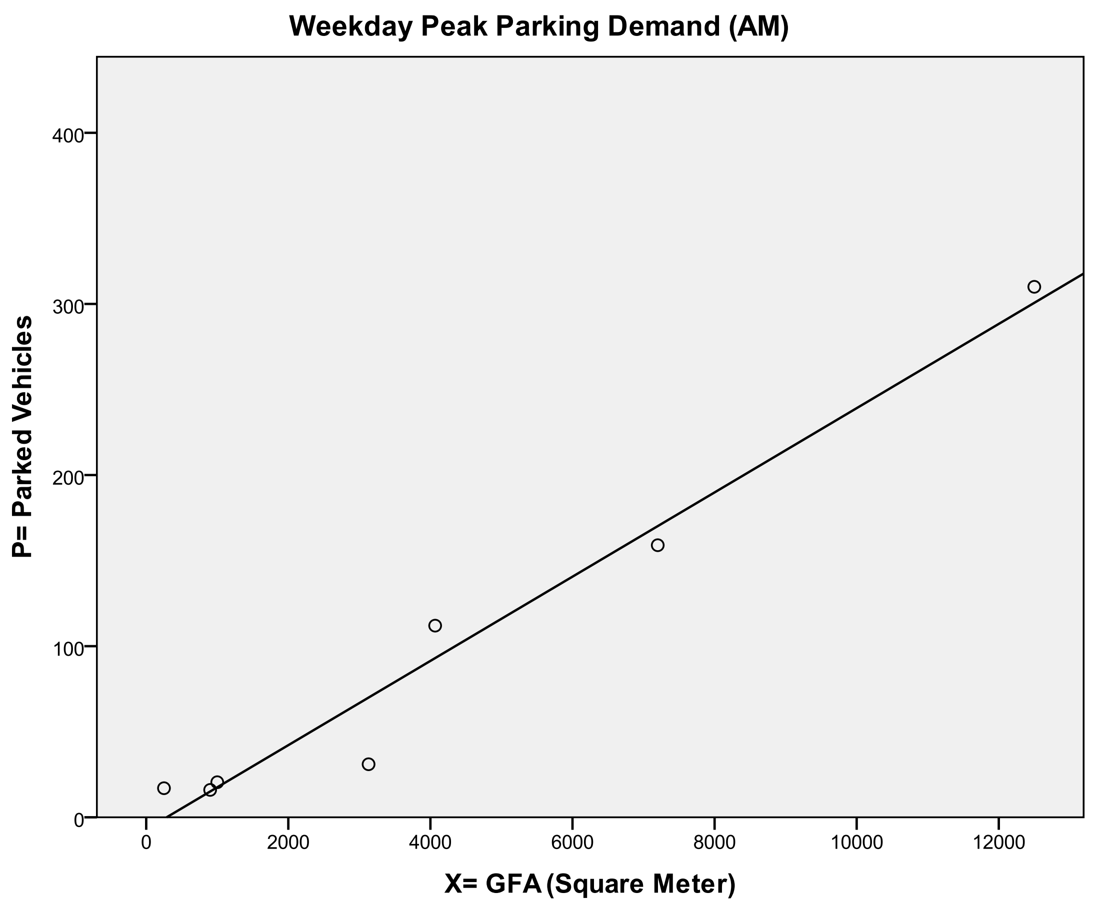
Average Peak Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**Weekday**
Number of Sites	**5**
Average Size	**16.2**
Standard Deviation	**1.19**
Coefficient of Variation (CV)	**110%**
Range	**0.40-3.40**
Rate	**1.09**
85^{th} Percentile	**1.94**
33^{rd} Percentile	**0.88**
Model	$\mathbf{P = -28.51 ln(x) + 96.07}$
Coefficient of Determination (R^2)	**0.78**

b. Institutional Office Class

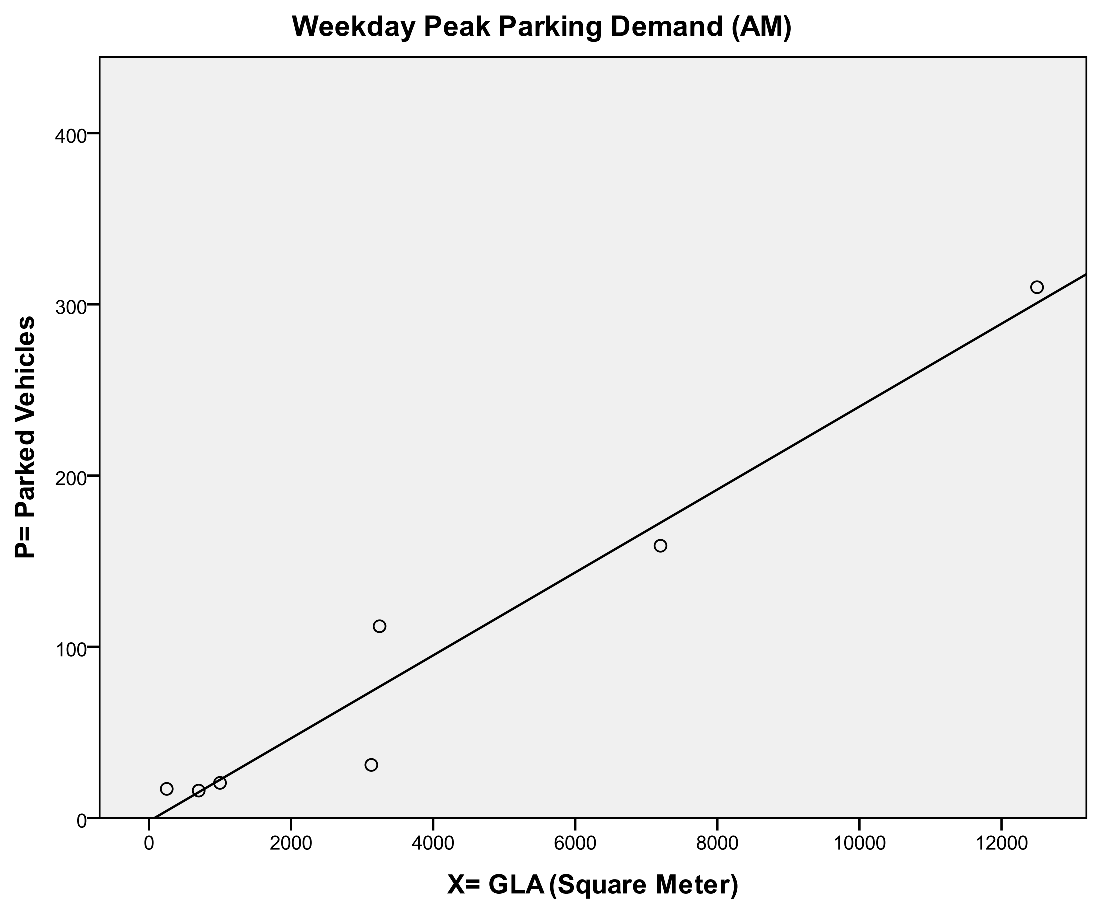
Average Peak Parking Demand vs. Number of Employees	
Survey Time Range	AM (7:00 - 10:00) on a Weekday
Number of Sites	7
Average Size	209.8
Standard Deviation	0.40
Coefficient of Variation (CV)	88%
Range	0.31-1.42
Rate	0.45
85th Percentile	0.88
33rd Percentile	0.37
Model	P= 0.478* X-5.269
Coefficient of Determination (R^2)	0.96



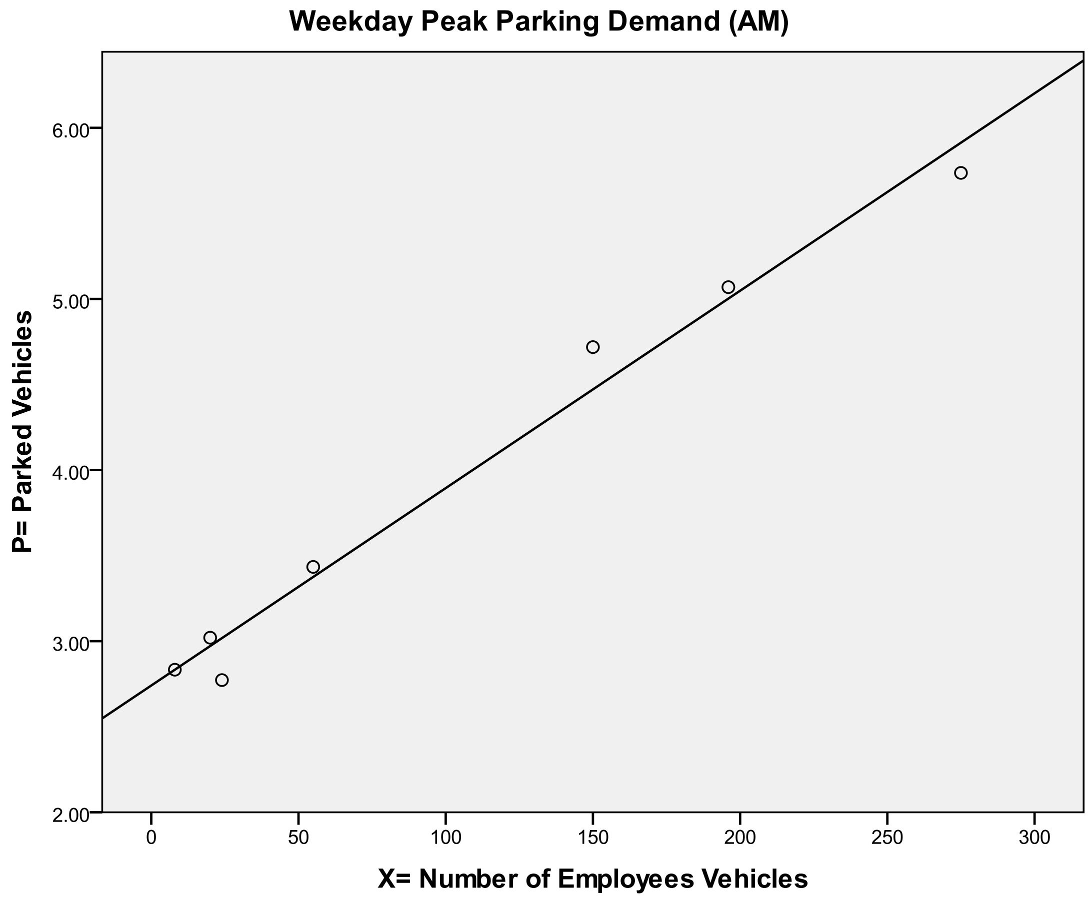
Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	**AM (7:00 - 10:00) on a Weekday**
Number of Sites	**7**
Average Size	**4149.6**
Standard Deviation	**1.88**
Coefficient of Variation (CV)	**0.82%**
Range	**0.99-6.80**
Rate	**2.29**
85^{th} Percentile	**3.16**
33^{rd} Percentile	**2.04**
Model	**P= 0.025* X-7.082**
Coefficient of Determination (R^2)	**0.97**



Average Peak Parking Demand vs. GLA (per 100 Square Meter)	
Survey Time Range	AM (7:00 - 10:00) on a Weekday
Number of Sites	7
Average Size	4003.7
Standard Deviation	1.87
Coefficient of Variation (CV)	79%
Range	0.90-6.80
Rate	2.37
85th Percentile	3.79
33rd Percentile	2.21
Model	P= 0.024* X-1.882
Coefficient of Determination (R^2)	0.95

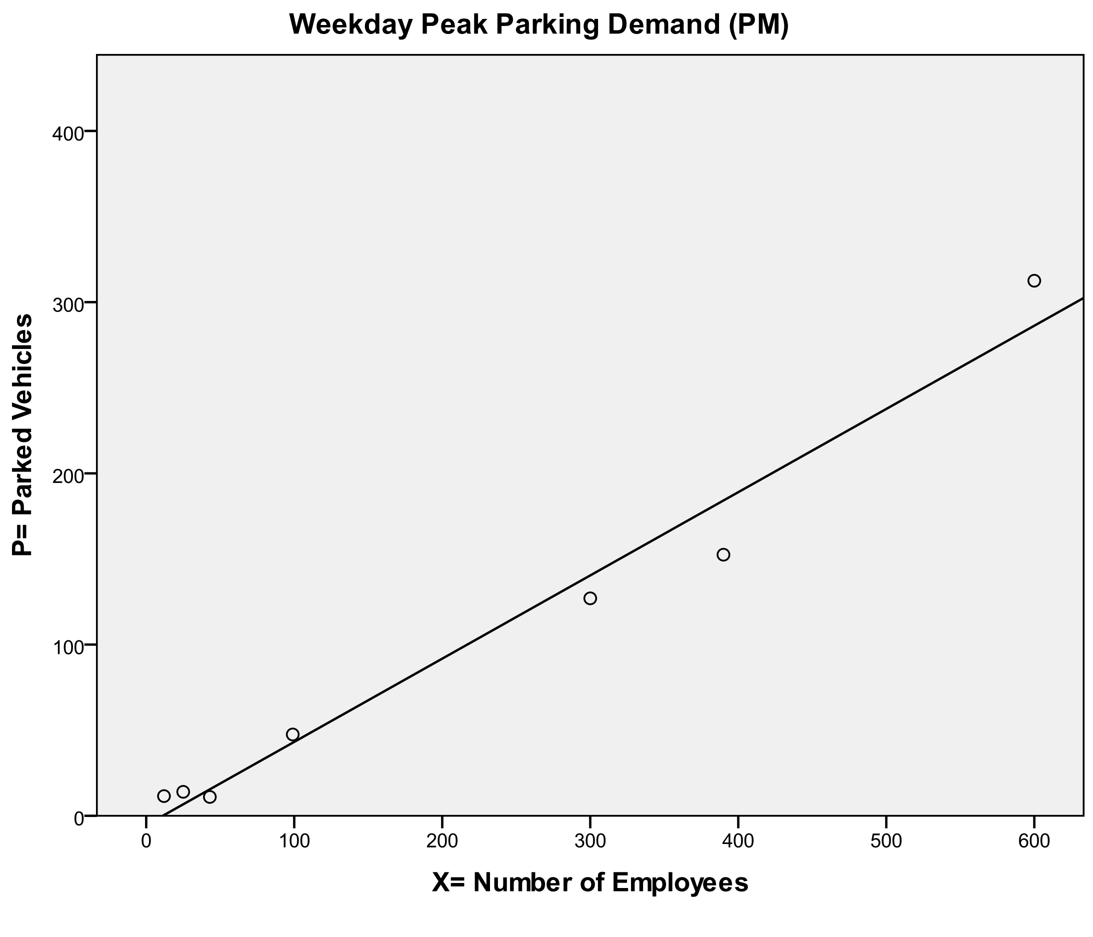


Average Peak Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**AM (7:00 - 10:00) on a Weekday**
Number of Sites	**7**
Average Size	**104**
Standard Deviation	**0.53**
Coefficient of Variation (CV)	**0.58%**
Range	**0.56-2.13**
Rate	**0.91**
85th Percentile	**1.23**
33rd Percentile	**0.75**
Model	**$P = 15.502\ e^{0.012x}$**
Coefficient of Determination (R^2)	**0.98**

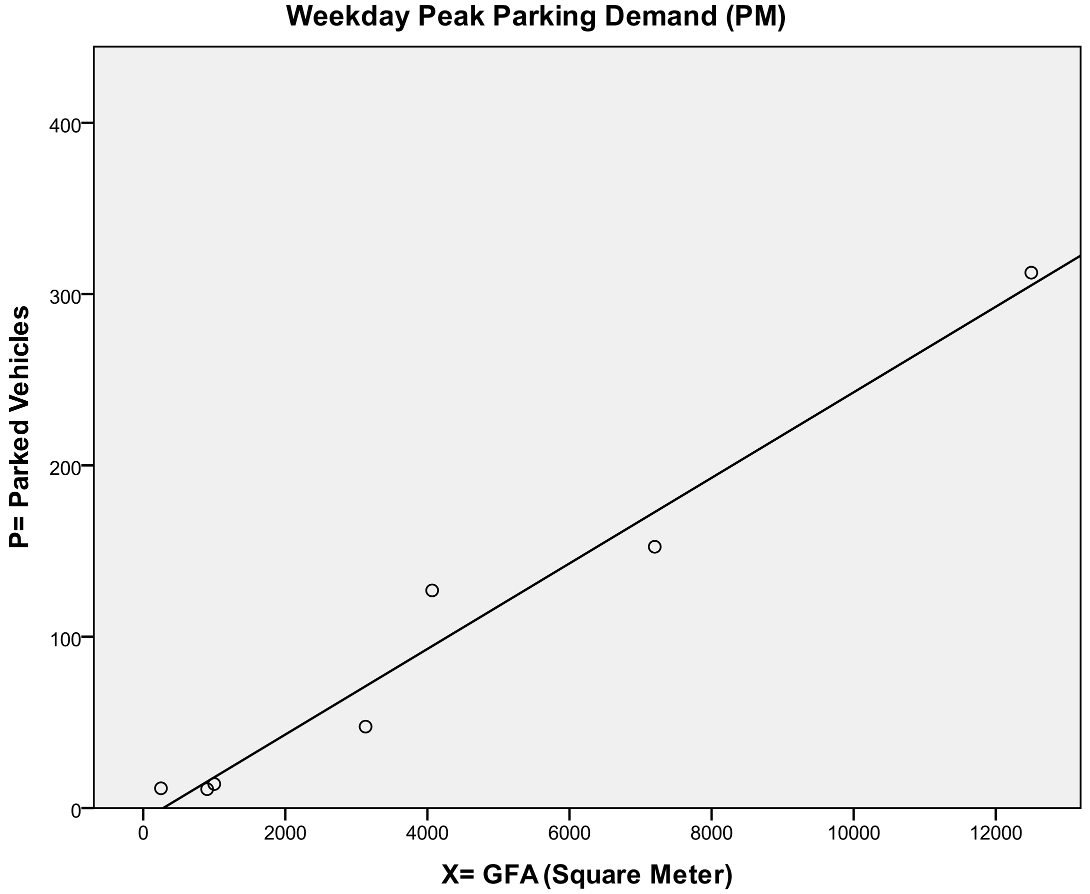


Average Peak Parking Demand vs. Number of Employees

Survey Time Range	**PM (13:30 - 17:00) on a Weekday**
Number of Sites	**7**
Average Size	**209.8**
Standard Deviation	**0.22**
Coefficient of Variation (CV)	**48%**
Range	**0.26-0.96**
Rate	**0.46**
85^{th} Percentile	**0.60**
33^{rd} Percentile	**0.42**
Model	**P=0.486* X-5.449**
Coefficient of Determination (R^2)	**0.97**

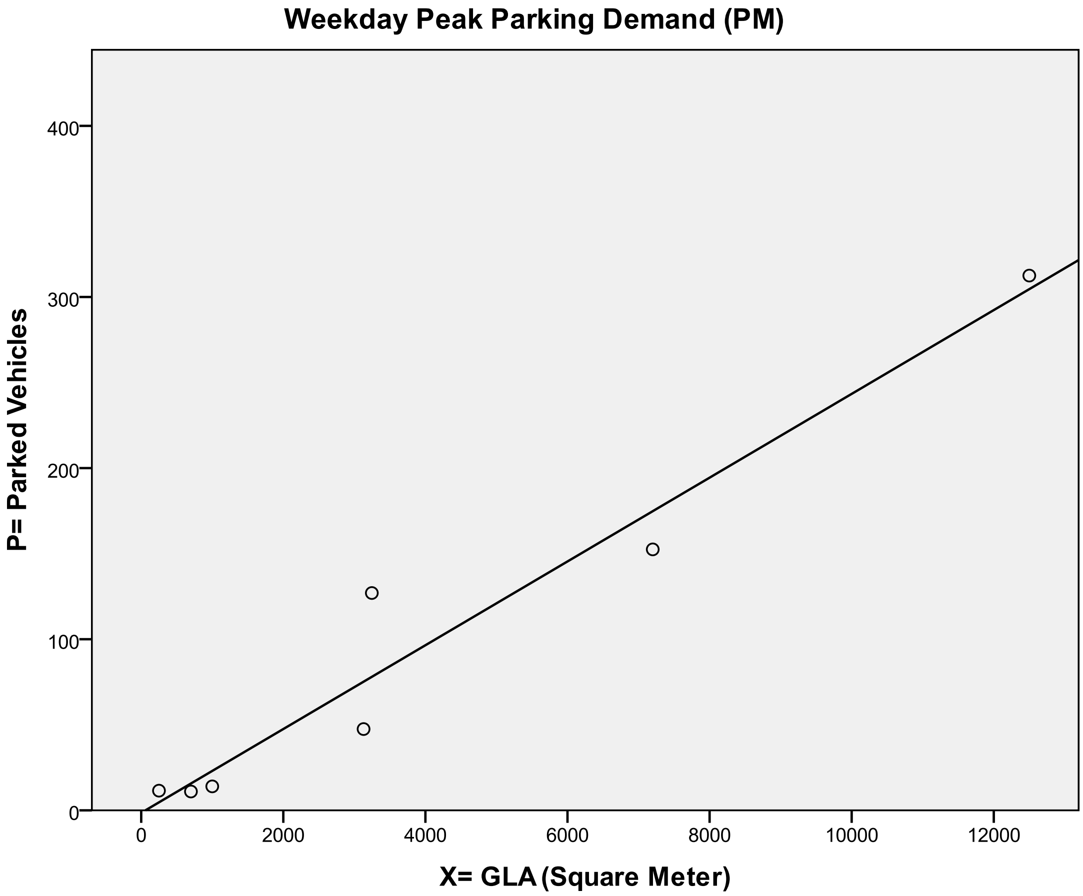


Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	PM (13:30 - 17:00) on a Weekday
Number of Sites	7
Average Size	4149.6
Standard Deviation	1.20
Coefficient of Variation (CV)	51%
Range	1.22-4.60
Rate	2.33
85th Percentile	3.27
33rd Percentile	1.52
Model	P=0.025* X-7.057
Coefficient of Determination (R^2)	0.97

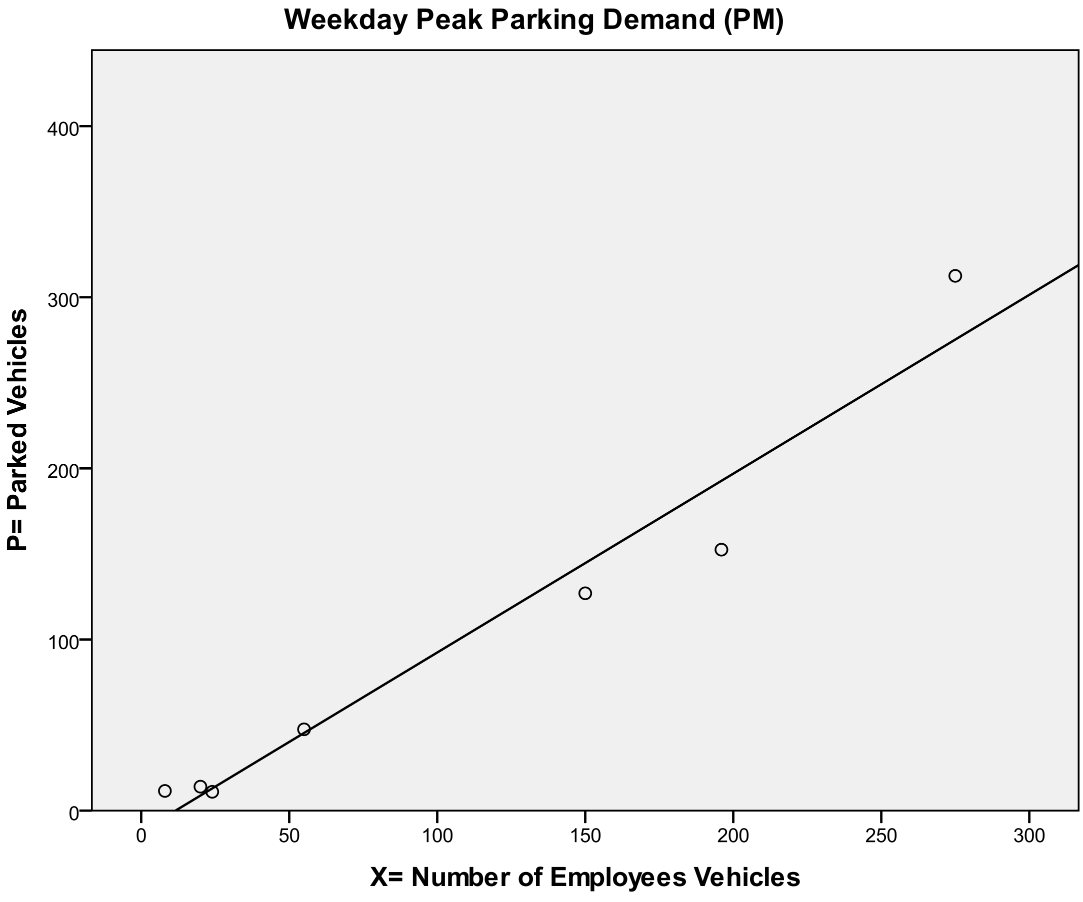


Average Peak Parking Demand vs. GLA (per 100 Square Meter)

Survey Time Range	**PM (13:30 - 17:00) on a Weekday**
Number of Sites	**7**
Average Size	**4003.7**
Standard Deviation	**1.26**
Coefficient of Variation (CV)	**52%**
Range	**1.40-4.60**
Rate	**2.41**
85^{th} Percentile	**3.98**
33^{rd} Percentile	**1.57**
Model	**P=0.024* X-1.449**
Coefficient of Determination (R^2)	**0.95**

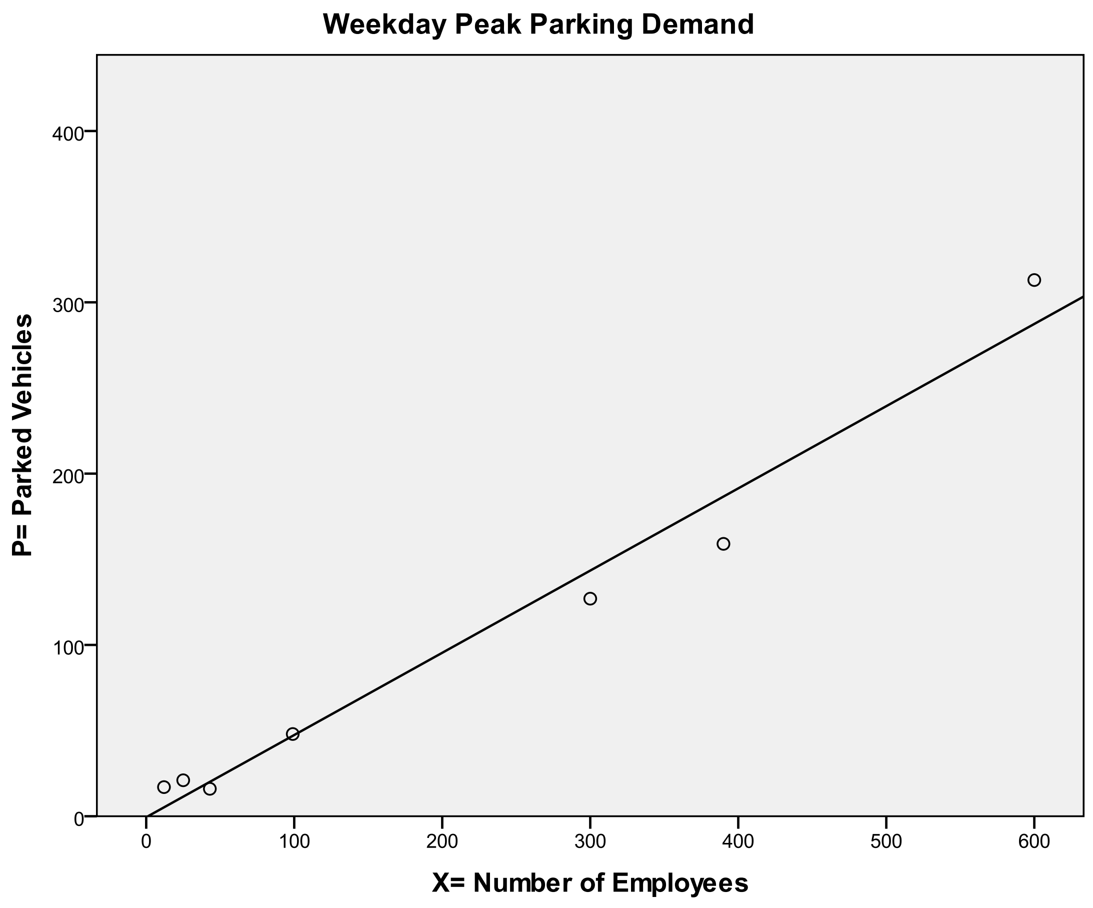


Average Peak Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**PM (13:30 - 17:00) on a Weekday**
Number of Sites	**7**
Average Size	**104**
Standard Deviation	**0.32**
Coefficient of Variation (CV)	**34%**
Range	**0.46-1.44**
Rate	**0.33**
85th Percentile	**1.17**
33rd Percentile	**0.78**
Model	**P=1.045* X-12.121**
Coefficient of Determination (R^2)	**0.95**

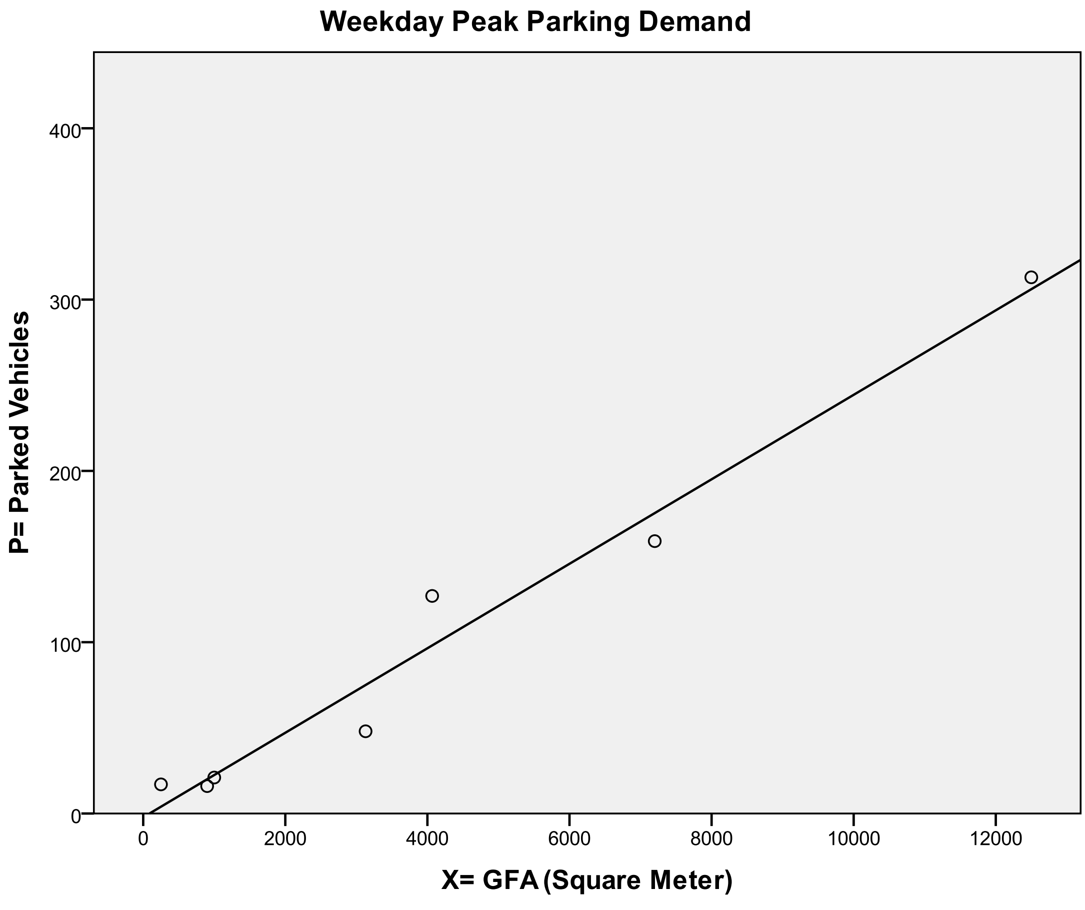


Average Peak Parking Demand vs. Number of Employees

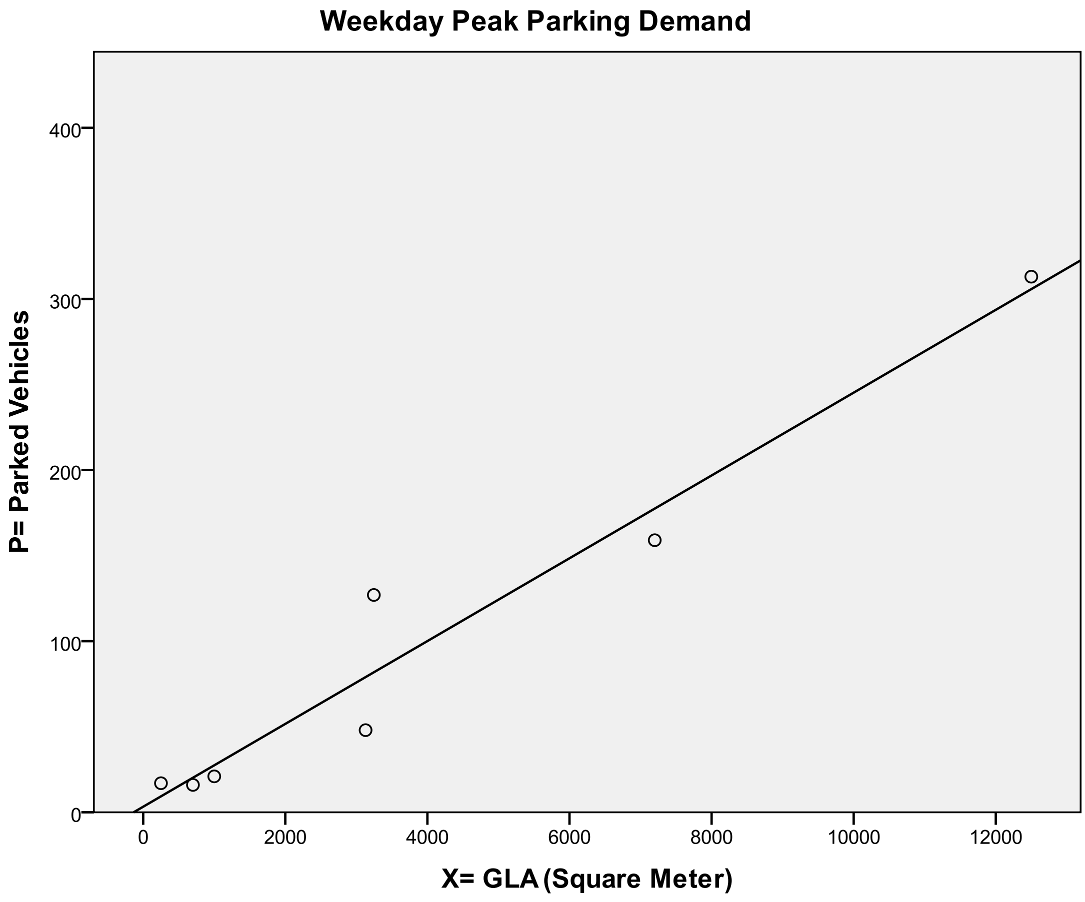
Survey Time Range	Weekday
Number of Sites	7
Average Size	209.8
Standard Deviation	0.38
Coefficient of Variation (CV)	79%
Range	0.37-1.42
Rate	0.48
85th Percentile	0.88
33rd Percentile	0.42
Model	P= 0.48*X-0.57
Coefficient of Determination (R^2)	0.97



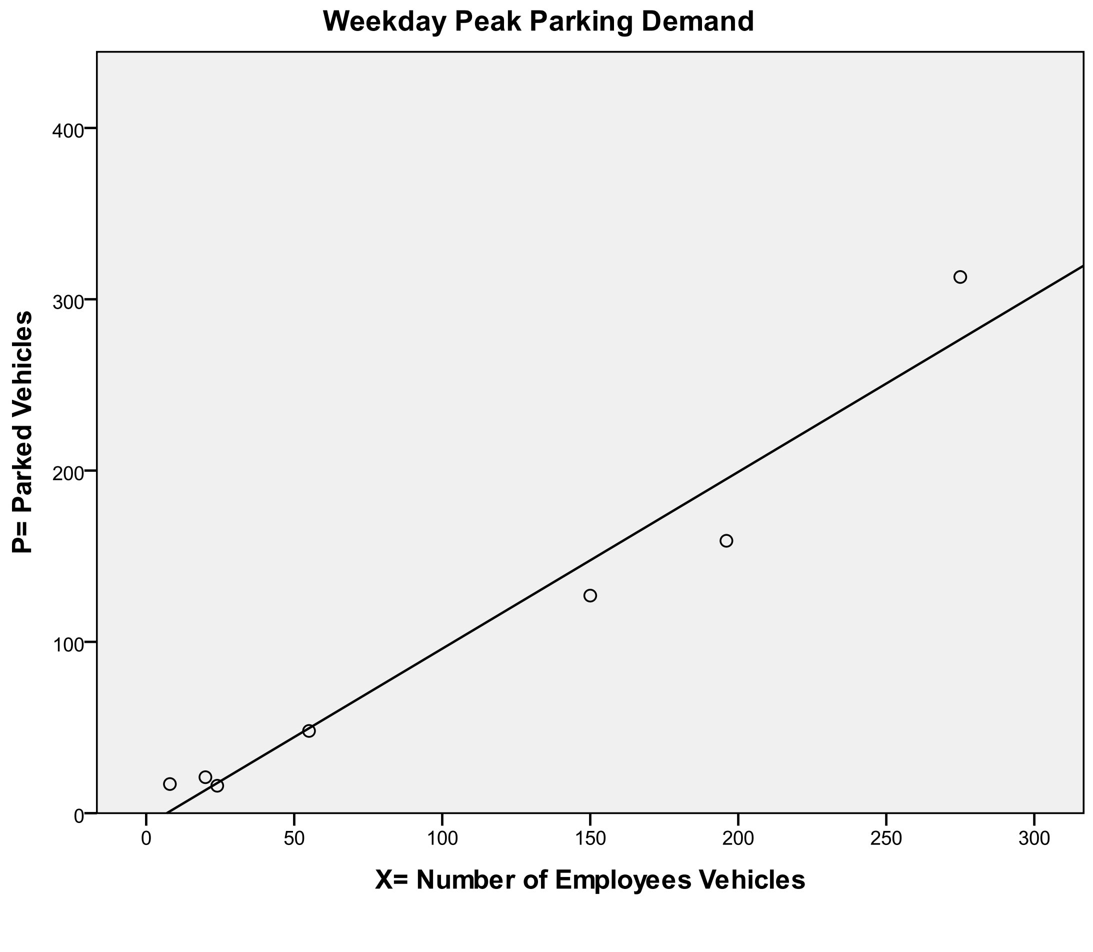
Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	**Weekday**
Number of Sites	**7**
Average Size	**4149.6**
Standard Deviation	**1.82**
Coefficient of Variation (CV)	**75%**
Range	**1.52-6.80**
Rate	**2.41**
85th Percentile	**3.49**
33rd Percentile	**2.04**
Model	**P= 0.025*X-2.18**
Coefficient of Determination (R^2)	**0.97**



Average Peak Parking Demand vs. GLA (per 100 Square Meter)	
Survey Time Range	**Weekday**
Number of Sites	**7**
Average Size	**4003.7**
Standard Deviation	**1.81**
Coefficient of Variation (CV)	**73%**
Range	**1.52-6.80**
Rate	**2.50**
85th Percentile	**4.20**
33rd Percentile	**2.21**
Model	**P= 0.024*X+ 3.26**
Coefficient of Determination (R^2)	**0.95**

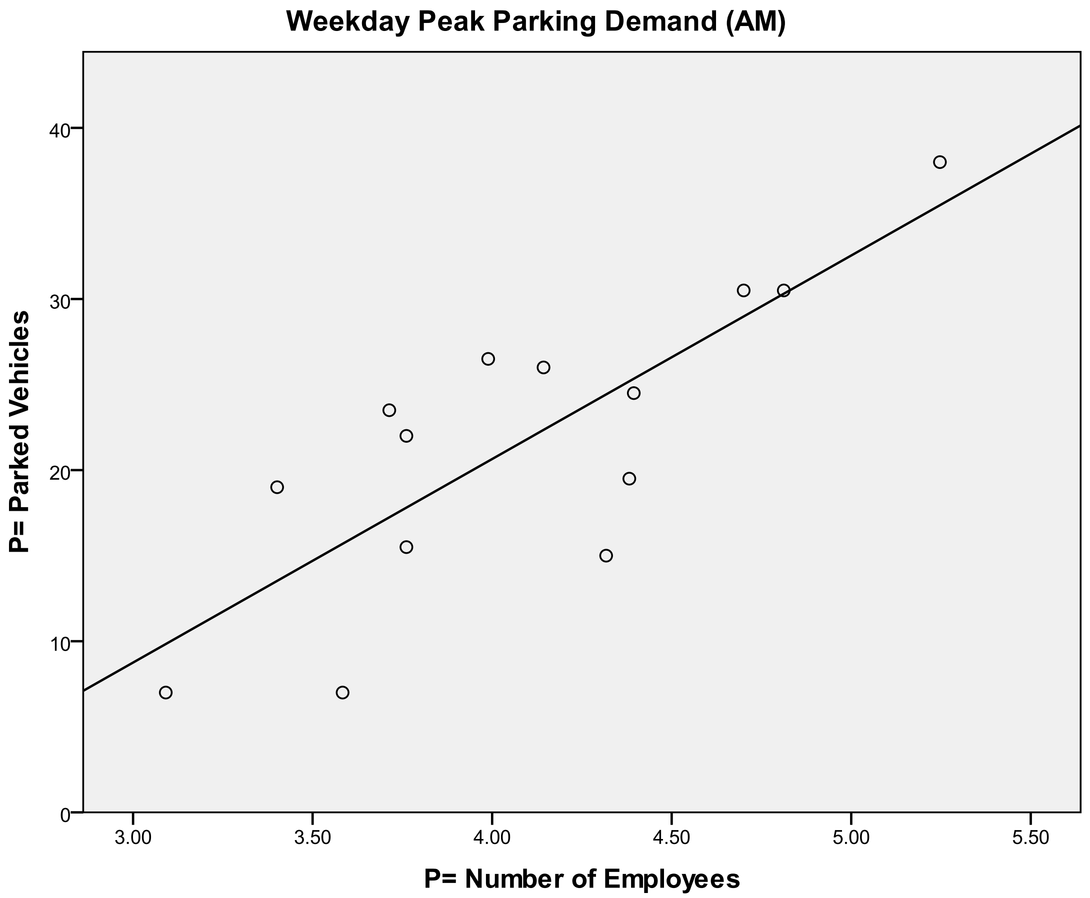


Average Peak Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**Weekday**
Number of Sites	**7**
Average Size	**104**
Standard Deviation	**0.49**
Coefficient of Variation (CV)	**1.24%**
Range	**0.67-2.13**
Rate	**0.96**
85th Percentile	**1.24**
33rd Percentile	**0.85**
Model	**P= 1.03*X-7.17**
Coefficient of Determination (R^2)	**0.95**



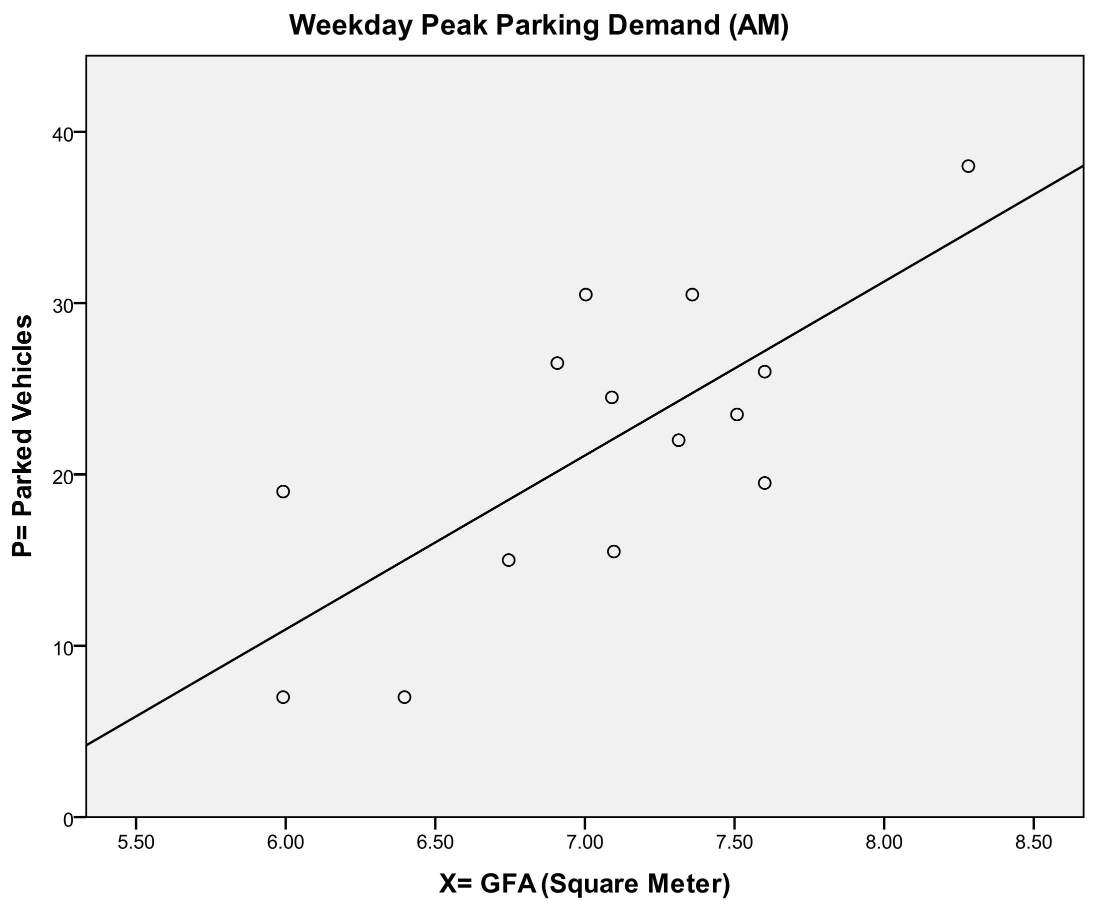
c. Government Office Class

Average Peak Parking Demand vs. Number of Employees	
Survey Time Range	AM (7:00 - 9:00) on a Weekday
Number of Sites	14
Average Size	70.8
Standard Deviation	0.15
Coefficient of Variation (CV)	48%
Range	0.19-0.63
Rate	0.31
85th Percentile	0.51
33rd Percentile	0.26
Model	$P = 11.89\ln(x) - 26.93$
Coefficient of Determination (R^2)	0.65

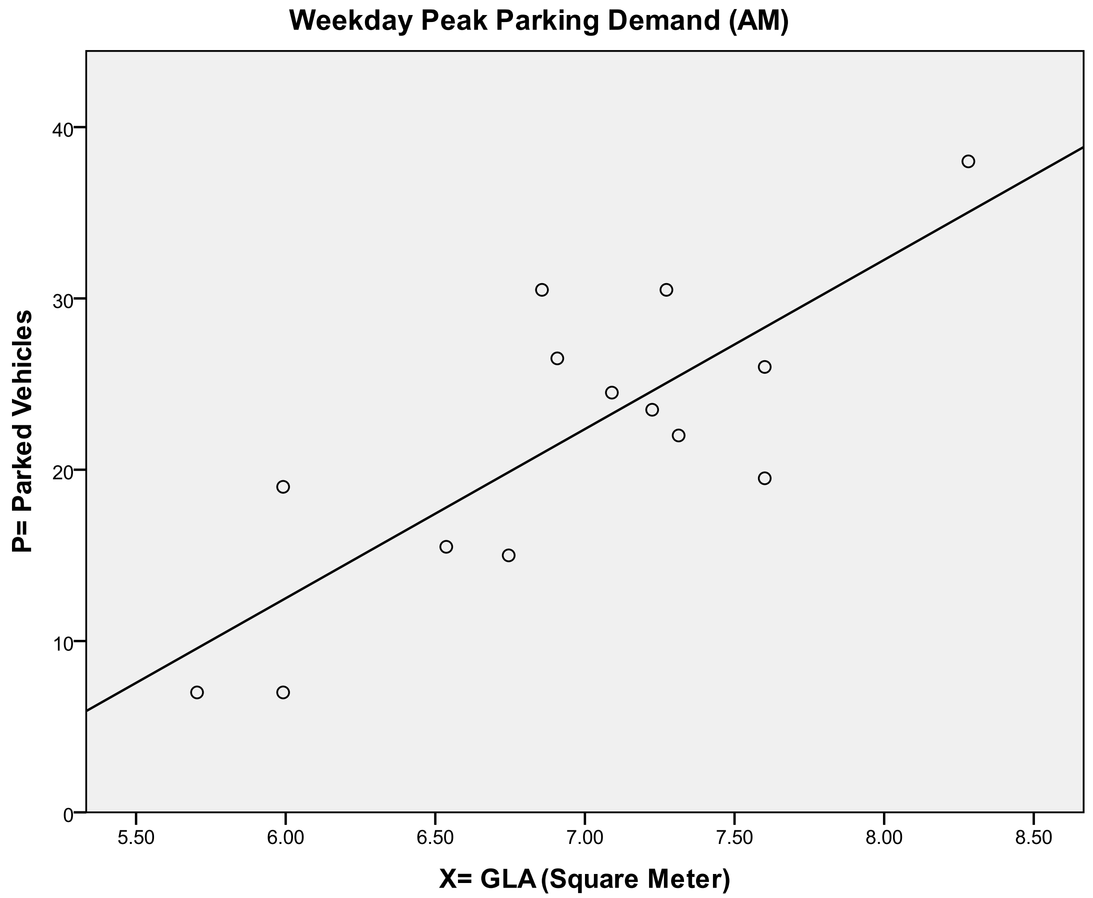


Average Peak Parking Demand vs. GFA (Square Meter)

Survey Time Range	**AM (7:00 - 9:00) on a Weekday**
Number of Sites	**14**
Average Size	**1400**
Standard Deviation	**1**
Coefficient of Variation (CV)	**65%**
Range	**0.96-4.75**
Rate	**1.55**
85th Percentile	**2.66**
33rd Percentile	**1.29**
Model	$\mathbf{P = 10.15ln(x) - 49.96}$
Coefficient of Determination (R^2)	**0.54**

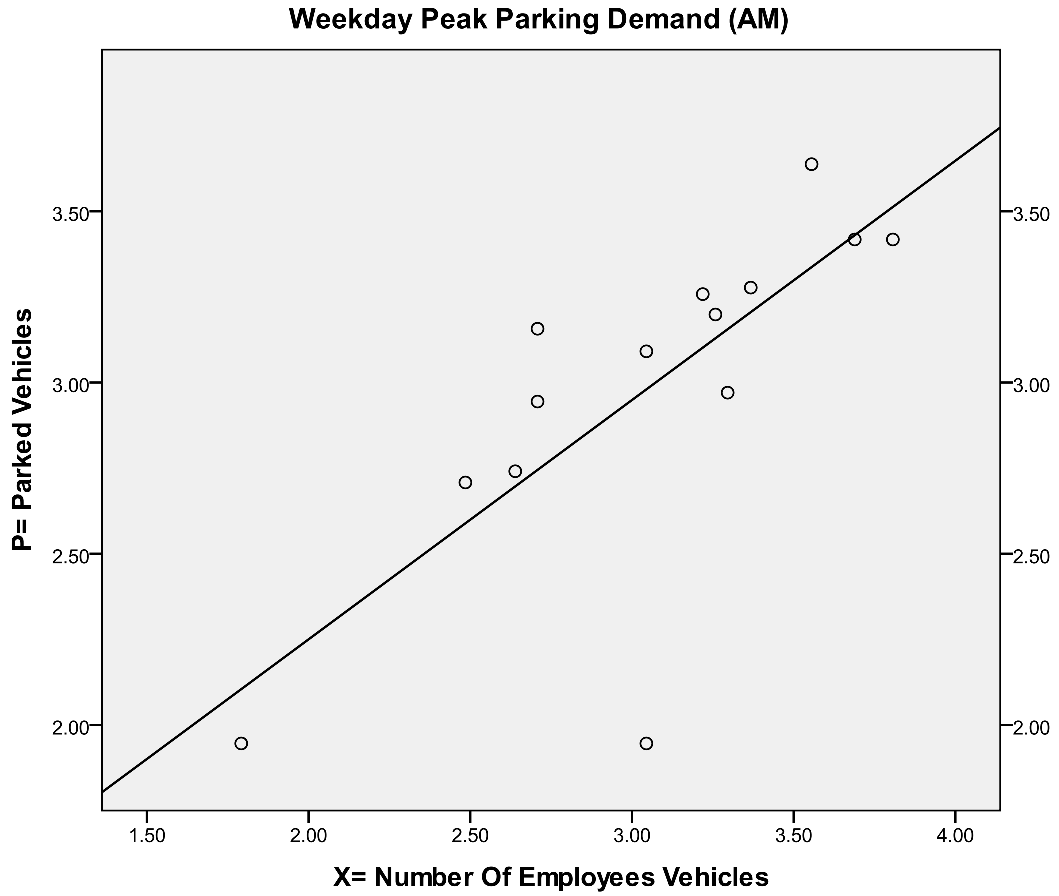


Average Peak Parking Demand vs. GLA (per 100 Square Meter)	
Survey Time Range	**AM (7:00 - 9:00) on a Weekday**
Number of Sites	**14**
Average Size	**1289.5**
Standard Deviation	**0.99**
Coefficient of Variation (CV)	**58%**
Range	**0.96-4.75**
Rate	**1.69**
85th Percentile	**2.68**
33rd Percentile	**1.72**
Model	$\mathbf{P = 9.88ln(x) - 46.77}$
Coefficient of Determination (R^2)	**0.64**

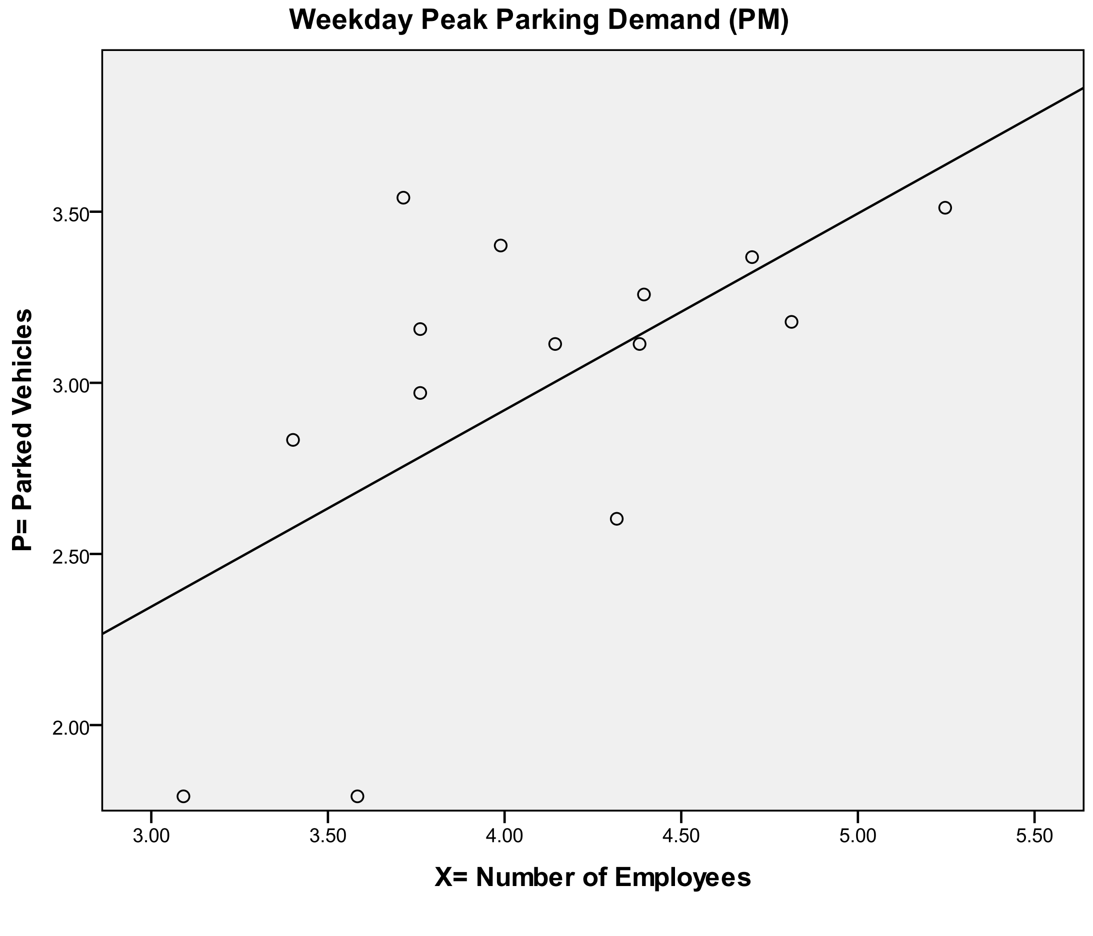


Average Peak Parking Demand vs. Number of Employees Vehicles

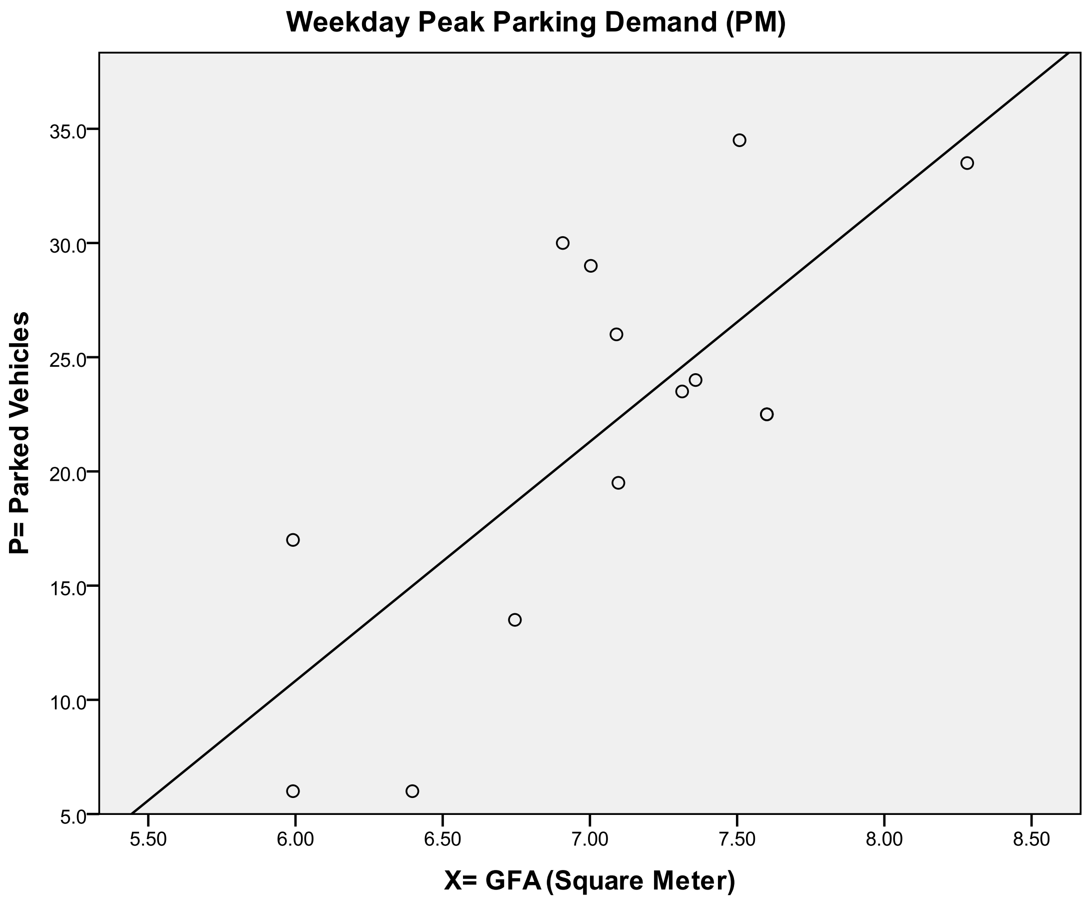
Survey Time Range	**AM (7:00 - 9:00) on a Weekday**
Number of Sites	**14**
Average Size	**23.6**
Standard Deviation	**0.30**
Coefficient of Variation (CV)	**33%**
Range	**0.33-1.57**
Rate	**0.92**
85th Percentile	**1.25**
33rd Percentile	**0.92**
Model	**P= -0.312*X+ 23.903**
Coefficient of Determination (R^2)	**0.78**



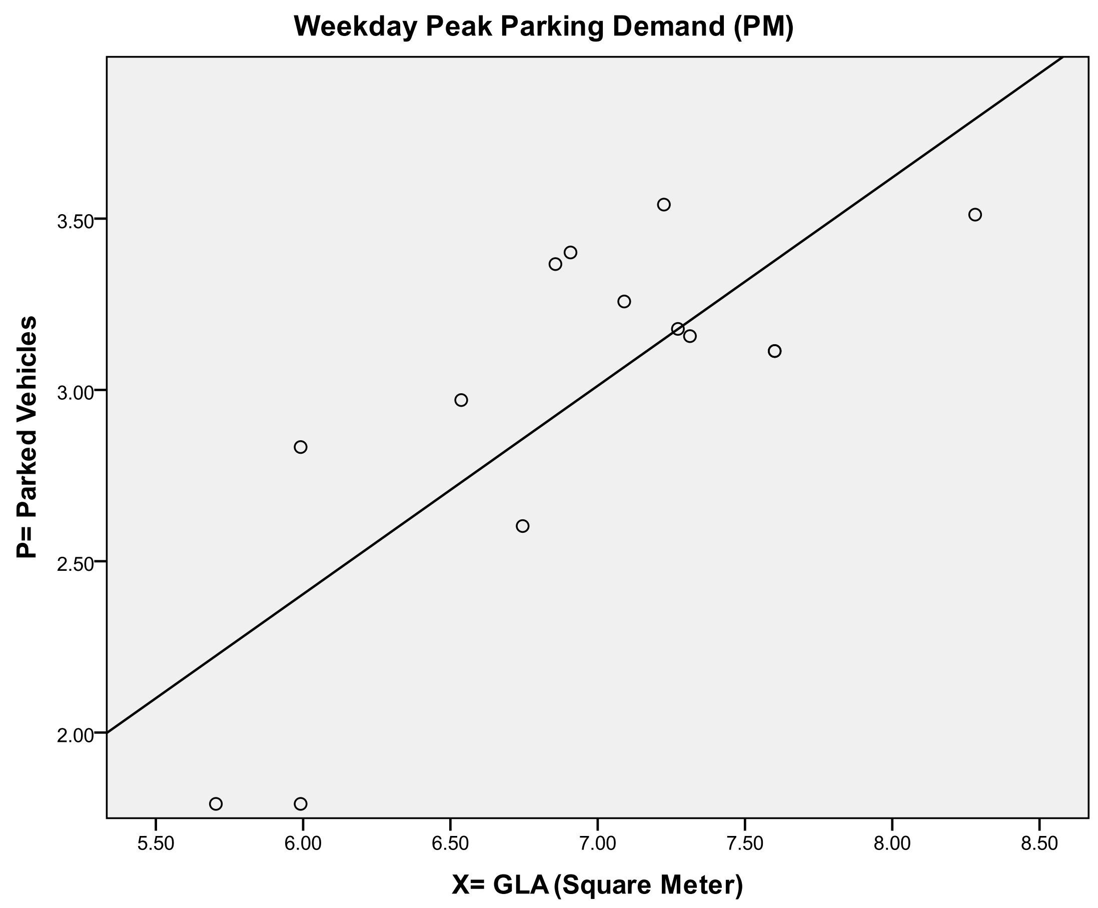
Average Peak Parking Demand vs. Number of Employees	
Survey Time Range	**PM (12:00- 16:00) on a Weekday**
Number of Sites	**14**
Average Size	**70.8**
Standard Deviation	**0.20**
Coefficient of Variation (CV)	**64%**
Range	**0.17-0.84**
Rate	**0.31**
85th Percentile	**0.56**
33rd Percentile	**0.27**
Model	**$P= 1.86*X^{0.574}$**
Coefficient of Determination (R^2)	**0.37**



Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	**PM (12:00- 16:00) on a Weekday**
Number of Sites	**14**
Average Size	**1400**
Standard Deviation	**0.92**
Coefficient of Variation (CV)	**59%**
Range	**0.85-4.25**
Rate	**1.57**
85th Percentile	**2.65**
33rd Percentile	**1.51**
Model	$\mathbf{P = 10.47ln(x) - 51.99}$
Coefficient of Determination (R^2)	**0.56**

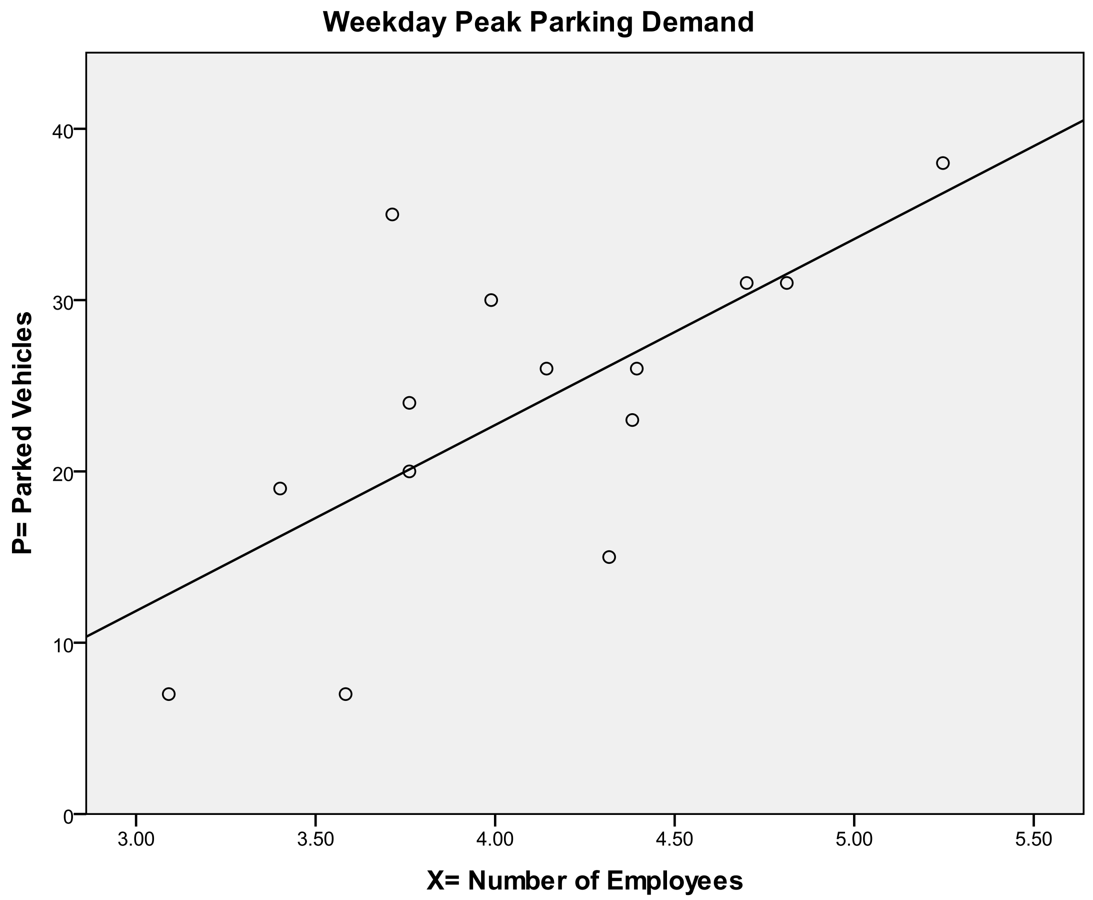


Average Peak Parking Demand vs. GLA (per 100 Square Meter)	
Survey Time Range	**PM (12:00- 16:00) on a Weekday**
Number of Sites	**14**
Average Size	**1289.5**
Standard Deviation	**0.95**
Coefficient of Variation (CV)	**55%**
Range	**0.85-4.25**
Rate	**1.70**
85th Percentile	**3**
33rd Percentile	**1.57**
Model	**$P= 0.289*X^{0.608}$**
Coefficient of Determination (R^2)	**0.59**

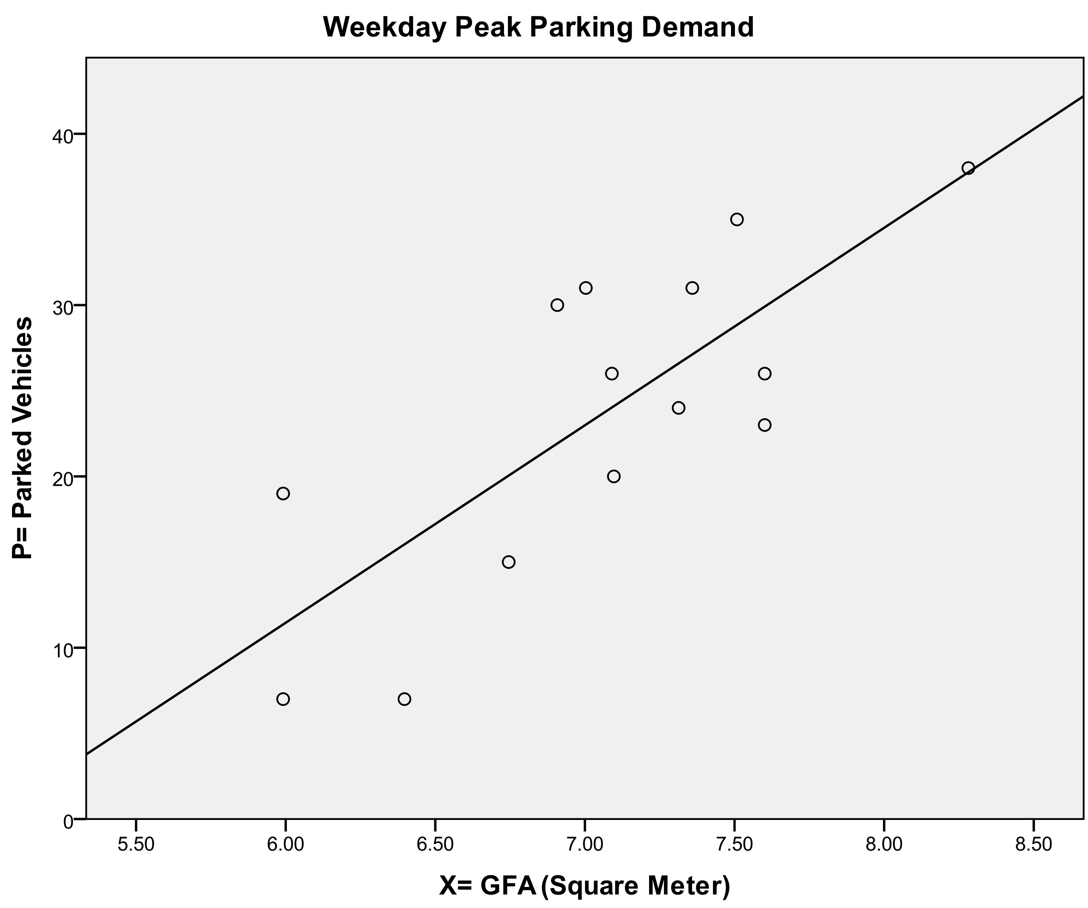


Average Peak Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**PM (12:00- 16:00) on a Weekday**
Number of Sites	**14**
Average Size	**23.6**
Standard Deviation	**0.46**
Coefficient of Variation (CV)	**49%**
Range	**0.29-0.92**
Rate	**0.93**
85th Percentile	**1.15**
33rd Percentile	**0.92**
Model	**$P= 2.63*X^{0.659}$**
Coefficient of Determination (R^2)	**0.40**

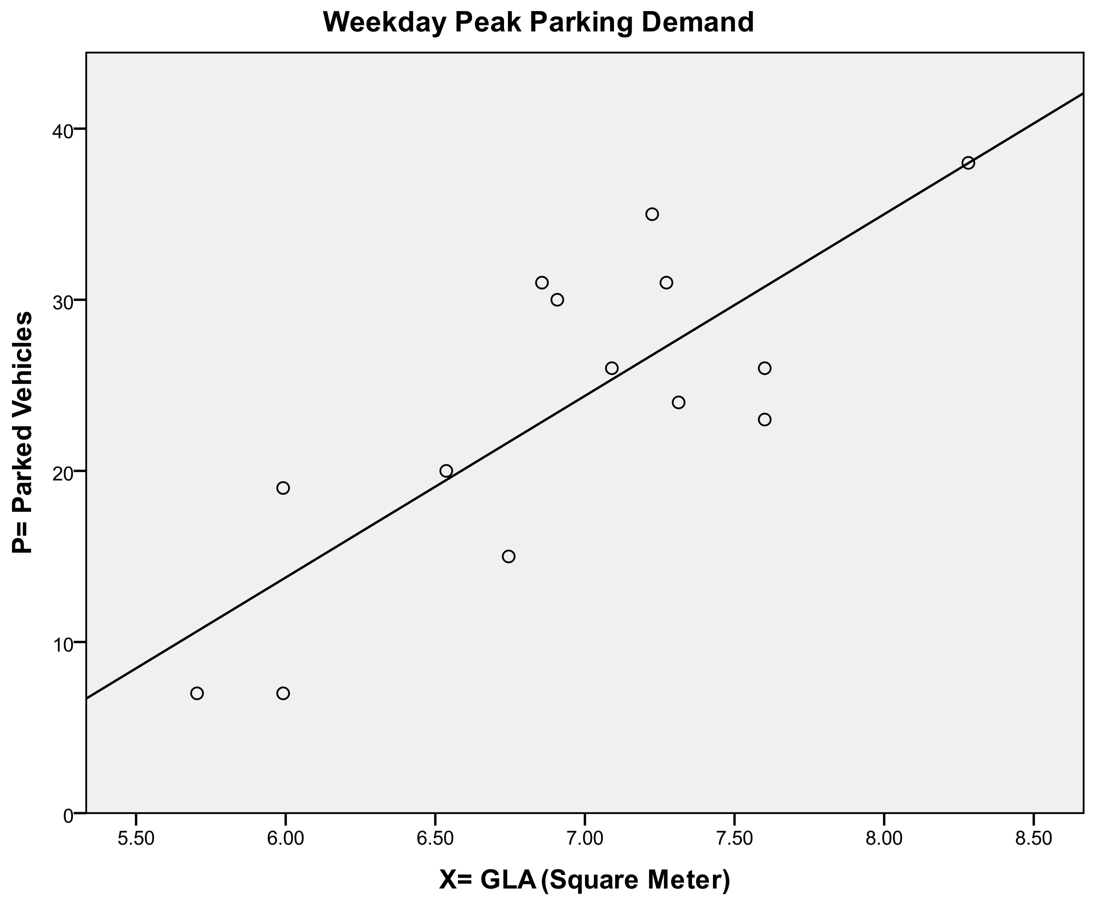
Average Peak Parking Demand vs. Number of Employees	
Survey Time Range	**Weekday**
Number of Sites	**14**
Average Size	**70.8**
Standard Deviation	**0.19**
Coefficient of Variation (CV)	**58%**
Range	**0.19-0.84**
Rate	**0.33**
85th Percentile	**0.56**
33rd Percentile	**0.28**
Model	**P=10.79 ln(x)-20.99**
Coefficient of Determination (R^2)	**0.46**



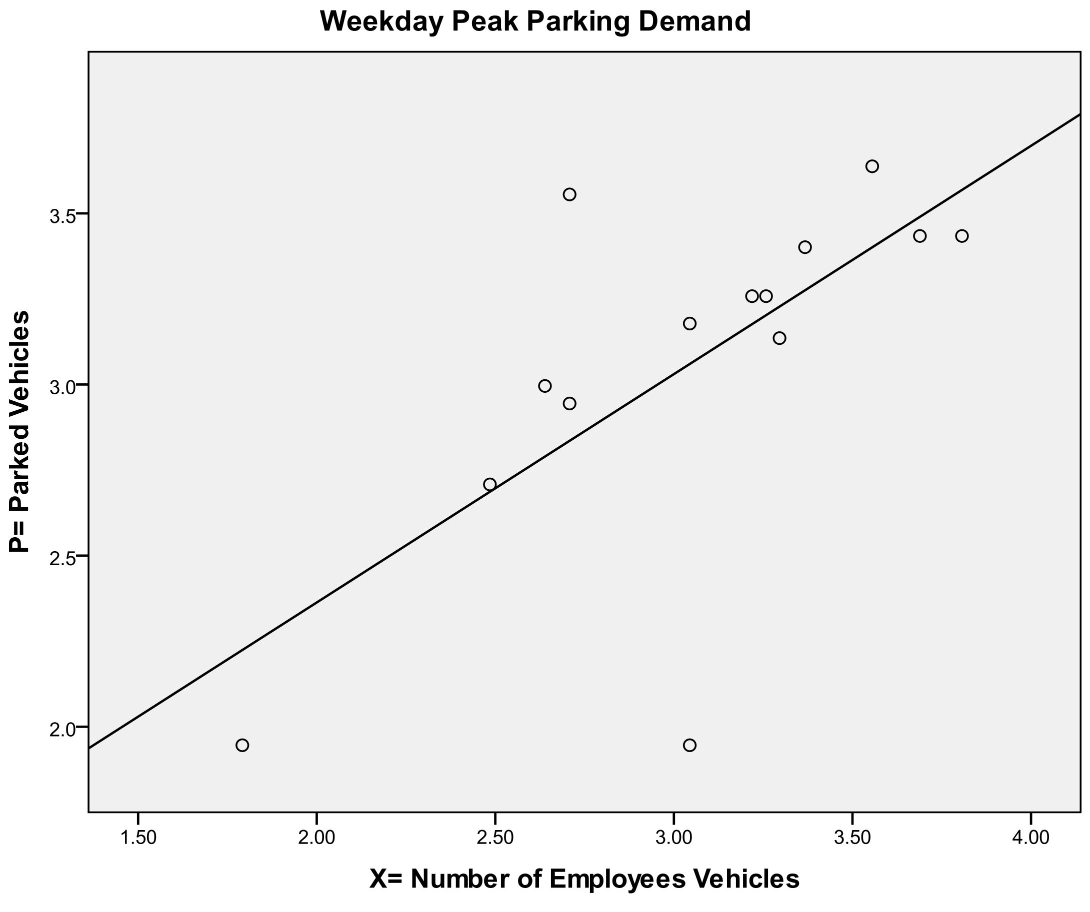
Average Peak Parking Demand vs. GFA (Square Meter)	
Survey Time Range	**Weekday**
Number of Sites	**14**
Average Size	**1400**
Standard Deviation	**0.99**
Coefficient of Variation (CV)	**59%**
Range	**0.96-4.75**
Rate	**1.68**
85th Percentile	**2.78**
33rd Percentile	**1.58**
Model	**P=11.38 ln(x)-56.91**
Coefficient of Determination (R^2)	**0.61**



Average Peak Parking Demand vs. GLA (per 100 Square Meter)	
Survey Time Range	**Weekday**
Number of Sites	**14**
Average Size	**1289.5**
Standard Deviation	**1**
Coefficient of Variation (CV)	**55%**
Range	**0.96-4.75**
Rate	**1.82**
85th Percentile	**3.01**
33rd Percentile	**1.75**
Model	**P=10.62 ln(x)-49.92**
Coefficient of Determination (R^2)	**0.64**



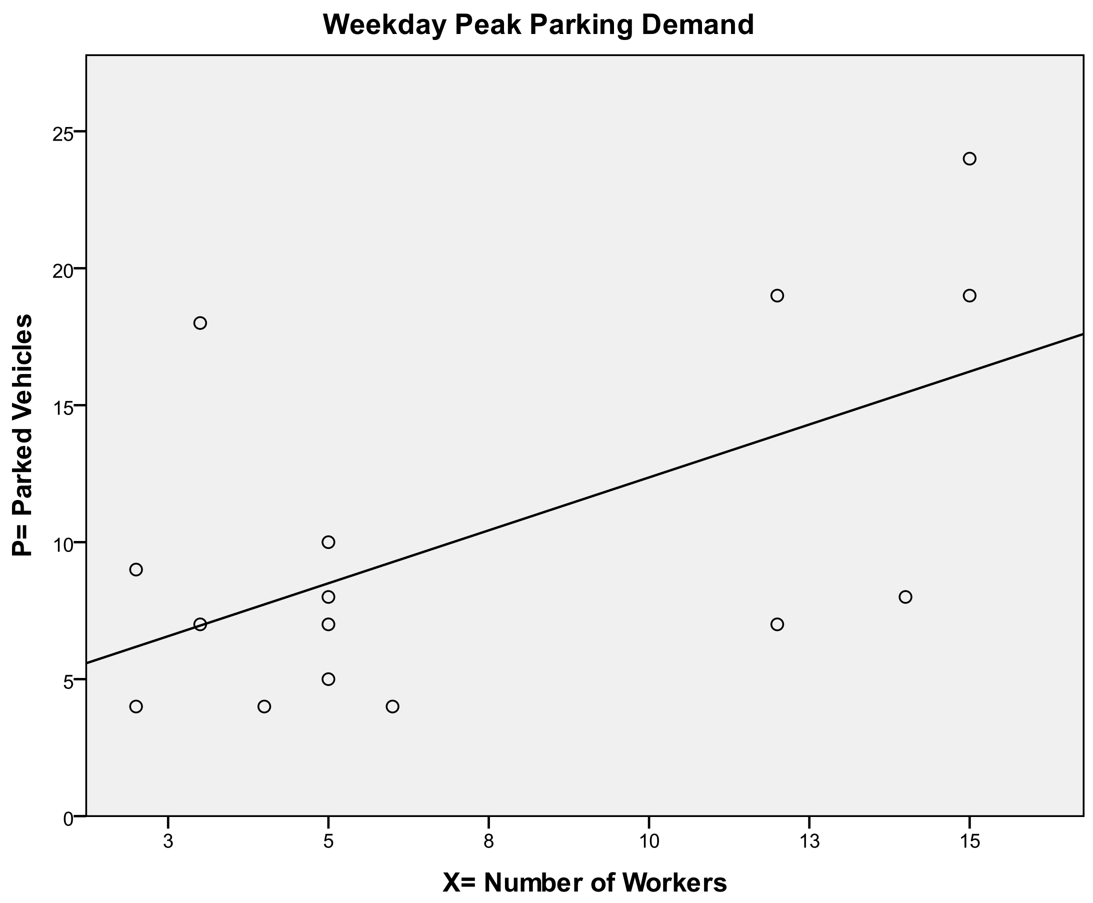
Average Peak Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**Weekday**
Number of Sites	**14**
Average Size	**23.6**
Standard Deviation	**0.61**
Coefficient of Variation (CV)	**52%**
Range	**0.43-3.0**
Rate	**1.17**
85th Percentile	**1.32**
33rd Percentile	**0.87**
Model	**$P= 2.8*X^{0.664}$**
Coefficient of Determination (R^2)	**0.43**



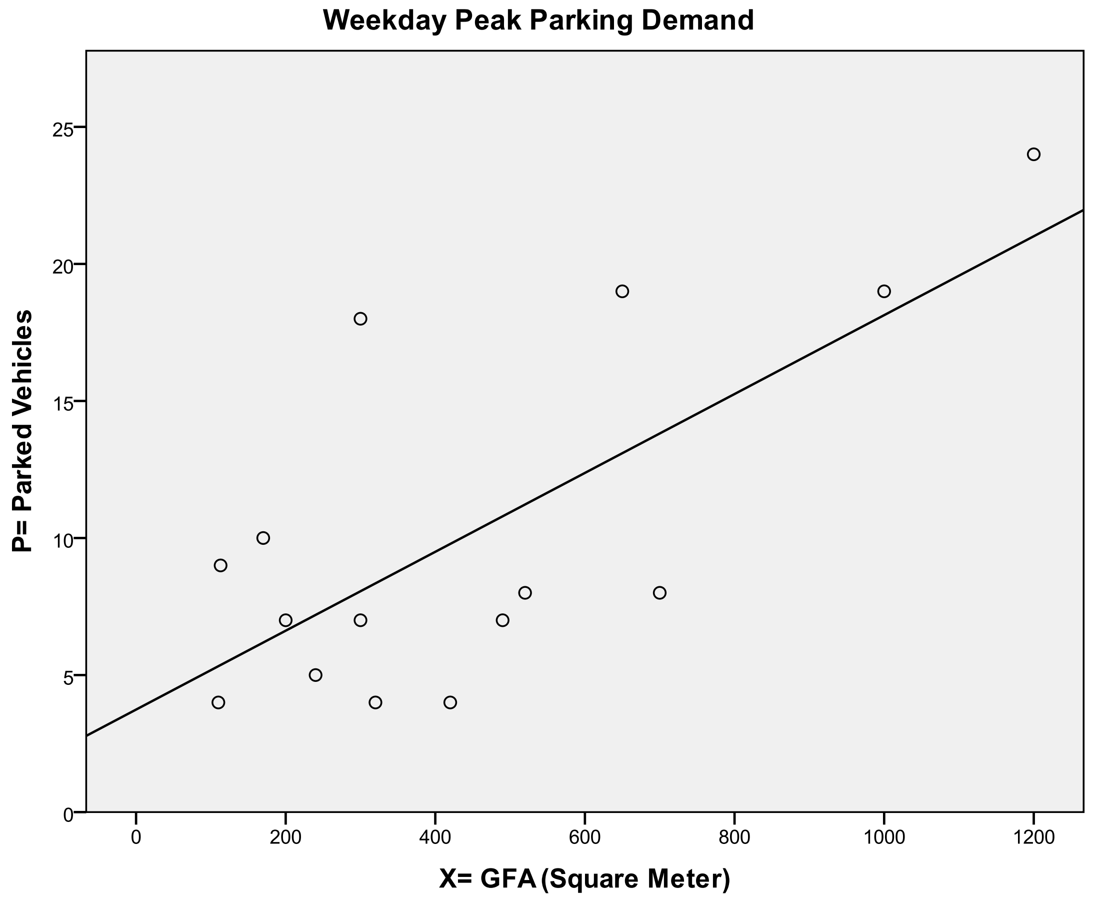
Retail Land Use

a. Supermarket Retail Class

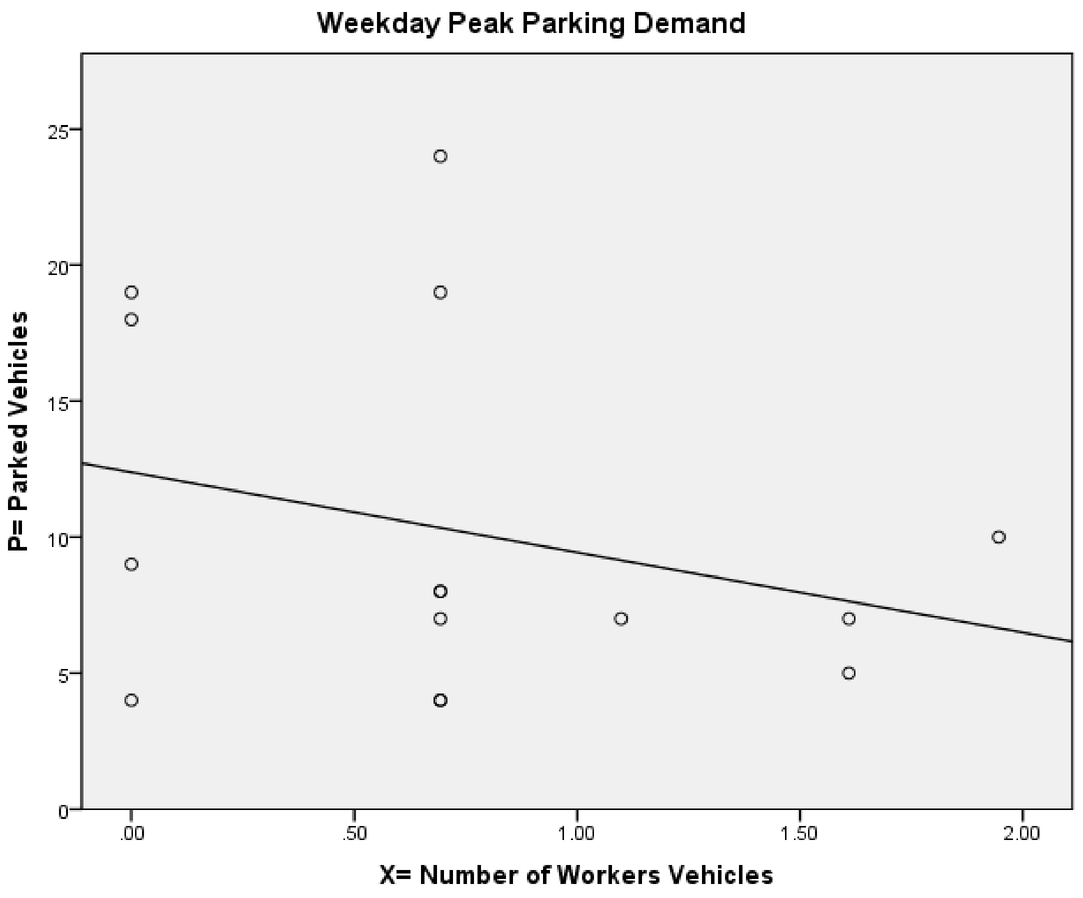
Average Peak Period Parking Demand vs. Number of Employees	
Survey Time Range	(7:00 - 22:00) on a Weekday
Number of Sites	15
Average Size	7.2
Standard Deviation	1.05
Coefficient of Variation (CV)	92%
Range	0.42-4.25
Rate	1.15
85th Percentile	1.96
33rd Percentile	0.89
Model	P= 0.773*X+ 4.636
Coefficient of Determination (R^2)	0.338



Average Peak Period Parking Demand vs. GLA (per 100 Square Meter)	
Survey Time Range	**(7:00 - 22:00) on a Weekday**
Number of Sites	**15**
Average Size	**448.8**
Standard Deviation	**1.74**
Coefficient of Variation (CV)	**83%**
Range	**0.83-6.0**
Rate	**2.08**
85th Percentile	**5.13**
33rd Percentile	**1.50**
Model	**P= 0.014*X+ 3.74**
Coefficient of Determination (R^2)	**0.509**

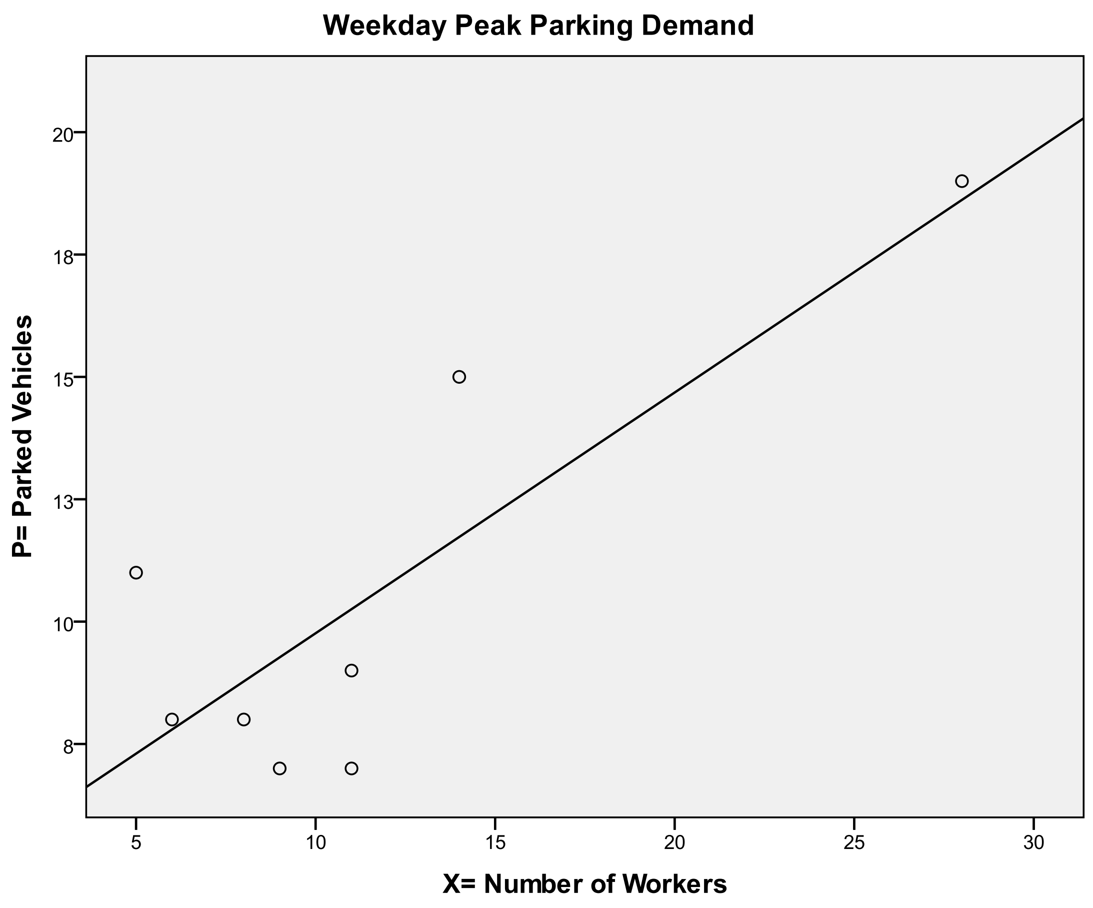


Average Peak Period Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**(7:00 - 22:00) on a Weekday**
Number of Sites	**15**
Average Size	**2.53**
Standard Deviation	**5.93**
Coefficient of Variation (CV)	**152%**
Range	**0.90-18.50**
Rate	**3.91**
85th Percentile	**11.53**
33rd Percentile	**2.11**
Model	$\mathbf{P = -2.947\ln(x) + 12.384}$
Model Confidence Interval	**(1-0.313)**
Coefficient of Determination (R^2)	**0.078**

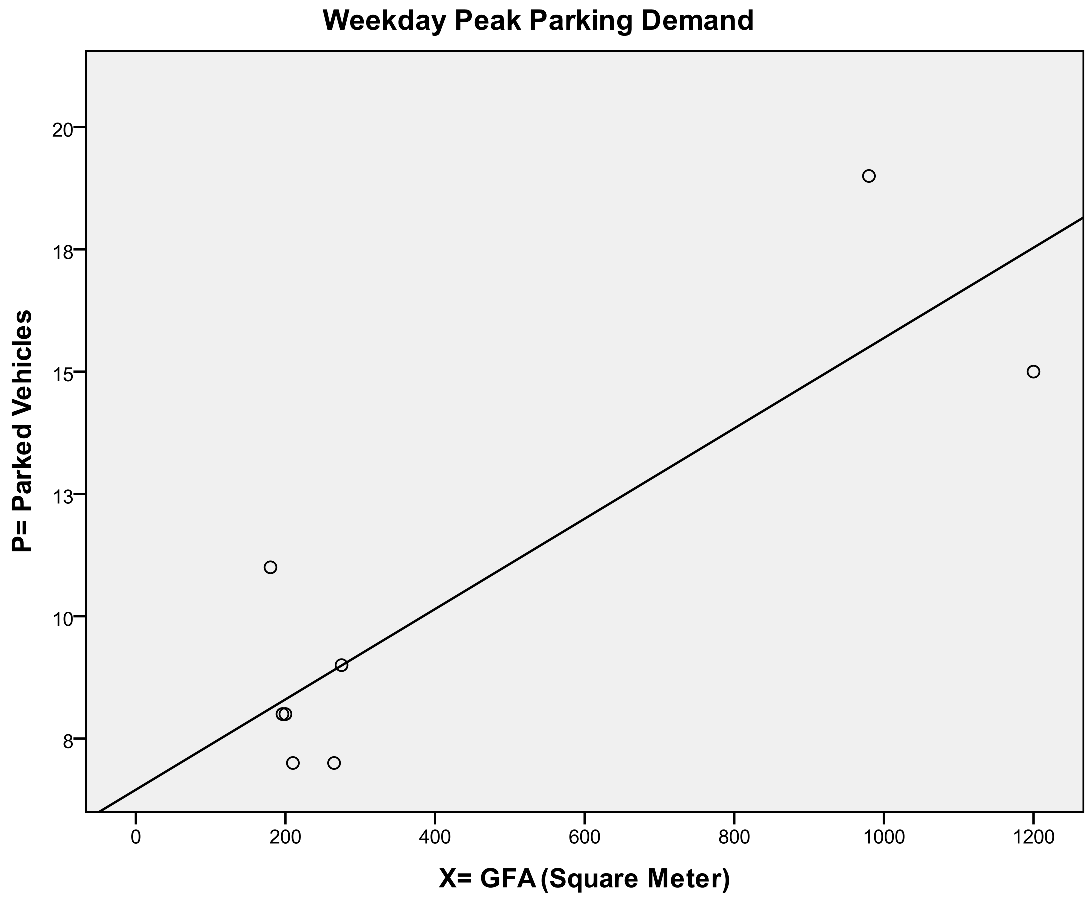


b. Strip Retail Class

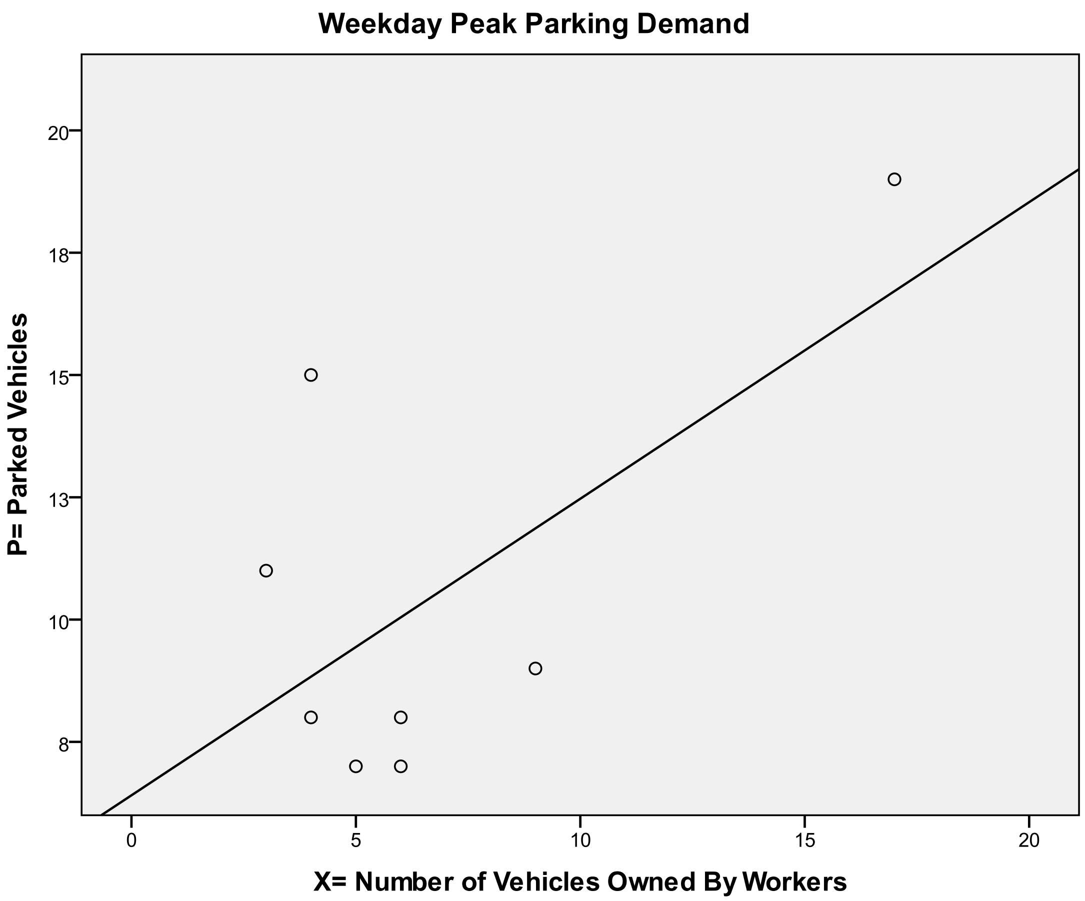
Average Peak Period Parking Demand vs. Number of Employees	
Survey Time Range	(7:00 - 22:00) on a Weekday
Number of Sites	8
Average Size	11.5
Standard Deviation	0.51
Coefficient of Variation (CV)	63%
Range	0.50-2.10
Rate	0.82
85th Percentile	1.03
33rd Percentile	0.67
Model	P= 0.492*X+ 4.843
Coefficient of Determination (R^2)	0.678



Average Peak Period Parking Demand vs. GLA (per 100 Square Meter)	
Survey Time Range	**(7:00 - 22:00) on a Weekday**
Number of Sites	**8**
Average Size	**438.3**
Standard Deviation	**1.13**
Coefficient of Variation (CV)	**51%**
Range	**1.17-4.72**
Rate	**2.22**
85th Percentile	**3.74**
33rd Percentile	**2.71**
Model	**P= 0.009*X+ 6.453**
Coefficient of Determination (R^2)	**0.752**



Average Peak Period Parking Demand vs. Number of Employees Vehicles	
Survey Time Range	**(7:00 - 22:00) on a Weekday**
Number of Sites	**8**
Average Size	**6.75**
Standard Deviation	**1.08**
Coefficient of Variation (CV)	**71%**
Range	**1-3.63**
Rate	**1.52**
85th Percentile	**3.42**
33rd Percentile	**1.21**
Model	**P= 0.606*X+ 6.408**
Model Confidence Interval	**(1-0.093)**
Coefficient of Determination (R^2)	**0.40**



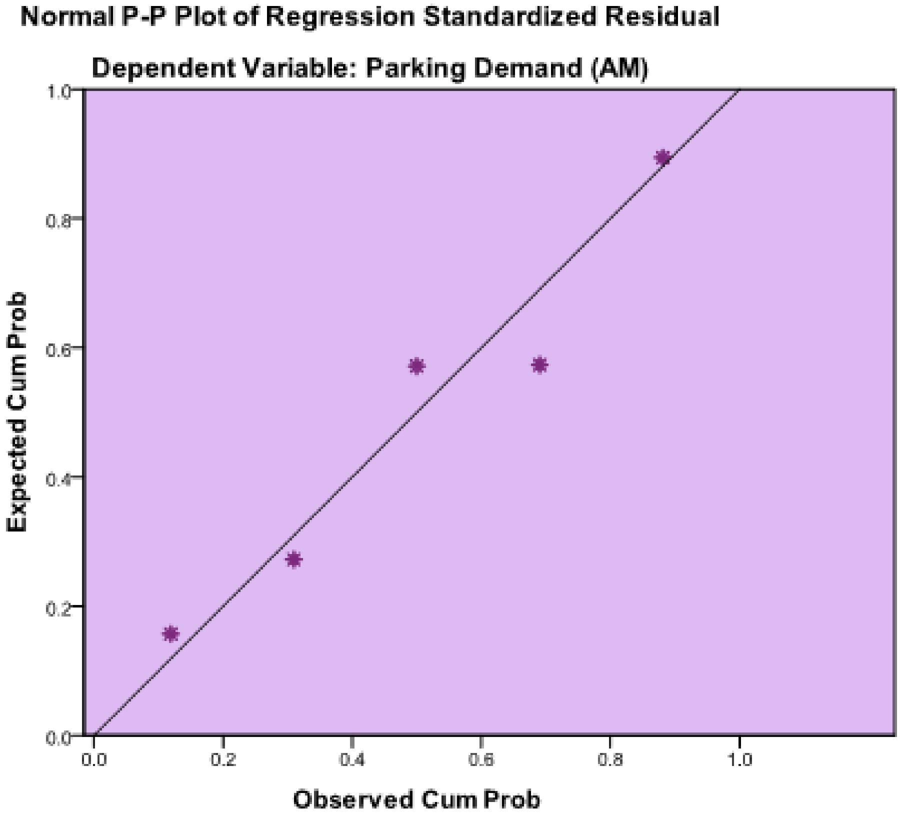
Appendix (E): Residual Plots

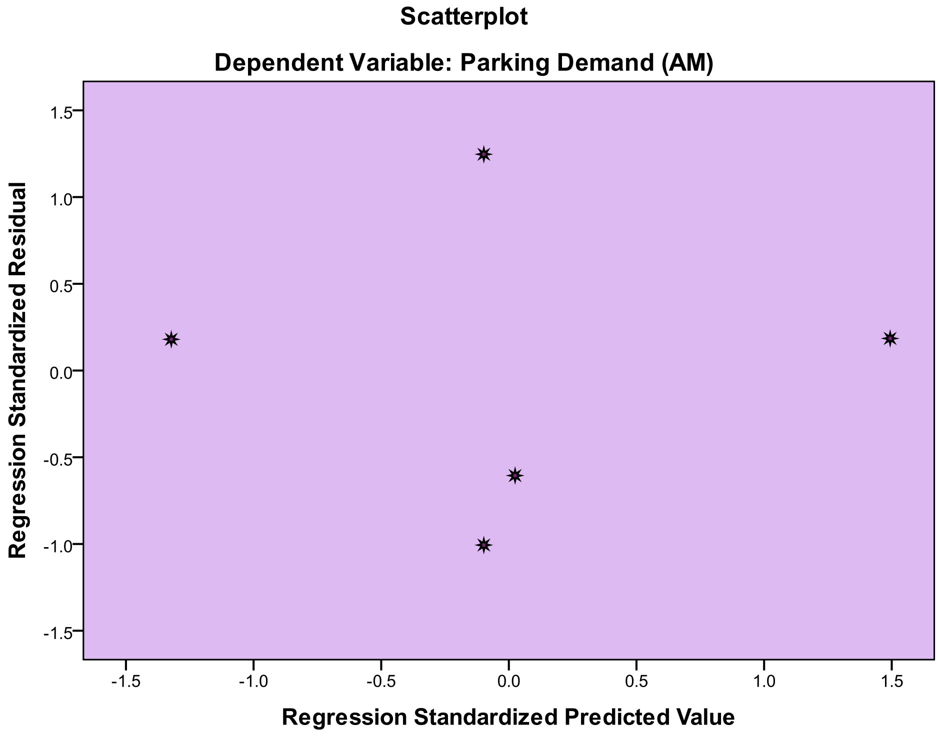
Sample of Residual Plots

- ## Attached Housing Land Use

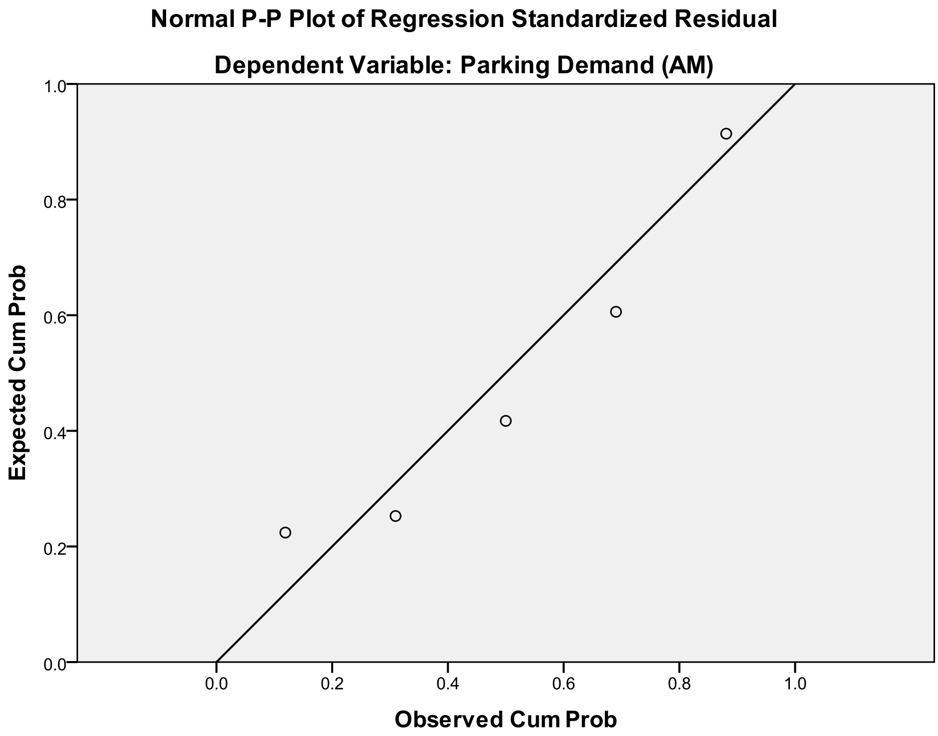
AM Period

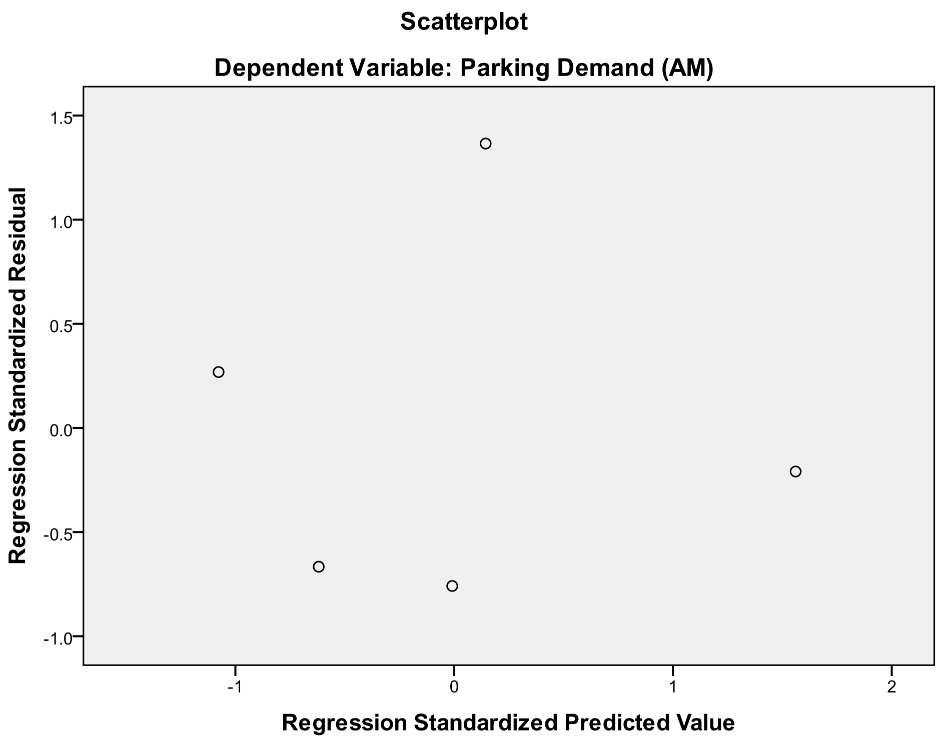
Independent Variable: Number of Occupied AH Units


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Parking Demand (AM)
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0

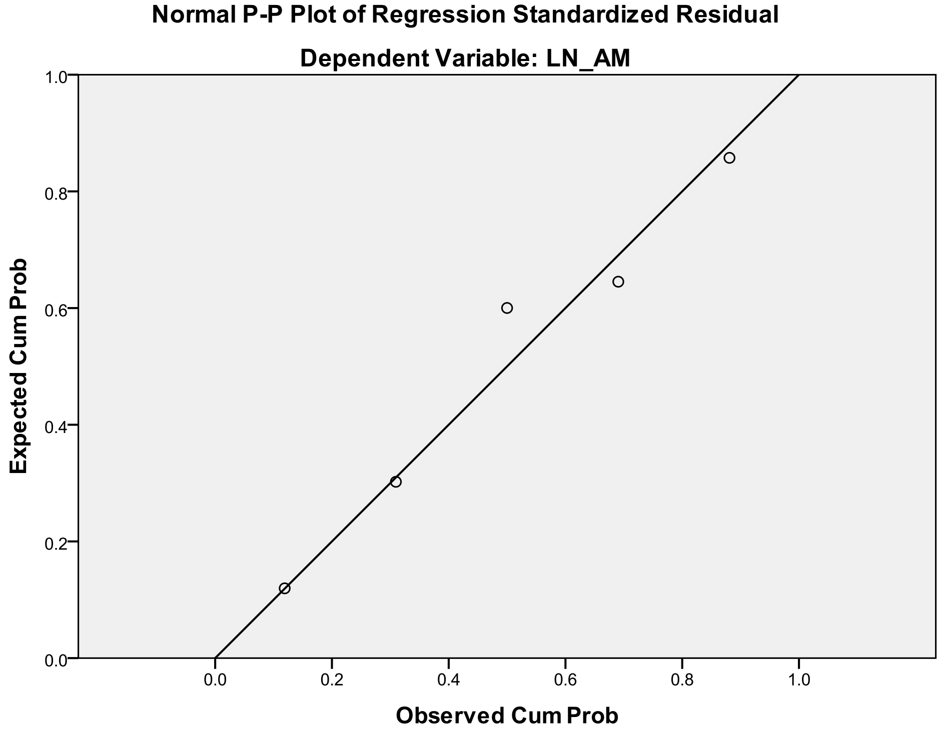

Scatterplot
Dependent Variable: Parking Demand (AM)
Regression Standardized Residual
Regression Standardized Predicted Value
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5

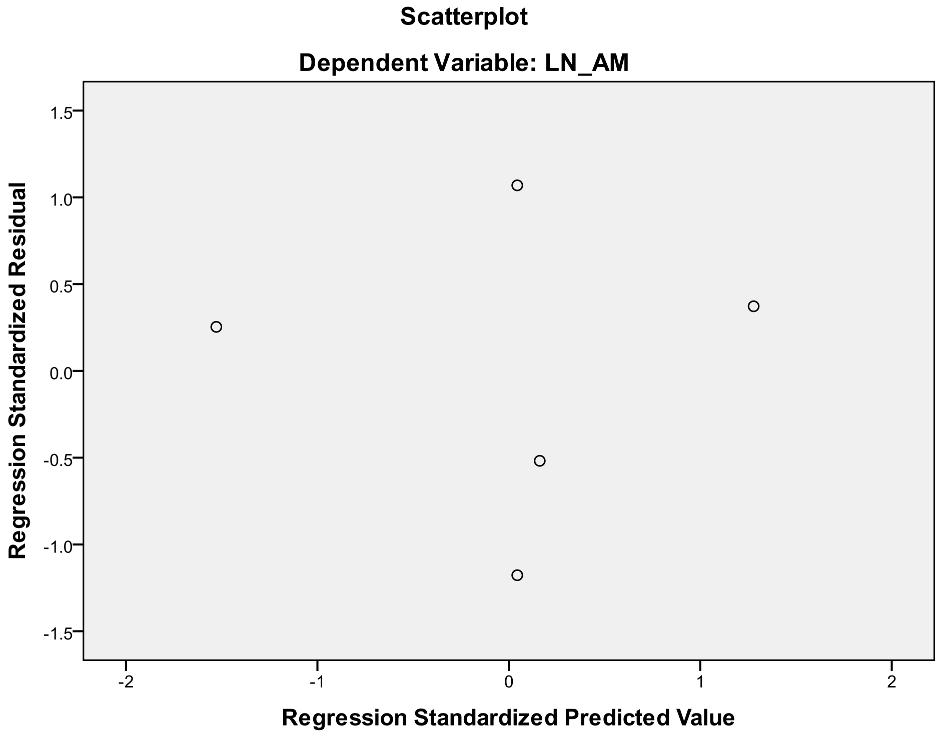
Independent Variable: Number of Inhabitants





Independent Variable: Number of Occupied AH Units

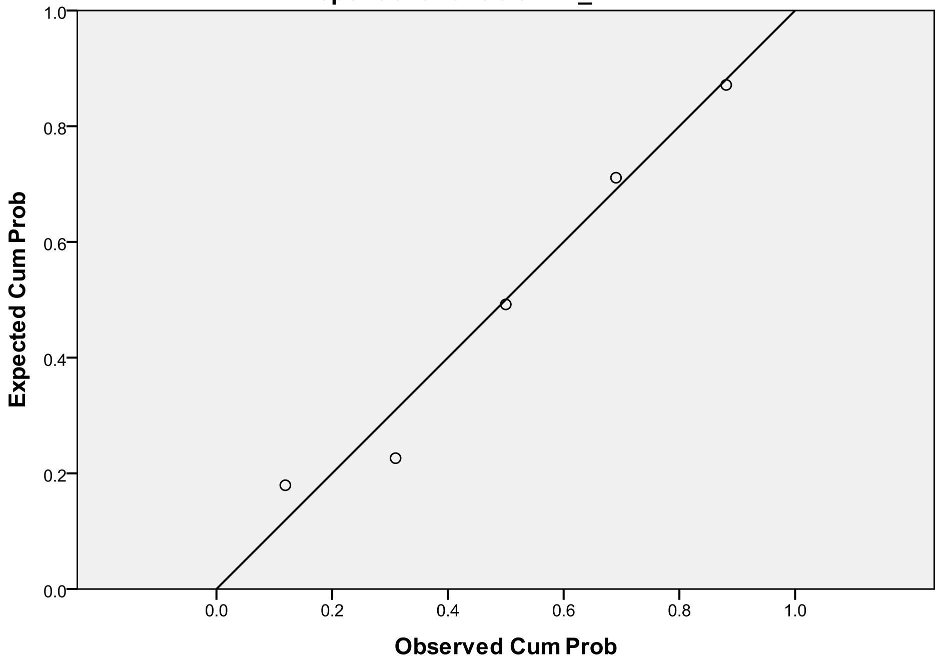




Independent Variable: Number of Inhabitants

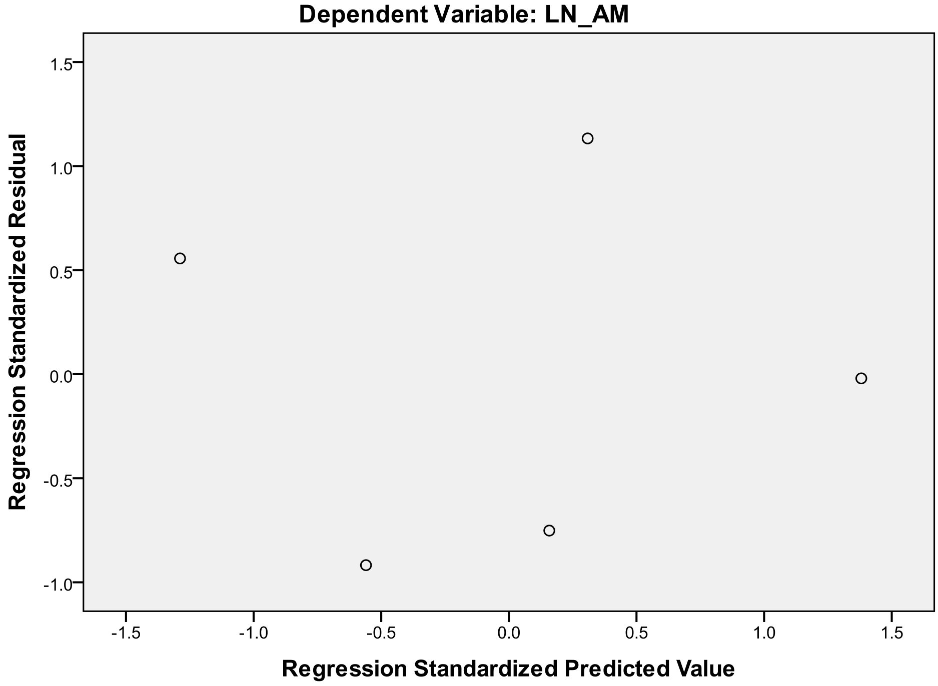
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: LN_AM



Scatterplot

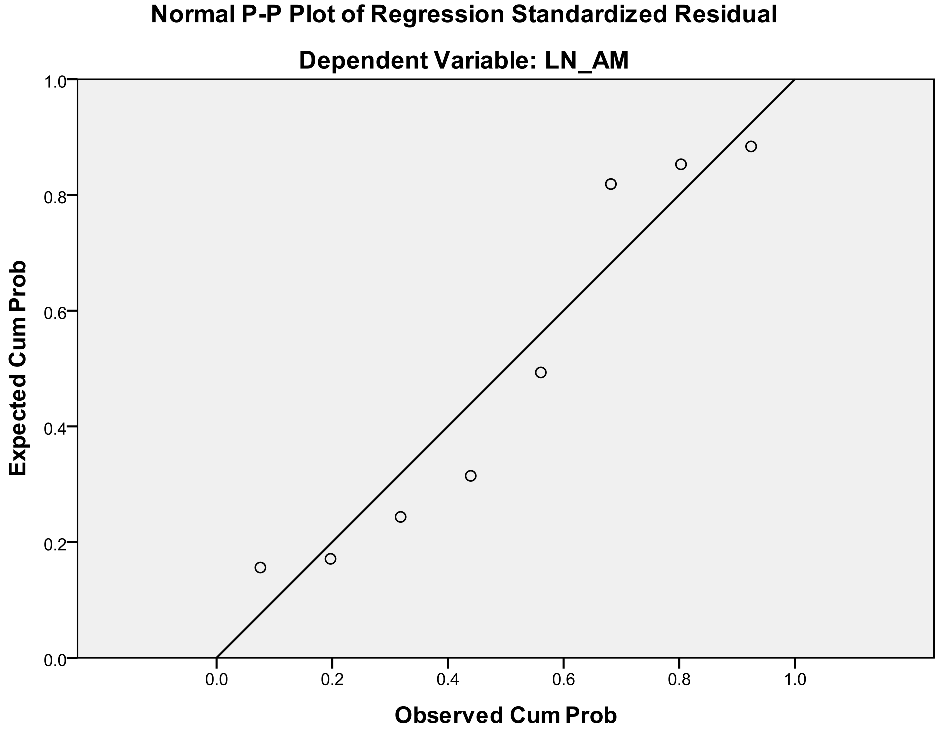
Dependent Variable: LN_AM

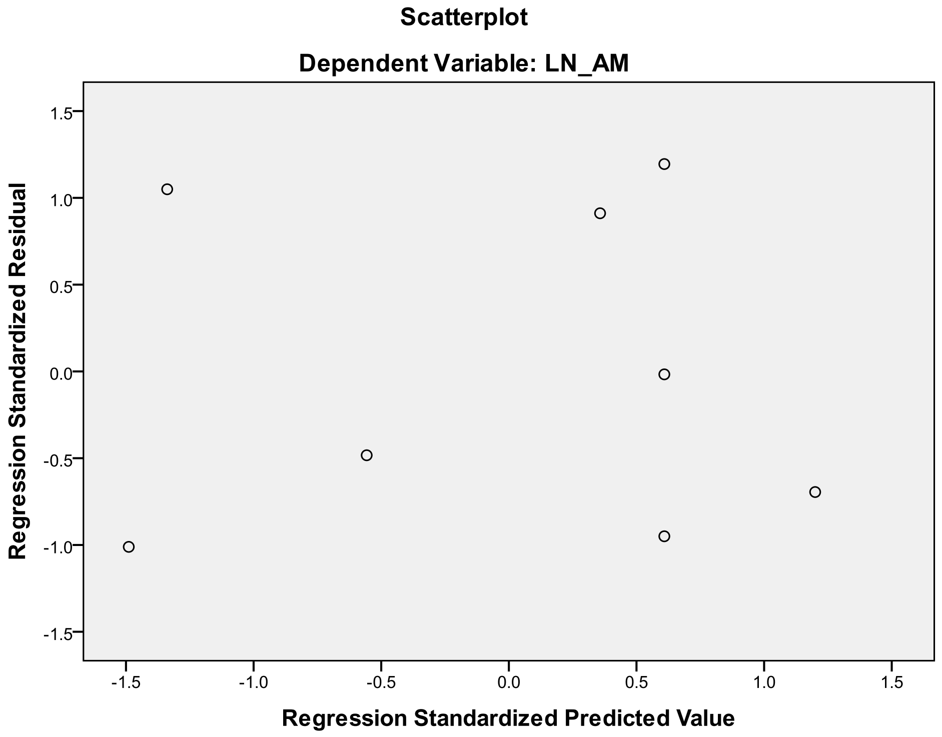


Detached Housing Land Use Class

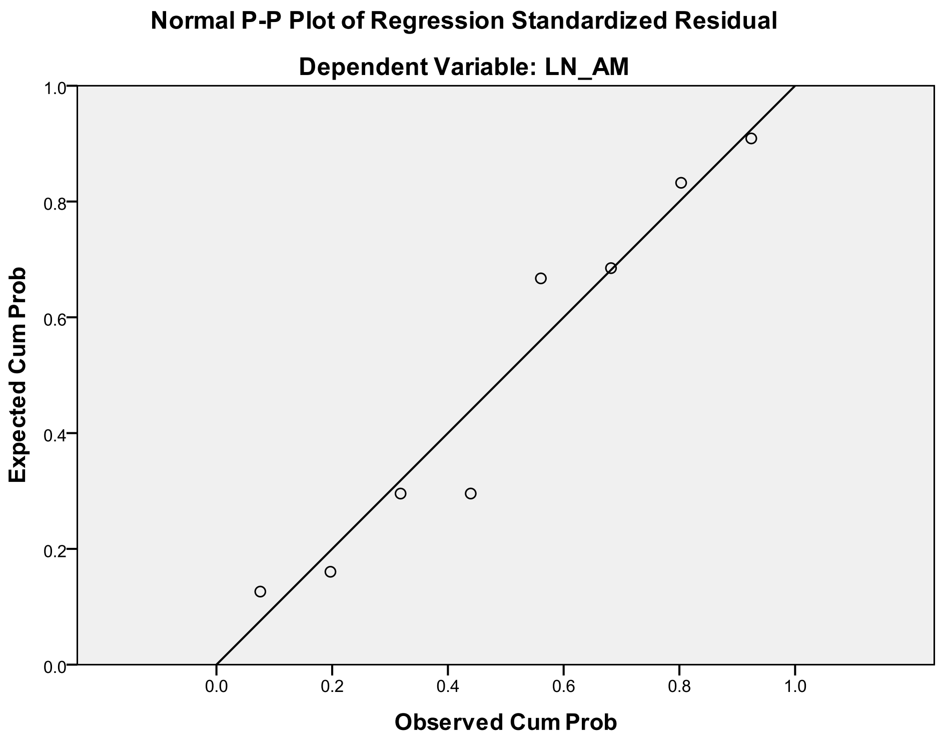
Power Relationship

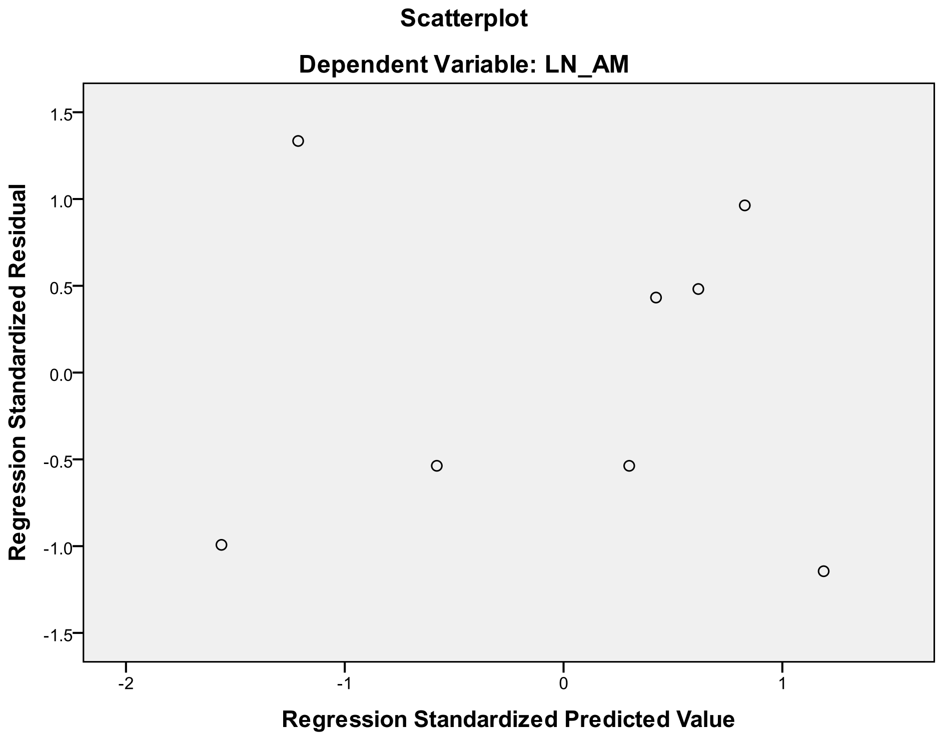
Independent Variable: Number of Occupied AH Units



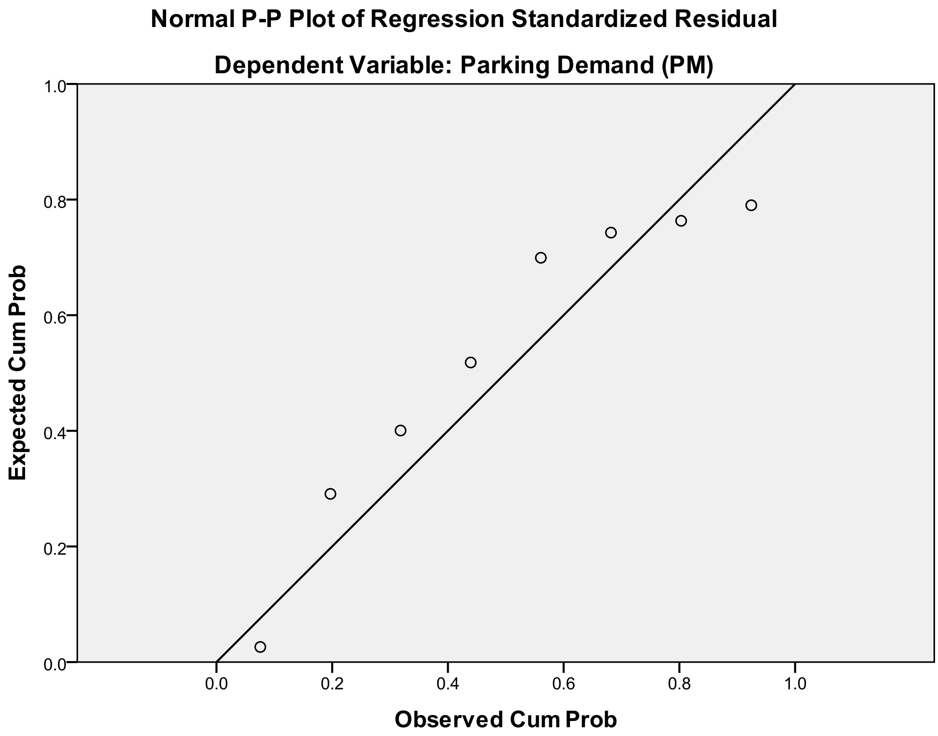


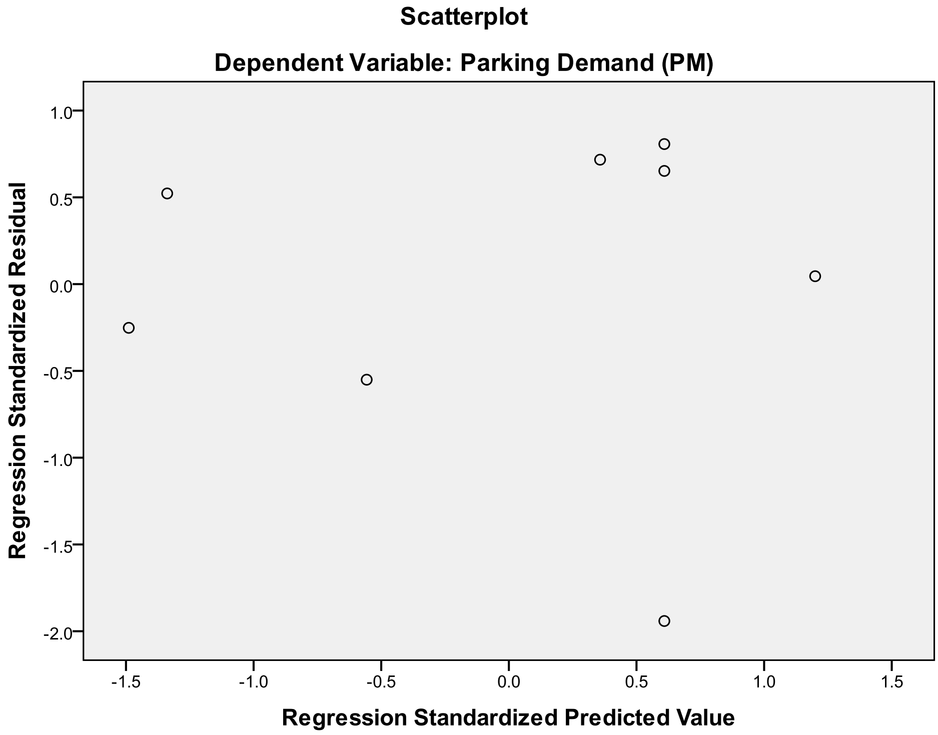
Independent Variable: Number of Inhabitants



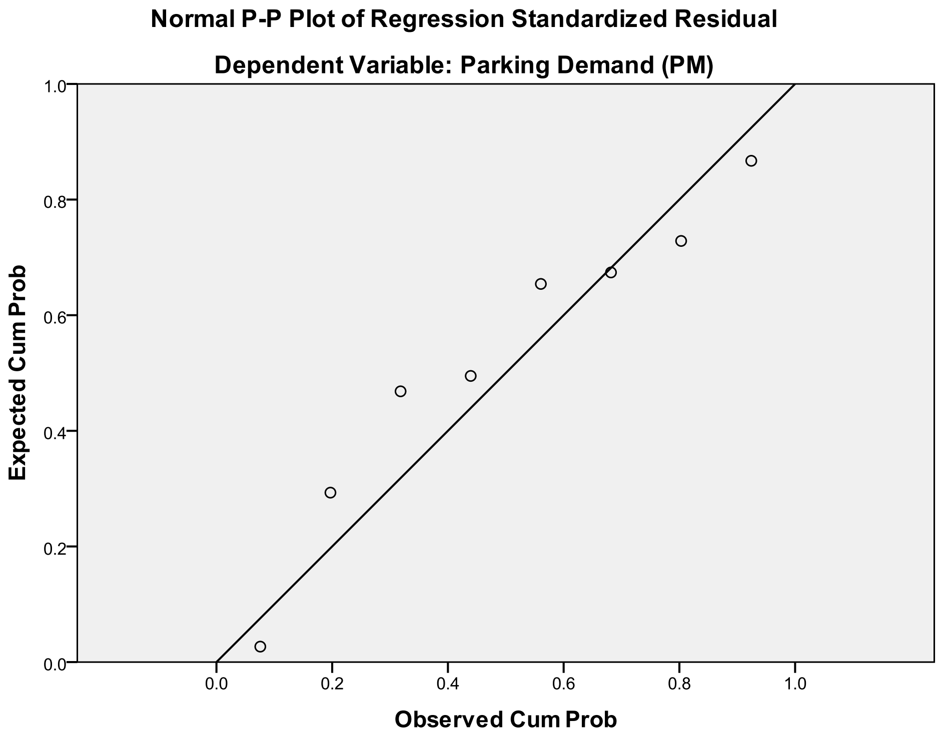


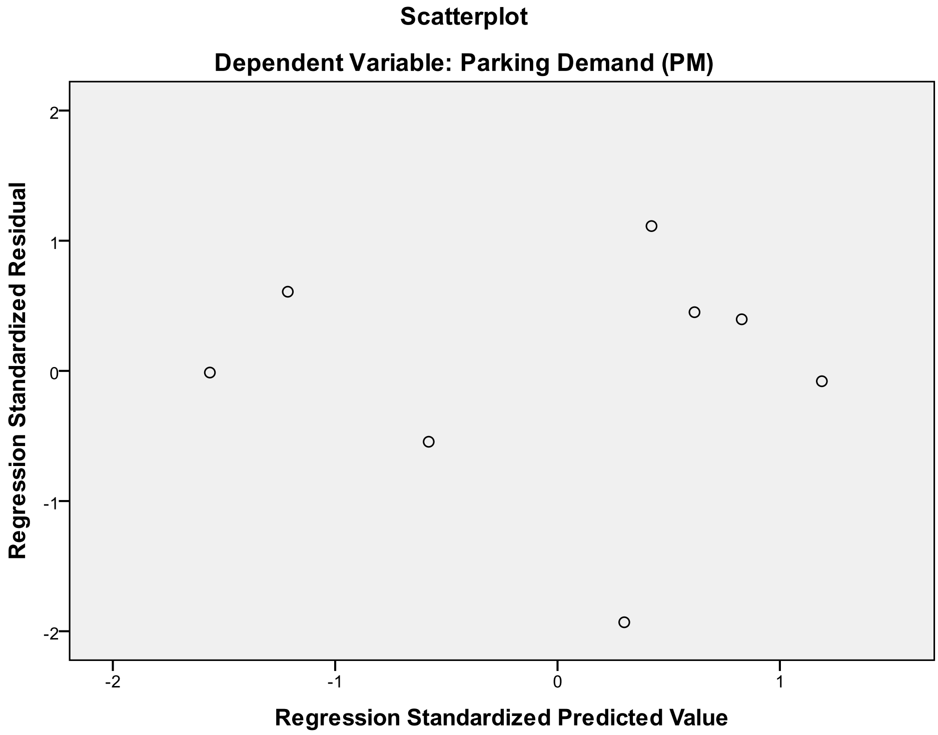
Independent Variable: Number of Occupied AH Units





Independent Variable: Number of Inhabitants

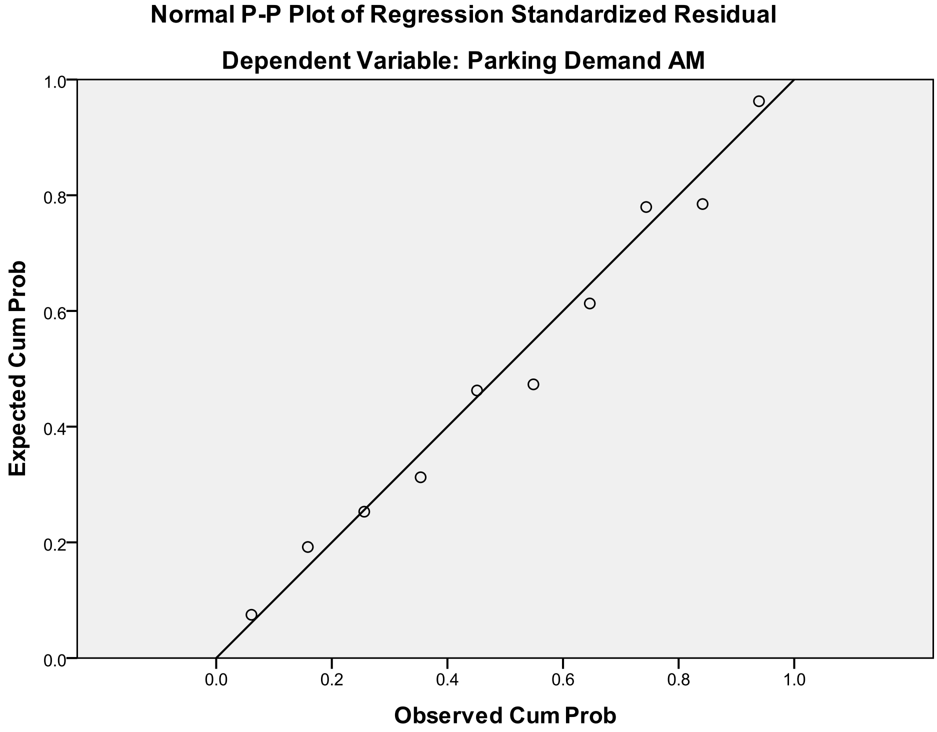


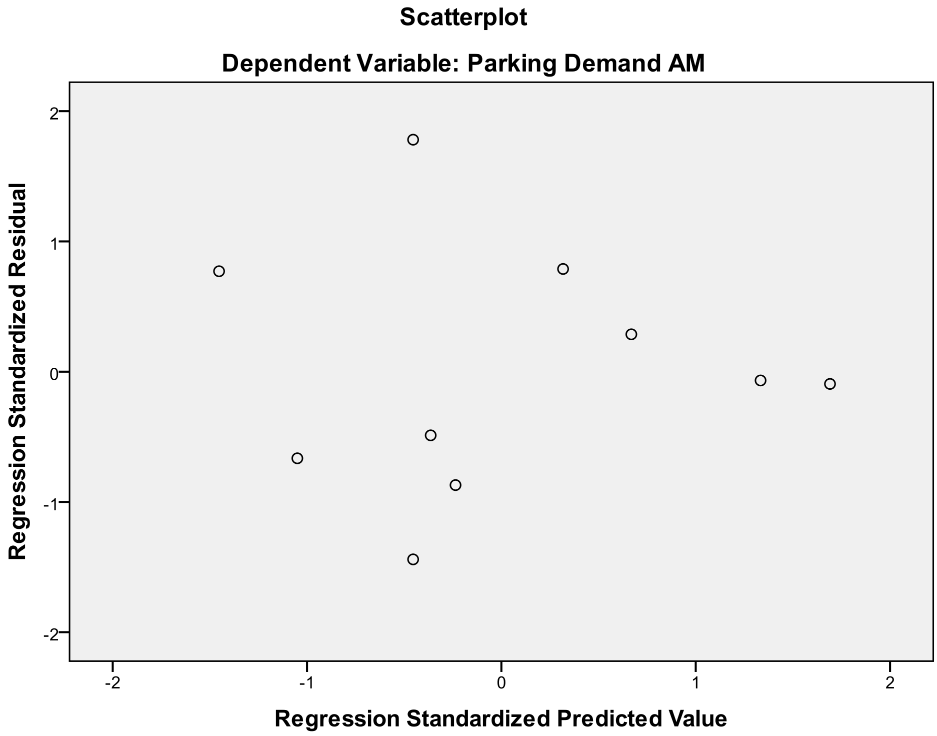


Apartment Housing Land Use Class

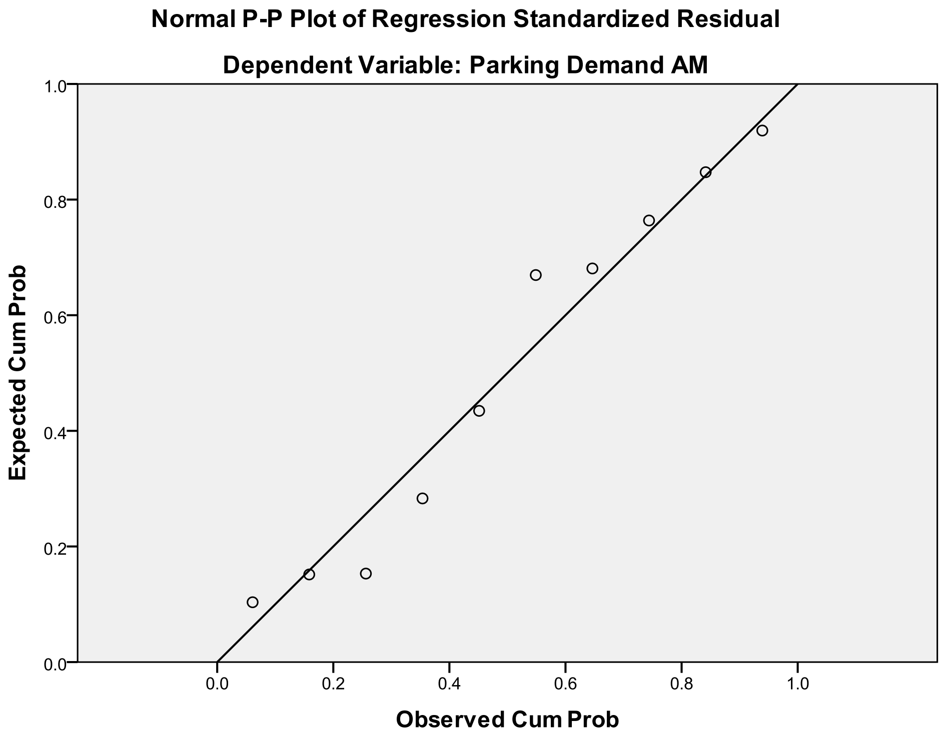
AM Period

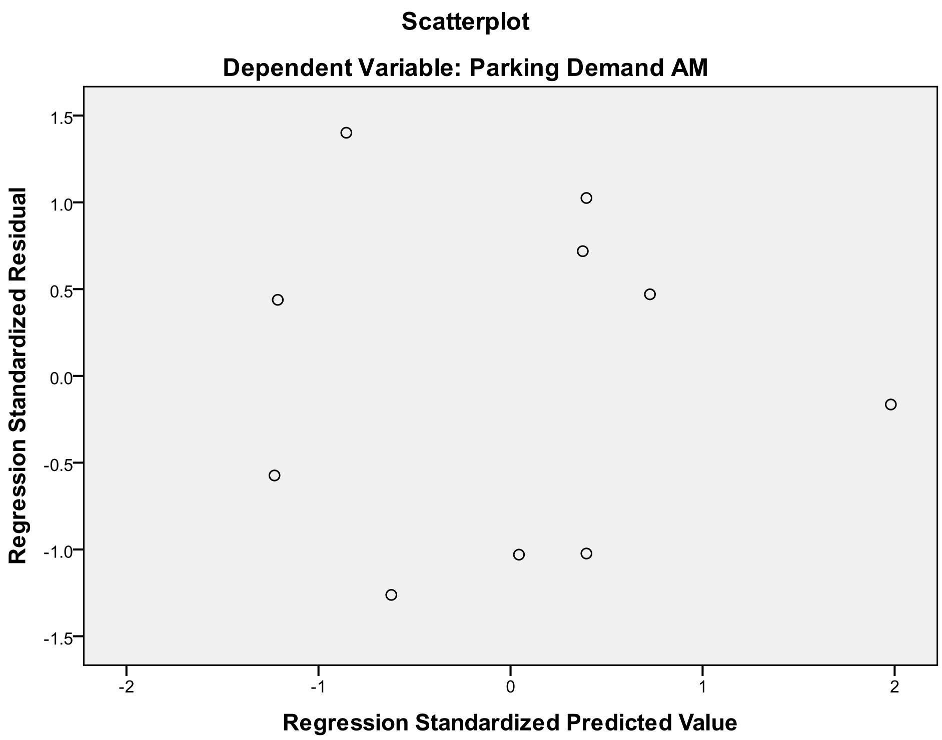
Independent Variable: Number of Inhabitants



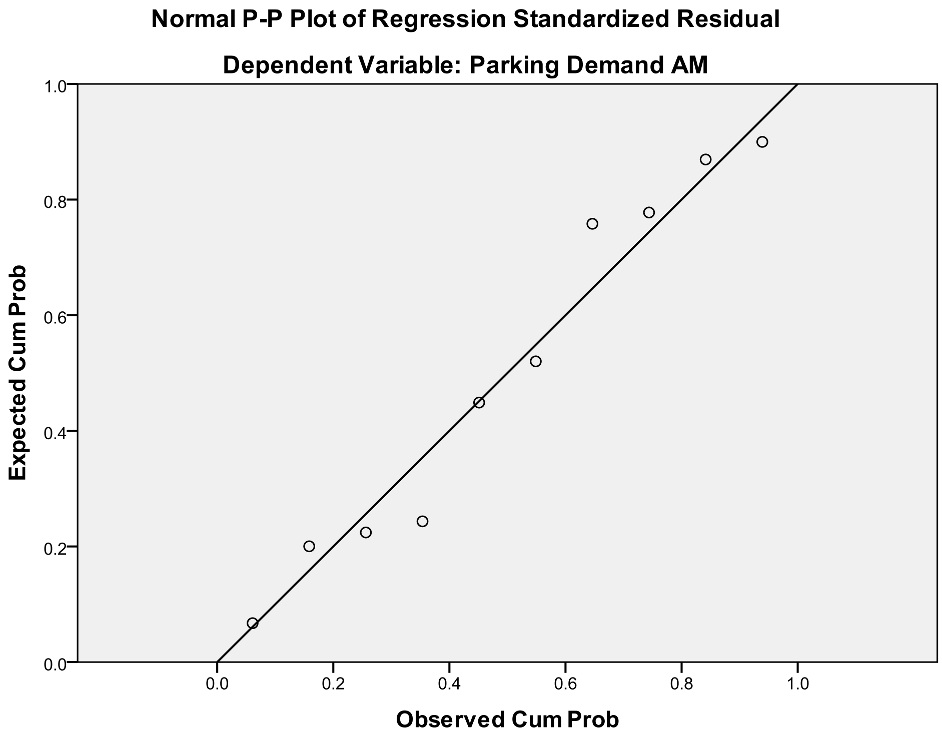


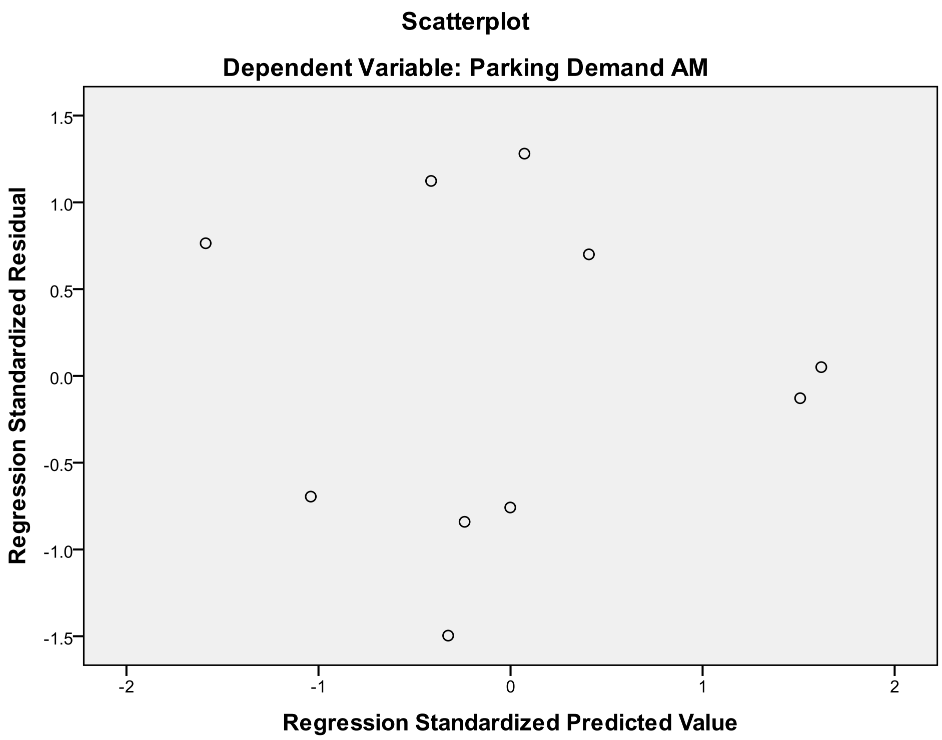
Independent Variable: GFA (sq. m.)





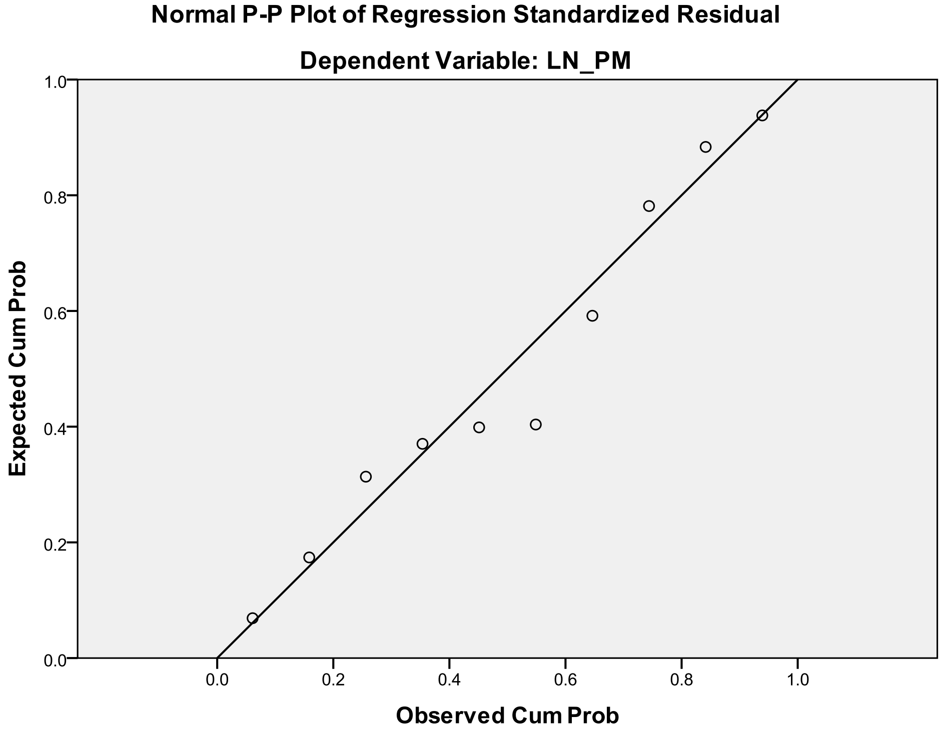
Independent Variable: Number of Occupied AH Units

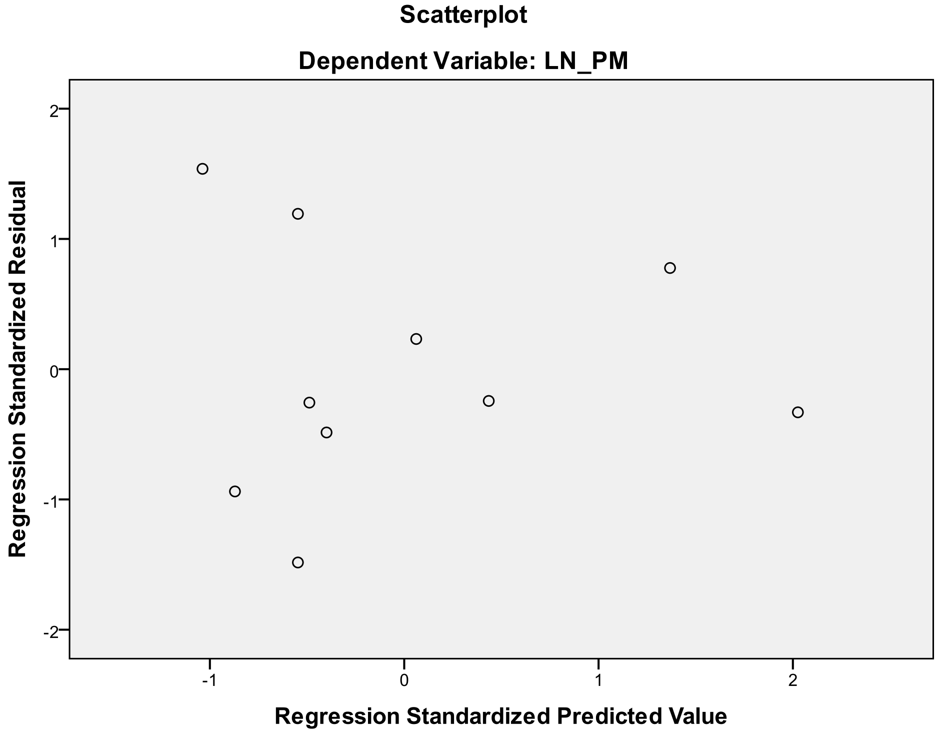




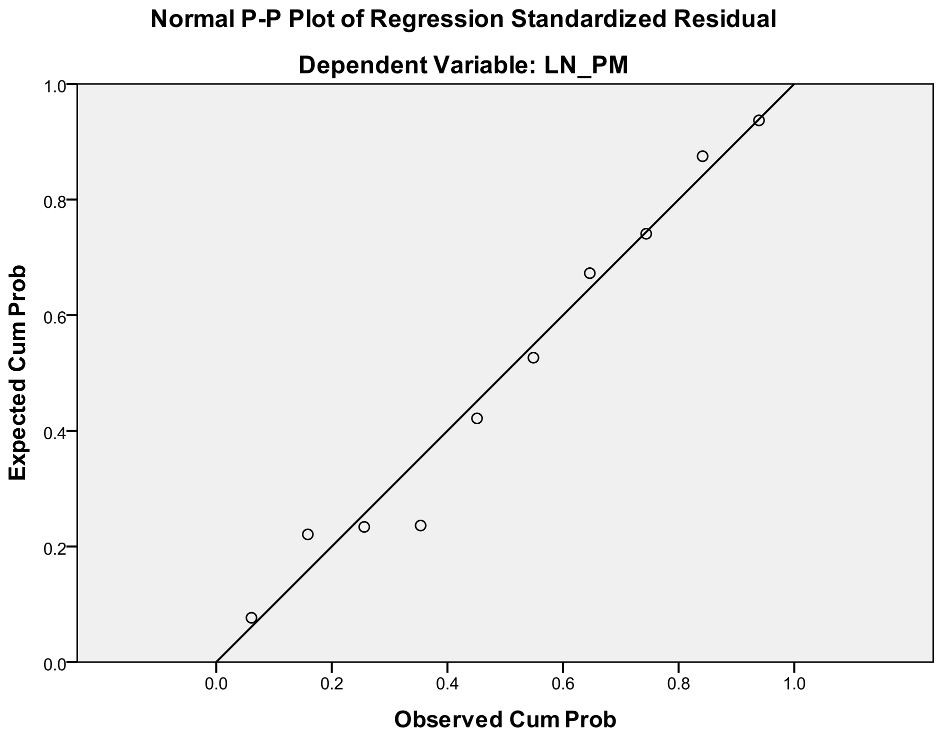
PM Period

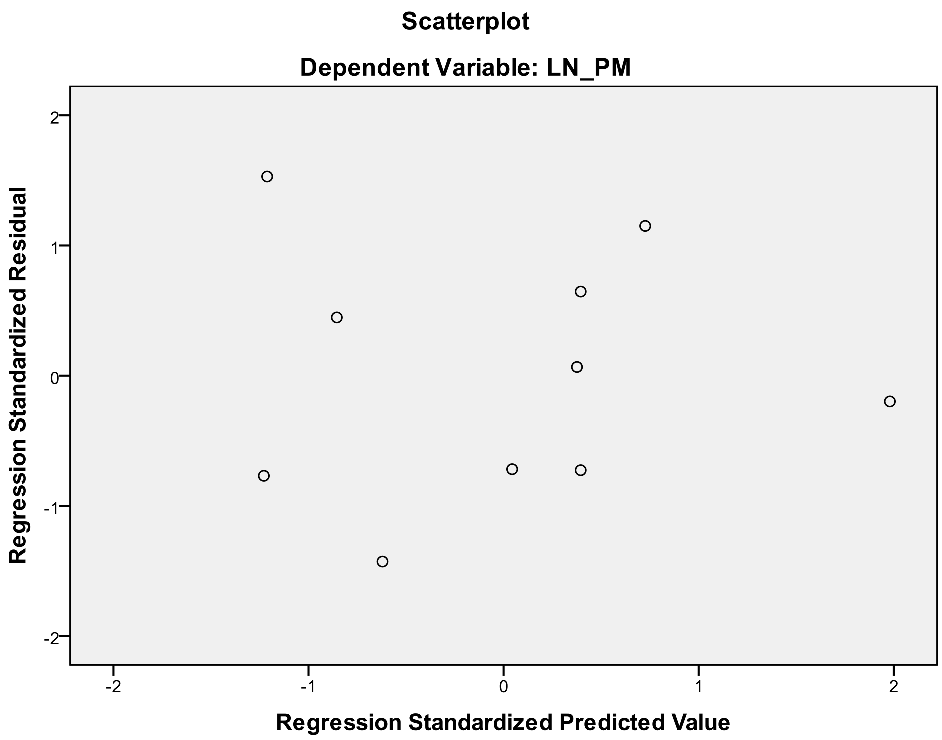
Independent Variable: Number of Inhabitants



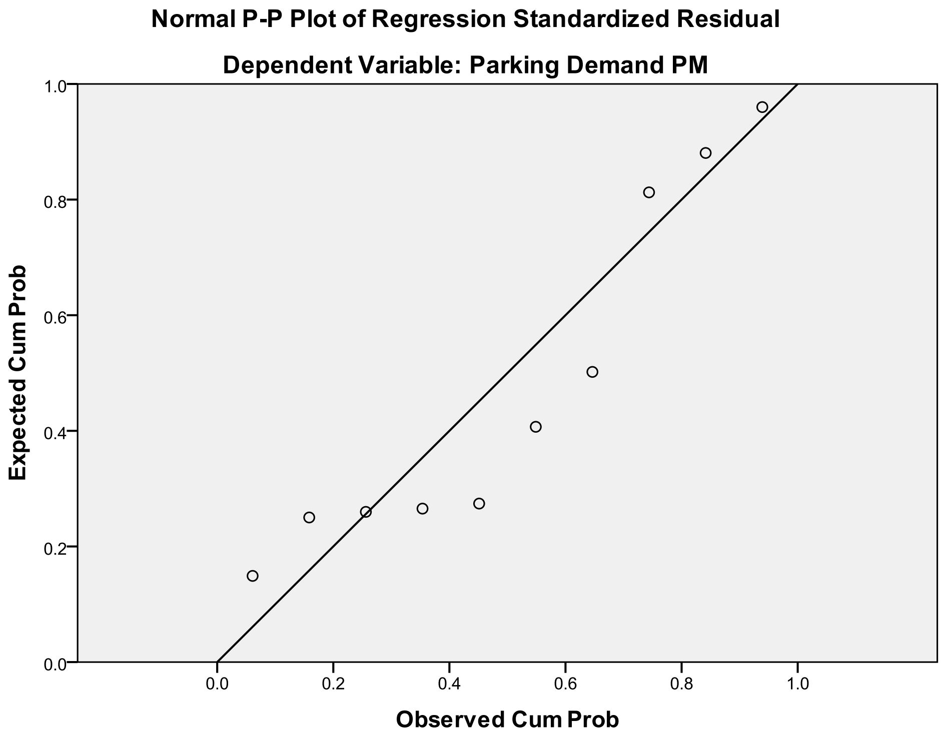


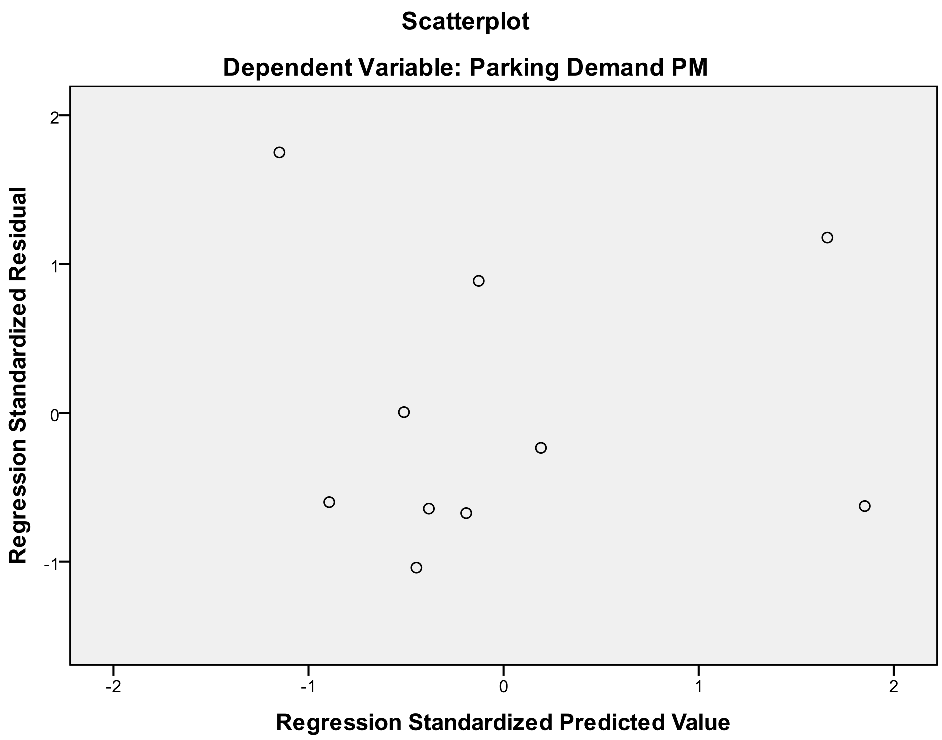
Independent Variable: GFA (sq. m.)





Independent Variable: Number of Occupied AH Units



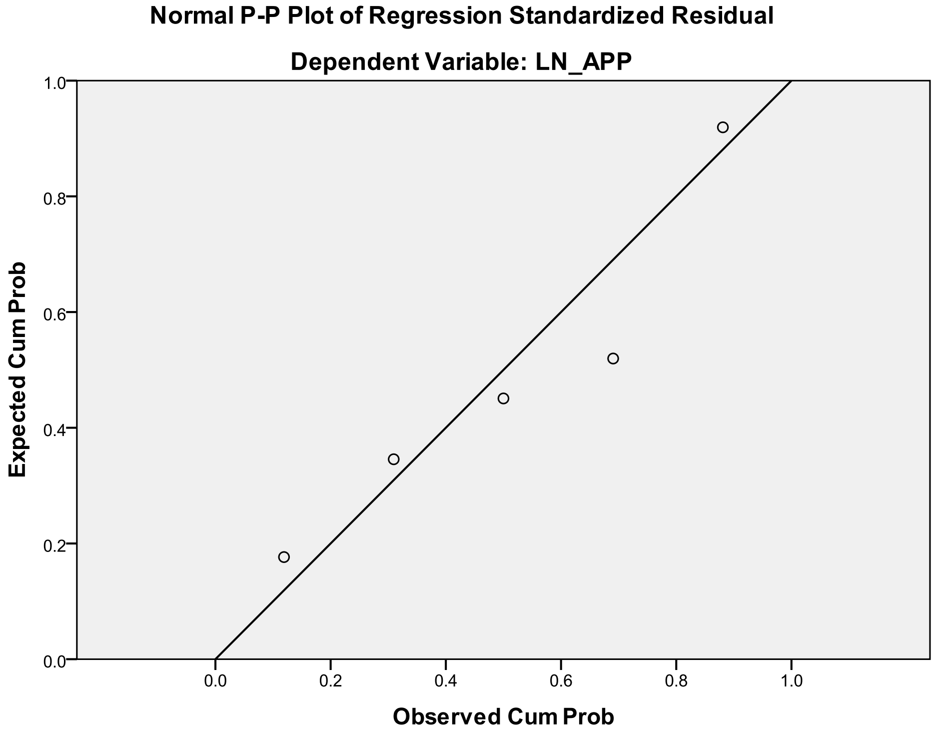


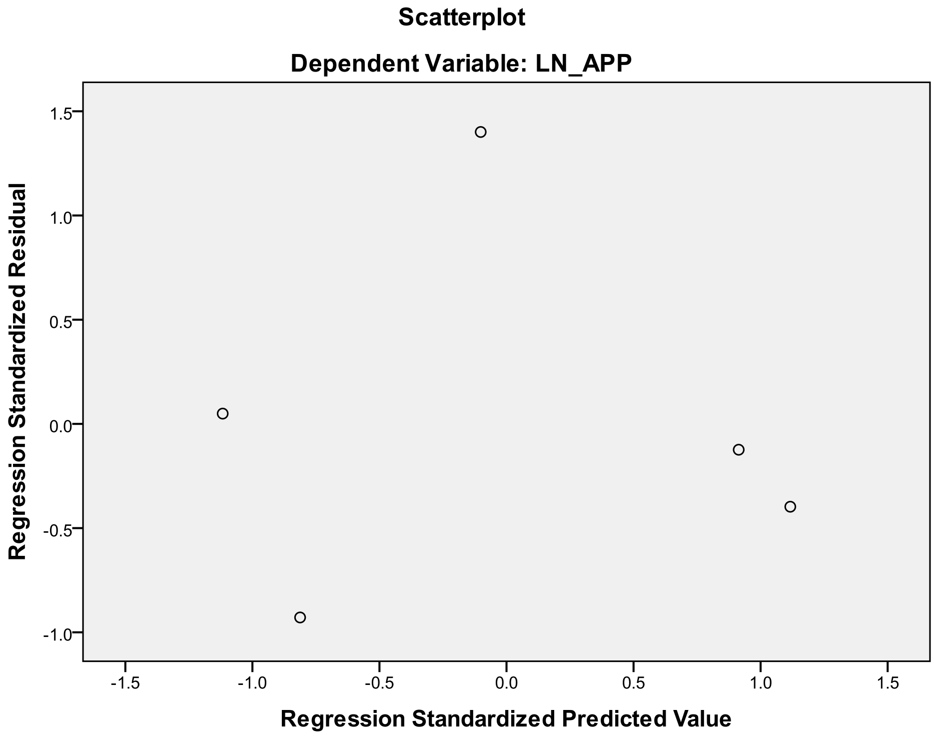
Office Land Use

General Office Land Use Class

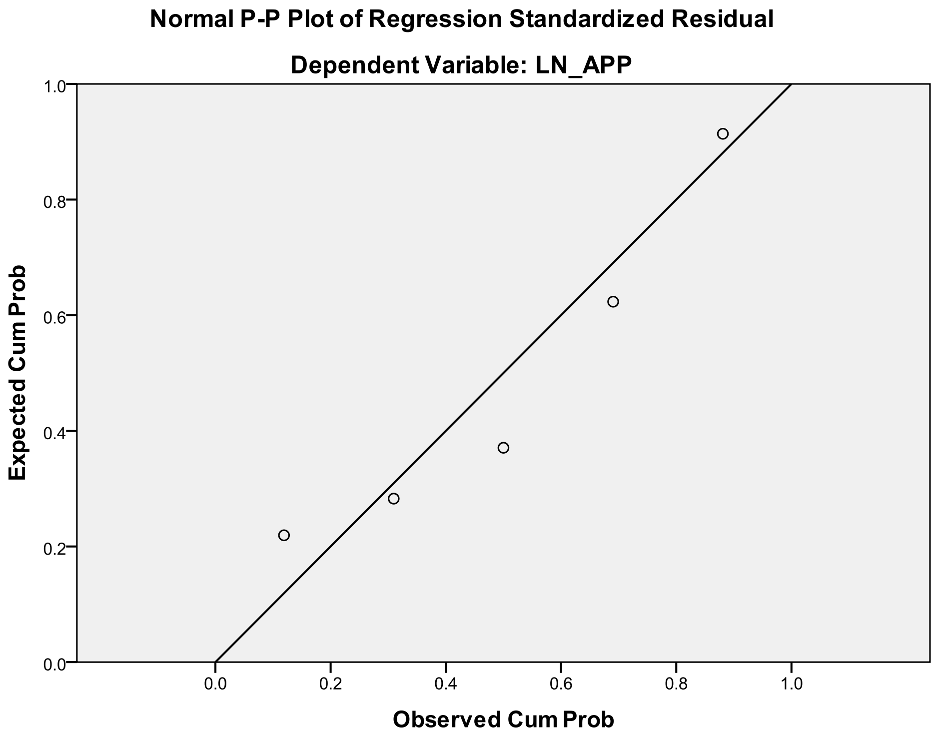
Peak Period

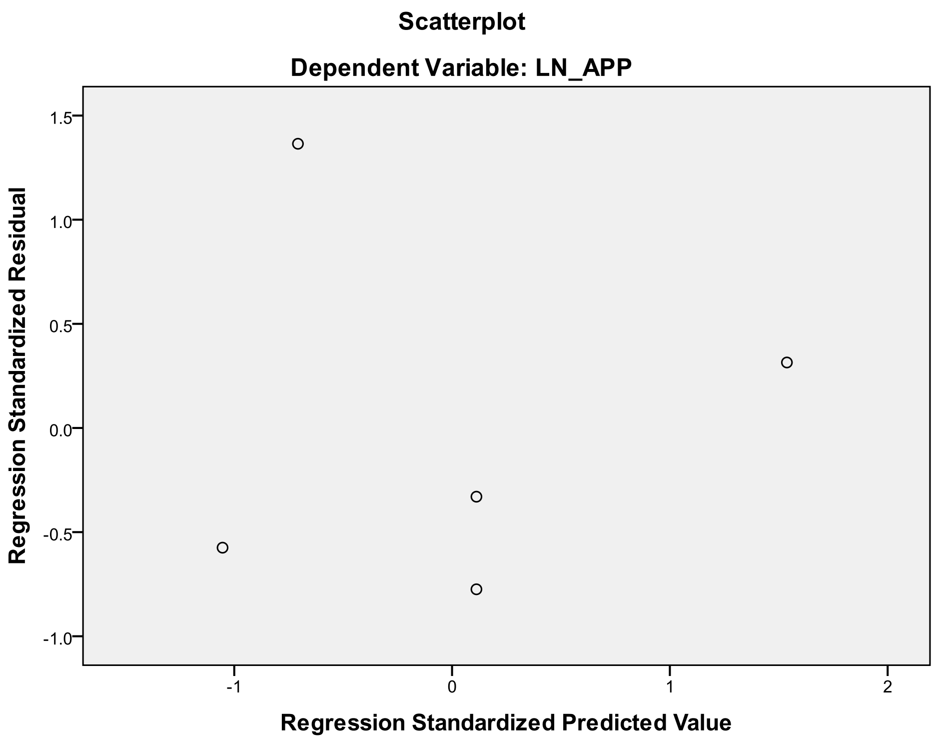
Independent Variable: Number of Workers


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: LN_APP
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0

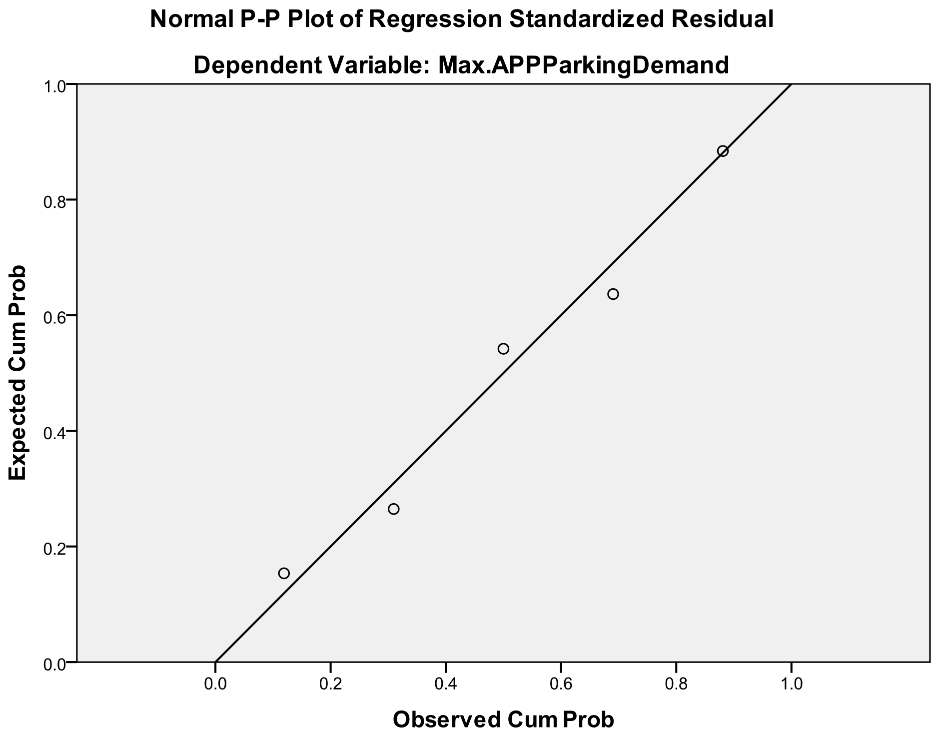

Scatterplot
Dependent Variable: LN_APP
Regression Standardized Residual
Regression Standardized Predicted Value
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5

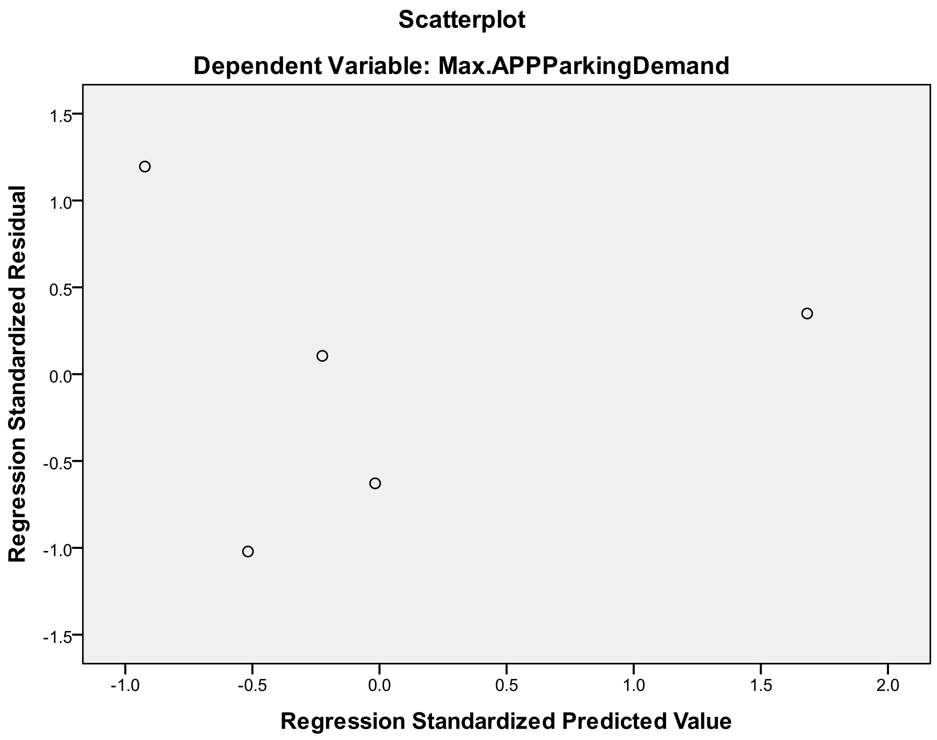
Independent Variable: GFA (sq. m.)



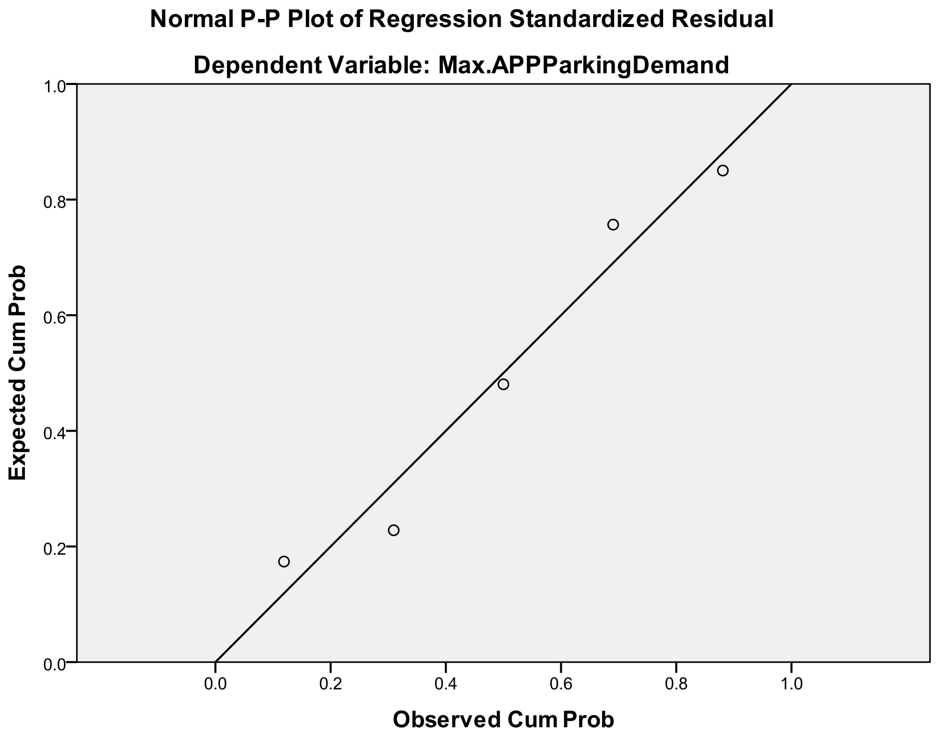


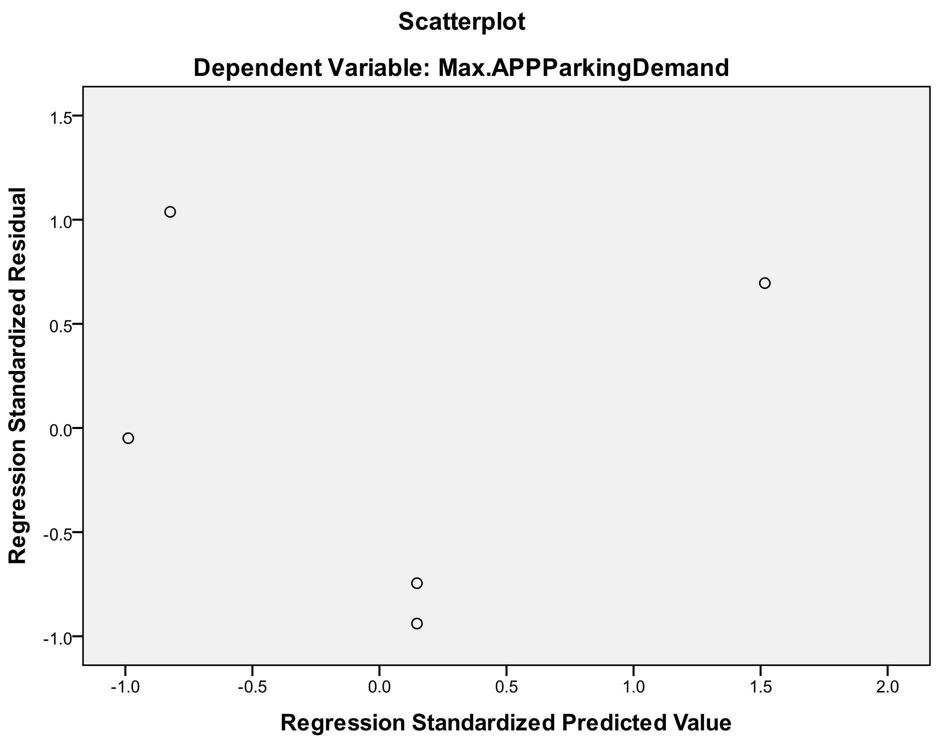
Independent Variable: GLA (sq. m.)





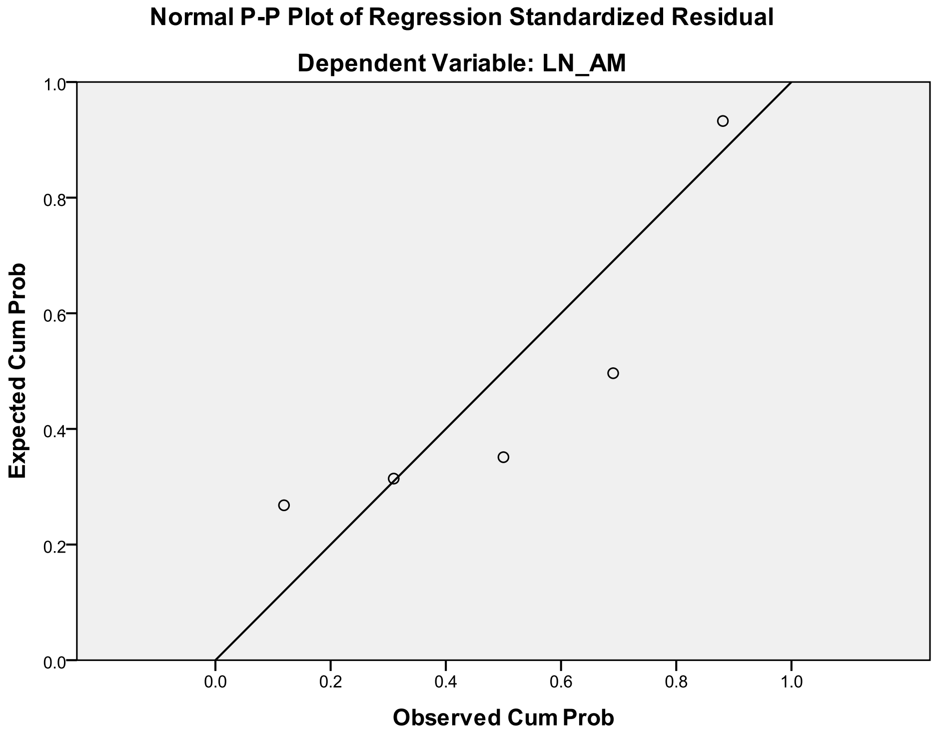
Independent Variable: Workers Vehicles

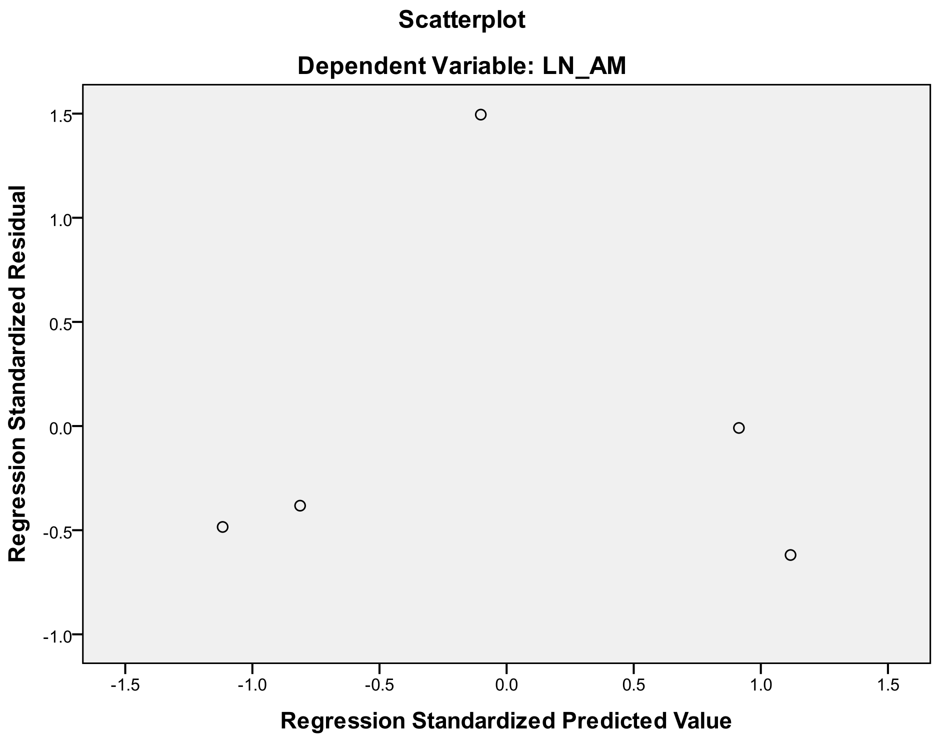




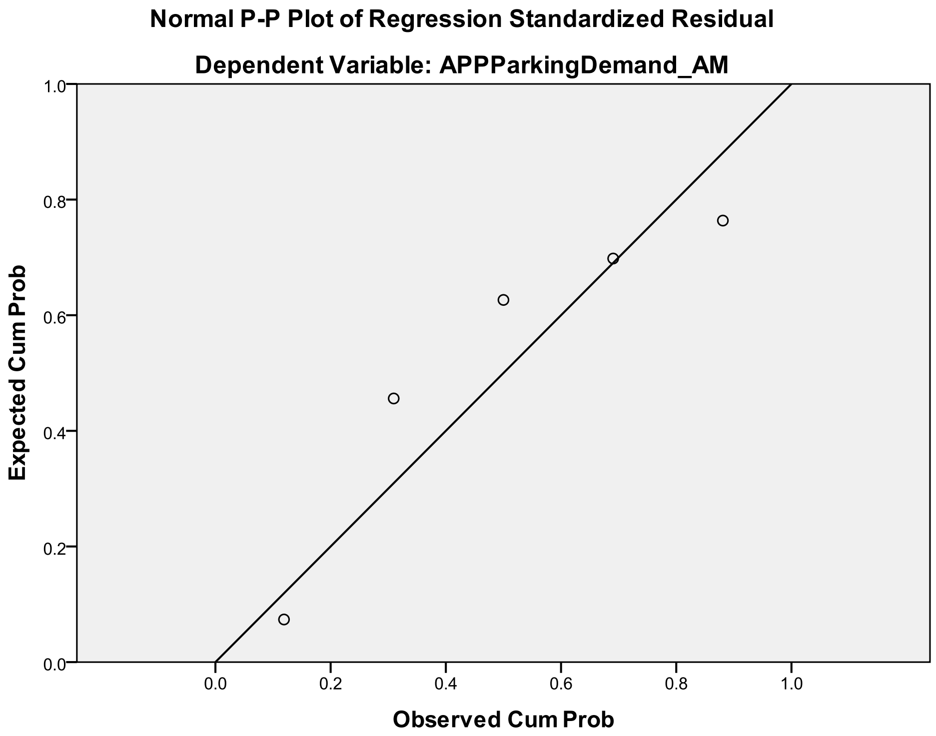
AM Period

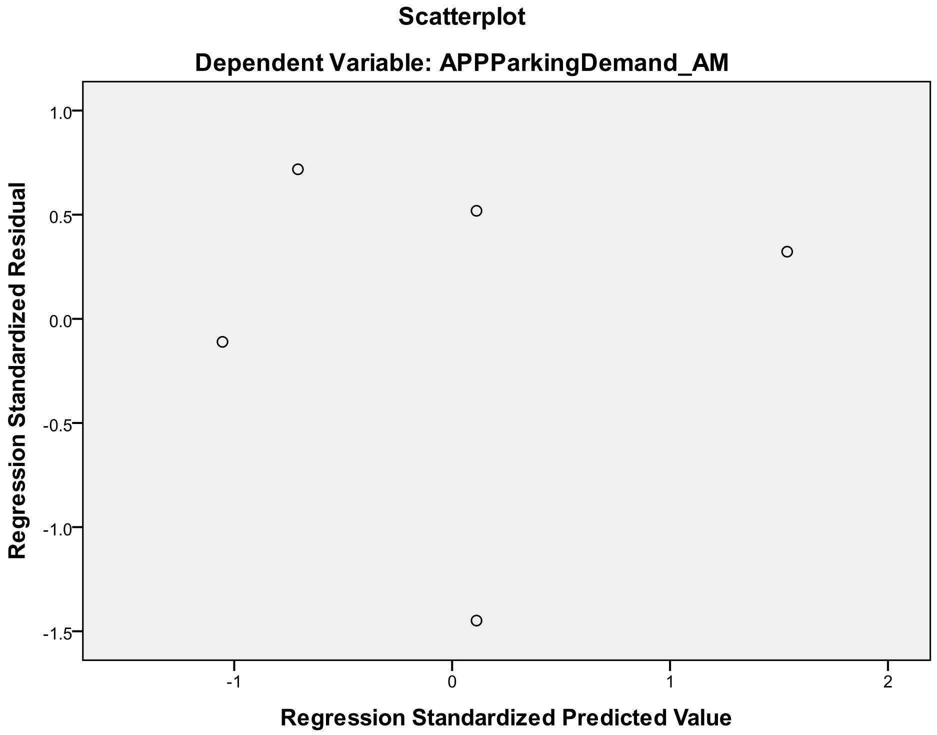
Independent Variable: Number of Workers



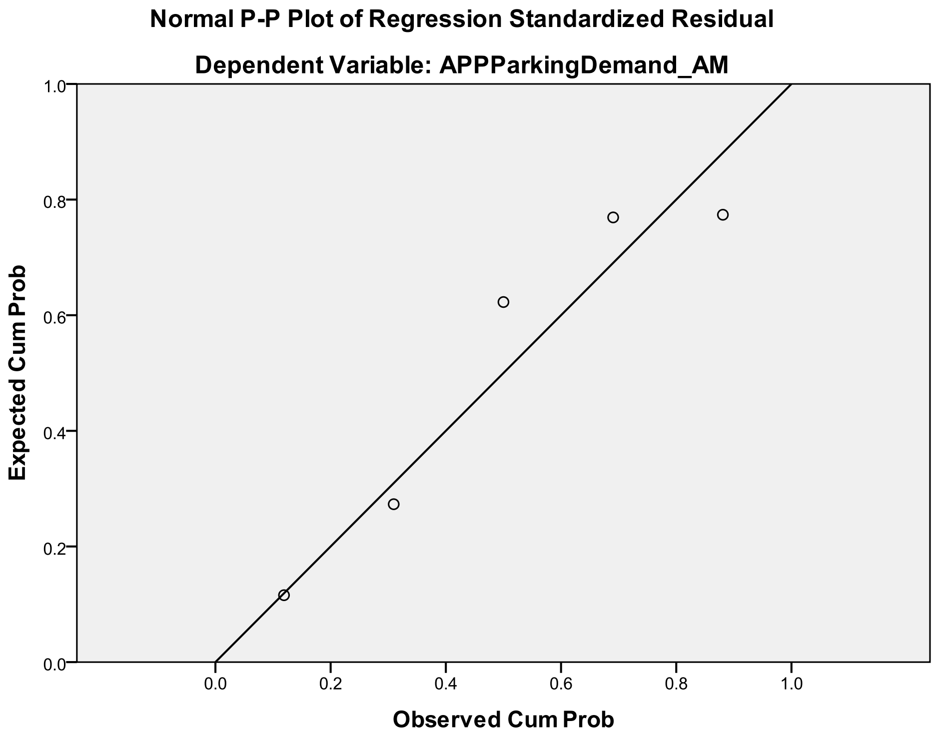


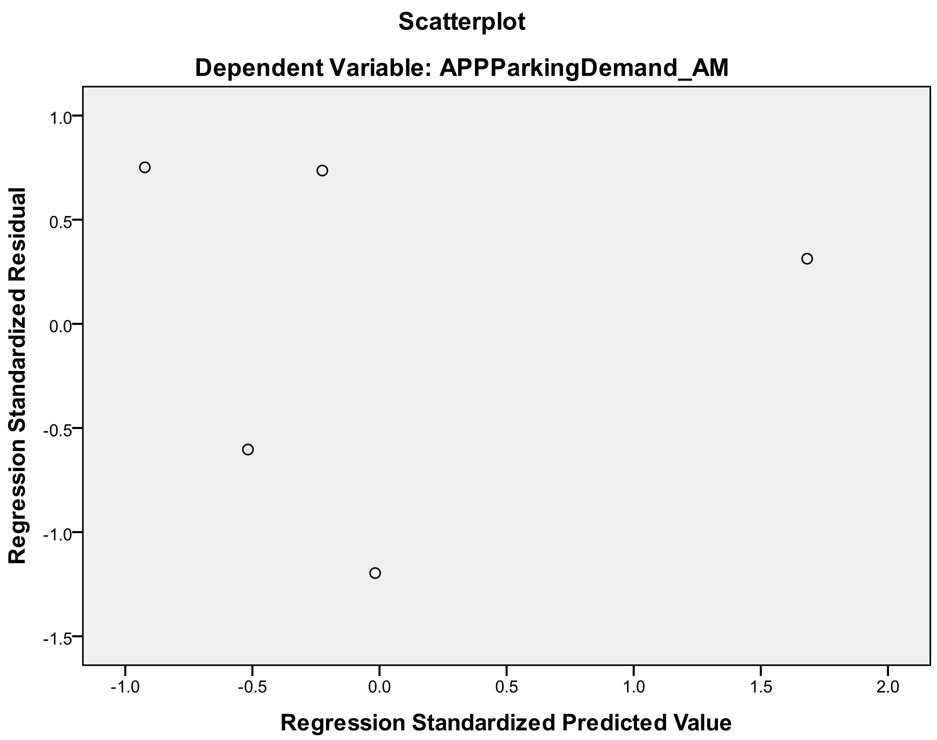
Independent Variable: GFA (sq. m.)



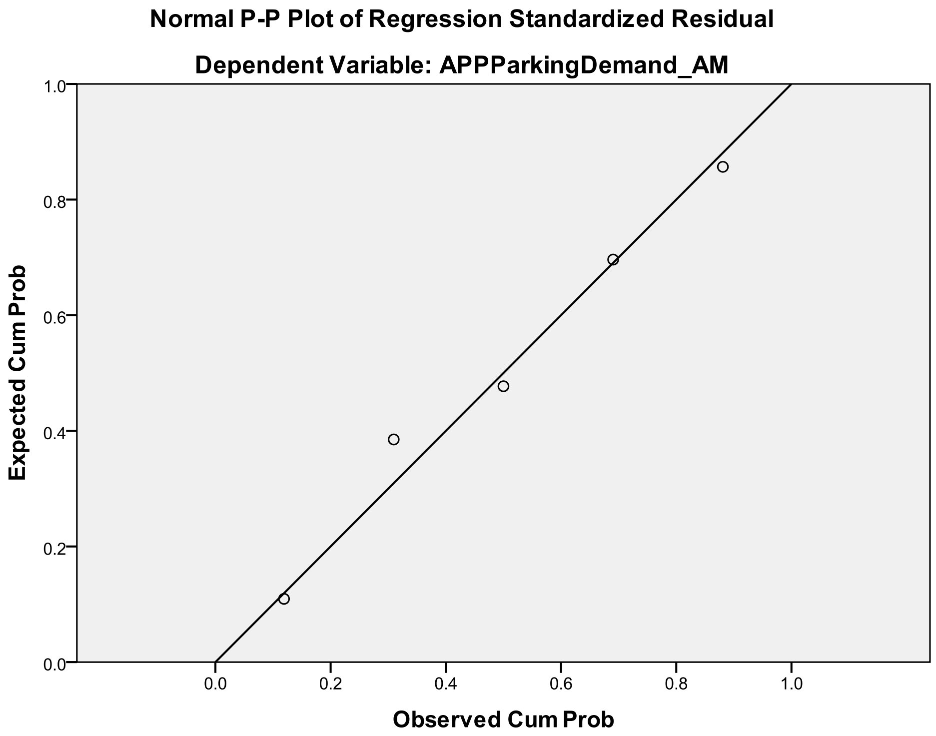


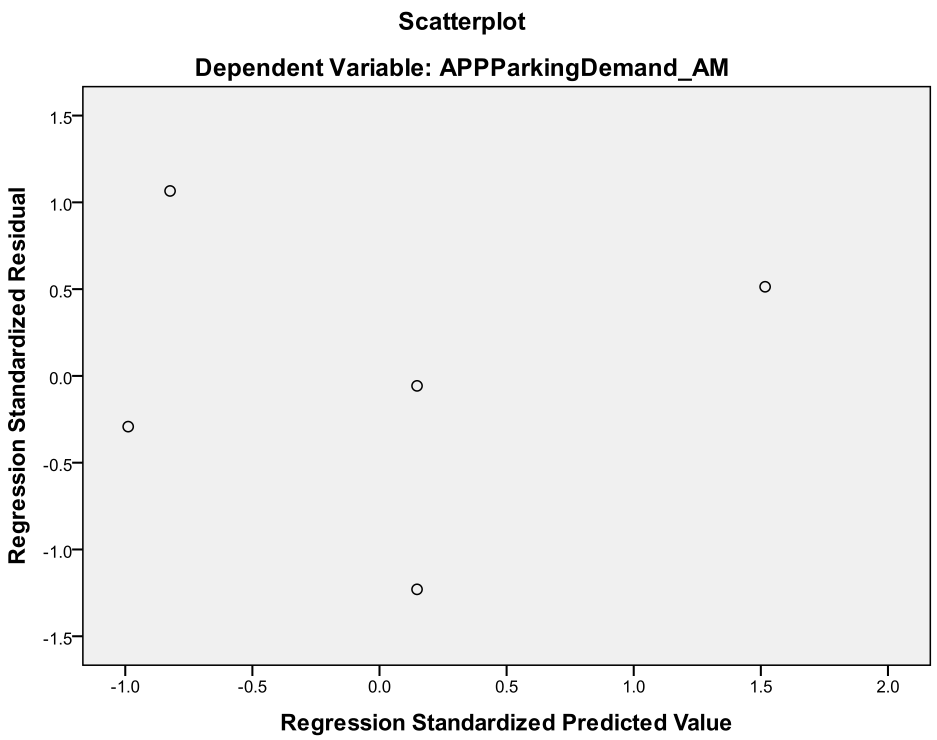
Independent Variable: GLA (sq. m.)





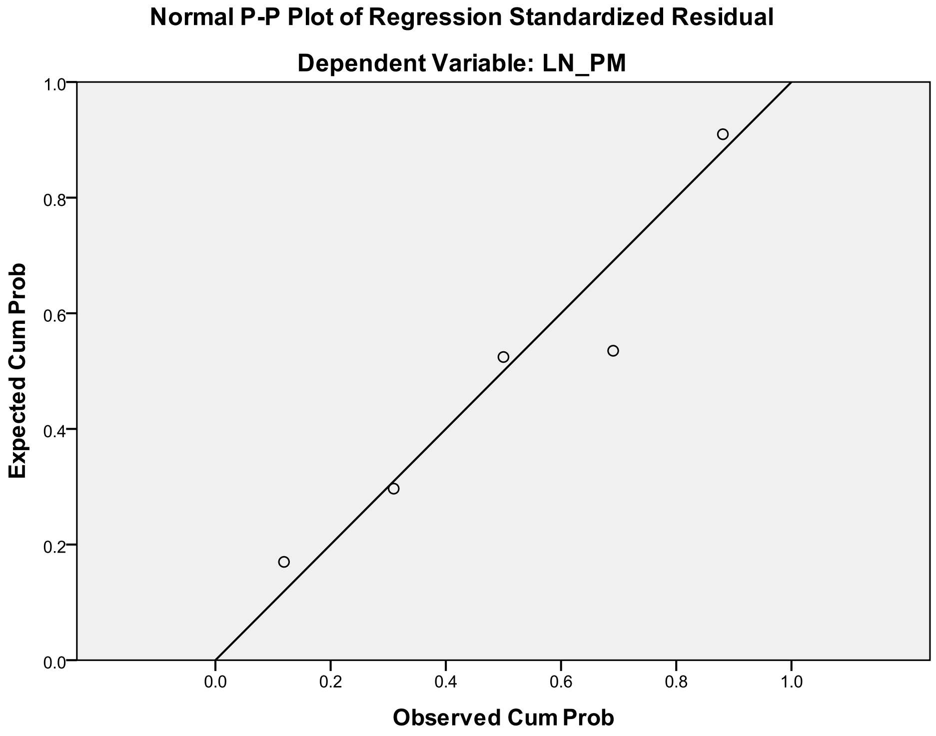
Independent Variable: Workers Vehicles

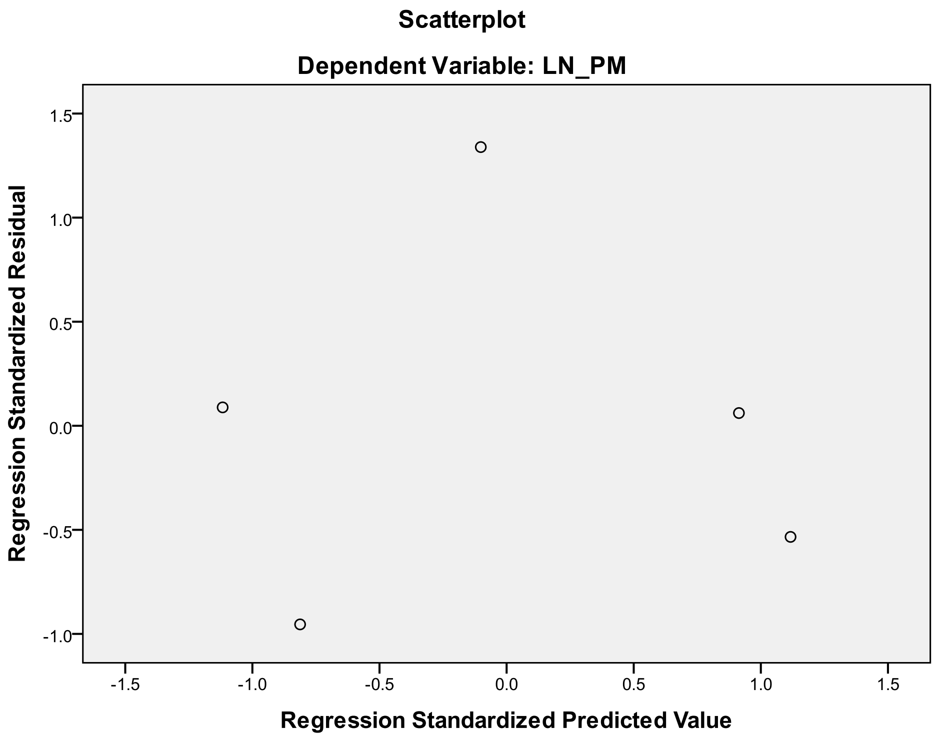




PM Period

Independent Variable: Number of Workers

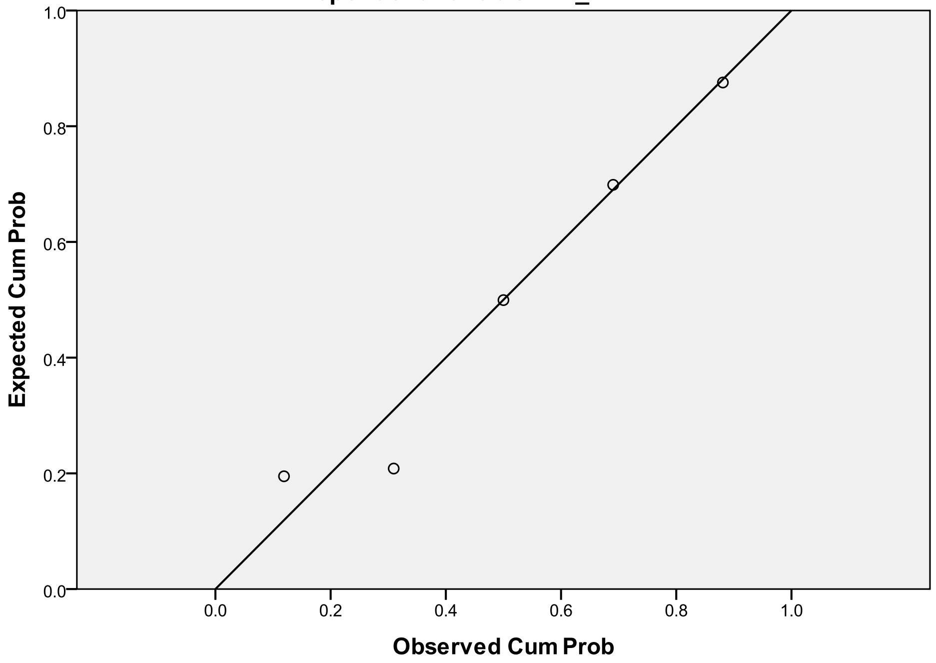




Independent Variable: GFA (sq. m.)

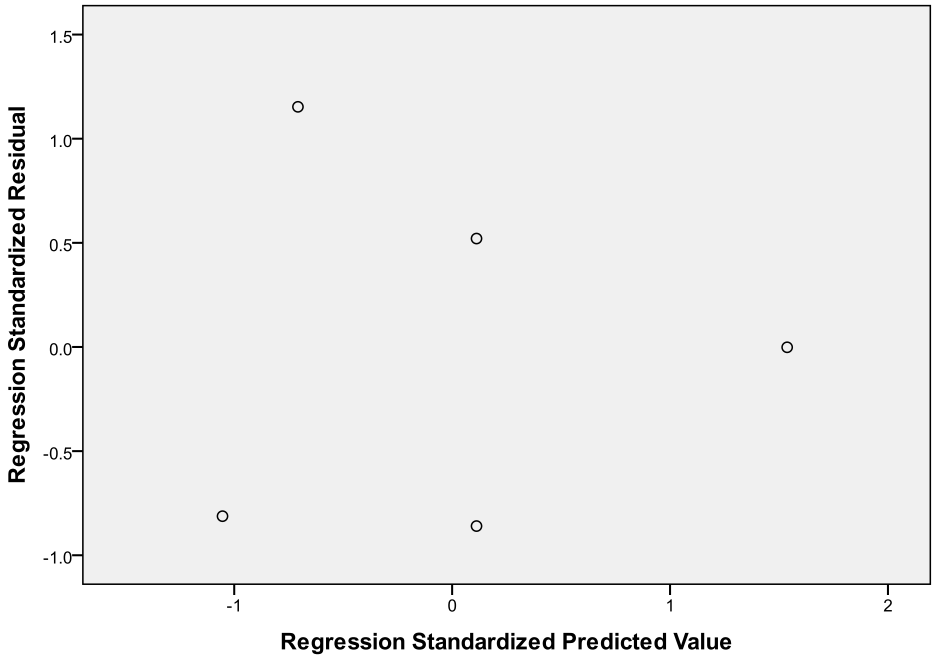
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: LN_PM

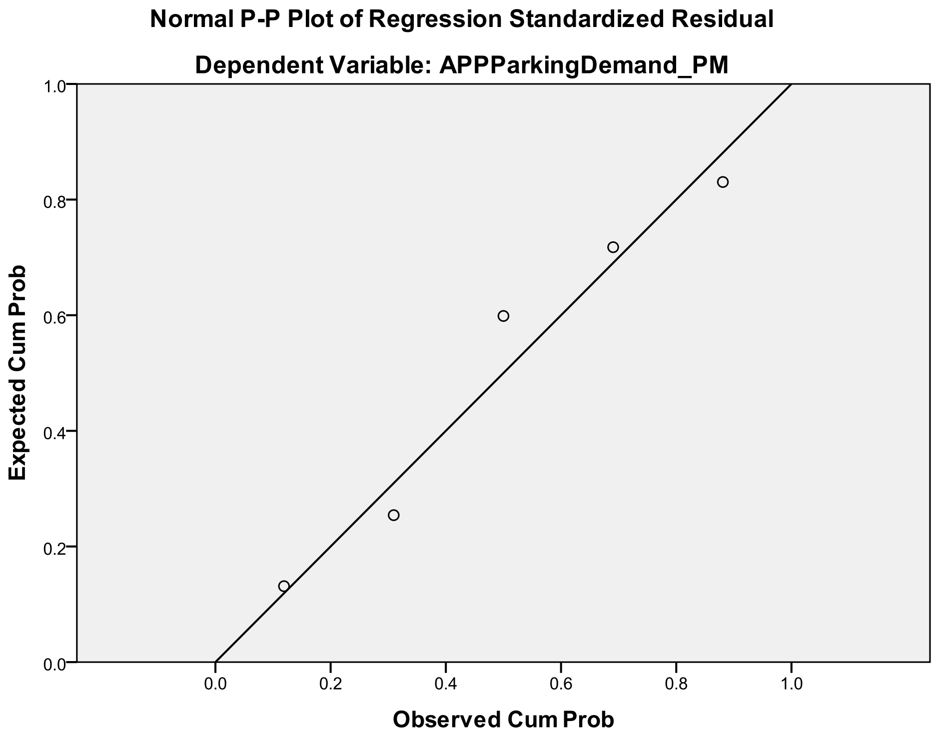


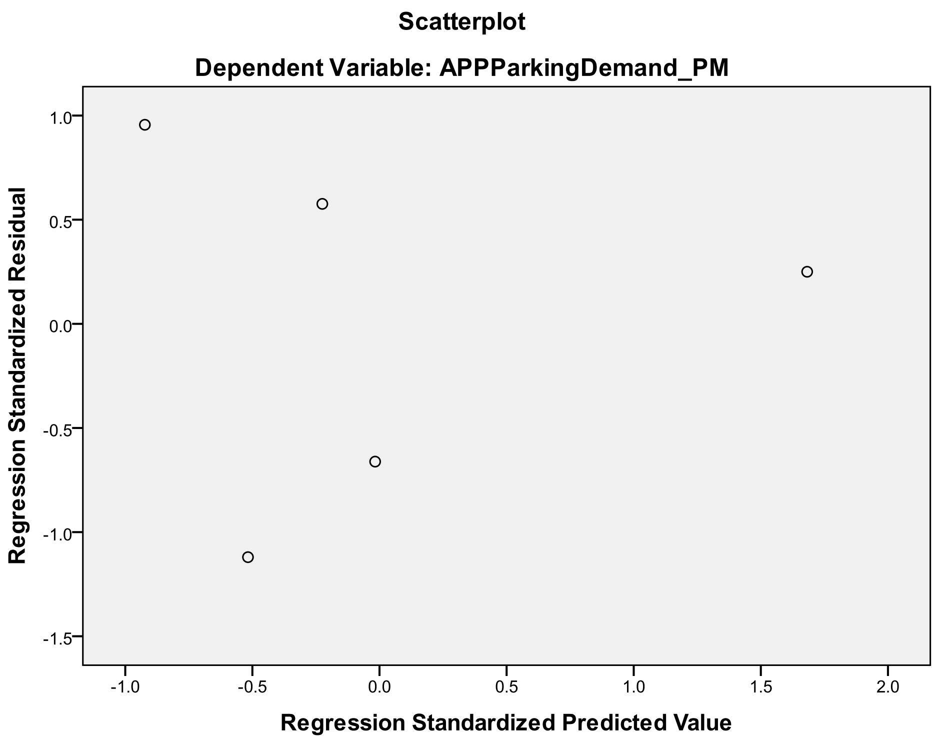
Scatterplot

Dependent Variable: LN_PM

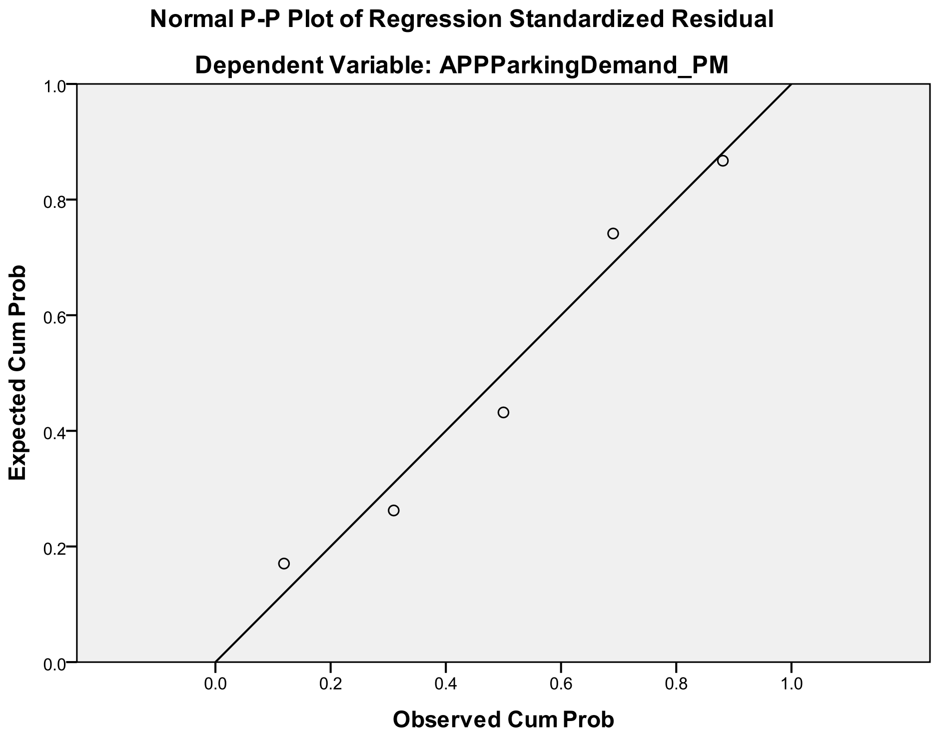


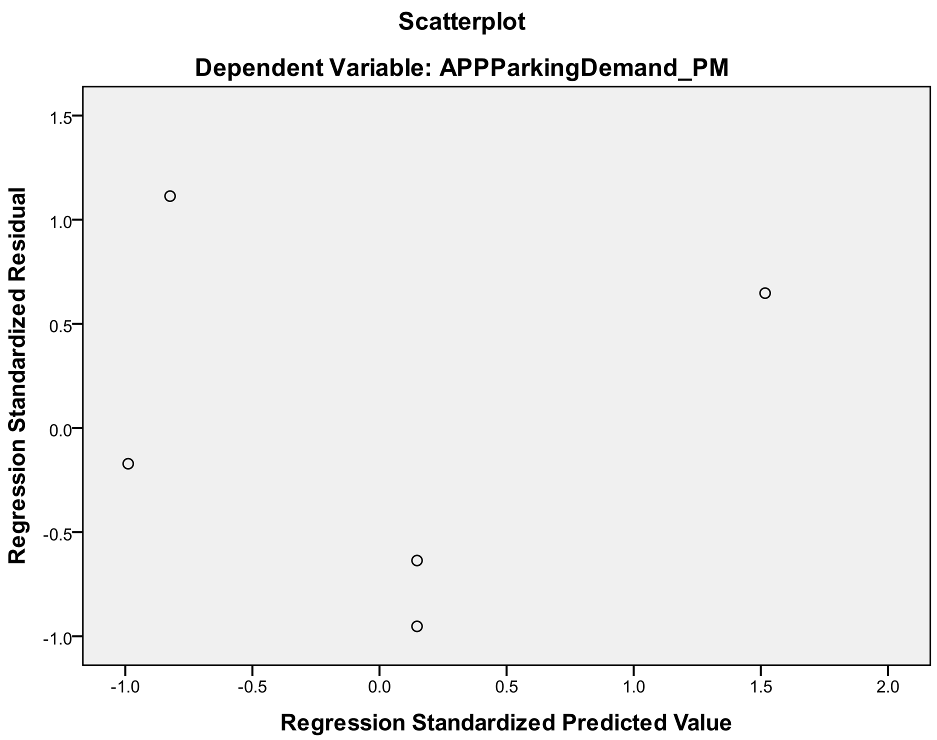
Independent Variable: GLA (sq. m.)





Independent Variable: Workers Vehicles

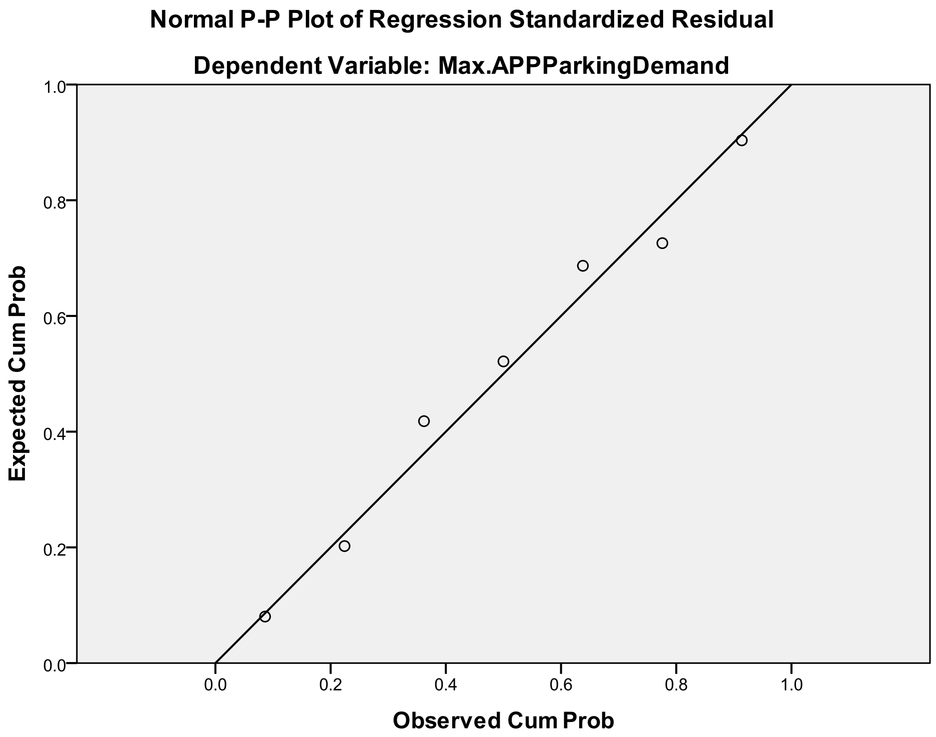


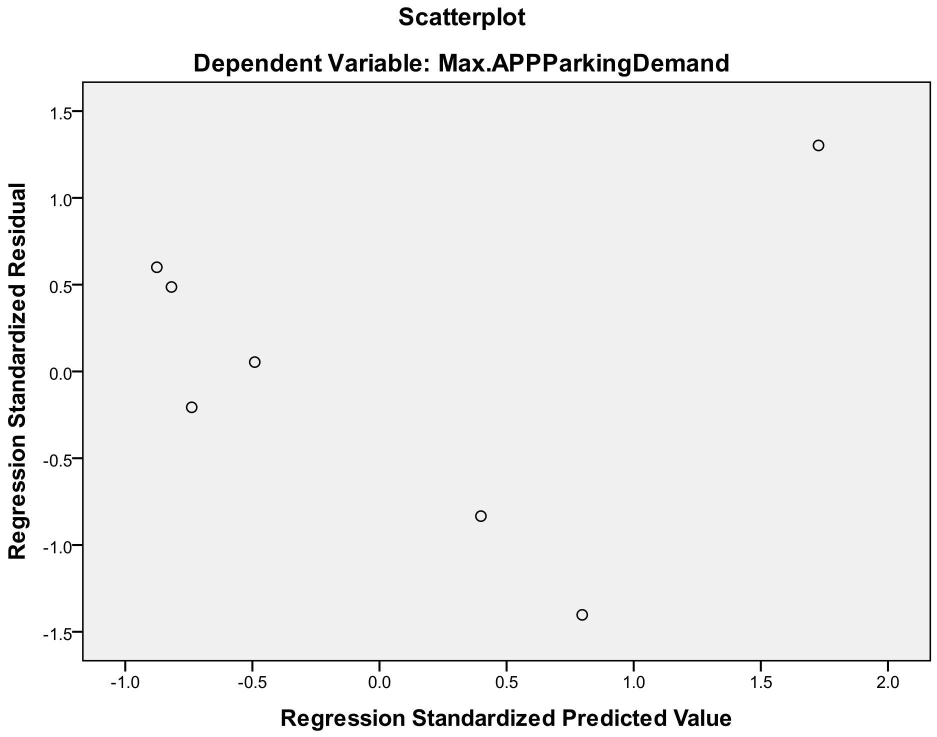


Institutional Office Class

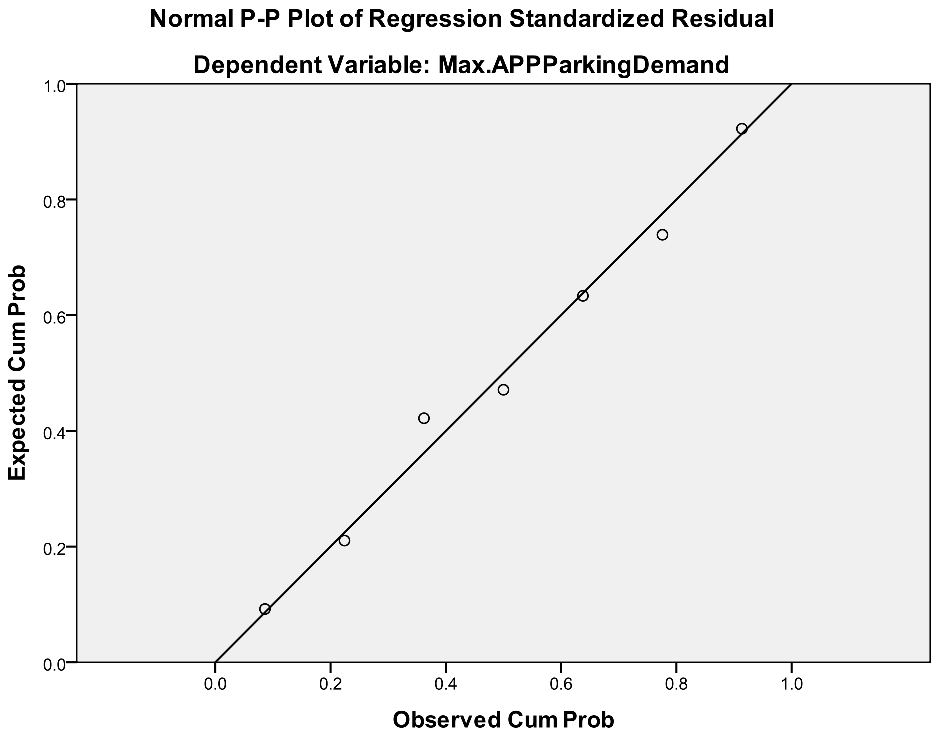
Peak

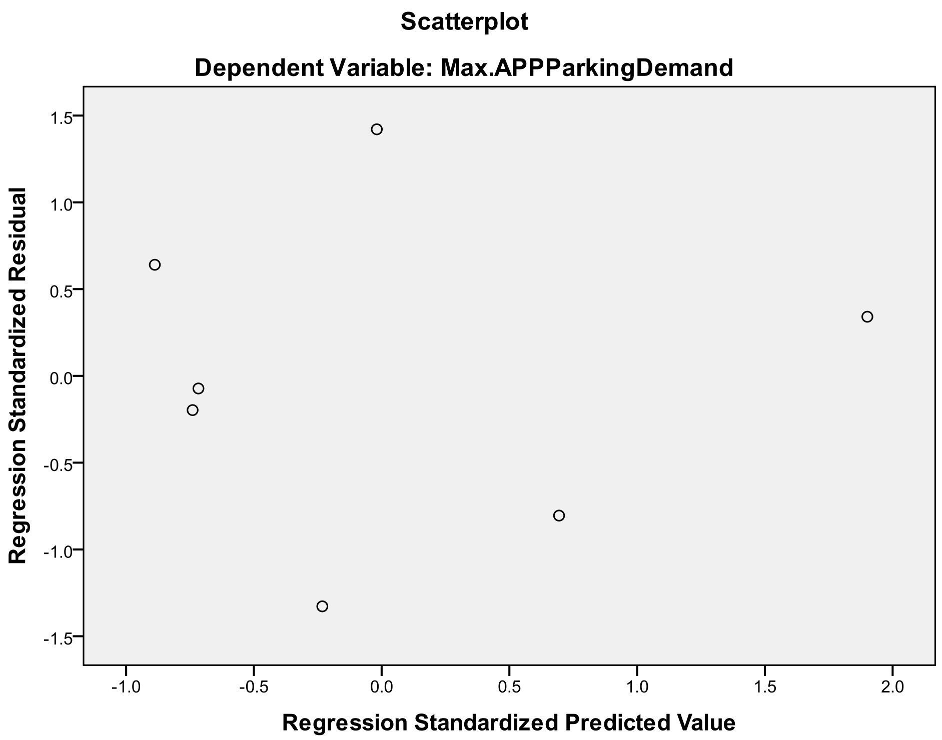
Independent Variable: Number of Workers



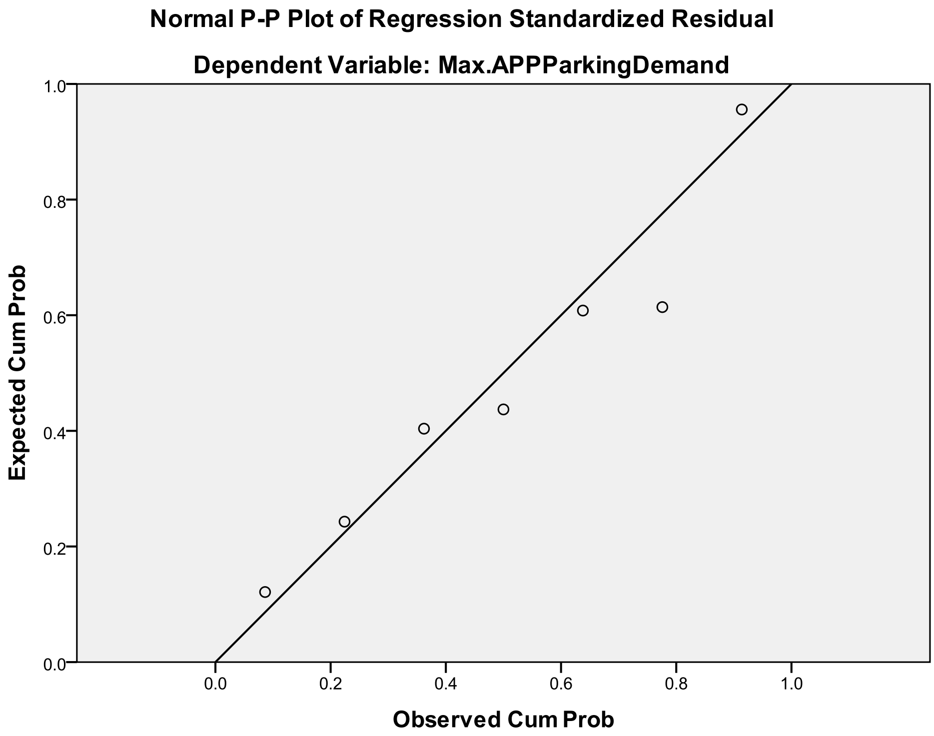


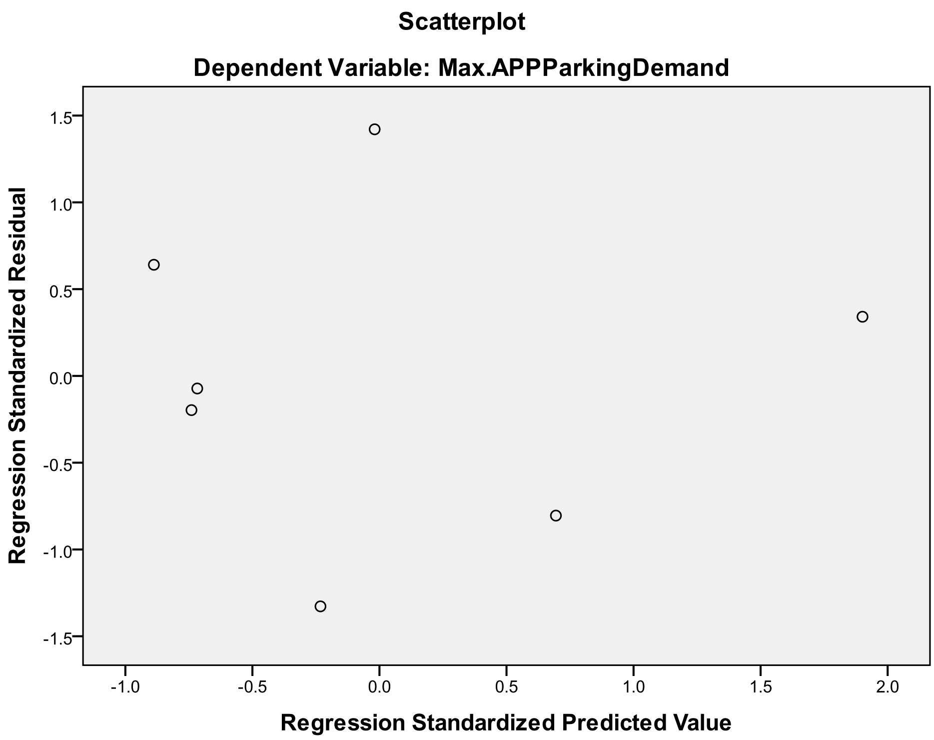
Independent Variable: GFA (sq. m.)



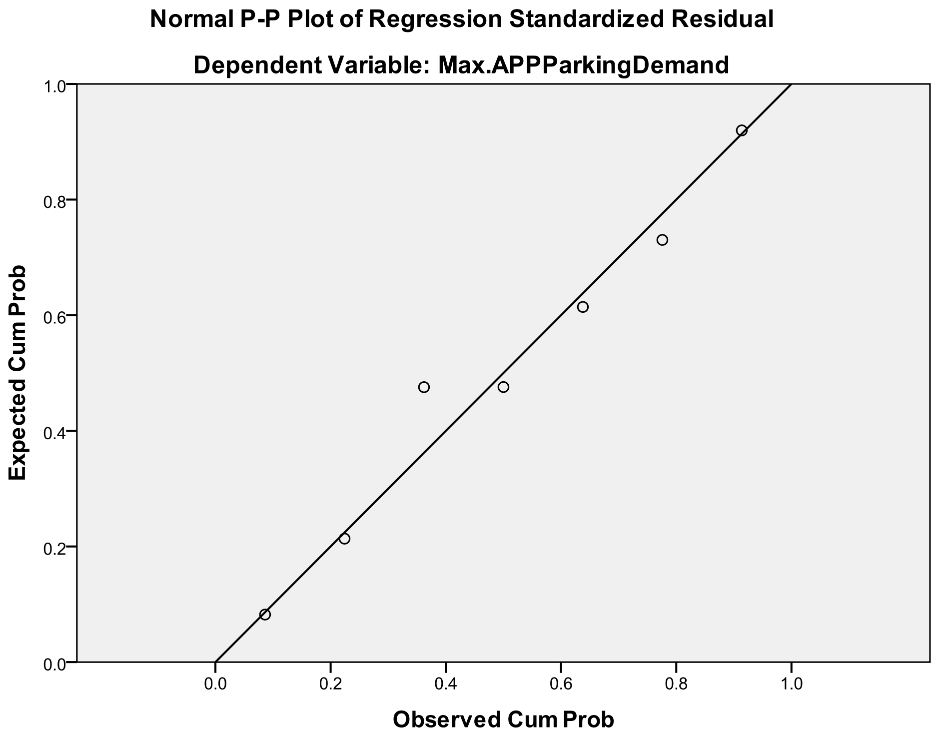


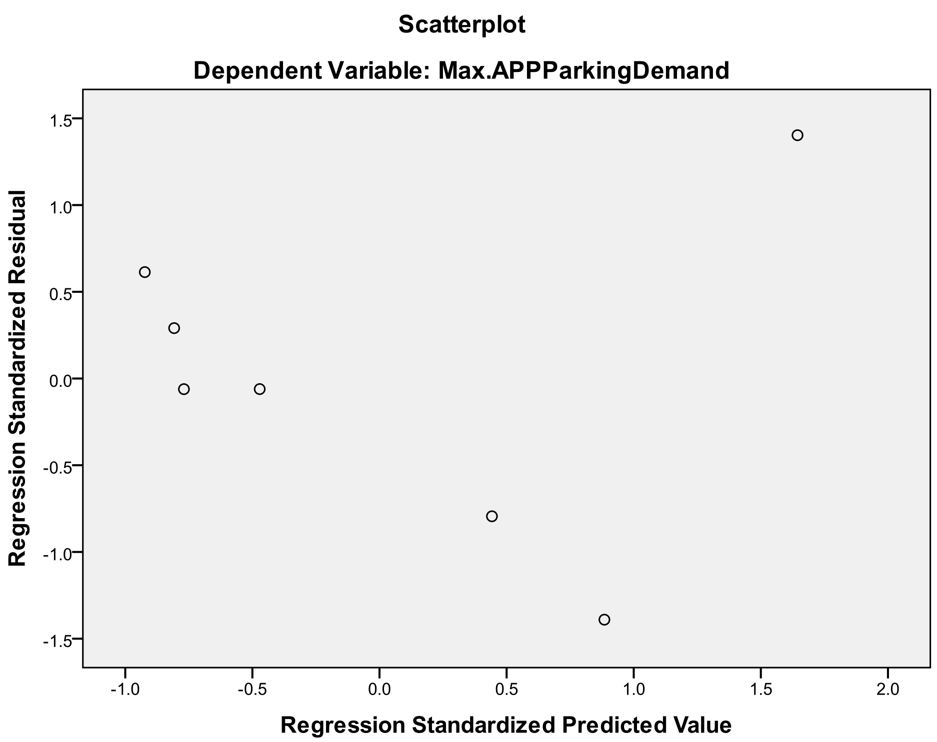
Independent Variable: GLA (sq .m.)





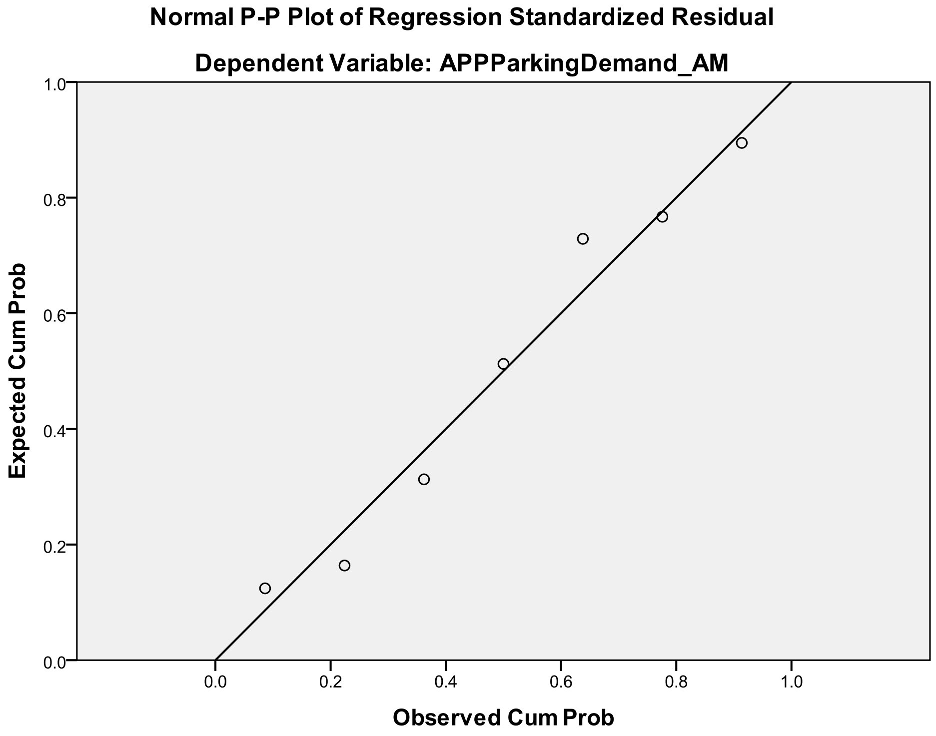
Independent Variable: Workers Vehicles

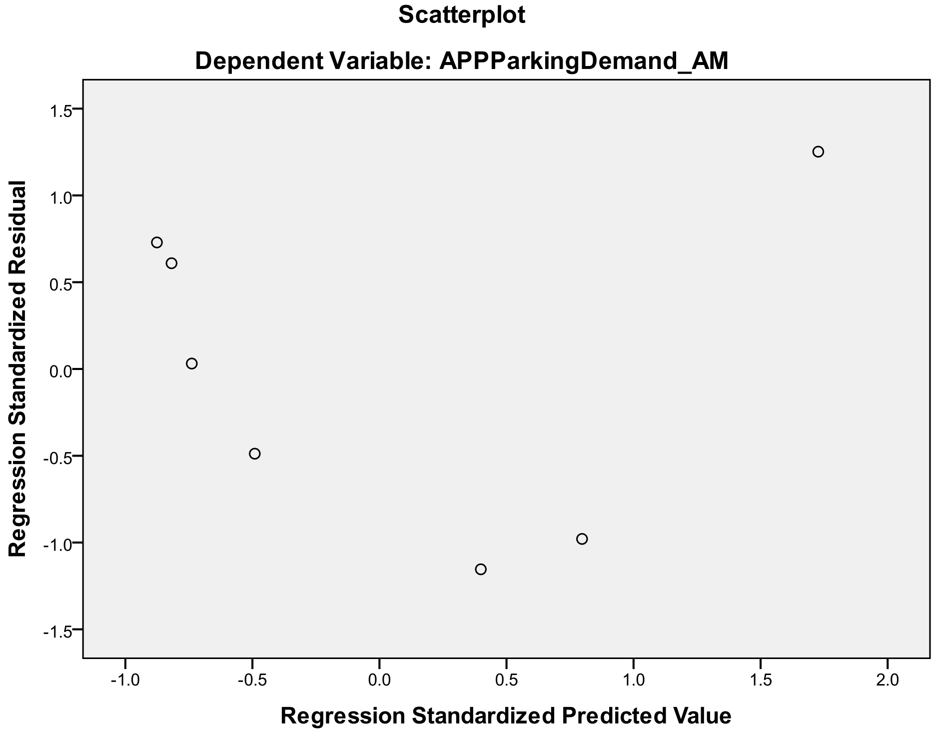




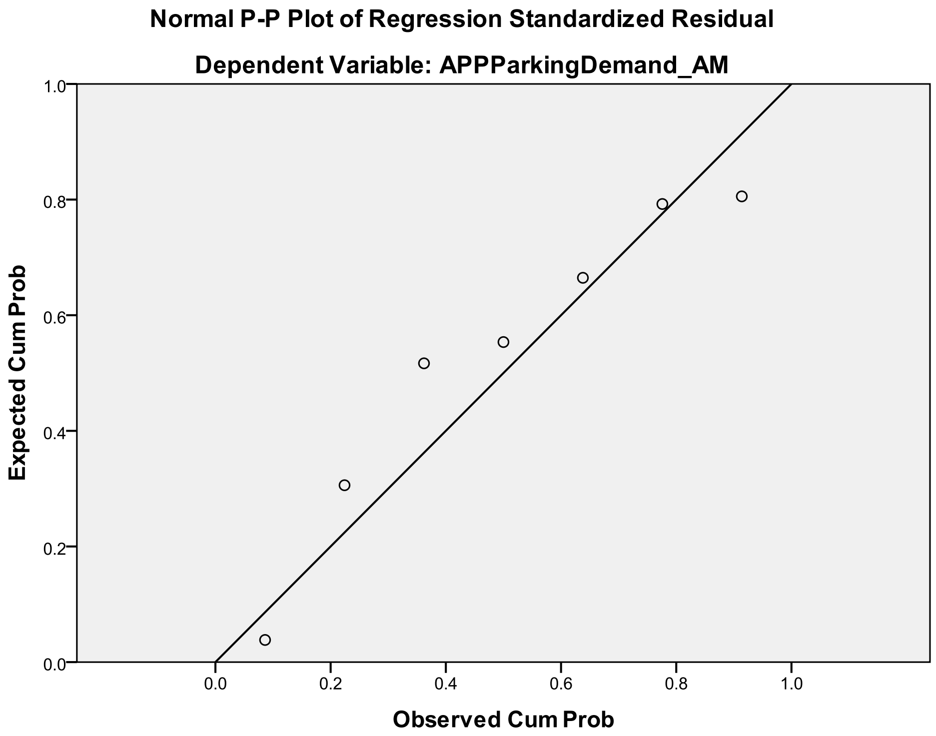
AM Period

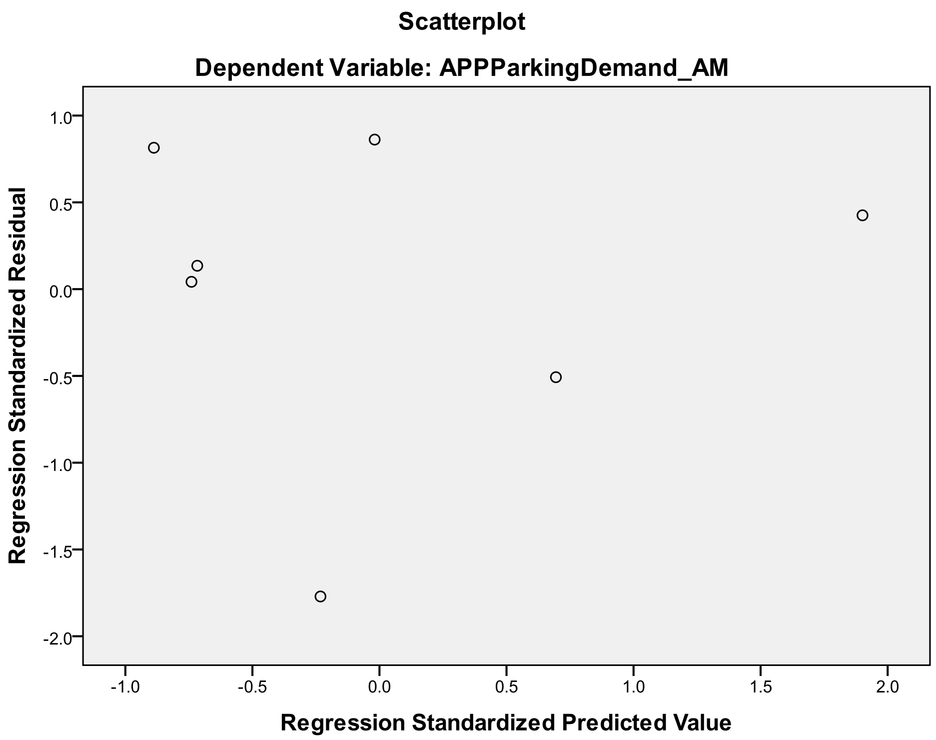
Independent Variable: Number of Workers





Independent Variable: GFA (sq. m.)

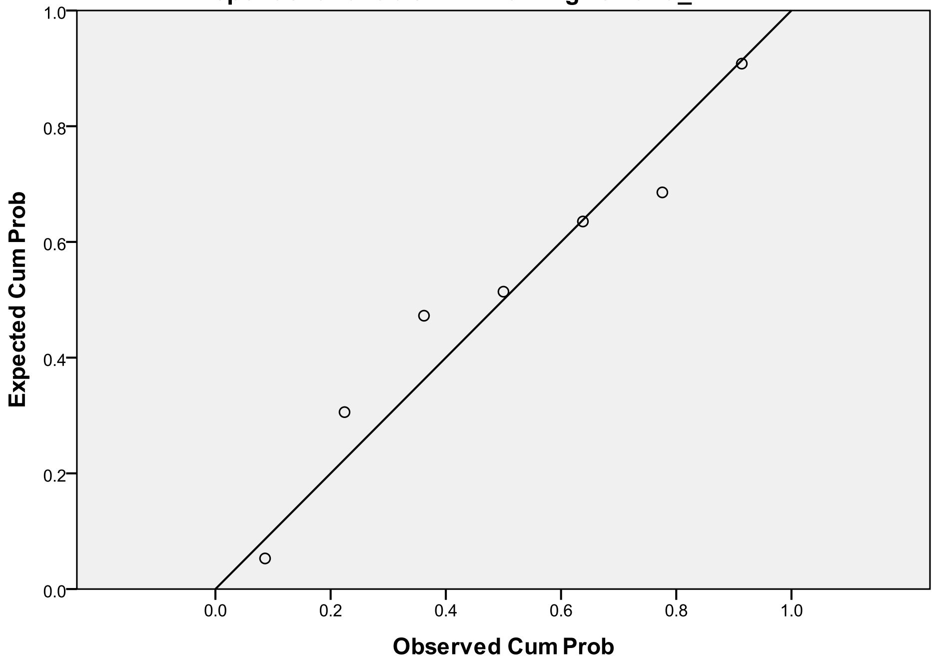




Independent Variable: GLA (sq. m.)

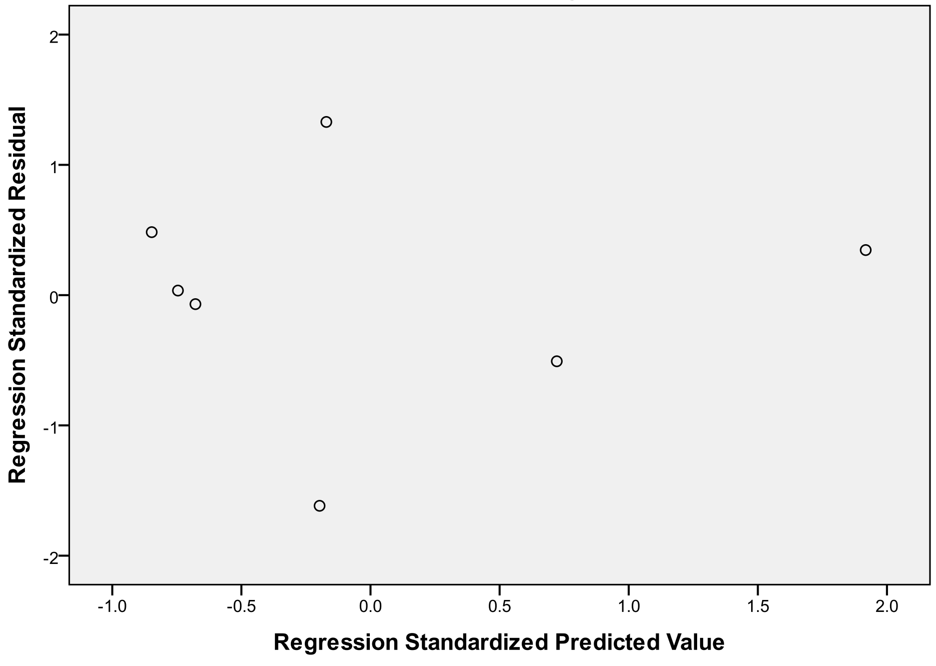
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: APPParkingDemand_AM

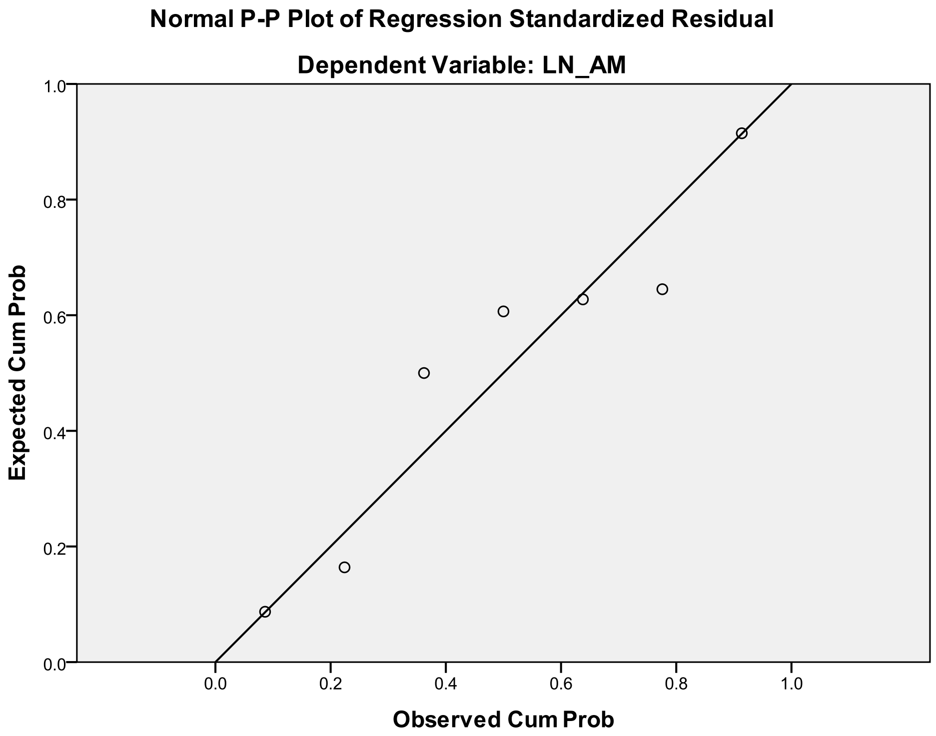


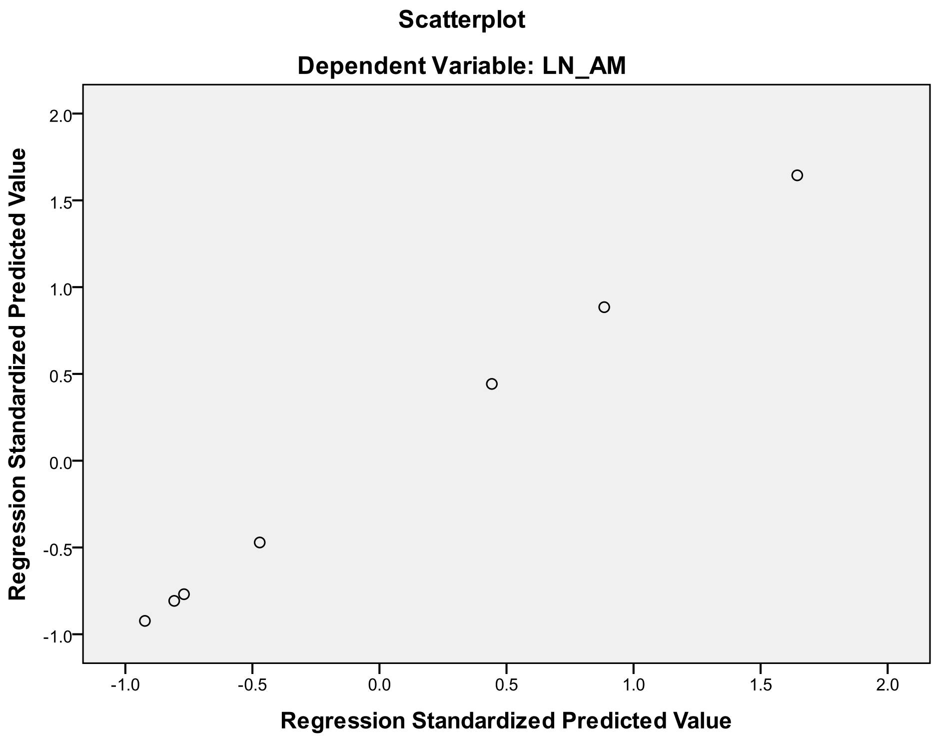
Scatterplot

Dependent Variable: APPParkingDemand_AM



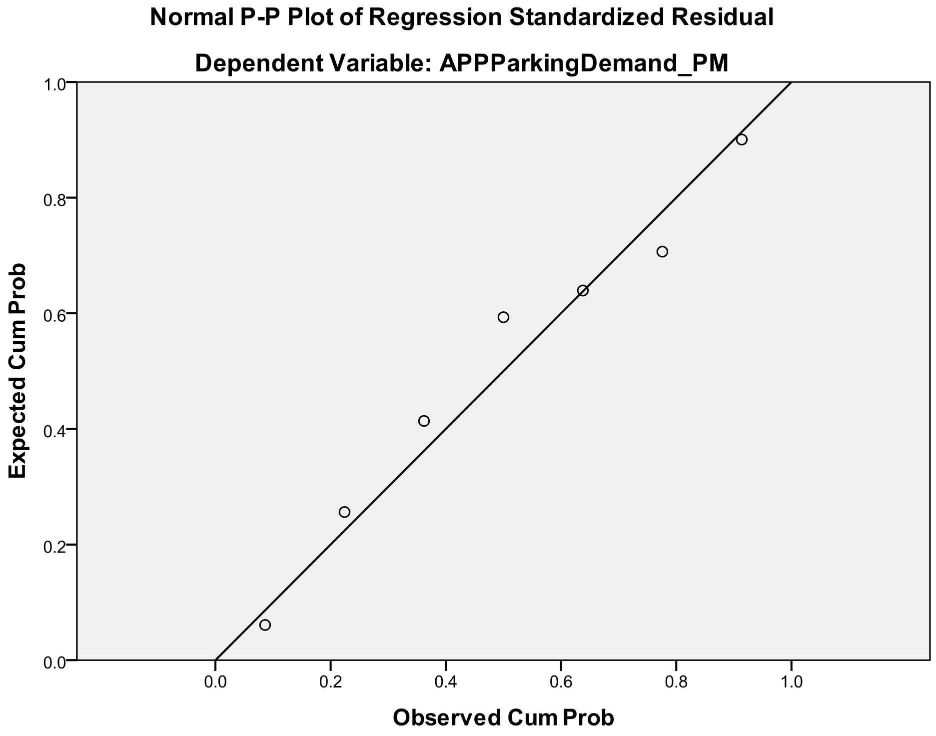
Independent Variable: Workers Vehicles



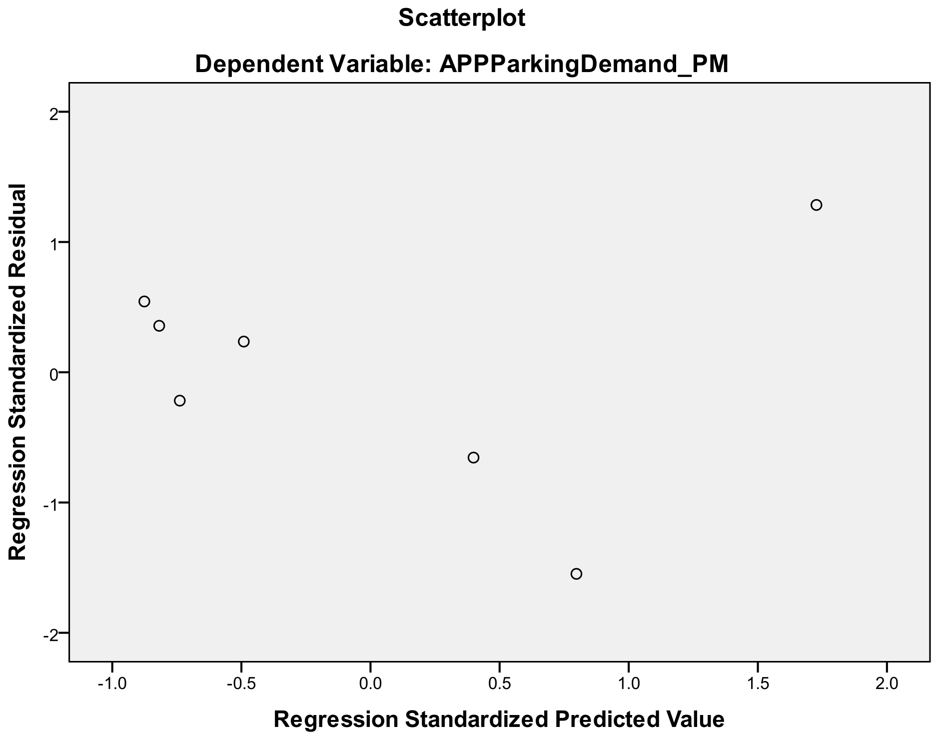


PM Period

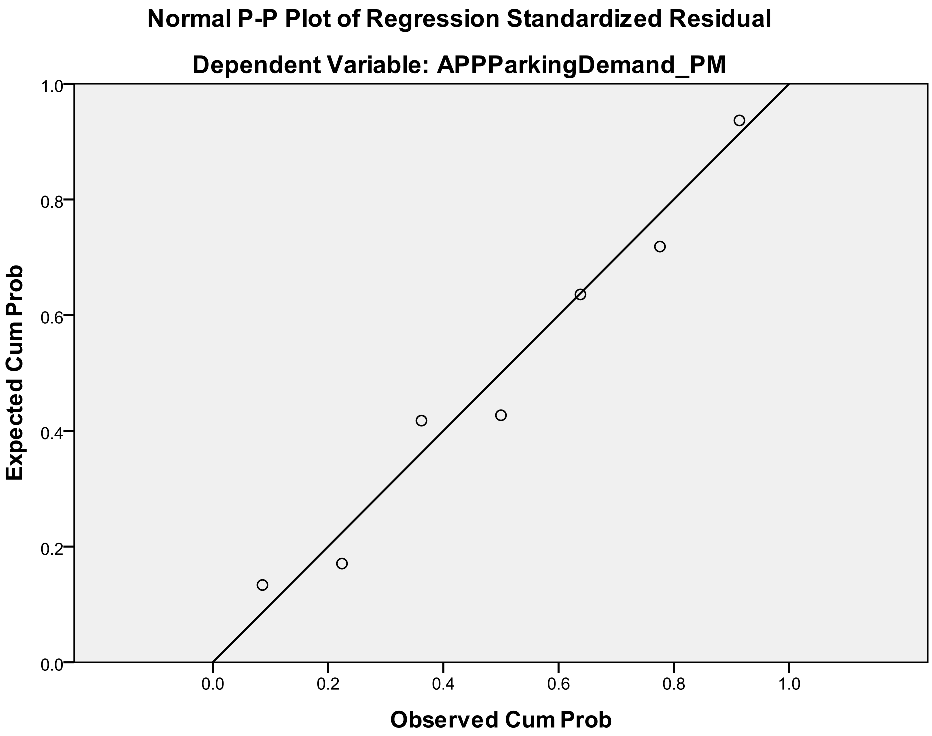
Independent Variable: Number of Workers

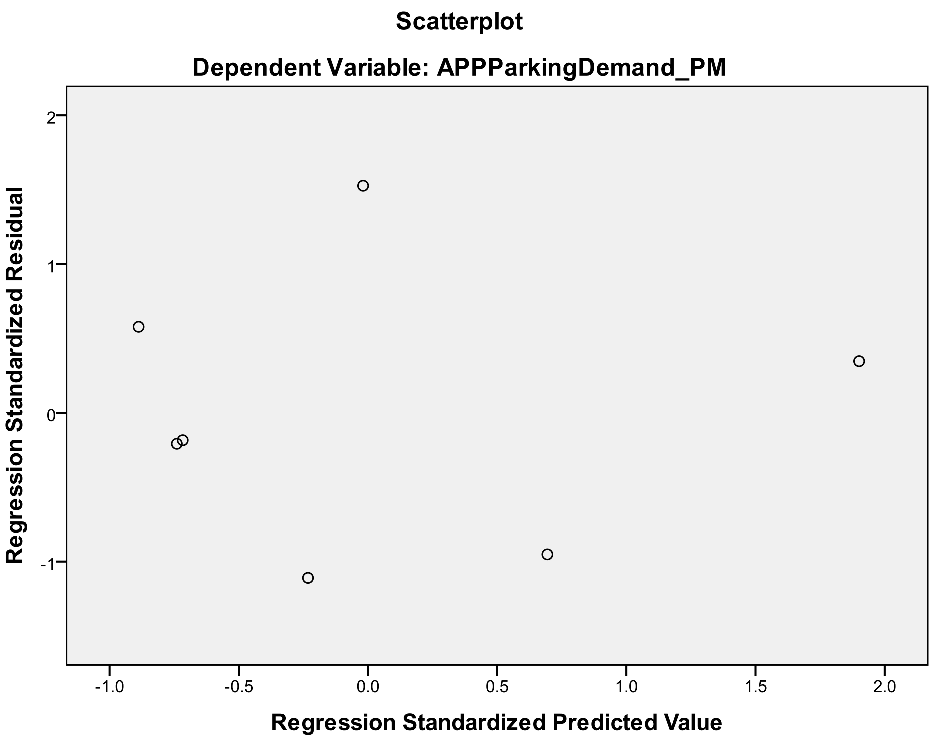


Independent Variable: GFA (sq. m.)

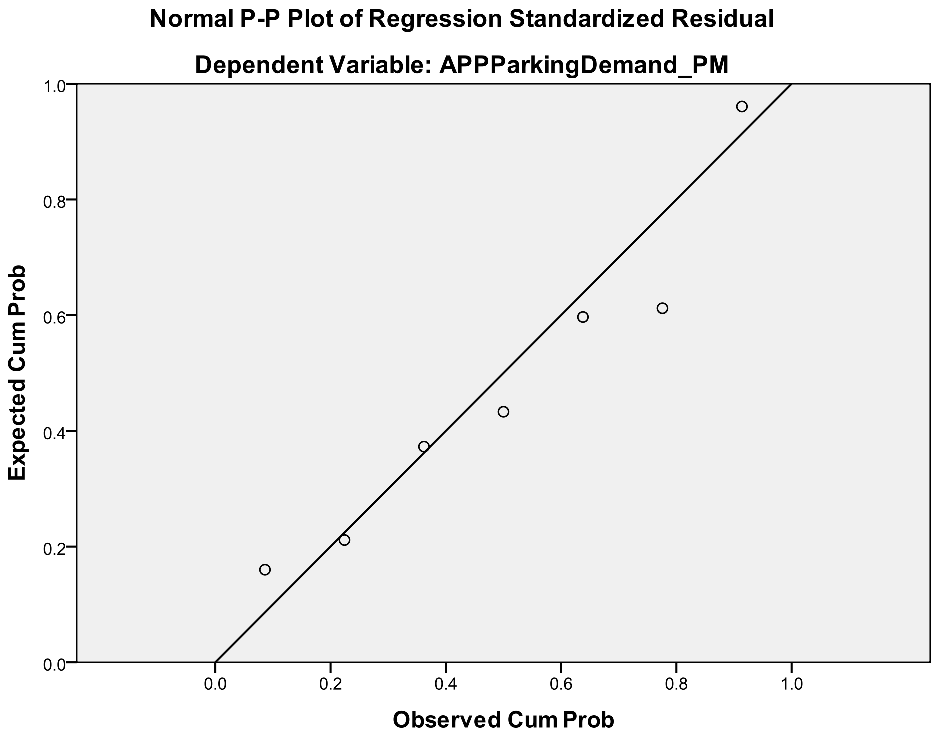


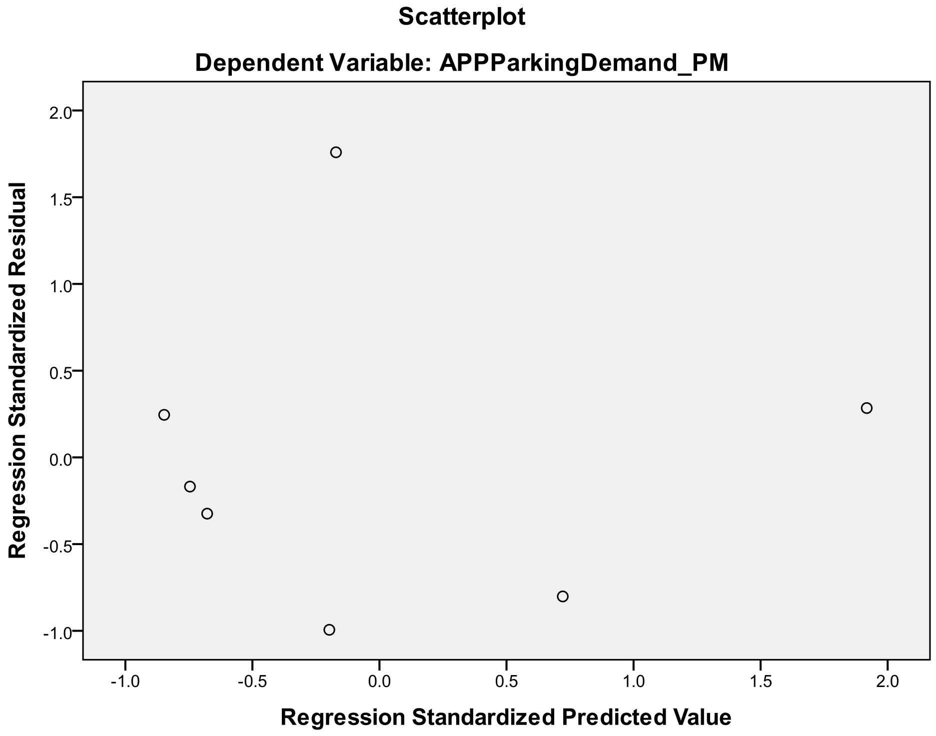
Independent Variable: GLA (sq. m.)





Independent Variable: Workers Vehicles

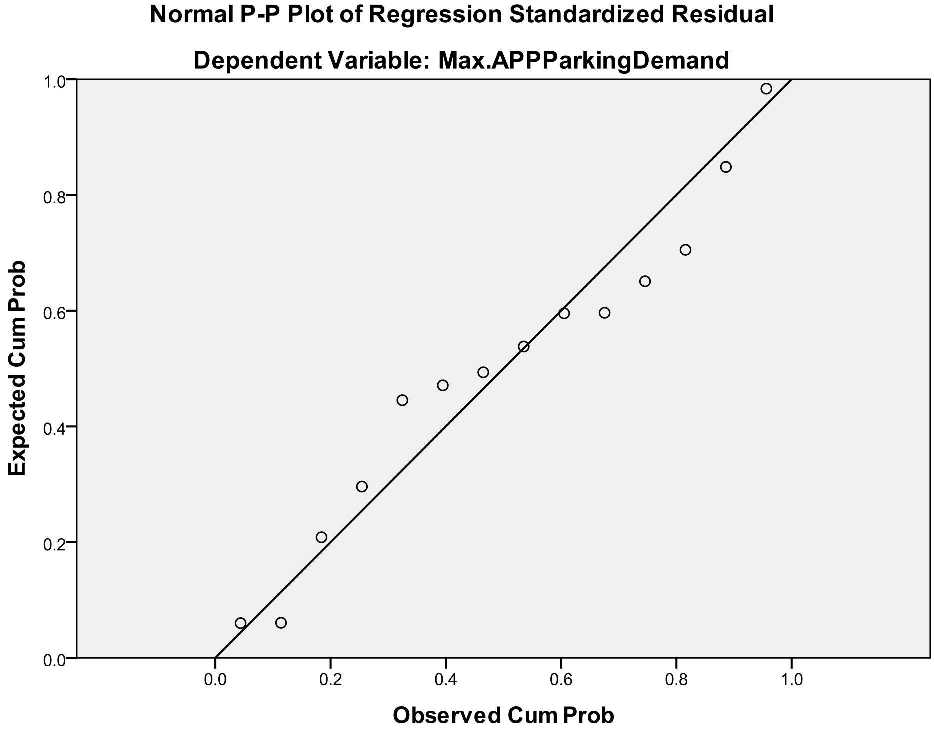


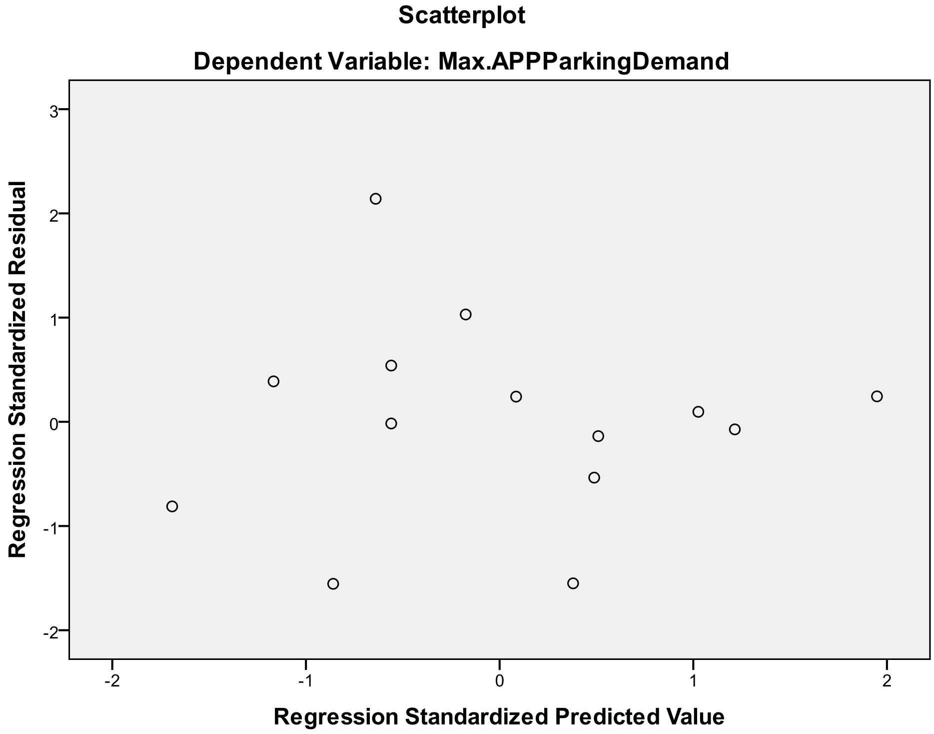


Government

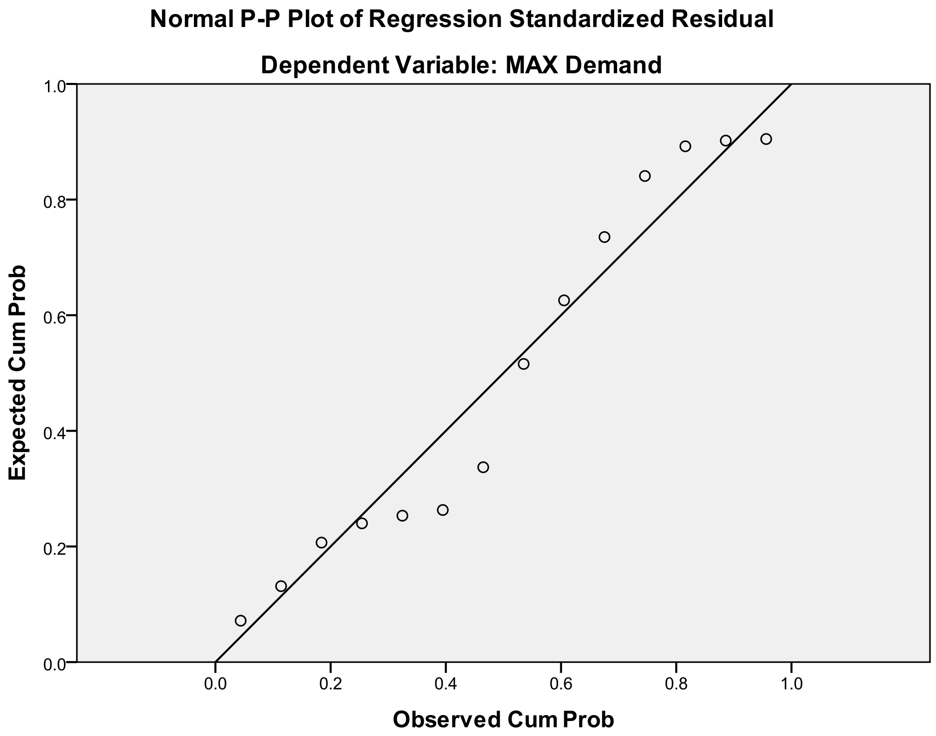
Peak Period

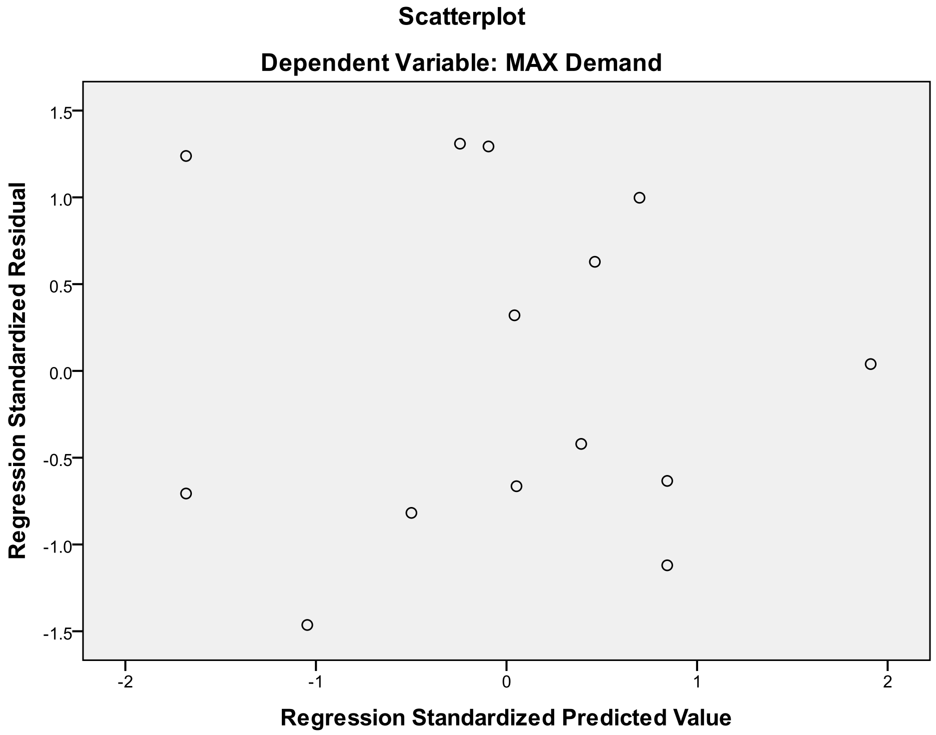
Independent Variable: Number of Workers



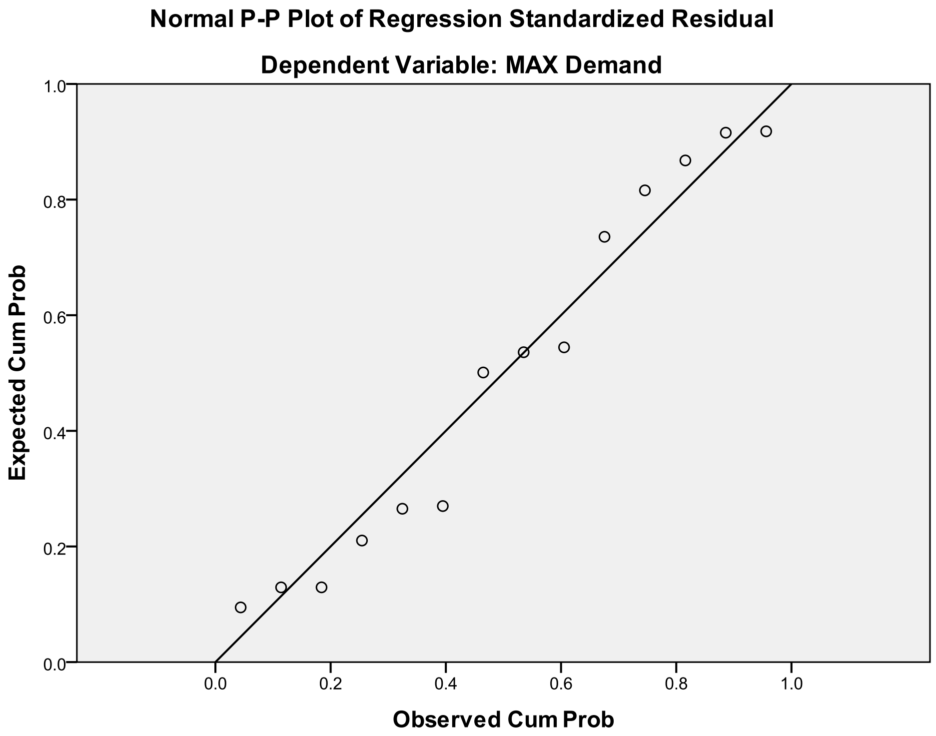


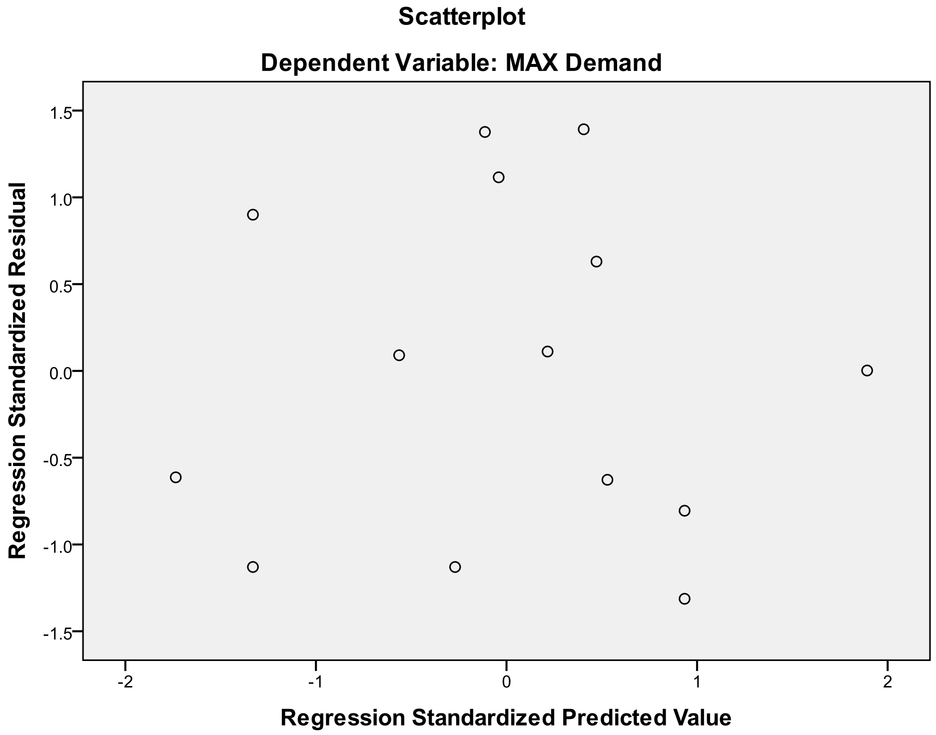
Independent Variable: GFA (sq. m.)



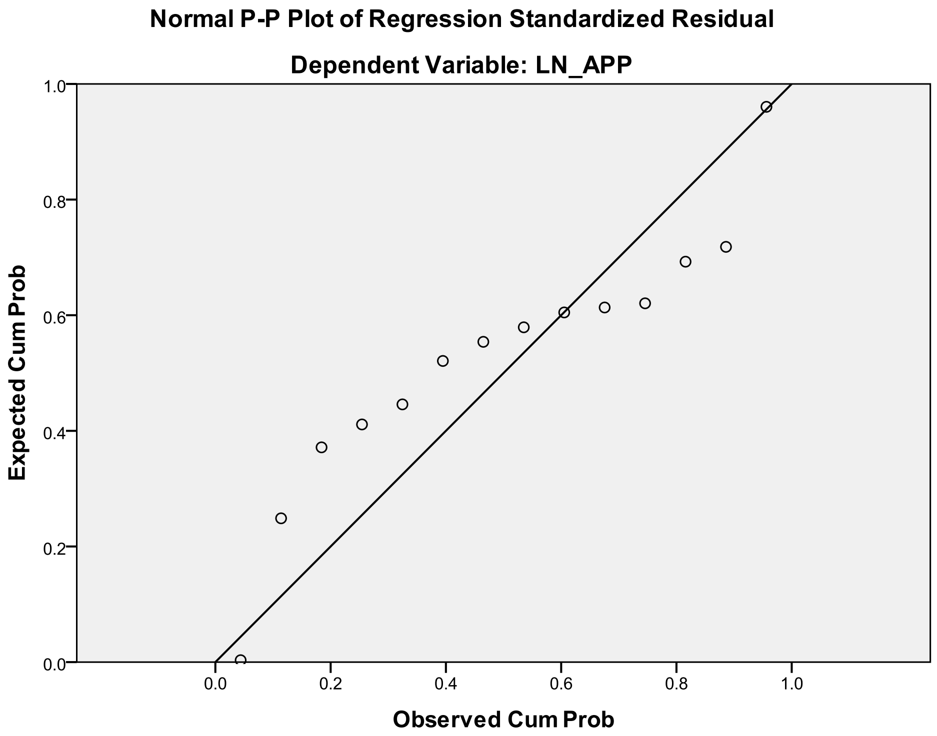


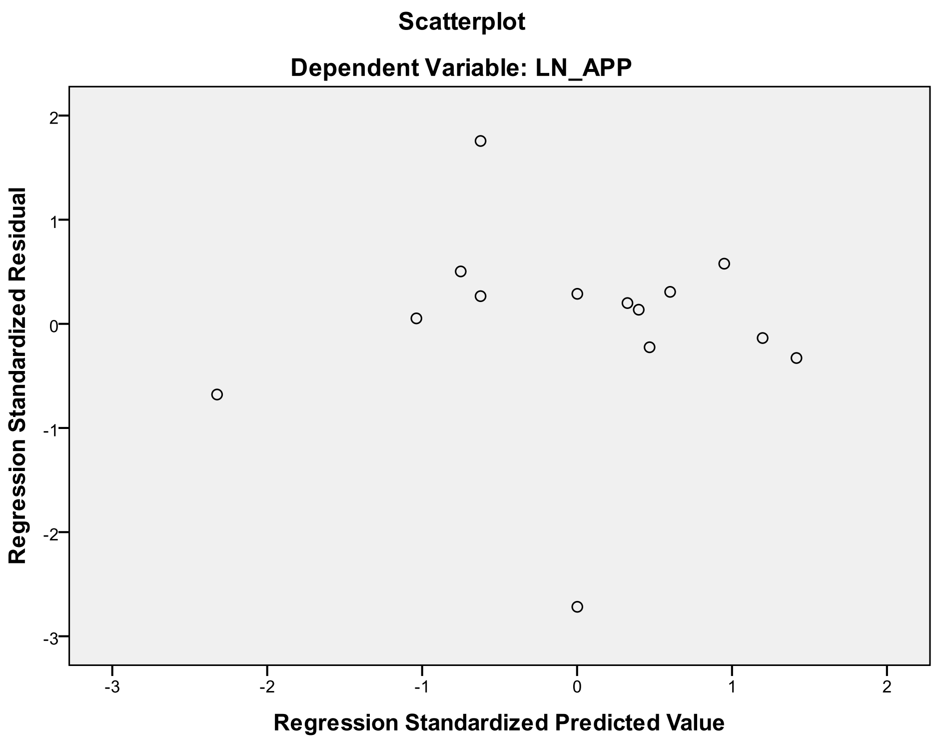
Independent Variable: GLA (sq. m.)





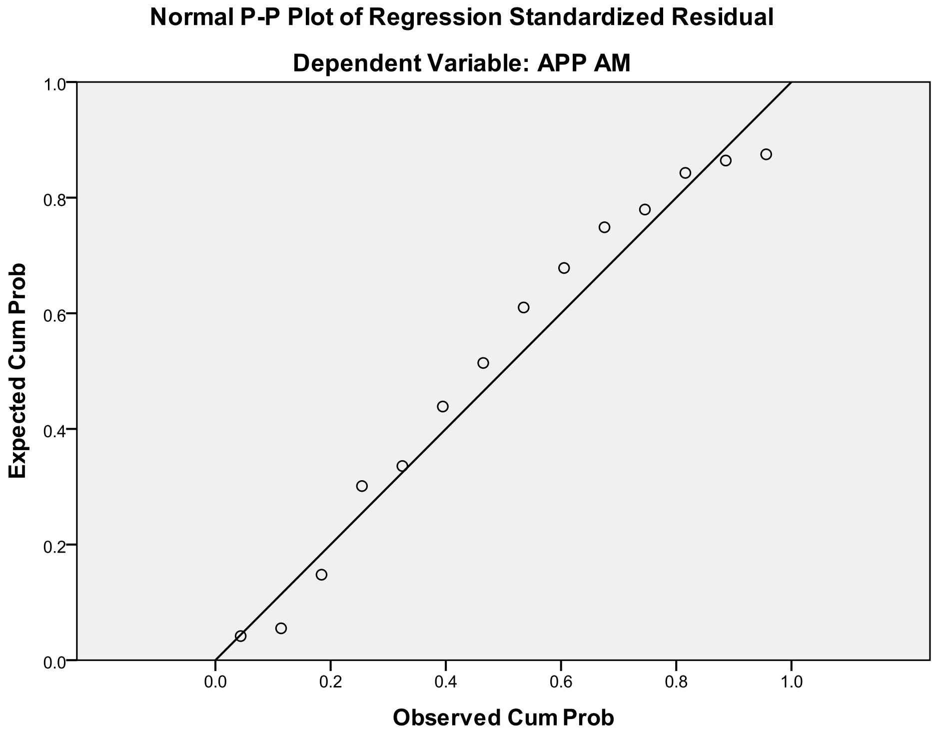
Independent Variable: Workers Vehicles

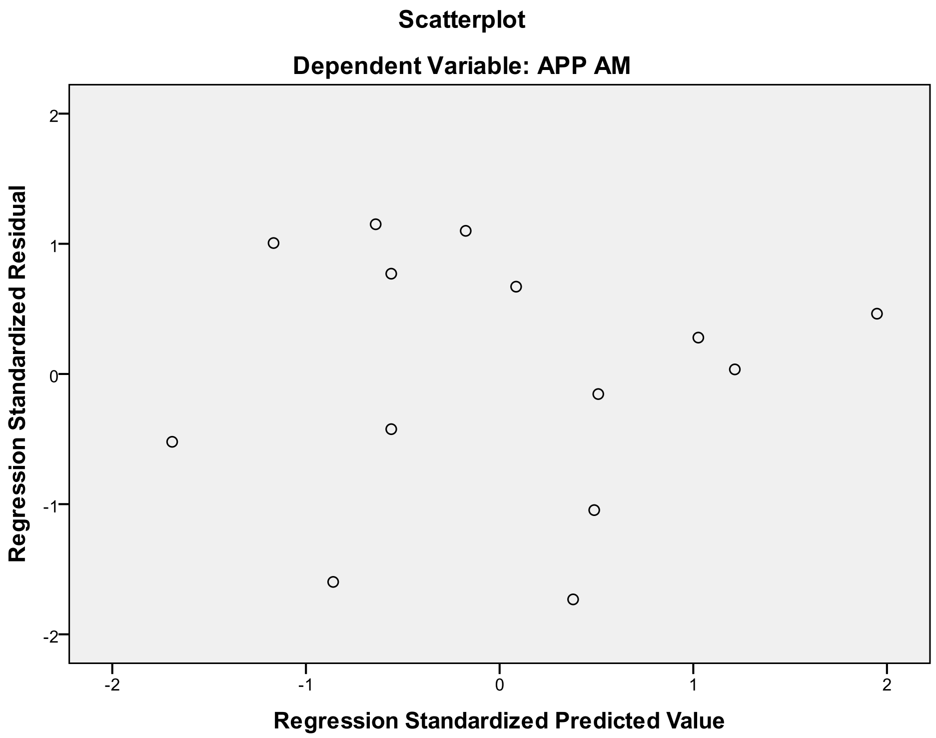




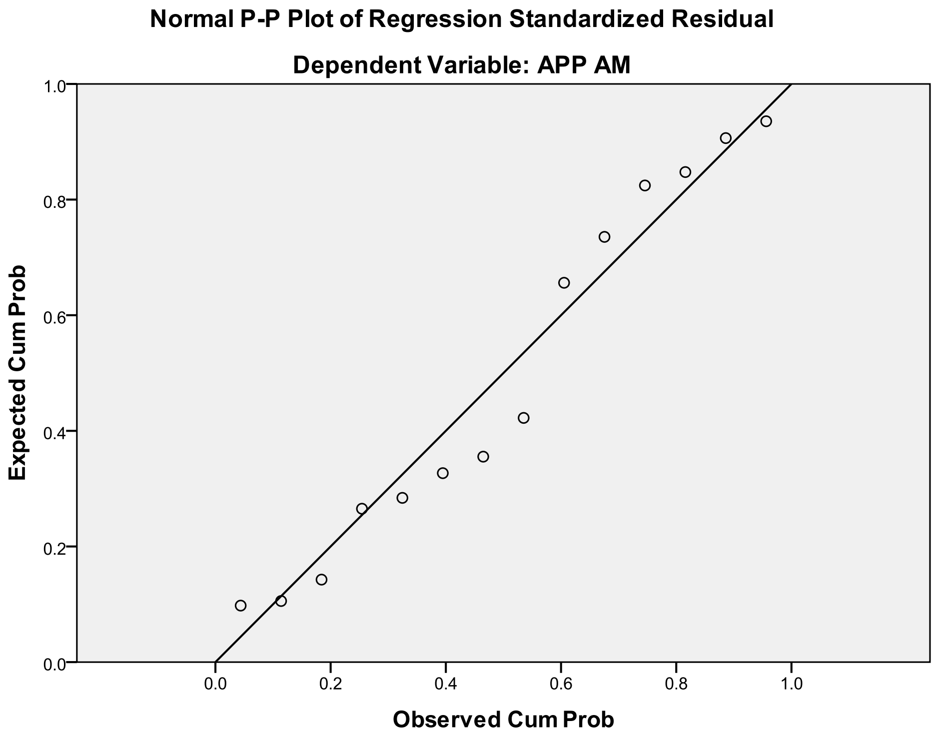
AM Period

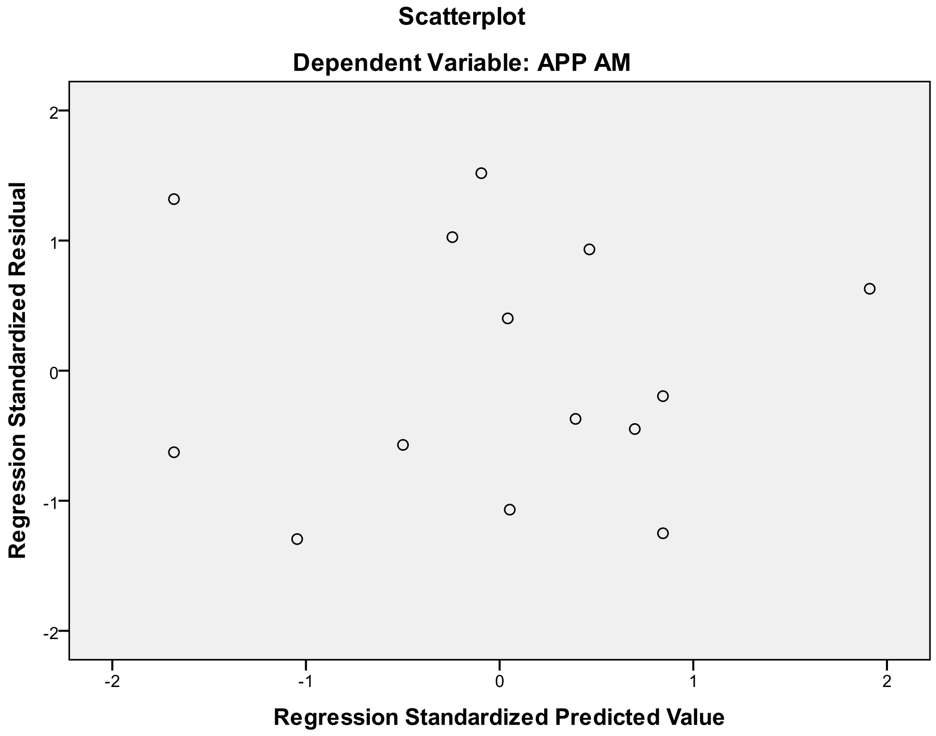
Independent Variable: Number of Workers



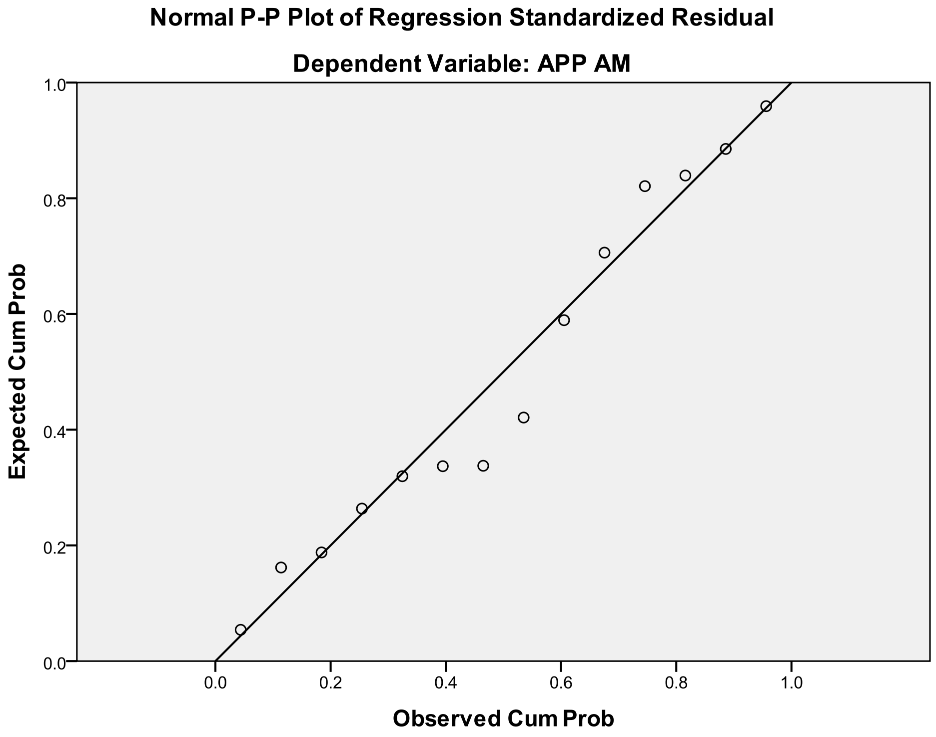


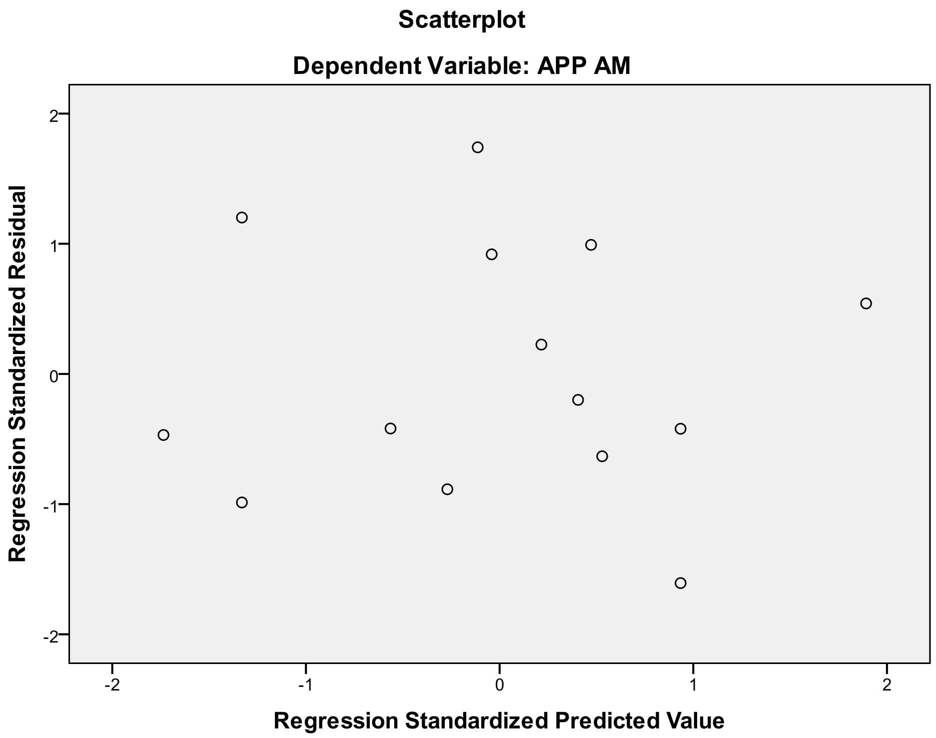
Independent Variable: GFA (s q. m.)



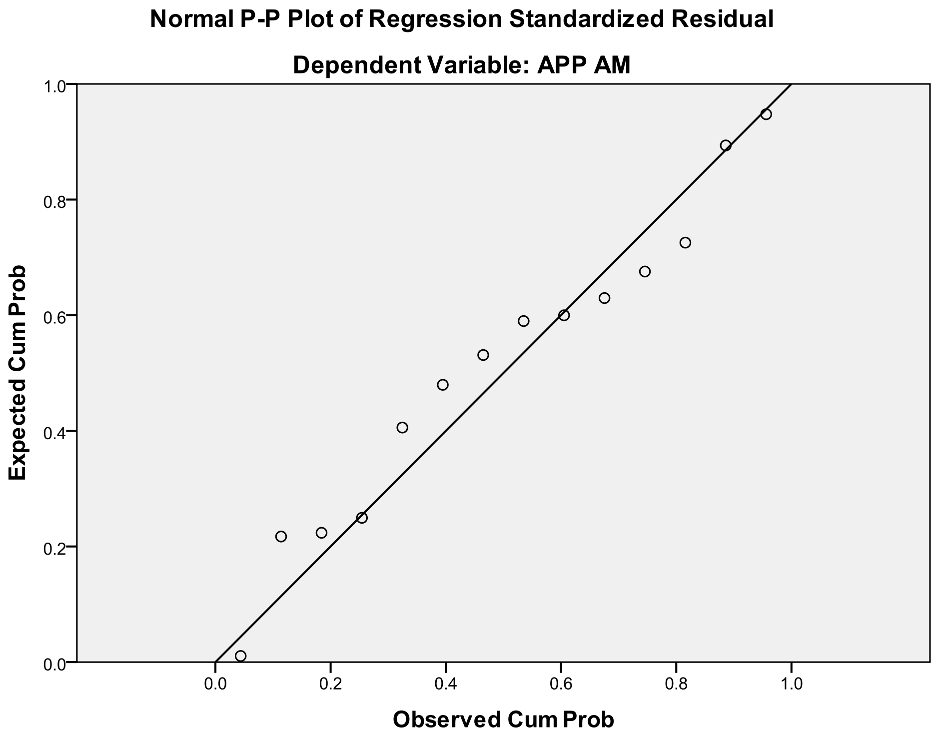


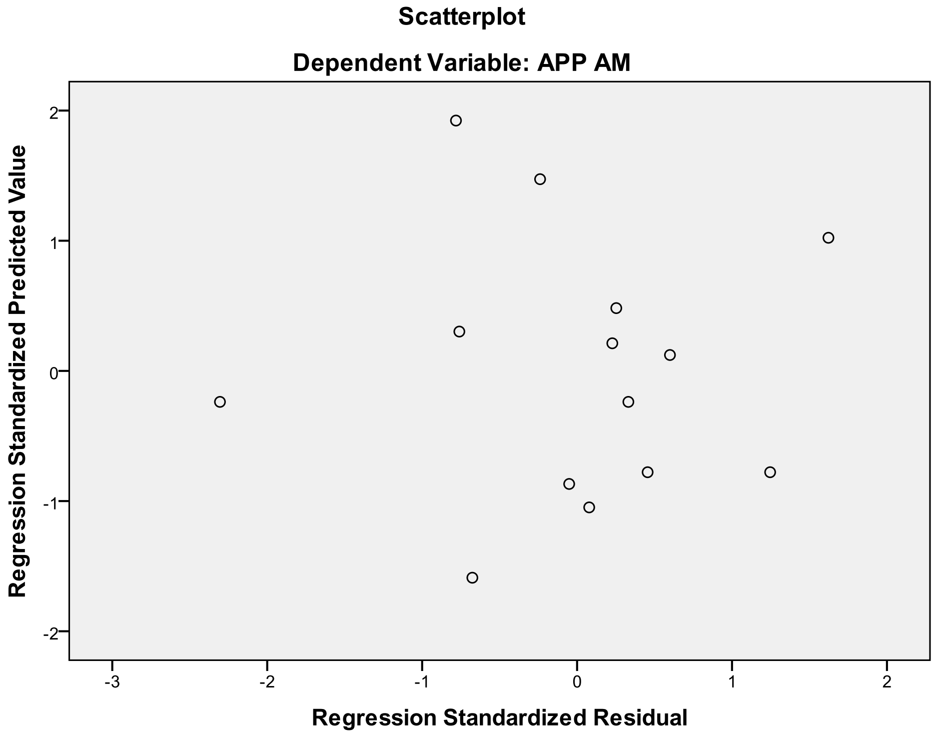
Independent Variable: GLA (sq. m.)





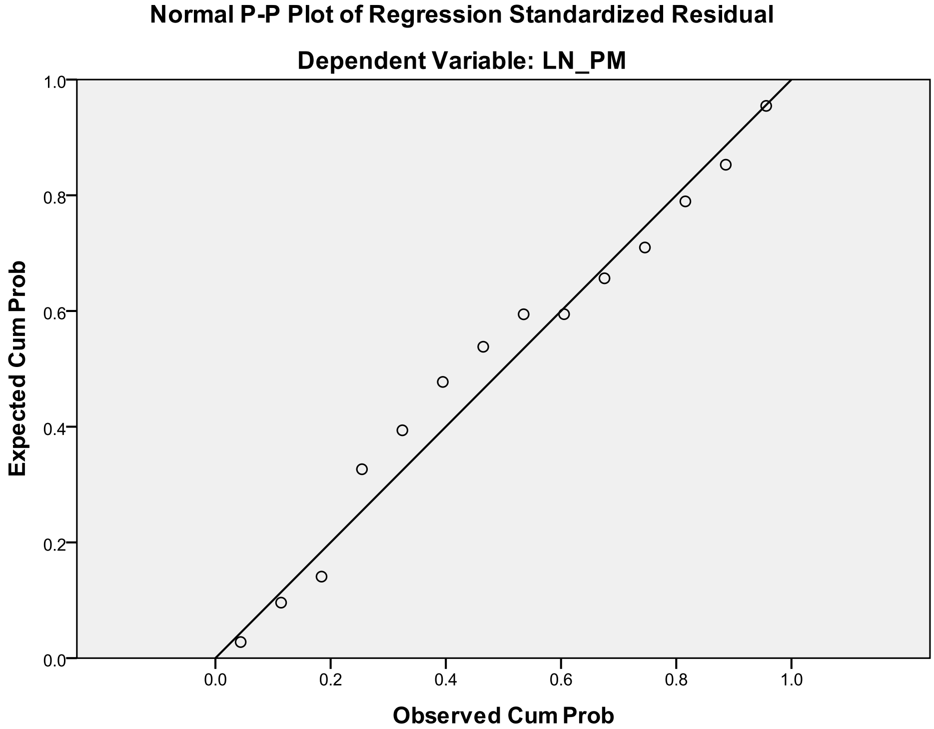
Independent Variable: Workers Vehicles

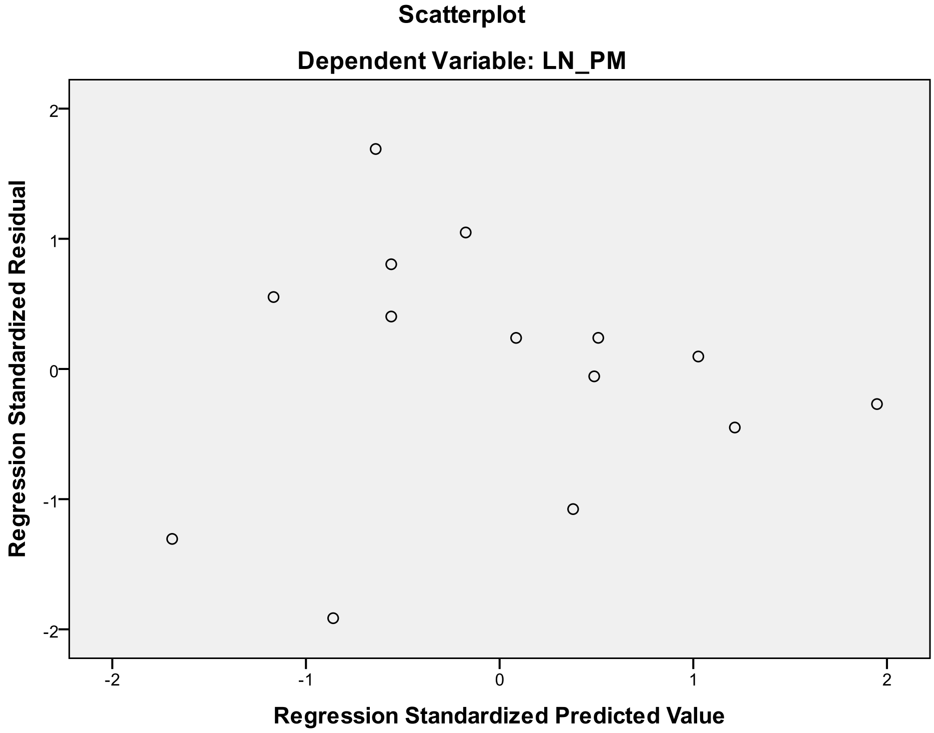




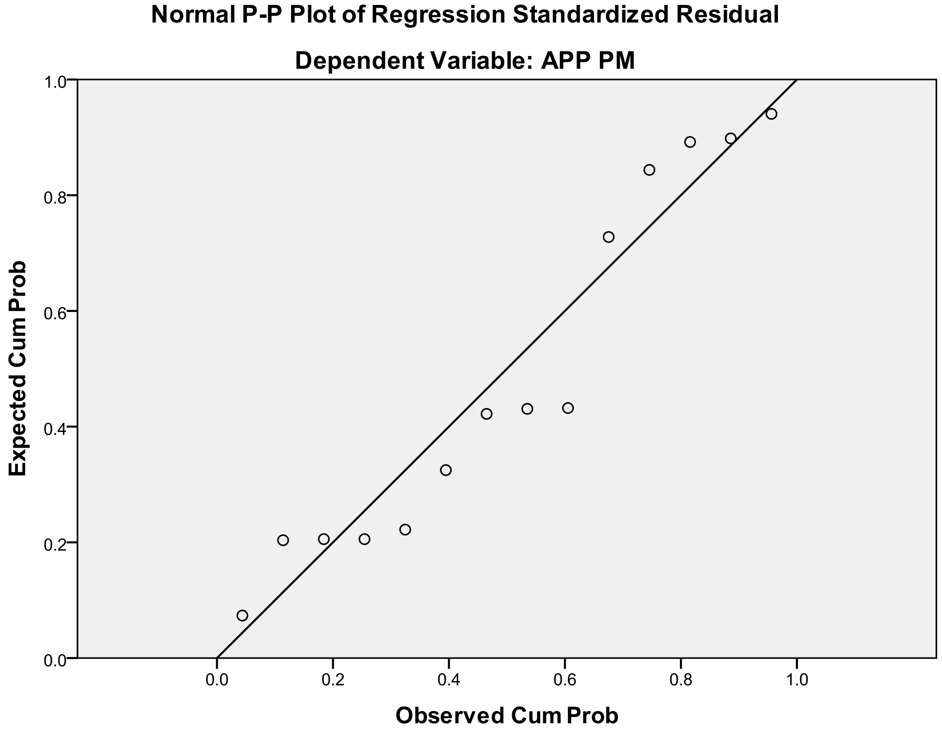
PM Period

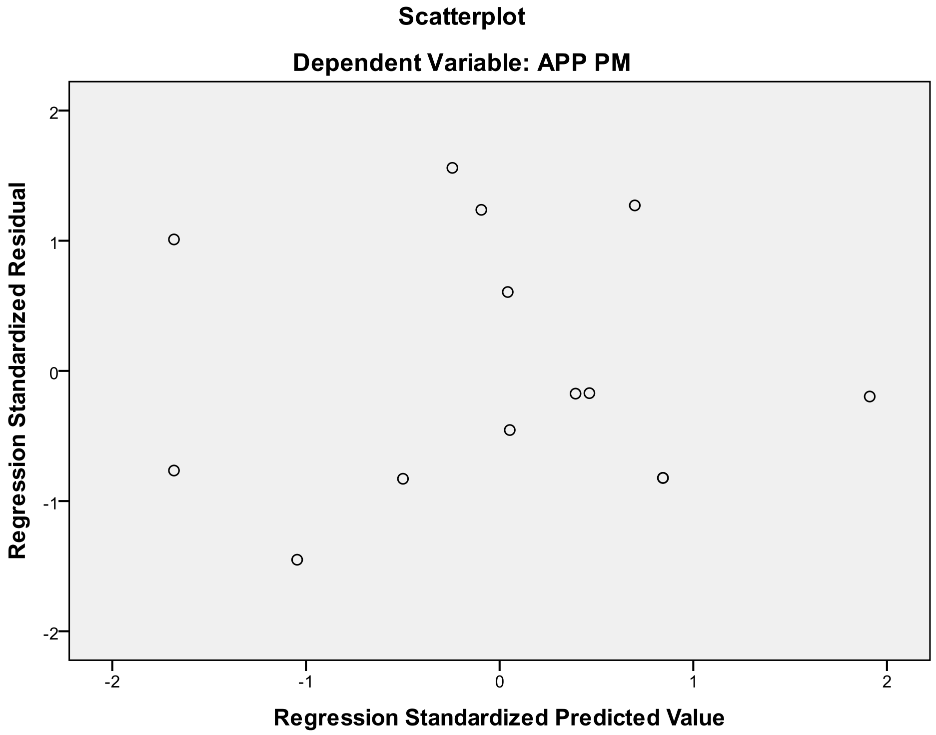
Independent Variable: Number of Workers





Independent Variable: GFA (sq. m.)

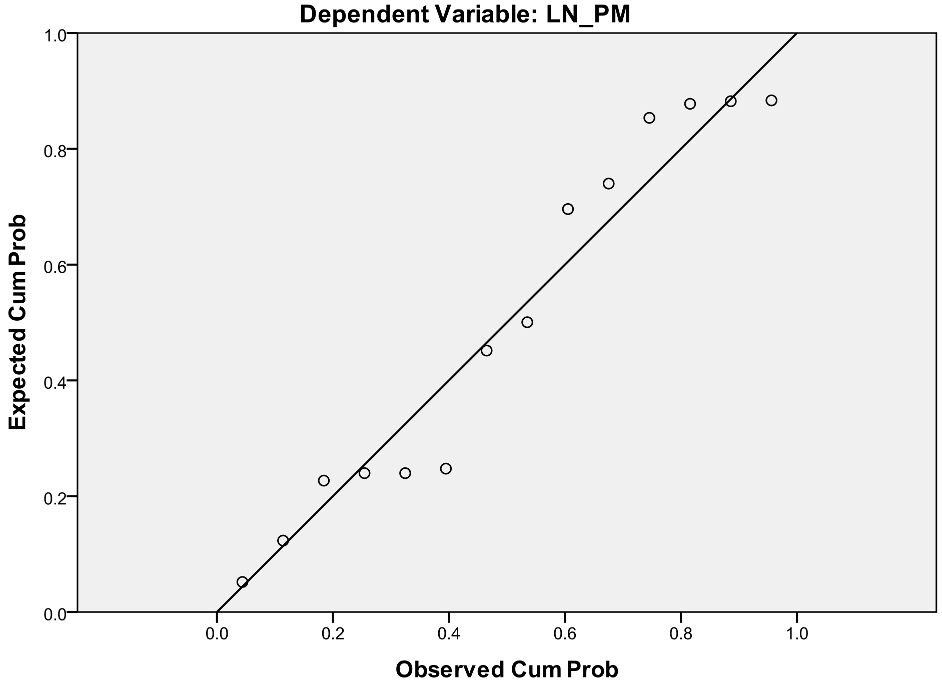




Independent Variable: GLA (sq. m.)

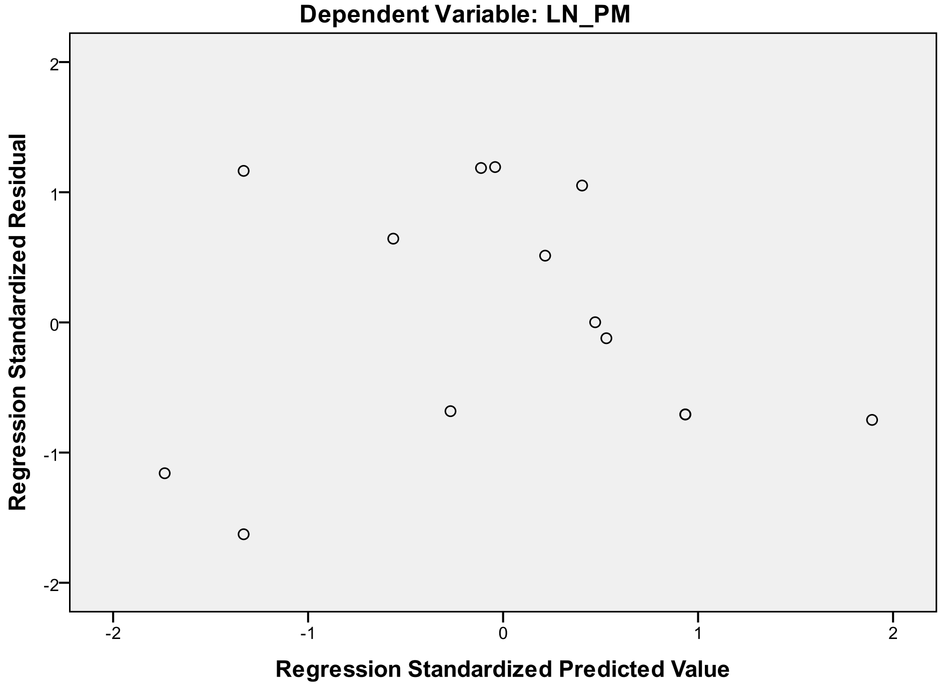
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: LN_PM

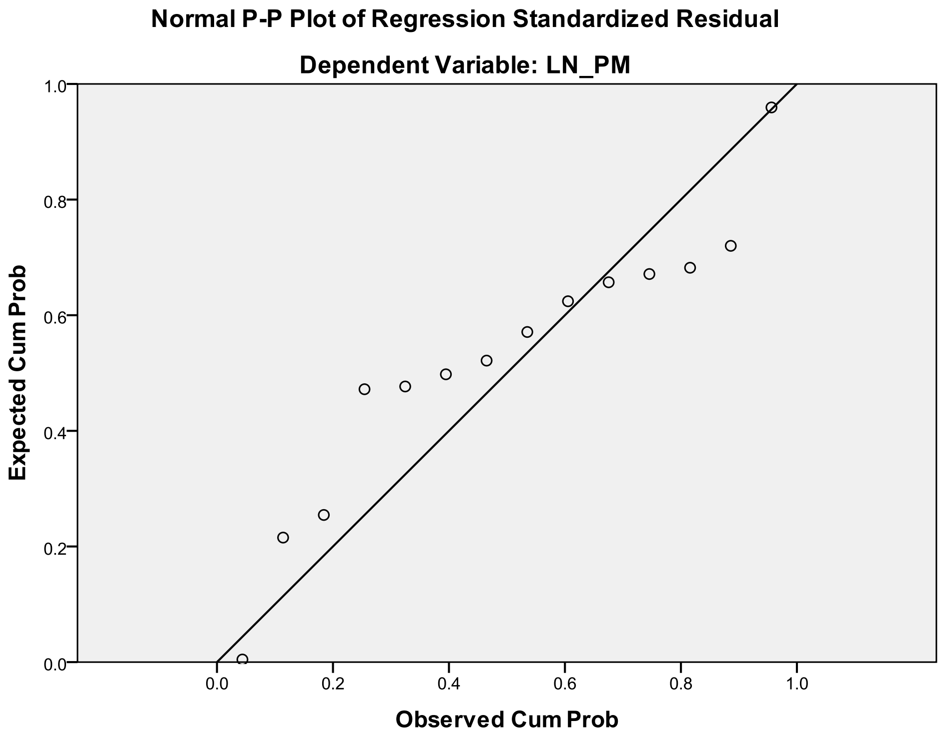


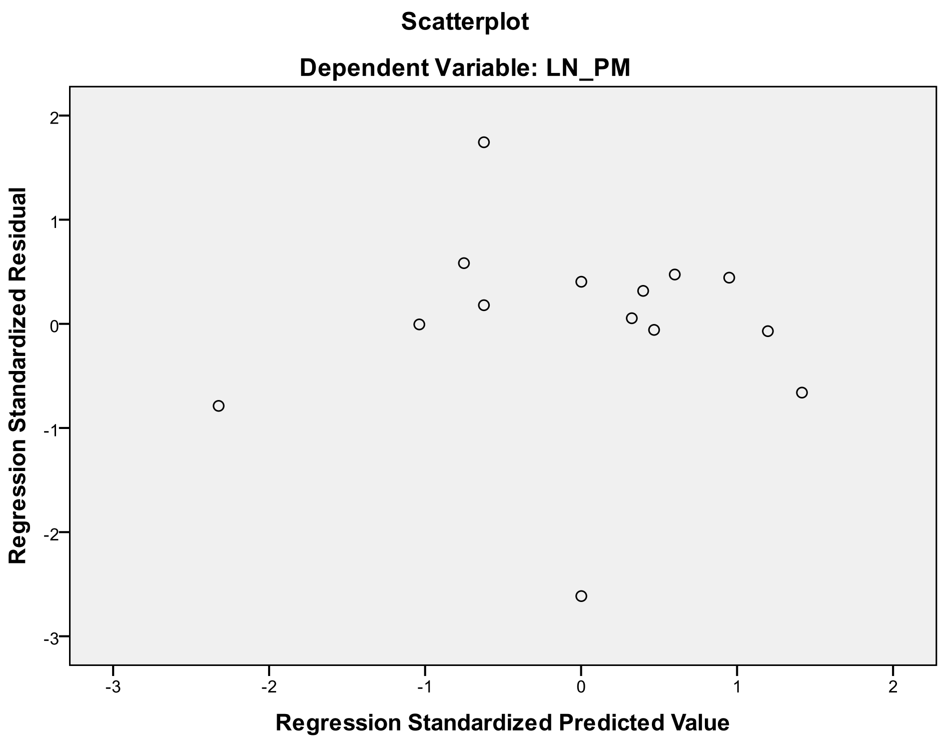
Scatterplot

Dependent Variable: LN_PM



Independent Variable: Workers Vehicles



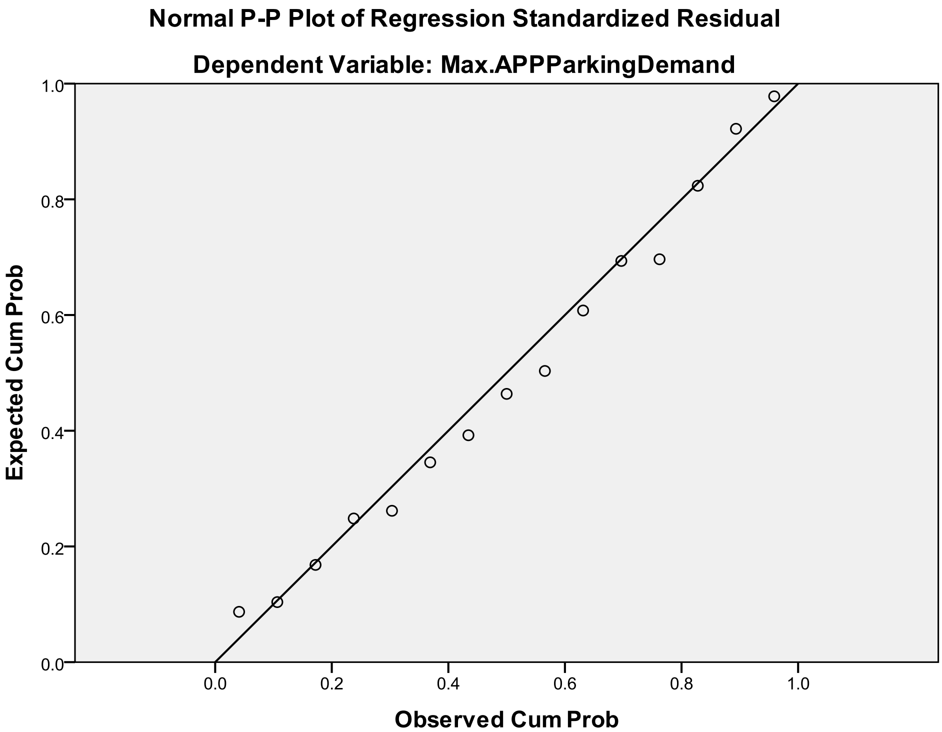


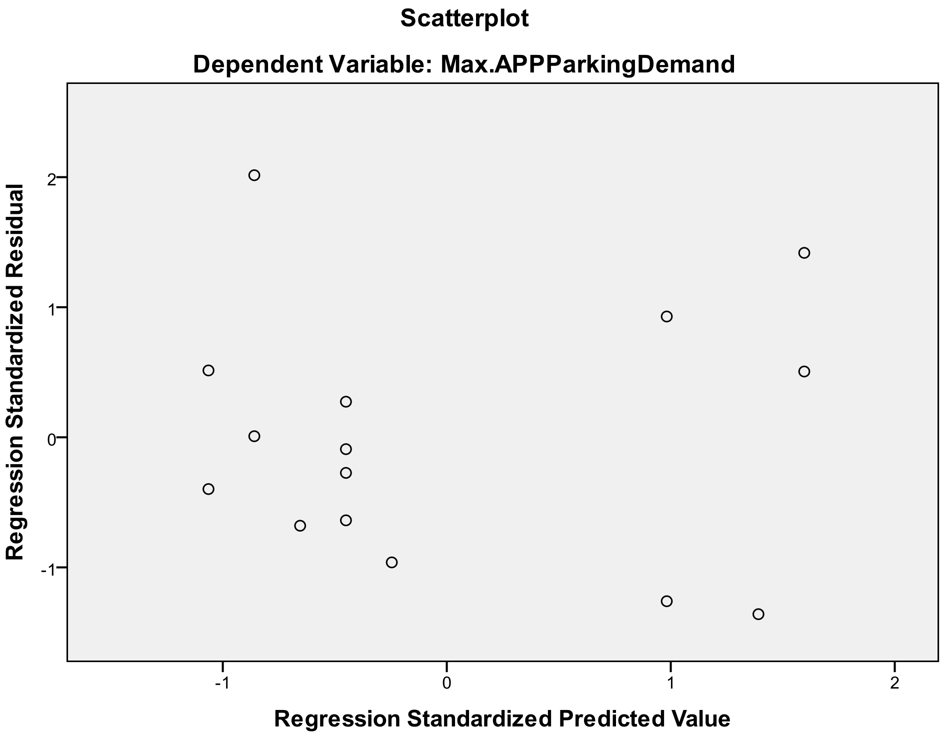
Retail Land Use

Peak of Development/s

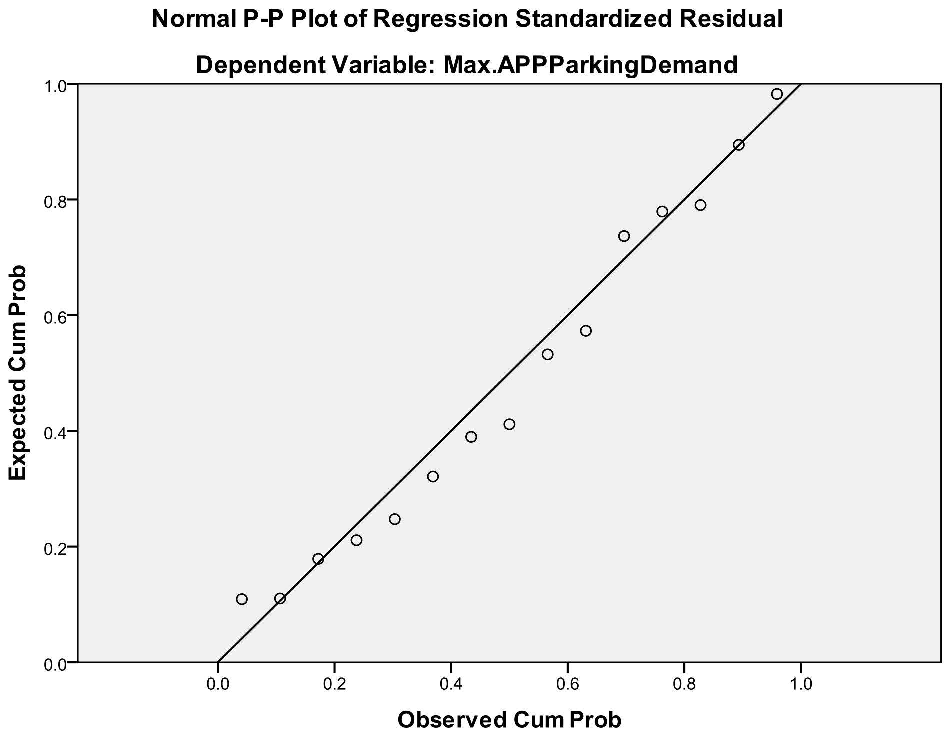
Supermarket Retail Class

Independent Variable: Workers

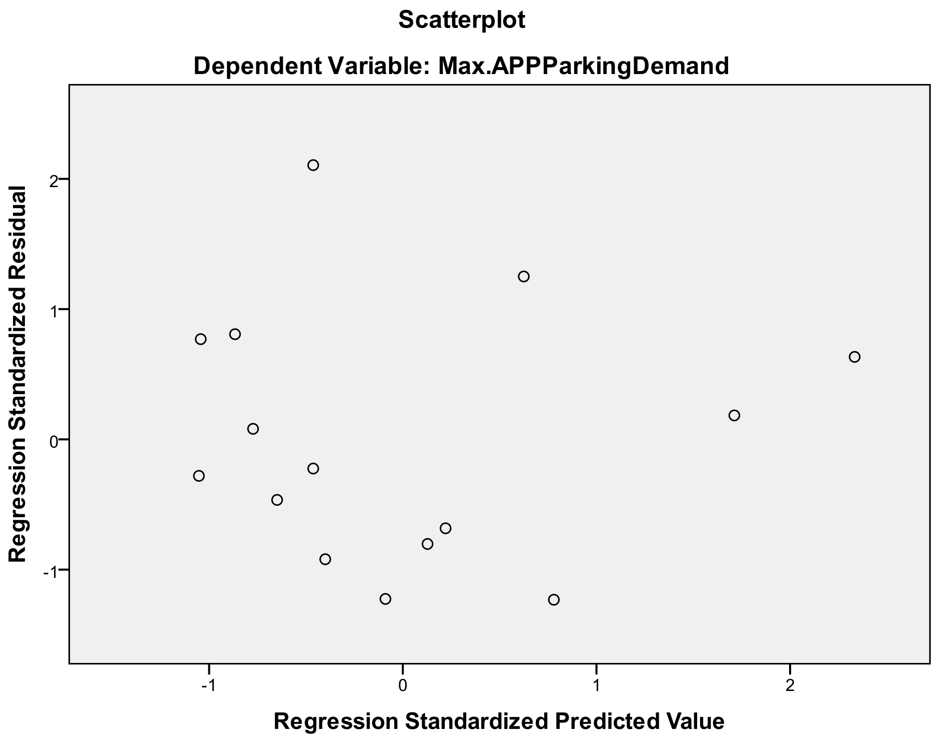

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Max.APPParkingDemand
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0


Scatterplot
Dependent Variable: Max.APPParkingDemand
Regression Standardized Residual
Regression Standardized Predicted Value
-1
0
1
2

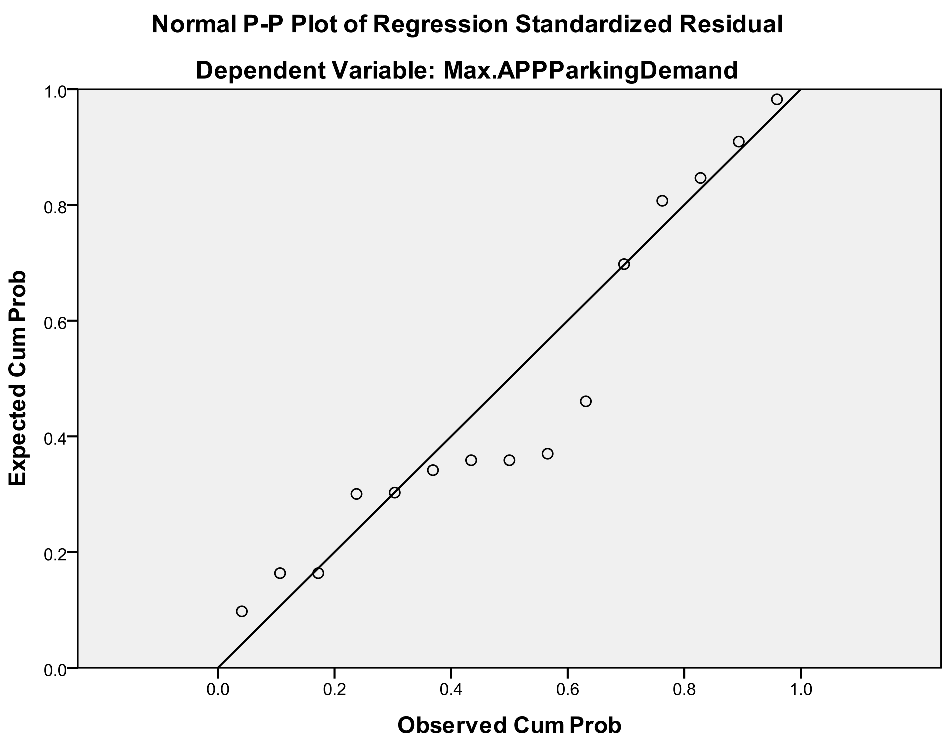
Independent Variable: GFA/GLA (sq. m.)

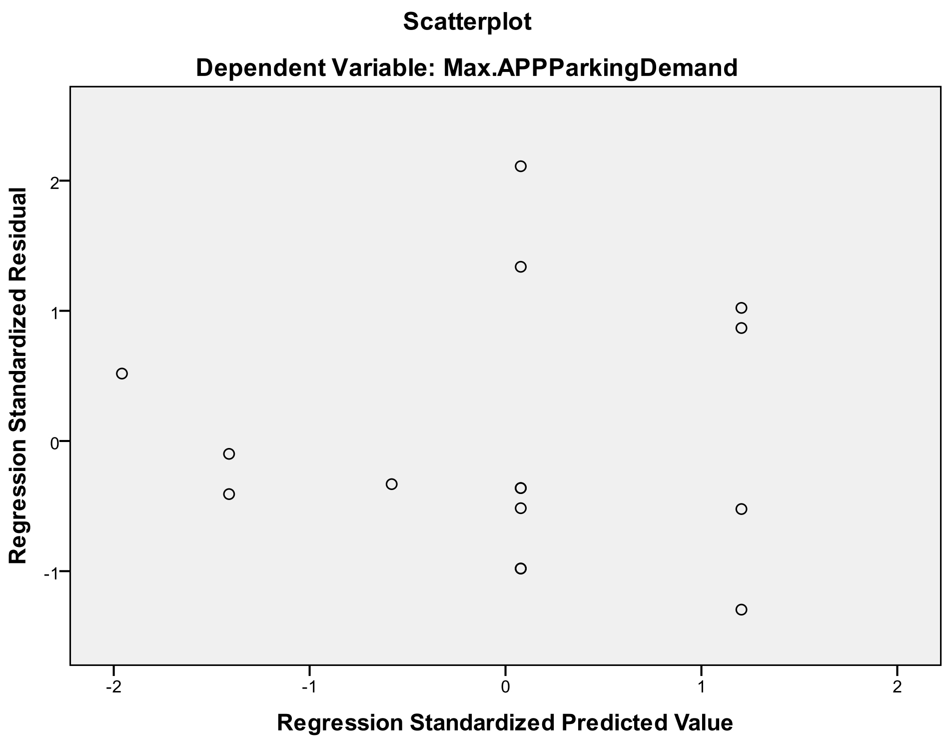


4



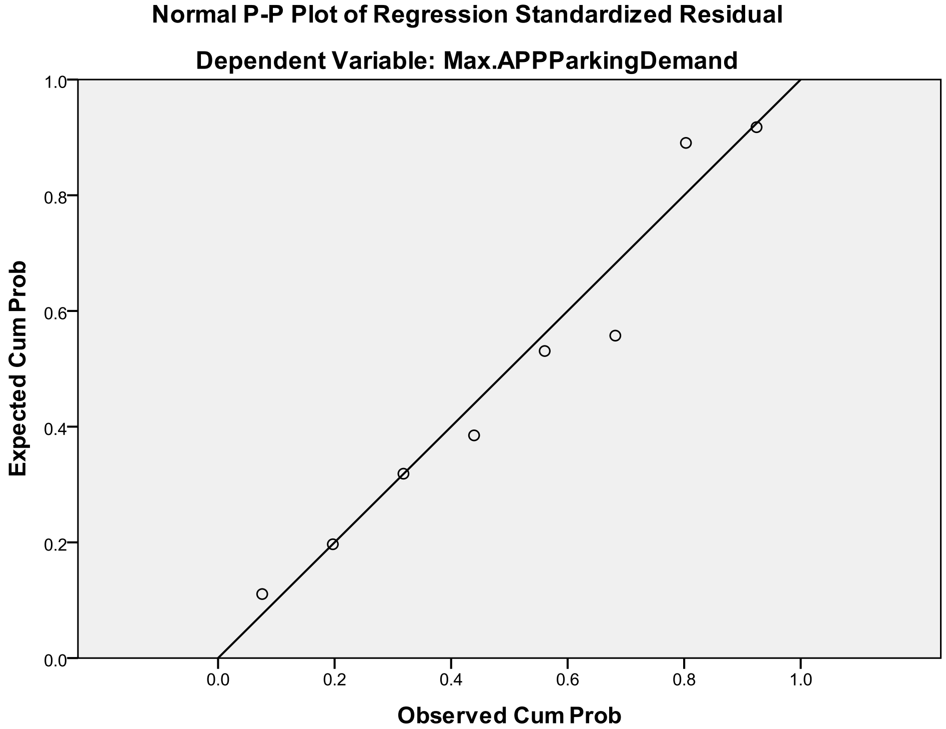
Independent Variable: Workers Vehicle

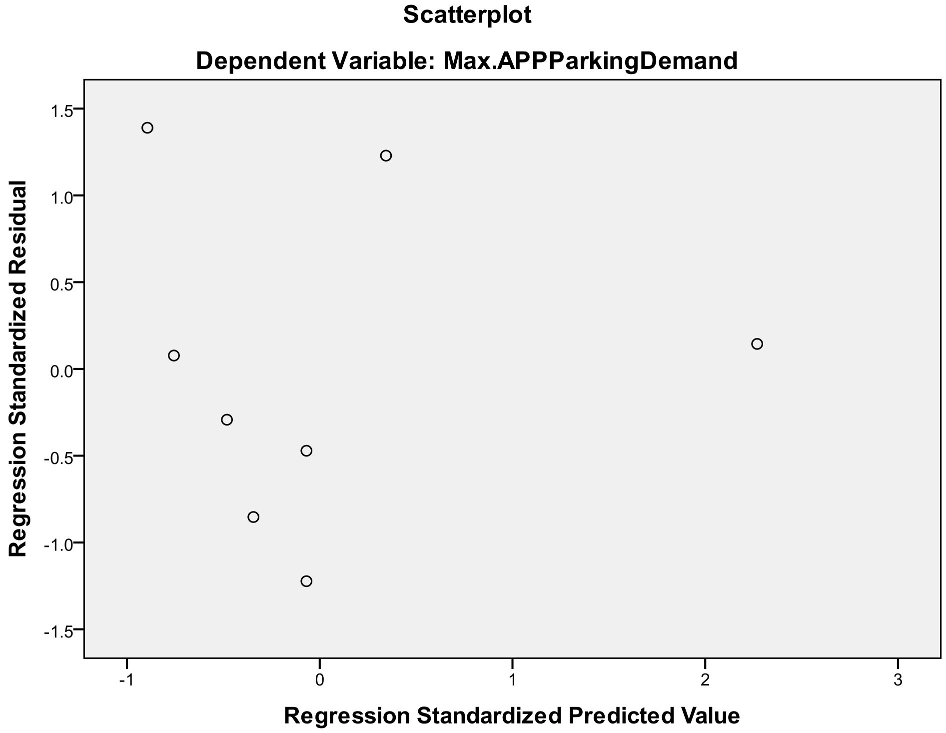




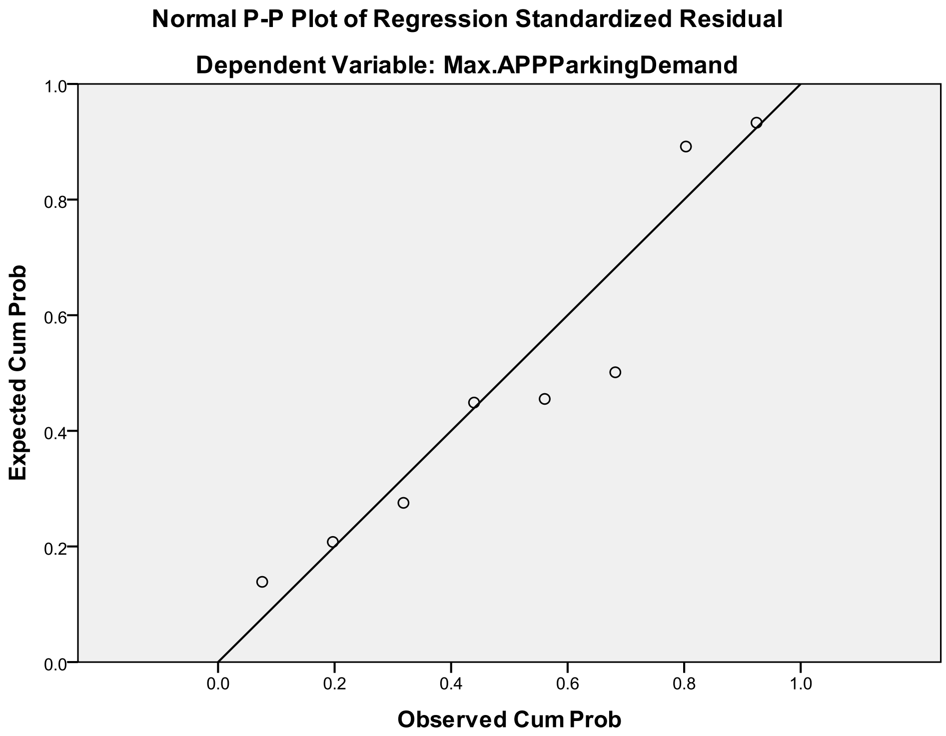
Strip Retail Class

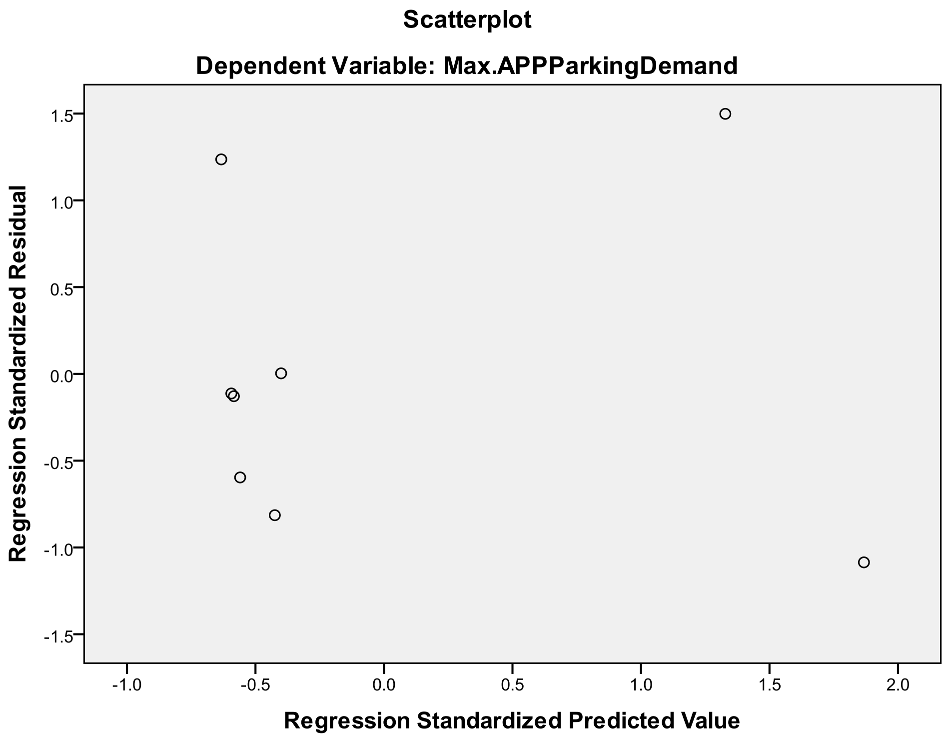
Independent Variable: Workers





Independent Variable: GFA/GLA (sq. m.)

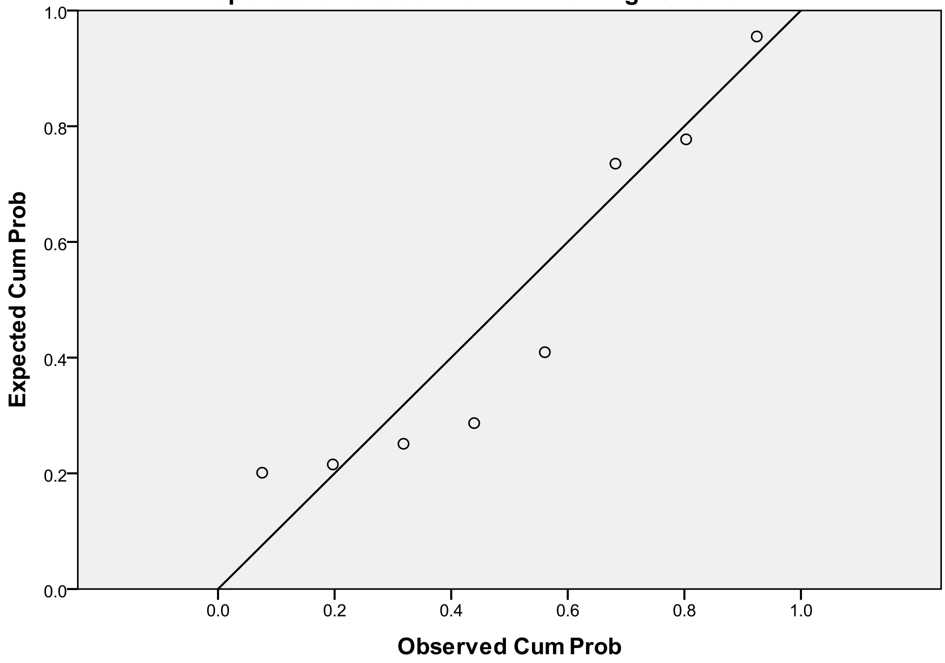




Independent Variable: Workers Vehicle

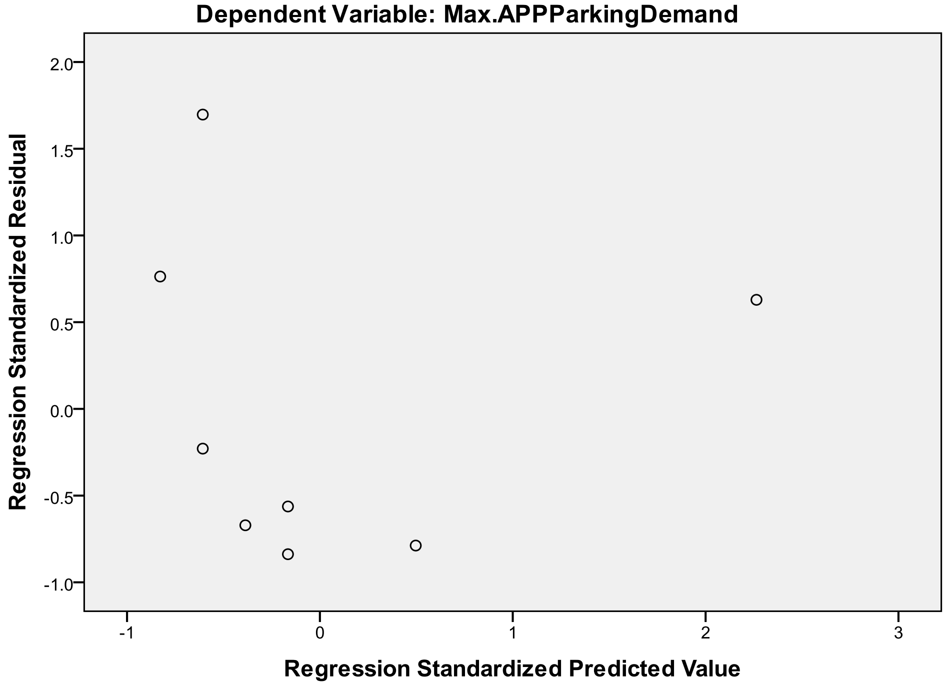
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: Max.APPParkingDemand



Scatterplot

Dependent Variable: Max.APPParkingDemand



Appendix (F): Part of Palestinian Regulations

بسم الله الرحمن الرحيم

السلطة الوطنية الفلسطينية

مجلس الوزراء

ذ. منطقة السكن الريفي.

ر. منطقة السكن الزراعي.

2. المناطق التجارية وتقسم إلى ما يلي:

أ. منطقة التجاري المحلي.

ب. منطقة التجاري الطولي.

ت. منطقة المعارض التجارية.

ث. منطقة المركز التجاري الرئيسي.

ج. منطقة المركز التجاري الفرعي.

3. المناطق الصناعية وتقسم إلى ما يلي:

أ. منطقة الصناعات.

ب. مجمعات الصناعات الخفيفة والحرفية.

4. منطقة المكاتب.

5. منطقة المباني العامة.

6. منطقة المرافق السياحية.

مـــادة (24)

مواقف السيارات

لا يسمح بترخيص أي بناء إلا إذا حددت على المخططات الخاصة به مواقف للسيارات داخل حدود أرض المشروع.

مـــادة (25)

المواقف في المباني السكنية

يجب توفير مواقف للسيارات في المباني السكنية على النحو الآتي:

1. سكن (أ) أو سكن (ب) أو المباني السكنية العالية أو الفلل أو سكن (أ) مرتفع أو السكن الزراعي أو السكن الريفي موقف سيارة واحدة لكل وحدة سكنية.

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2. سكن (ج) أو سكن (د) أو البلدة القديمة موقف سيارة واحدة لكل وحدتين سكنيتين.

مـــادة (26)

المواقف في المباني التجارية

يجب توفير مواقف للسيارات في المباني التجارية على النحو الآتي:

1.موقف سيارة واحدة لكل (50) م2 من مساحة المخازن والمعارض.

2.موقف سيارة واحدة لكل (70) م2 من مساحة الاستعمالات الأخرى في البناء.

مـــادة (27)

المواقف في المباني الصناعية

يجب توفير مواقف السيارات في المباني الصناعية على النحو الآتي:

1. المكاتب والمخازن: موقف سيارة واحدة لكل (70) م2 من مساحة البناء.

2. المشاغل والمستودعات: موقف سيارة واحدة لكل (200) م2 من مساحة البناء وبما لا يقل عن موقف لكل خمسة عاملين.

مـــادة (28)

المواقف في مباني المكاتب

يجب توفير موقف سيارة واحدة لكل (70) م2 من مساحة البناء في مباني المكاتب.

مـــادة (29)

المواقف في المباني العامة

يجب توفير مواقف للسيارات في المباني العامة على النحو الآتي:

1. المدارس ورياض الأطفال موقف سيارة واحدة لكل (200)م2 من مساحة البناء، وموقف تحميل وتنزيل لغايات المدارس بنفس مواصفات موقف الباص بطول (12م) وعرض (4م) على أن يتم تخصيص مساحة بعمق (3م) بموازاة شارع المدرسة ليسهل التوقف.

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2. الجامعات والمعاهد وكليات المجتمع يخصص موقف سيارة واحدة لكل (50)م2 من مساحة البناء بالإضافة لموقف باص واحد لكل (500) م2 من مساحة البناء.

3. المستشفيات يخصص موقف سيارة واحدة لكل ثلاثة أسره بما في ذلك أسرة الطوارئ والعيادات بالإضافة لموقف واحد لكل (50) م2 من مساحة المكاتب.

4. الدوائر والمؤسسات العامة والمباني الحكومية والمتاحف والمكتبات العامة يخصص موقف سيارة واحدة لكل (50) م2 من مساحة البناء.

5. بيوت العجزة والملاجئ يخصص موقف سيارة واحدة لكل (100) م2 من مساحة البناء.

مـادة (30)

المواقف في المرافق السياحية

يجب توفير مواقف للسيارات في المرافق السياحية على النحو الآتي:

1. الفنادق وتخضع للأحكام الآتية:

أ. الفنادق من الدرجة الممتازة يخصص سيارة واحدة لكل غرفتي نوم.

ب. الفنادق المحلية من الدرجه الأولى (4) أو (5) نجوم يخصص سيارة واحدة لكل ثلاث غرف نوم.

ت. الفنادق المحلية من الدرجة الثانية (3) نجوم فما دون يخصص سيارة واحدة لكل أربع غرف نوم.

ث. الشقق المفروشة والسياحية يخصص سيارة واحدة لكل (100) م2 من مساحة البناء.

ج. مكاتب الإدارة والمحاسبة في الفنادق يخصص سيارة واحدة لكل (50) م2 من مساحتها.

2. المطاعم وقاعات الاجتماعات والمؤتمرات والأفراح يخصص سيارة واحدة لكل (20) م2 من مساحة البناء.

3. دور السينما والمسارح يخصص موقف سيارة واحدة لكل عشرة مقاعد بالإضافة لموقف باص واحد لكل ثلاثمائة مقعد.

4. النوادي والملاهي يخصص موقف سيارة واحدة لكل (50) م2 من مساحة البناء بالإضافة لموقف باص لكل (500) م2 من مساحة البناء.

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5. الملاعب والأماكن الرياضية العامة "إستاد": موقف سيارة واحدة لكل عشرة مقاعد بالاضافة لموقف باص واحد لكل (500) مقعد.

مادة (31)

مواصفات مواقف السيارات

لغايات تحديد عدد مواقف السيارات التي يجب توفرها في أي بناء ولتأمين سهولة دخول وخروج كل سيارة دون أية عرقلة يجب أن تتوفر الشروط الآتية:

1. أن لا يقل طول موقف السيارة عن (5,5 م) وعرض الموقف عن (2,5 م) وطول موقف الباص عن (12 م) وعرضه عن (4 م).
2. أن لا يتعدى انحدار الممر الخارجي "الرامب" عن (20%).
3. أن يتم ربط الممر الخارجي بالمسطحات الداخلية وبالطرق الخارجية بأقسام لا يزيد انحدارها عن (10%) وبطول من محور الممر قدره خمسة أمتار على الأقل.
4. أن يؤمن ارتفاعاً حراً على كامل عرض الممر الخارجي قدره متران على الأقل.
5. أن لا يقل عرض الممر الخارجي عن:

أ. (3,5) م لمواقف السيارات التي لا تزيد عدد السيارات فيها على (30) سيارة.

ب. (5,25) م لمواقف السيارات التي يزيد عدد السيارات فيها عن (30) سيارة. وفي حال تأمين مدخل ومخرج مستقلين يطبق البند (أ) من هذه الفقرة على كل منهما.

6. أن لا يقل نصف قطر المنعطف الداخلي عن أربعة أمتار ولا يقل نصف قطر المنعطف الخارجي عن ثمانية أمتار.
7. أن لا تتعدى بداية الممر الخارجي خط البناء الأمامي باتجاه الشارع.
8. أن لا يتعدى انحدار الممرات الداخلية التي يسمح بوقوف السيارات على جانبيها عن (5%) وأن لا يقل عرضها عن:

أ. أربعة أمتار إذا كانت السيارات متوقفة باتجاه موازي للممر.

ب. خمسة أمتار إذا كانت السيارات متوقفة باتجاه يشكل زاوية (45) درجة مع اتجاه الممر.

ت. ستة أمتار إذا كانت السيارات متوقفة باتجاه يشكل زاوية قائمة مع اتجاه الممر.

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9. يجوز للجنة المختصة قبول مواقف مسقوفة للسيارات في الارتدادات الجانبية فقط، وبعد حد الارتداد الأمامي شريطة أن لا يقل عرض الموقف عن(2,5 م) ولا يقل طوله عن (5,5م).

10. يجوز للجنة المختصة قبول مواقف مكشوفة للسيارات في ساحات أمامية أو جانبية أو خلفية بما فيها الارتدادات.

مــادة (32)

المواقف في حال عدم توفر الإمكانيات الفنية أو الانشائية

للجنة المختصة في حال عدم توفر الإمكانيات الفنية أو الانشائية لتأمين العدد المطلوب لمواقف السيارات وفق أحكام هذا النظام ضمن حدود قطعة الأرض، أن ترخص البناء شريطة أن لا يقل عدد المواقف المتوفرة عــن (70%) من العدد المطلوب لكامل البناء بعد دفع رسوم بدل المواقف غير المتوفرة وفق الجـدول رقـم (4) الملحق بهذا النظام.

مــادة (33)

المواقف في حال وجود بناء قائم

في حال عدم توفر الامكانيات لتأمين العدد المطلوب لمواقف السيارات بسبب وجود بناء قائم للجنة المختصة أن ترخص البناء بالعدد المتوفر من مواقف السيارات بعد دفع رسوم بدل المواقف غيرالمتوفرة وفق الجـدول رقم (4) الملحق بهذا النظام.

مــادة (34)

دراسة الطلب

الحالات التي لا تنطبق عليها أحكام المادتين (32) و(33) من هذا النظام يتم دراسة الطلب من اللجنة المختصة ورفع التوصية بشأنه إلى اللجنة الأعلى.

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مـــادة (35)

إنشاء مواقف عامة للسيارات

تخصص المبالغ التي تستوفى عن مواقف السيارات غير المتوفرة لغايات إنشاء مواقف عامة للسيارات وتودع في صندوق خاص لهذه الغاية.

مـــادة (36)

الأبنية المتصلة بالطريق العام

لا يشترط توفير مواقف السيارات للأبنية المتصلة بالطريق العام بدرج عام أو ممر عام يقل عرضه عن ثلاثة أمتار ولا يستوفى عليها رسوم بدل مواقف.

مـــادة (37)

مواقف سيارات بالأجرة

في حال رغبة طالب الترخيص بعمل مواقف سيارات بالأجرة لا يحسب عددها ضمن العدد المطلوب للبنــاء وفق المادة (24) من هذا النظام.

مـــادة (38)

مشاريـــع التقسيـــم

لغايات هذا النظام يجب أن يراعى في مشروع أي تقسيم أو إفراز ما يلي:

1. أن يكون التقسيم أو الإفراز مطابقاً لمخطط التنظيم التفصيلي المقرر بما في ذلك سعة الطرق.
2. أن يكون الحد الأدنى لمساحات القطع وأبعادها وفقاً للجدول رقم (1) الملحق بهذا النظام.

مـــادة (39)

أحكام الطرق في مشاريـــع التقسيـــم

1. لا يجوز فتح أي طرق إضافية نافذة على الطرق العامة المقررة بعد التصديق على مشروع التقسيم إلا بموافقة اللجنة المختصة.

Vitae

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جامعة النجاح الوطنية

كلية الدراسات العليا

تحديد معدلات احتياجات المركبات لأنواع مختارة من استخدامات الأراضي في الضفة الغربية

اعداد

جميل محمد جميل حمادنه

إشراف

د. خالد الساحلي

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

2015

تحديد معدلات احتياجات المركبات لأنواع مختارة من استخدامات الأراضي في الضفة الغربية

اعداد

جميل محمد جميل حمادنه

إشراف

د. خالد الساحلي

الملخص

تقدير الطلب على مواقف المركبات في فلسطين بحاجة إلى مزيد من الدراسات المتخصصة للاستناد عليها في تخطيط وتصميم وإدارة مواقف المركبات. علاوة على ذلك، فإن استخدام النماذج والمعدلات المستخدمة إقليمياً أو دولياً لن تكون مناسبة لطبيعة فلسطين. لذلك أجري هذا البحث من أجل تأسيس مرجع موثوق يستخدم في تقدير أعداد مواقف المركبات اللازم توافرها لثلاثة استخدامات رئيسية مختلفة وهي: الاستخدام السكني والاستخدام المكتبي والاستخدام التجاري.

ثلاثة وسبعون موقعا من الاستخدامات المختلفة تم اختيارها بالاستناد إلى البحث الدقيق والمقابلات وإمكانية الحصول على المعلومات اللازمة. غطت هذه المواقع الاستخدامات الرئيسية الثلاثة السابقة وتفرعاتها المختلفة (ثلاثة تفرعات لكل استخدام). وشملت الدراسة المدن الرئيسية في الضفة الغربية.

تمت عملية جمع المعلومات يدويا، حيث تضمنت خصائص كل موقع، وتعداد لمواقف المركبات لمدة يومين مختلفين خلال فترات مختلفة (صباحية، مسائية، وفترة الذروة للموقع أو/والطرق المجاورة).

بناء على تحليل للمعلومات المجمعة تم التوصل إلى عدة نماذج ومعدلات لمواقف المركبات اللازمة، حيث يمكن استخدام هذه المخرجات كمواصفات محلية لتحديد عدد مواقف المركبات اللازمة للاستخدامات الثلاثة السابقة. بالاستناد إلى منهجية العمل التي استخدمت من قبل معهد مهندسي المواصلات الأمريكي؛ تم تطوير نماذج بأشكال خطية ولوغاريتمية وأسية.

النماذج المخرجة لها دقة متفاوتة في تحديد أعداد مواقف المركبات للمنشآت الحالية والمستقبلية. كما أن النماذج المتحصل عليها يمكن تطبيقها في المناطق الحضرية للمـــدن. ســـتة وخمســـون نموذجا ومعدلا تم التوصل إليها، وتختلف هذه في دقتها. تم تلخيص ووضع النماذج والمعـــدلات الجيدة (ذات الدلالات الإحصائية الجيدة كمعامل التحديد، R^2) لكل استخدام فرعي في جـــداول. النماذج ذات الدقة العالية (R^2>0.6) يوصى باستخدامها، بينما ذات الدقة المنخفضة فإنه يوصى باستخدام المعدلات بدلا منها.

وعليه فإن الطلب على المواقف للاستخدام السكني والمكتبي والتجاري ذات الخصائص المتشابهة مع هذه الدراسة يمكن تقدير احتياجاتها استنادا إلى النماذج والمعدلات الناتجة من هذه الدراسة. هذه الرسالة تشكل الخطوة الأولى لدليل فلسطيني مستقبلي "**تحديـــد احتياجـــات الاســـتخدامات المختلفة من مواقف المركبات**"بحيث يشمل هذا الدليل على العديد من استخدامات الأراضي، كما سيشكل دليلا توجيهيا لوزارة الحكم المحلي والبلديات في تحديد متطلبات المنشآت من مواقـــف المركبات.