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Estimating parking generation rate for Karbala holy city using multi-variables approach

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ABSTRACT

Car parking planning, design, and management processes are very important to all cities and places to ensure efficient traffic system. Estimating the demand of car parking represents the significant start point for the success of these processes. Generally, there are many local and international estimating criteria, but such criteria need continuing update due to many reasons related to socioeconomic factors, lifestyle changes, development in technology, etc. Moreover, the majority of these criteria depend on single parameter for the estimation of parking demand; such as bed or employee for hospital, gross floor area or employee for office, and so on. The main aim of this research is to estimate the park generation rate for specific land uses depend on multivariable to increase the accuracy and limiting the effect of variation in parameters. Statistical analysis was conducted to create predicting models for each land use. The collected data was nominated for Karbala holy city, where different parameters are scaled for different city sectors. Groups of statistical models (i.e., simple, multi linear and nonlinear statistical models, and Weighted Linear Regression (WLR)) were used to create best representative relationship between the number of demands for car parking and multivariable parameters or factors affecting these lands used demands. Resulted statistical models were tested for best fit using statistical indices for model verification. Results disclose the significant of multivariable model compare with simple models. Also, WLR model shows it validity compare with multi-regression model for almost land use models. Consequently, for more accurate estimation the multi variable models are initiated with continuous need for updating.

Keywords: Multi variable model; Parking generation; Park spaces; transportation demand; Weighted Linear Regression

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1. Introduction

Generally, people are beginning and finish their trips as a pedestrian, of course some exception for drive-through facilities that now increase at such special destinations or services, like banks and fast-food restaurants. Therefore, the pedestrian portion of the trip starts or ends at a parking space. Planning, design and management of parking are focused commonly on two requirements: estimating the demand spaces for a particular development or land uses, and best location for parking facilities. Consequently, these requirements result in locally based zoning regulations for each land use type with minimum parking spaces that must be provided.

The fourth edition of the Institute of Transportation Engineers' (ITE) parking manual classify 69 land uses[1] while the fifth edition increases the land uses to 121, such change in classification reflects the need for continuing updating in order to gain the most accurate parking space demand. On other hand, such manuals present data from the year 1980 which used to build parking demand indices [2]. Since 1987 it notes significant differences in parking statistics that correlate land uses with independent variables. For example, for a specific governmental building, the demand will be mini if it is relied upon employees, while it became higher when estimation is dependent on gross floor area (GFA). Consequently, this is denoted the need for more accurate estimation method. Also, the homogeneity of the data has a major role in determining the coefficient, so that the relationship is more reliable, and the guide also provides information and guidance on choosing the best parking site [1]. As example for type of land use, it notes that the Residential -Single Home is expressed in terms of dwelling units, vehicles, persons, and total area; Restaurant in terms of number of desks; Super Market in term building area [3].

Douglass [4] examined several cities, including these in Australia, United States, United Kingdom, and New Zealand, which all showed a significant relationship between the generation of trips with land uses. Also, he noticed that there are differences in traffic in several seasons in which affecting the amount of demand for parking within the year. He found that investigated parking lots were offered 85% of the total need. Regidor [5] carried out a survey for reviewing conducted studies in the Philippines for identifying the most important issues related to parking and tour generation. He identified many important issues related to parking requirements including the total parking area, the ratio of the land uses to the distance from the city center. Consequently, an evaluation was gained to the trip and parking demand rates of the Philippines' transportation practices. The study confirmed that the traffic analysis disclosed various rates depends on land use type and factors of demand generation, similar findings have proven by others [6-8]. However, an evaluation of factors and concerns related to the local trip and parking rates have to determine accurately, consequently the recommendations for future demand directions are based on information derived [9, 10].

Al-Harahsheh [11] developed statistical models to estimate the needs of parking vehicles with various uses of land uses in different cities in Jordan, included 17 shopping centers, 35 residential buildings, 53 hospitals, 40 hotels, 42 administrative buildings, 21 restaurants. In his study, three determinants were taken in the most appropriate selection process, three criteria were adopted in the selection process, namely: the shape of the study area and the location of the parking lots must be well defined, the locations must be specific in different cities, finally the situation should cover the need for the city, i.e. it contains the number of spaces suitable for the need. Five land uses were cleared during the AM and PM peak periods on a typical business day [12, 13].

Generally, survey the literatures disclosed that the need for parking spaces depends upon many factors [14, 15], some of which are difficult to assess. The type and size of land use(s) in development are major factors, while the general density of the development environment and the amount and quality of public transportation access available, also are affect the parking spaces. Therefore, a prediction equation is establishing to estimate the required spaces depends on mentioned factors (variables) individually [16, 17]. The current procedure of calculating equations that suggested by Institute of Transportation Engineers (ITE) [1, 18].

The correlation between park demand and park space with land uses was also investigated. This topic is considered one of the important matters as modern cities are suffered from the large increase in car ownership, where this increase reflects as a serious problem of congestion and noise [19, 20].

2. Research aim and significant

In this research, the holy city of Karbala was nominated as a study area for creating statistical models to estimate the park generation rate for specific land uses depend on multivariable to increase the accuracy and limiting the effect of variation in parameters. Several methods were used, including simple linear regression, multiple linear regression, and weighted least squares method, to finalize statistical equations using the SPSS program [21-23]. The developed models are comprising various variables compared to the existing equations that dependent on only one variable as mentioned previously. It is believed that multivariable equation facilitate the interaction of various parameters to close the particle solution , residential units for example, depend not only on dwelling unit as in some previous studies [24], because of the nature of the housing condition in the region is that the income and age of adults have a significant impact on several car owners. Subsequently, this is what distinguishes in this research, so, that it is meaning that the researcher did not rely on one variable in determining equations and these equations are more in line with the region and more accurate [25, 26].

3. Methodology

The adopted method includes some surveys which were conducted on all types of land use(s) in the study area, and identifying the parking generation and supply needs as follows:

3.1 Collection of data

In addition to the library review of the references, field surveys were conducted for the sites that were identified within the study area, taking into account, the determinants for each region. On the basis of which, the data to be collected was determined, also the size of the initial sample was determined using the Stephen Thompson equation [27, 28], consequently, the appropriate sites were selected for the sample collection.

1- Classification of Land use

The land use was specified depending on current designation of the urban planning department for the city of Karbala. The city was divided into several sections of land uses as follows: Residential- Single Home, Restaurant, Super Market, Commercial Shops, Education, Medical / Clinics, and University [29, 30].

2- The criteria specified in the site selection

The research methodology for selecting survey sites was based on several criteria as suggested by Al-harahsheh [11] The site must be not newly established

- Also, the sites where the surveys were conducted are occupied at least by 85%.
- The sites should be well defined
- There are no cases that prevent surveyors from reaching the area, such as abnormal conditions like construction, etc.

The data collection process was carried out by preparing forms containing the required information for preparing the models of estimating the number of cars for each type of land use. After that, the mentioned criteria were used to specify the sites that represented all sectors of Karbala city. For important, the data collection method was done through interviews.

3- Period of data collection

The data collection period is important because there are periods in which the data are somewhat uneven [31]. As a result, this study covered normal days, meaning that the period in which data were collected are weekdays (Monday, Tuesday, and Wednesday). Consequently, these days were not holidays. The surveying was conducted from 9 AM tile 5 PM. Moreover, there were some types of land use were surveyed randomly, where the number of cars in it is fixed, such as (Residential- Single Home, Restaurant, Education, and university). In other types, the time of collecting data is important and has a major impact on them, such as (Super Market, Commercial Shops and Medical / Clinics), the time is specified only for these species that were previously mentioned.

3.2 Analysis of data

The number of parking demand for any parking represents the number of parked cars at a particular time[32] . Therefore, simple linear regression, multiple linear regression, and non-linear (such as exponential, logarithmic, etc.) were used to obtain the special equations for each type of land use. Finally, the WLR of data was used.

The parking demand of each land use depends on several important basic factors, for example with respect to Residential- Single Home, the main factor is the dwelling units [24] , while others were suggested in this study like family income, the family numbers, and adult numbers. Table 1 identifies the land use types (response) with all suggested independent multivariable factors for each land use, which initiate the park generation or demand.

The goodness of fit of the developed model normally is measured by R^2 or adjusted R^2. When the sample size is small, the adjusted R^2 is recommended as it adjusts the values of R^2 . Commonly for small sample size, the estimated R^2 is tend to be higher than actual R^2, however, adjuster R^2 is suggested when it differs significantly from R^2 [33]. R^2 is expressed the variation in the percentage of needed parking spaces that associate with the variance in the sample size of independent variable [34] . As stated by Ewing et al [35], when the sites are sufficient, it is preferred to use $R^2$with value greater than 0.5. This method is also used in many countries of the world, for example, as in Australia, the United States of America and the United Arab Emirates. Statistical checks were performed for all models and also the rate to ensure the accuracy of the model or the rate produced in the prediction. The analysis of variance was preformed to disclose how to create the regression equation for the dependent and independent variables [4]. T-test was conducted to exam the hypothesis and checking the significance of coefficients included in the developed model. Test of hypotheses include the use of the T-test null hypothesis (H0), which is indicate that at predefined confidence level, the coefficient is not significant and does not impact the developed model. Alternatively, hypothesis (H1) demonstrations that the coefficient is significantly impacts the developed model [4]. The Statistical Package for the Social Sciences (SPSS) was used to perform the mentioned statistical analyses.

Table 1. Dependent and independent variables of studied land uses

Parking generator (response)	Independent variable			
	x1	x2	x3	x4
Residential -Single Home	Number of family	Dwelling unite	monthly family income	number of adults in the family
Restaurant	Number of employees	Number of desks	Number of people	-
Commercial Shops	Number of employees	Building area	Number of customers	-
Super Market	Number of employees	Building area	Number of customers	-
Education	Number of employees	Number of students	-	-
Medical / Clinics	Number of employees	Patient number	-	-
university	Number of employees	Building area	Number of students	-

3.3 Prediction Models

This study focused on optimizing the most appropriate models that correlate the dependent variable (park demand) with different measured independent variables which will explained hereinafter. Various models, (namely, simple linear regression, multiple linear regression, simple nonlinear regression, multi nonlinear regression, and weighted linear regression) are nominated for such optimization. The linear regression is the simplest model that represent a relation between dependent and independent variables. In statistics, however, a relation is consider as simple linear regression model when a single explanatory variable is related to response [36, 37]; it considers as two-dimensional sample points with one independent and another dependent variables, and determines a linear relation (a non-vertical straight line) that, as precisely as possible, estimates the dependent variable values as a function of the independent variables. The term “simple” indicates that the outcome variable is varies to a single predictor. On other side, for more than one explanatory variable, the process is called multiple linear regression. This term is distinct from multivariate linear regression, where multiple correlated dependent variables are predicted, rather than a single scalar variable[38].

Nonlinear regression is a form of regression analysis in which observational data are modeled by a function which is a nonlinear combination of the model parameters and depends on one or more independent variables. The data are fitted by a method of successive approximations.[35]. Weighted linear regression(WLR), is a generalization of ordinary least squares and linear regression in which the errors covariance matrix is allowed to be different from an identity matrix. WLR is also a specialization of generalized least squares in which the above matrix is diagonal [36].

Finally, the models explained in above were used to predict the relationship between car parking demand and multivariable factor limiting this demand such as land use, family income, employee, etc. However, simple regression is achieved for comparison only, while the main aim of this study is to prove the significant of multi regression models in contrast to simple ones. It is worth mentioned that all data for each type of mentioned land uses above has been tested as the normal distribution data [35], after that, it has been observed that some data were not subject to normal distribution.

4. Results of predicted models for parking generation

The collected data were first categorized, processed, and outliers using SPSS program. The predictive linear regression must be equal to zero for a sample that was withdrawn from the community, meaning there is no relationship between the two variables (x, y) .It is worth mentioned that the scatter plot of collected data revealed the invalidity of simple linear regression relationships. Therefore, multiple linear regression enhanced the validity of the created parking generation model, however linear regression, multi linear regression, and non-linear regression are suggested[39]. Also, weighted least square linear regression was suggested when one of the regular least squares conditions is not met, and when dealing with unequal variance in Y by performing a weighted least square fit.

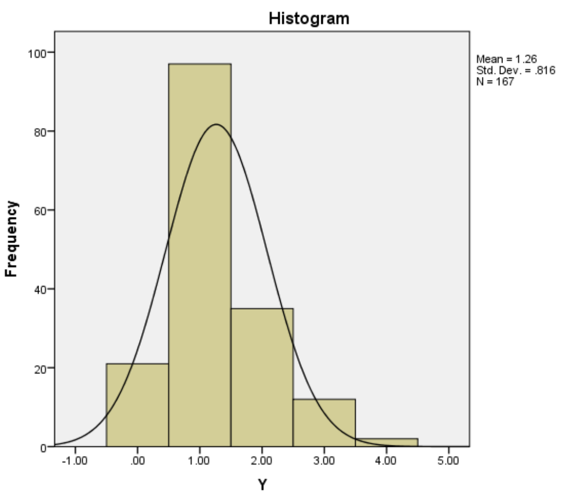
To prevent the duplication through this paper, the analysis and model creation process of one land use (i.e. Residential- Single Home) is presented hereinafter, while only the final models for other land uses are presented through Tables (8-14). The test was performed on the variables for the Residential- Single Home with number of data equal to 167. From Table 1, it is noted that the independent variables (i.e., Number of family, Dwelling units, monthly family income, and number of adults in the family) are correlated to response (i.e., Residential- Single Home). Some tests were performed to explore the normality of data, and then the appropriate way to determine and analyze this data.

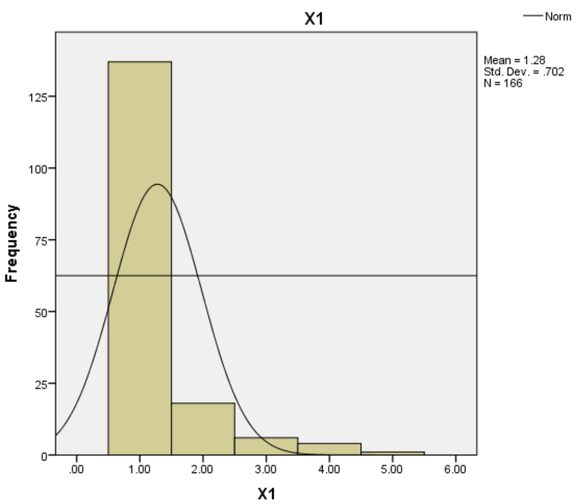
From the SPSS program,[40] the analysis option had chosen from tool bar, after that, the frequency histograms are determined for all variables as shown in Figure (1). This figure disclosed that the some data are not subject to the normal distribution. On other side, Table 2 shows the statistics of the data collected for Residential- Single Home land use and its variables. Such results disclose the importance of introducing multivariable approach in estimating the parking generation base, as example, on the variance values, the manifestation of the variance values are not equal.

Table 2. Descriptive Statistics for Residential- Single Home land use data

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Y	167	.00	4.00	1.2635	.81554	.665
X1	166	1.00	5.00	1.2771	.70174	.492
X2	167	2.00	6.00	4.4731	1.25061	1.564
X3	167	250.00	3000.00	1326.8802	588.53041	346368.046
X4	166	2.00	6.00	3.8193	1.46593	2.149
Valid N (listwise)	165					

The third test conducted on the data is the Levene test, the compare means was chosen, and one-way ANOVA has been putted. The test is conducted to disclose the homogeneity between dependent and independent variables. The homogeneity of variance test is noted from Table 3, the significant values are less than 0.05 for all factors. This also means that the y-values are not consistent with the rest of the variables.





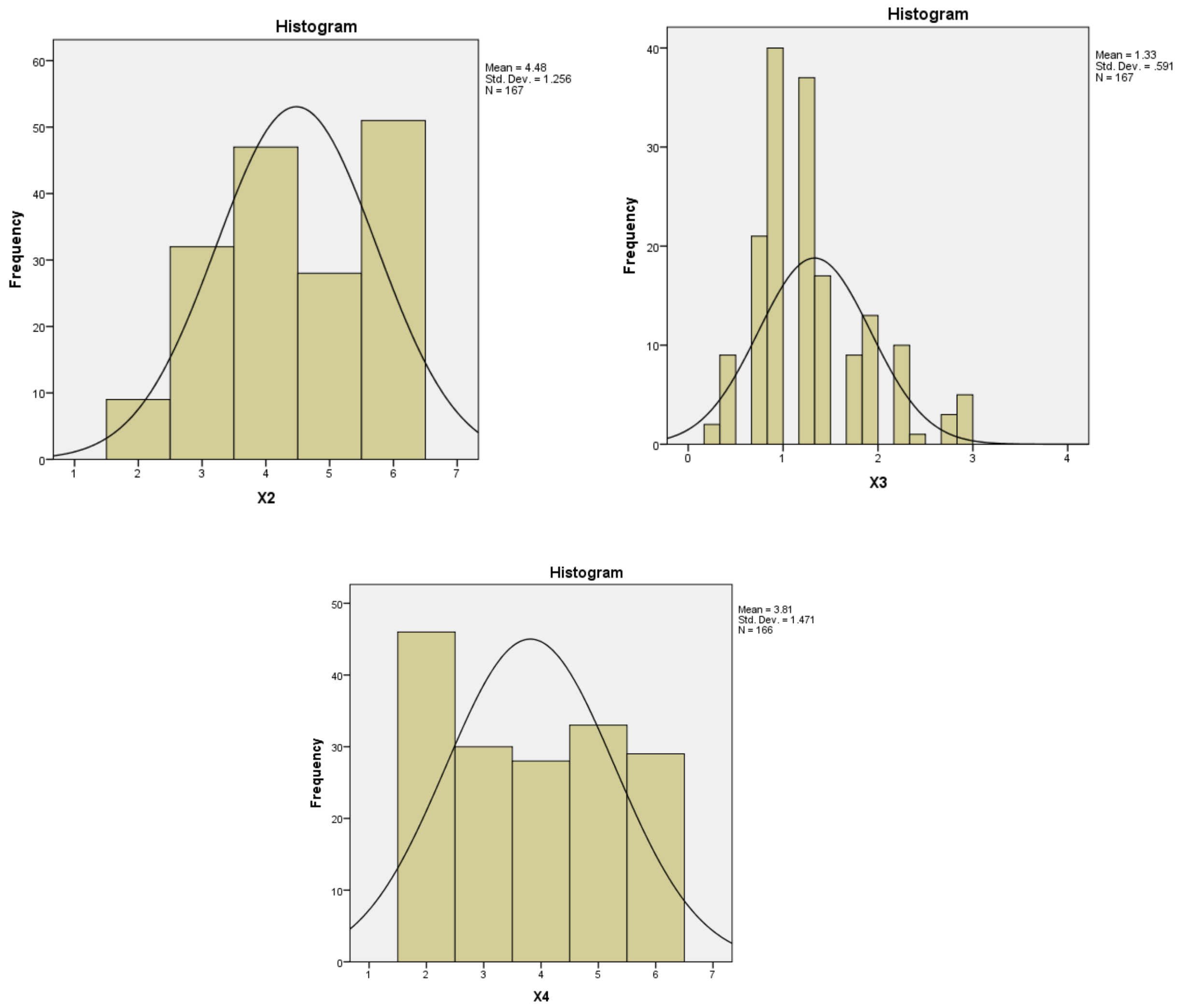


Figure 1. Normal distribution for y (Residential- Single Home), X1 (Number of family), X2 (Dwelling units), X3 (monthly family income), and X4 (number of adults in the family)

Table 3. Test of Homogeneity of Variances Y between other variables

variable	Levene Statistic	df1	df2	Sig.
X1	4.196	3	161	.007
X2	2.711	4	162	.032
X3	2.483	10	154	.009
X4	16.984	4	161	.000

It is noticed from Figure 2 that the dependent variable scatter plot has widespread data, which encouraged for choosing the WLR method in calculating the multiple statistical equation for multiple variables . However, the multi linear regression is determine to estimate the park generation of Residential- Single Home as summarized in Table 4, while Table 5 summarized a model using WLR, where the factor of weight had been calculated firstly, then it was used to create the model. As a result, the WLR model can significantly represent the observed value in contrast to multi linear regression as can be seen from the result stated in Tables 4 and 5.

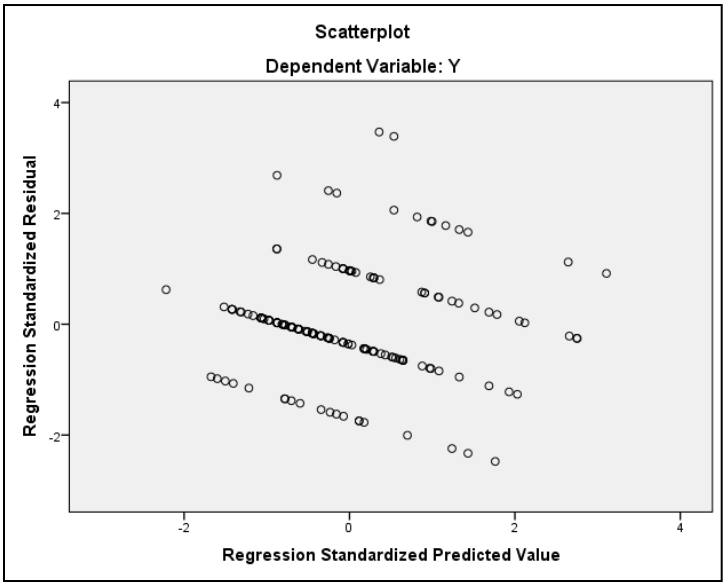


Figure 2. Scatterplot of dependent variable Residential- Single Home land use

Table 4. Model Summary for multi linear regression of Residential- Single Home land use

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.789[a]	0.623	0.64	.672
a. Predictors: (Constant), X4, X3, X1, X2				
b. Dependent Variable: Y				

Table 5. Model summary for WLR model of Residential- Single Home land use

Model Summary[b,c]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.961	0.923	.956	.99655
a. Predictors: (Constant), X4, X3, X1, X2				
b. Dependent Variable: Y				
c. Weighted Least Squares Regression - Weighted by WLR factor				

Moreover, Table 6 disclosed that the sum of squares of regression for WLR model is significantly higher that of residual, the sig. is close to zero and the mean square is reasonable. However, all these characteristics of WLR model plus the value of R^2 sustain the significant of the model in representing the observation. In other words, in estimating the park generation of such land use depends on multivariable factors. Furthermore, the mentioned factors reveal their importance in the model with acceptable reliability as their sig. is almost zero as can be seen in Table 7. An exception is the X1 (number of family) which could be retained to its variance or the its order in the created model. This imply a need for extra alteration to increase the reliability of this factor within the model.

Table 6. Summary of ANOVA data for WLR model of Residential- Single Home land use

ANOVA[a,b]					
Model	Sum of Squares	df	Mean Square	F	Sig.

1	Regression	3562.412	4	890.603	896.782	3.494E-75
	Residual	158.898	160	.993		
	Total	3721.310	164			

a. Dependent Variable: Y
b. Weighted Least Squares Regression - Weighted by WLR factor
c. Predictors: (Constant), X4, X3, X1, X2

Table 7. Summary of coefficients of independent variable (X1, X2, X3, X4) with dependent variable(Y) for WLR model of Residential- Single Home land use.

Coefficients [a,b]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.666	0.045		3.923	0.000182
	X1	0.187	0.043	-0.003	-0.155	.877
	X2	0.241	0.002	0.358	19.066	5.1354E-12
	X3	1.214	0.009	0.863	50.656	1.5453E-70
	X4	0.06	0.004	0.383	20.830	4.6323E-34

a. Dependent Variable: Y
b. Weighted Least Squares Regression - Weighted by WLR factor

Detailed statistical analysis using simple, multi linear and nonlinear models were conducted to finalize the best model for park generation of Residential- Single Home land use, as can be seen in Table 8. The results reveal the significant of multi variable models compare with simple linear and nonlinear model, namely, all the indices (i.e., R^2, sig., sum of regression, sum of residual, etc.) confirm that using multi independent variables in WLR model offers the best model for estimate the demand. Moreover, increasing the number of independent variables enhance the WLR model noticeably.

Table 1. Parking generation and supply needs for Residential- Single Home

Land use: residential- single home No. of studies:167							
PER	EQUATION	Statics method	R	R^2	Sum of regression	Sum of residual	Sig.
X1	$P = 0.763+0.785\ X$	Linear	0.472	0.223	37.457	164.747	$6.23x10^{-9}$
	$P = 1.528 + 1.523\ \ln(X)$	Logarithmic	0.469	0.22	36.556	165.647	$1.018x10^{-8}$
	$P = 3.907 + (-\frac{2.381}{x})$	Inverse	0.452	0.204	33.626	168.578	$4.5x10^{-8}$
	$P = 0.488 + 1.119\ X - 0.070\ X^2$	Quadratic	0.474	0.225	37.695	164.509	$4.49x10^{-8}$
	$P = 1.364 - 0.309X + 0.566\ X^2 - 0.080\ X^3$	Cubic	0.477	0.228	38.191	164.013	$1.77x10^{-7}$
	$P = 0.929\ (1.450^{X})$	*Compound*	0.459	0.211	8.615	39.344	$1.148x10^{-8}$
	$P = 1.332\ (X^{0.736})$	power	0.466	0.217	8.794	39.165	$7.8x10^{-9}$
	$P = 0.929\ (e^{0.372 * X})$	Exponential	0.455	0.207	8.615	39.344	$1.147x10^{-8}$
X2	$P = -0.004 + (1.221X)$	Linear	0.263	0.069	20.634	181.569	$2.6x10^{-5}$
	$P = 1.229 + (0.993\ \ln(X))$	Logarithmic	0.263	0.069	19.220	182.983	$5x10^{-5}$
	$P = 0.455 - \frac{3.564}{x}$	Inverse	0.253	0.064	16.651	185.553	$1.7x10^{-5}$
	$P = 0.488 + 0.327\ X - 0.010\ X^2$	Quadratic	0.265	0.070	21.073	181.130	$1.7x10^{-5}$
	$P = 1.176 - 0.258\ X + 0.139\ X^2 - 0.012\ X^3$	Cubic	0.265	0.070	21.073	181.130	$4.4x10^{-4}$
	$P = 0.812(-1.782^{X})$	*Compound*	0.268	0.072	5.111	42.848	$1.7x10^{-5}$

	$P = -0.162(X^{0.736})$	power	0.268	0.072	4.795	43.164	$3.1x10^{-5}$
	$P = 0.851\ (e^{0.120*X})$	Exponential	0.268	0.072	5.111	42.848	$1.147x10^{-8}$
	P = 0.627+ (0.243 X)	Linear	0.612	0.374	80.703	121.500	$5.47x10^{-20}$
	P = 0.267+ (1.778 ln(X))	Logarithmic	0.587	0.344	72.794	129.410	$1.045x10^{-17}$
	$P = 3.298+(-\frac{1.947}{X})$	Inverse	0.515	0.265	54.495	147.708	$6.58x10^{-13}$
X3	$P = 0.063+ (1.132X) + (0.025X^2)$	Quadratic	0.612	0.374	80.897	121.306	$6.36x10^{-19}$
	$P = 1.594-2.025\ X + 1.987X^2 - 0.367X^3$	Cubic	0.619	0.383	82.927	119.276	$1.372x10^{-18}$
	$P = 0.649 * (1.776^X)$	*Compound*	0.575	0.331	17.485	30.474	$5.74x10^{-18}$
	$P = 1.156 * (X^{0.848})$	power	0.511	0.261	16.20	31.759	$1.79x10^{-16}$
	$P = 0.649 * (e^{0.575*X})$	Exponential	0.592	0.351	17.485	30.474	$5.74x10^{-18}$
	P = 0.421+0.359X	Linear	0.453	0.205	44.703	157.501	$1.44x10^{-10}$
	P = 0.258+1.211ln(X)	Logarithmic	0.439	0.193	72.794	129.410	$1.045x10^{-17}$
	$P = 2.89+ (\frac{-3.607}{x})$	Inverse	0.418	0.175	37.795	164.409	$5.39x10^{-9}$
X4	$P = 0.789+ 0.135X-0.029X^2$	Quadratic	0.454	0.206	80.897	121.306	$6.36x10^{-19}$
	$P = 2.429-1.340X+ 0.431X^2- 0.034X^3$	Cubic	0.457	0.209	45.565	156.638	$4.54x10^{-9}$
	$P = 0.766\ (1.195^X)$	Compound	0.462	0.213	11.251	36.708	3.3110^{-11}
	$P = 0.699(X^{0.61})$	power	0.456	0.208	10.808	37.151	$9.09x10^{-11}$
	$P = 0.766\ (e^{0.178\,X})$	Exponential	0.462	0.213	11.251	36.708	$3.311x10^{-11}$
X1, X2	P=-0.54+0.741X1+0.19X2	Multi regression	0.515	0.265	50.709	151.495	$5.22x10^{-11}$
	P=-0.53+0.715X1+0.31X2	WLR	0.869	0.755	501.77	422.708	$1.353x10^{-28}$
X1, X2, X3	P=-0.905+0.619X1+0.081X2+1.054X3	Multi regression	0.723	0.522	105.66	96.539	$5.045x10^{-26}$
	P=-0.470+0.59X1+0.05X2+0.888X3	WLR	0.948	0.898	2823.046	320.133	$1.36x10^{-80}$
X1, X2, X3, X4	P=--1.358+0.58X1-0.008X2+X3+0.267X4	Multi regression	0.789	0.623	125.95	76.249	$2.5322x10^{-33}$
	P=-1.666+0.187X1-0.241X2+1.214X3+0.06X4	WLR	0.961	0.923	3562.412	158.898	$3.494x10^{-75}$

Similar to mentioned sample of Residential -Single Home model statistical analysis, other type of land uses was subjected to precise analysis to optimize the best fit (model) which can be used for parking generation estimation. Moreover, the collected data for the land types (i.e., Restaurant, Super Market, Commercial Shops, Education, Medical / Clinics and university) were processed using simple, multi linear and nonlinear models to achieve the draw aim. As a result, the obtained models are presented in Tables 9-15. For each land use a set of equations that are built with different validation indices. Two main finding can disclose from the obtained results, the first is the significant of multivariable models for all land uses over the simple linear or nonlinear models. While the second is the outstanding of WLR method compare with multi-regression method for all land use models, with one exception (i.e., restaurant), as can be seen in Table 16.

Table 9. Parking generation and supply needs for Restaurant

Land use: restaurant No. of studies:217							
PER	Equation	Statics method	R	R2	Sum of reg.	Sum of residual	Sig.
X1	P = 0.739+ 0.128X	Linear	0.01	0.100	1.820	184.171	0.146
	P = 0.582+.512 ln(X)	Logarithmic	0.01	0.100	1.835	184.156	0.145
	$P = 1.783 + (-\frac{-1.732}{x})$	Inverse	0.009	0.095	1.715	184.276	0.159
	$P = 0.456+ 0.272X-0.016X^2$	Quadratic	0.01	0.100	1.877	184.113	0.338
	$P = 0.488-0.224X -0.002X^3$	Cubic	0.011	0.105	1.901	184.090	0.333
	$P = 0.951(1.055^X)$	*Compound*	0.007	0.084	0.312	45.309	0.225
	$P = 0.865\ (X^{0.230})$	power	0.008	0.089	0.370	45.251	0.187
	$P = 0.951\ (e^{0.053*X})$	Exponential	0.007	0.084	0.312	45.309	0.225

X2	P = 0.619+ (0.033X)	Linear	0.947	0.896	166.64	19.342	$1.22x10^{-107}$
	P = -0.045+ (0.567ln(X))	Logarithmic	0.699	0.488	91.026	94.965	$3.2x10^{-33}$
	P = 1.755- $\frac{-2.174}{x}$	Inverse	0.370	0.137	25.497	160.494	$1.868x10^{-8}$
	P = 0.901+0.007X	Quadratic	0.975	0.951	176.96	9.022	$2.4x10^{-141}$
	P = 1.217-0.054X+0.002X²	Cubic	0.990	0.98	182.36	3.625	$8.4x10^{-182}$
	$P = 0.850(1.016^X)$	*Compound*	0.937	0.878	40.044	5.577	$4.35x10^{-100}$
	$P = 0.590(X^{0.293})$	power	0.728	0.53	24.236	21.385	$3.14x10^{-37}$
	$P = 0.850\ (e^{0.016*X})$	Exponential	0.937	0.878	40.044	5.577	$4.35x10^{-100}$
X3	P = 0.928+ (0.027X)	Linear	0.06	0.245	11.525	174.465	0.000212
	P = 0.305+ (0.407 ln(X))	Logarithmic	0.054	0.232	10.275	175.716	0.000481
	P = 1.704+(-$\frac{-3.471}{X}$)	Inverse	0.031	0.176	5.917	180.073	0.008450
	P = 0.55+ (0.075X) + (-0.001X²)	Quadratic	0.068	0.261	13.024	172.967	0.000423
	P = 2.606-0.369X +0.025X²	Cubic	0.162	0.402	30.541	155.449	$2.44x10^{-8}$
	$P = 0.965 * (1.015^X)$	*Compound*	0.07	0.265	3.299	42.322	0.00006
	$P = 0.698 * (X^{0.214})$	power	0.061	0.247	2.850	42.771	0.0002
	$P = 0.965 * (e^{0.015*X})$	Exponential	0.07	0.265	3.299	42.322	0.00006
X1,X2	P=-0.639- 0.04X1+0.033X2	Multi regression	0.947	0.896	166.64	19.341	$6.58x10^{-106}$
	P=-0.766-0.017X1+0.031X2	WLR	0.924	0.855	1897.01	329.593	$1.68x10^{-89}$
X1,X2,X3	P=0.55+0.054X1+0.035X2-0.14X3	Multi regression	0.953	0.908	168.85	17.139	$5.83x10^{-110}$
	P=0.495+0.054X1+0.033X2-0.009X3	WLR	0.94	0.884	2714.079	361.276	$9.76x10^{-99}$

Table 10. Parking generation and supply needs for Commercial Shops

Land use: commercial shops No. of studies:130							
PER	Equation	Statics method	R	R2	Sum of reg.	Sum of residual	Sig.
X1	P = 0.715+0.22X	Linear	0.330	0.109	6.502	52.89	$1.28x10^{-4}$
	P = 0.876+0.498 ln(X)	Logarithmic	0.300	0.09	5.370	54.02	0.000536
	P = 1.752+ ($\frac{-0.898}{x}$)	Inverse	0.265	0.07	4.135	55.26	0.002516
	P = 1.816 -0.699 X-0.163X²	Quadratic	0.387	0.15	8.922	50.47	0.000035
	P = -0.916-3.15X -1.428X²-0.199X³	Cubic	0.483	0.233	13.84	45.55	$2.79x10^{-7}$
	$P = 0.826(1.152^X)$	*Compound*	0.363	0.132	2.683	17.71	$2.4x10^{-5}$
	$P = 0.913\ (X^{0.322})$	power	0.332	0.11	2.249	18.14	0.000121
	$P = 0.826\ (e^{0.141*X})$	Exponential	0.363	0.132	2.683	17.71	0.000024
X2	P = 0.748+ (0.014X)	Linear	0.834	0.695	41.29	18.09	$1.42X10^{-34}$
	P = -1.231+ (0.742 ln(X))	Logarithmic	0.775	0.6	35.63	23.76	$4.914X10^{-27}$
	P = 1.963- $\frac{-15.391}{x}$	Inverse	0.551	0.304	18.03	41.36	$1.32X10^{-11}$
	P = 0.680+0.017X	Quadratic	0.835	0.697	41.39	18.001	$2.17X10^{-33}$
	P = 0.630-0.021X	Cubic	0.835	0.697	41.41	17.979	$2.74X10^{-32}$
	$P = 0.874(-1.009^X)$	*Compound*	0.838	0.702	14.31	6.076	$3.39X10^{-35}$
	$P = 0.259(X^{0.451})$	power	0.804	0.646	13.17	7.224	$2.09X10^{-30}$
	$P = 0.874\ (e^{0.008*X})$	Exponential	0.838	0.702	14.318	6.076	$3.39X10^{-35}$
X3	P = 0.784+ (0.145X)	Linear	0.506	0.256	15.193	44.202	$9.734X10^{-10}$
	P = 0.677+ (0.561ln(X))	Logarithmic	0.485	0.235	13.941	45.455	$5.97X10^{-9}$
	P = 1.801+(-$\frac{-1.192}{X}$)	Inverse	0.390	0.152	9.021	50.375	$5X10^{-6}$

	P = 0.612+ (0.227X) + (-0.008X²)	Quadratic	0.512	0.262	15.564	43.831	$4.85X10^{-9}$
	P = 1.285--0.324X + 0.111X² -0.007X³	Cubic	0.536	0.287	17.022	42.374	$3.34X10^{-9}$
	$P = 0.866 * (1.096^{X})$	*Compound*	0.550	0.302	6.159	14.235	$1.538X10^{-11}$
	$P = 0.817 * (X^{0.350})$	power	0.516	0.266	5.422	14.972	$4.029X10^{-10}$
	$P = 0.866 * (e^{0.092* X})$	Exponential	0.550	0.302	6.159	14.235	$1.53X10^{-11}$
X1,X2	P= 0.587+0.057X1+0.14X2	Multi regression	0.838	0.702	41.690	17.705	$7.65X10^{-34}$
	P=0.805-0.12X1+0.014X2	WLR	0.972	0.944	3239.328	190.452	$8.02X10^{-80}$
X1,X2,X3	P=-0.595+0.059X1+0.014X2-0.005X3	Multi regression	0.838	0.702	3253.819	175.960	$2.11X10^{-80}$
	P=-0.873+0.005X1+0.015X2-0.4X3	WLR	0.970	0.940	2267.553	275.147	$3.71X10^{-60}$

Table 11. Parking generation and supply needs for Super Market

Land use : super market No. of studies:143							
PER	Equation	Statics method	R	R2	Sum of reg.	Sum of residual	Sig.
X1	P = 0.796+0.174X	Linear	0.005	0.071	0.718	137.799	0.392
	P = 0.130+0.955ln(X)	Logarithmic	0.005	0.071	0.718	137.799	0.393
	$P = 2.711+ (\frac{-5.221}{x})$	Inverse	0.005	0.071	0.718	137.799	0.393
	P = 0.796 +0.174X	Quadratic	0.005	0.071	0.718	137.799	0.393
	$P = 0.746(1.140^{X})$	*Compound*	0.012	0.110	0.405	33.525	0.1942
	$P = 0.452\ (X^{0.717})$	power	0.012	0.110	0.405	33.525	0.1942
	$P = 0.746\ (e^{0.131* X})$	Exponential	0.012	0.110	0.405	33.525	0.1942
X2	P = -1.461+ (0.017X)	Linear	0.867	0.752	104.165	34.353	$1.57X10^{-44}$
	P = -16.034+ (3.413ln(X))	Logarithmic	0.858	0.736	101.992	36.526	$1.2X10^{-42}$
	$P = 5.438- \frac{-657.021}{x}$	Inverse	0.846	0.715	99.079	39.439	$2.72X10^{-40}$
	P = 0.432-0.002X	Quadratic	0.872	0.76	105.280	33.237	$4.06X10^{-44}$
	$P = 0.303(-1.009^{X})$	*Compound*	0.890	0.792	26.857	7.073	$7.37X10^{-50}$
	$P = 1.764\ (X^{0.000157})$	power	0.896	0.803	27.253	6.677	$1.26X10^{-51}$
	$P = 0.303(e^{0.009 * X})$	Exponential	0.890	0.803	26.857	7.073	$7.37X10^{-50}$
X3	P = -0.399+ (0.220X)	Linear	0.580	0.336	46.533	91.985	$3.33X10^{-14}$
	P = -1.801+ (1.592ln(X))	Logarithmic	0.499	0.249	34.424	104.093	$2.35X10^{-10}$
	$P = 2.792+(-\frac{8.991}{X})$	Inverse	0.392	0.154	21.366	117.152	0.000001
	P = 2.912+ (-0.549X) + (0.041X²)	Quadratic	0.680	0.462	64.043	74.475	$1.36X10^{-19}$
	P = 1.667-0.067X -.015X² -0.002X³	Cubic	0.683	0.466	64.499	74.018	$7.9X10^{-19}$
	$P = 0.521 * (1.118^{X})$	*Compound*	0.593	0.352	11.935	21.994	$5.95X10^{-15}$
	$P = 0.252 * (X^{0.813})$	power	0.514	0.264	8.973	24.957	$5.05X10^{-11}$
	$P = 0.521 * (e^{0.111* X})$	Exponential	0.593	0.352	11.935	21.994	$5.95X10^{-15}$
X1,X2	P= -0.060-0.255X1+0.017X2	Multi regression	0.873	0.763	105.650	32.868	$1.85X10^{-44}$
	P=-0.85-0.149X1+0.018X2	WLR	0.797	0.636	634.154	363.005	$1.9X10^{-31}$
X1,X2,X3	P=-0.282-0.349X1+0.016X2-0.046X3	Multi regression	0.877	0.770	106.647	31.871	$3.72X10^{-44}$
	P=-0.853-0.147X1+0.018X2+0.01X3	WLR	0.905	0.819	782.240	172.435	$1.89X10^{-51}$

Table 12. Parking generation and supply needs for Education

Land use : education No. of studies :406							
PER	Equation	Statics method	R	R2	Sum of reg.	Sum of residual	Sig.
x1	P = 1.922+.022X	Linear	0.440	0.194	98.796	410.942	$1.25X10^{-20}$
	P = -1.152+1.105ln(X)	Logarithmic	0.448	0.201	102.570	407.168	$1.25X10^{-20}$
	P = 4.076+ ($\frac{-41.669}{x}$)	Inverse	0.428	0.183	93.411	416.327	$1.91X10^{-21}$
	P = 1.430 +0.044X	Quadratic	0.448	0.201	102.452	407.286	$2.58X10^{-20}$
	P = 0.139+0.137X-0.002X^2	Cubic	0.453	0.205	104.509	405.229	$7.67X10^{-20}$
	$P = 1.719(1.009^{X})$	*Compound*	0.418	0.175	18.390	86.581	$1.31X10^{-18}$
	$P = 0.431\ (X^{0.493})$	power	0.442	0.195	20.422	84.548	$1.03X10^{-20}$
	$P = 1.719\ (e^{0.009*X})$	Exponential	0.418	0.175	18.390	86.581	$1.25X10^{-20}$
X2	P = 1.823+ (0.002X)	Linear	0.221	0.049	25.028	484.711	0.000007
	P = -0.481+ (0.521ln(X))	Logarithmic	0.122	0.015	7.477	502.261	0.014734
	P = 2.824+ ($\frac{-18.353}{x}$)	Inverse	0.009	0.00008	0.041	509.698	0.8577
	P = 7.380+ (-0.018X)	Quadratic	0.495	0.245	125.052	384.686	$2.68X10^{-25}$
	P = -0.089+ 0.000147X+19.2X^3	Cubic	0.569	0.319	165.178	344.560	$1.25X10^{-20}$
	$P = 1.542 * (1.001^{X})$	*Compound*	0.245	0.06	6.252	98.718	$6.63X10^{-7}$
	$P = 0.357 * (X^{0.310})$	power	0.158	0.025	2.651	102.319	0.00133
	$P = 1.542 * (e^{0.001*X})$	Exponential	0.245	0.06	6.252	98.718	$6.63X10^{-7}$
X1,X2	P=-0.279+0.026X1+0.003X2	Multi regression	0.552	0.304	155.111	354.627	$2.12X10^{-32}$
	P=0.138+0.012X1+0.002X2	WLR	0.964	0.928	890.870	377.048	$1.36X10^{-106}$

Table 13. Parking generation and supply needs for Medical / Clinics

Land use : medical / clinics No. of studies :102							
PER	Equation	Statics method	R	R2	Sum of regression	Sum of residual	Sig.
X1	P = 0.829+0.149X	Linear	0.562	0.316	8.874	19.168	$7.59X10^{-10}$
	P = 0.233+0.868ln(X)	Logarithmic	0.588	0.346	9.692	18.350	$8.22X10^{-11}$
	P = 2.470+ ($\frac{-3.550}{x}$)	Inverse	0.560	0.314	8.799	19.243	$9.26X10^{-10}$
	P = 0.186 +0.359X-0.016X^2	Quadratic	0.593	0.352	9.863	18.179	$4.8X10^{-10}$
	P = -0.431+0.759X-0.085X^2+0.004X^3	Cubic	0.596	0.355	9.960	18.082	$2.21X10^{-9}$
	$P = 1.002(1.087^{X})$	*Compound*	0.553	0.306	2.771	6.290	$1.67X10^{-9}$
	$P = 0.670\ (X^{0.521})$	power	0.620	0.385	3.486	5.574	$3.57X10^{-12}$
	$P = 1.002\ (e^{0.083*X})$	Exponential	0.553	0.306	2.771	6.290	$1.67X10^{-9}$
X2	P = -0.230+ (0.566X)	Linear	0.647	0.419	11.739	16.302	$2.02X10^{-13}$
	P = -0.230+ (1.630ln(X))	Logarithmic	0.618	0.382	10.701	17.340	$4.63X10^{-12}$
	P = 3.141+$\frac{-4.464}{x}$	Inverse	0.592	0.35	9.827	18.215	$5.65X10^{-11}$
	P = 3.034 -1.654X+0.350X^2	Quadratic	0.713	0.508	14.250	13.792	$5.56X10^{-16}$
	P =-9.210+10.079X-3.153X^2+0.333X^3	Cubic	0.761	0.579	16.232	11.810	$2.41X10^{-18}$
	$P = 0.488 * (1.419^{X})$	*Compound*	0.704	0.495	4.486	4.575	$1.615X10^{-16}$

	$P = 0.471 * (X^{1.034})$	power	0.689	0.475	4.307	4.754	$1.125X10^{-15}$
	$P = 0.488 * (e^{0.350*X})$	Exponential	0.704	0.495	4.486	4.575	$1.615X10^{-16}$
X1, X2	P=-0.135+0.051X1+0.443X2	Multi regression	0.66	0.436	12.223	15.819	$4.93X10^{-13}$
	P=-0.11-0.037X1+0.592X2	WLR	0.997	0.994	25550.382	155.896	$1.77X10^{-110}$

Table 14. Parking generation and supply needs for university

Land use :university No. of studies :281							
PER	Equation	Statics method	R	R2	Sum of reg.	Sum of resid.	Sig.
X1	P = 1.448	Linear	0.173	0.03	7.576	243.198	0.003587
	P = -0.227+0.3 ln(X)	Logarithmic	0.295	0.087	21.865	228.909	$5.1X10^{-7}$
	P = 2.306+ $(\frac{-217.33}{x})$	Inverse	0.424	0.18	45.095	205.679	$1.32X10^{-13}$
	P = -0.141 -0.006 X	Quadratic	0.511	0.261	65.577	185.197	$6.79X10^{-19}$
	P = 1.261- X	Cubic	0.515	0.265	66.499	184.275	$1.77X10^{-110}$
	$P = 0.1.261(1^{X})$	*Compound*	0.221	0.049	3.285	63.516	0.000189
	$P = 0.464 (X^{0.18})$	power	0.344	0.118	7.887	58.913	$3.76X10^{-9}$
	$P = 1.261 (e^{0})$	Exponential	0.221	0.049	3.285	63.516	0.000189
X2	P = 0.910+ (0.003X)	Linear	0.870	0.757	189.75	61.016	$5.29X10^{-87}$
	P = -0.51+ (0.473 ln(X))	Logarithmic	0.797	0.635	159.13	91.643	$1.69X10^{-62}$
	P = 2.164- $\frac{-20.2}{x}$	Inverse	0.597	0.357	89.554	161.22	$2.129X10^{-28}$
	P = 1-0.001X	Quadratic	0.871	0.759	190.25	60.525	$6.39X10^{-86}$
	P = 0.959+X	Cubic	0.872	0.76	190.48	60.292	$8.87X10^{-85}$
	$P = 0.959(1.001^{X})$	*Compound*	0.901	0.812	54.232	12.569	$1.76X10^{-102}$
	$P = 0.443(X^{0.256})$	power	0.835	0.697	46.588	20.213	$7.15X10^{-74}$
	$P = 0.959 (e^{0.001*X})$	Exponential	0.901	0.812	54.232	12.569	$1.75X10^{-102}$
X3	P =1.449+$2.085X^{-5}$	Linear	0.169	0.029	7.158	243.616	0.004659
	P = -0.826+ (0.297ln(X))	Logarithmic	0.268	0.072	18.105	232.670	0.000005
	P = 2.19- $\frac{-1528}{x}$	Inverse	0.344	0.118	29.602	221.172	$3.78X10^{-9}$
	P = -4.047+ (0.003X)	Quadratic	0.825	0.681	170.86	79.912	$2.88X10^{-69}$
	P = -3.652- 0.002X	Cubic	0.832	0.692	173.62	77.155	$2.26X10^{-71}$
	$P = 1.261 * (1^{X})$	*Compound*	0.217	0.047	3.142	63.658	0.000263
	$P = 0.315 * (X^{0.182})$	power	0.318	0.101	6.770	60.030	$5.45X10^{-8}$
	$P = 1.261 * (e^{0})$	Exponential	0.217	0.047	3.142	63.658	0.000263
X1, X2	P= 0.929 +0.003X2	Multi regression	0.871	0.758	190.14	60.626	$8.04X10^{-86}$
	P=0.996 +0.003X2	WLR	0.875	0.766	727.57	222.569	$1.03X10^{-87}$
X1, X2, X3	P=0.918-0.001X1+0.003X2	Multi reg.	0.871	0.759	790.27	159.867	$4.5X10^{-106}$
	P=0.922-0.01X1+0.003X2+0.0005X3	WLR	0.907	0.822	791.50	172.887	$2.737X10^{-102}$

Table 15. Parking generation and supply needs for all type of land use in Karbala City

Land use	Avg.	PER	Equation	Statics method	R	R2	NO. OF STUDIES
Residential - Single Home	1.723	X1, X2, X3, X4	P=-1.666+0.187X1-0.241X2+1.214X3+0.06X4	WLR	0.961	0.932	167
Restaurant	1.45	X1, X2, X3	P= 0.55+0.054X1+0.035X2-0.14X3	Multi regression	0.953	0.908	217
Commercial Shops	1.192	X1,X2, X3	P = 0.873+0.005X1+0.015X2-0.4X3	WLR	0.97	0.94	130
Super Market	1.8	X1, X2, X3	P = 0.018X2+0.01X3-(0.853+0.147X1)	WLR	0.905	0.819	143
Education	2.78	X1, X2	P=0.138+0.012X1+0.002X2	WLR	0.964	0.928	406

Medical / Clinics	1.91	X1, X2	P=-0.11-0.037X1+0.592X2	WLR	0.997	0.994	102
university	1.55	X1, X2,X3	P=0.922-0.01X1+0.003X2+0.0005X3	WLR	0.907	0.822	281

5. Conclusions

Estimating the demand of parking spaces is important because it has a great relationship with the development, design and planning of the transportation network. However, the holy City of Karbala is in high need for complete and specialized documents that provide engineers and planners with an estimate of the demand for parking spacings. This research is considered as a attempt to establish park generation models using multi variable factor affecting these generation. From the extensive statistical analysis of the collected data to create the best model for parking generation of different land uses, the following can be concluded:

1. Using recommended ITE parking manual estimation model is statistically insignificant
2. Utilizing simple regression model in estimating the park generation led to marginal estimation
3. Introducing multivariable factors in model creation of park generation show it outstanding validity, moreover, as much factor use, the best reliable model can obtain for all land use types.
4. WLR method reveals its significant compare with multi-regression statistical method in create park generation models for all land use type. Only one exception where the restaurant is represented by multi regression model which is slightly best than WLR method.

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