Parking Requirement of Institutional Land Use

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Abstract. Parking demand rates are one of the essential keys to urban city planning around the world. Most cities produced the most suitable parking rates, and models relied on their local conditions, regulations, and people's habits. In Iraq, there is a lack of parking studies, and therefore, there is a lot of missing information which if be found, will be very valuable for better enhancing and managing the transportation network system. Institutional land use or Government Ministries are the land use type in which this research tries to find its parking generation rates. The goal is to produce models and rates for parking generation by using certain independent variables according to the characteristics of the land-use type. The research study area is the urban areas outside Baghdad CBD. Several sites were selected located in different parts of Baghdad. The number of study sites is three. The collected data about sites are the total number of site employees, site gross floor area, and maximum parked vehicles at each site for an Am and Pm period. Each site has a clear parking lot; besides, the sites were selected relied on particular criteria. The field survey was done at each site for defining days and times. The final stage is a data analysis and producing parking generation rates and models to determine the required parking demand for this land-use type. Statistical analysis of data, model generation, was done by the computer program (SPSS). It concluded that the institutional land use produced 0.94 spaces per 100 m² of GFA and 0.1 spaces per employee.

Keywords: Parking Generation Rate, Transportation Planning; Parking Demand; Institutional land use.

1. Introduction
The rapid developments with low or inefficient planning produce high disadvantages that affect the city's urban morphology, city economies, transportation networks, and even private investments. The number of car owners has increased dramatically in recent decades globally, and Iraq in particular [1]. Ignoring the provision of suitable parking demand spaces for different land uses types would be led to a set number of parking spaces arbitrarily. So parking spaces will be either lower than required and in this case, there will be an increase in on-street parking which has many adverse effects besides its impact on the level of service. Alternatively, the parking spaces are more than required and that also is not desirable, as it will cause land loss, which can be used in other sufficient ways, besides the economic
losses. For example, in 2017, San Francisco city made a comparative report for the parking area, the report concluded that approximately 28% of available parking spaces are not used as an average, which means construction cost is 198,034,400 $. Moreover, the report indicated that from the surveys, a hundred parking spaces are not always used with median construction cost 19,700$ for space [2]. The phenomenon of parking varies during a time much relies on the law of supply and demand. For a particular area, the supply represents the available, total number of parking spaces, while the demand represents the desired vehicles to park in that area [3]. More clearly, the parking demand in a particular area is the peak accumulation of vehicles in a given time interval [4]. Also, parking demand is a function of both the arrival rates of vehicles and their stay duration [5]. In general, Iraq does not have a book or a manual to estimate parking generation rates. There is a lack of parking studies, and therefore, there is a lot of missing information, which will be very valuable for enhancing the transportation network system and help better manage the system. Therefore, providing parking generation rates and equations for each land use type will help in determining the required parking spaces for each new development.

2. Background

The phenomenon of difficult parking and disorderly parking is a serious problem, which has had enormous adverse effects on the life of the public and the development of the city [6]. The 5th edition of the Institute of Transportation Engineers (ITE) Parking Generation manual involves different land use classifications; ITE suggests variables for office land use analysis in terms of employees and area [7]. The parking generation studies have a wide range globally and historically. Many studies, reports, models, and rates of parking generation, have been submitted and published by different countries over the years. While every country has unique features, but all countries have specific characteristics in common with other countries. Church and Al-Kaisy, 2009 [8] studied parking generation data for a small offices complex located in Montana. The study results for the parking generation rate is 1.67 spaces is required for 1000 Ft² of GFA for office buildings. It concluded that the GFA of all categories has a strong relationship with the number of occupied parking spaces in peak hours. Al-Maseid et al., 1999 [9] in Jordan, prepared and published parking generation models for several different types of land uses. The study contains 208 sites distributed in different parts of Jordan to increase the domain of interference. The site's distributions were 53 hospitals, 35 apartments of building, 40 hotels, 12 restaurants, 17 malls, and 42 office buildings. The produced statistical parking models relied on max parking accumulation during the 15-minute intervals and different variables to the different land use. For the developed model for office building land use, two models were developed, one depending on the number of buildings offices and the other relying on gross floor area. The peak parking demand of office buildings was varied from 13 to 94 for buildings having 45 to 840 offices and an area of 900 to 18,000 m². In another study, Al-sahili and Hamadneh, 2016 [10] developed generation rates of parking facilities for Palestine city, 73 sites investigated with different land uses, 26 sites for office land use were investigated. He stated that GFA, GLA, and the number of vehicles owned by workers are the predominant independent variables for office land use, the resulted trip rate per GFA/100 m² equals 2.41. Kuah, 1991 [11] concerning estimate parking demand for mixed land use subject to TSM programs. He stated that developers must relay their decision on the right number of parking spaces to provide the required spaces that affect finance. The Department of Transport of Abu Dhabi prepared a manual for the minimum amount of parking spaces for different local land uses through the survey on nearly 400 different sites throughout the Emirate [12]. While the Findings from the study by Shatnawi, Ibrahim M [13] suggest that lower parking requirements for Abu Dhabi can be used when compared to the Dubai manual rates. Al-Ghanimy and Asmael 2020, [14] state that both GFA and the number of employees produced high reliability for parking generation models for educational sites.

The Mayoralty of Baghdad, the design department, published several laws and regulations about the building of local Iraqi units, one of these regulations is the parking regulation that circulated to the municipalities in 2012. The regulation provides the number of parking spaces required for different land uses types. For example, from the regulation, the required parking spaces for government institutional and local companies are 3 spaces for every 100 m².
3. Site Selection

Baghdad city is the study area; several sites in different parts of Baghdad were selected for data collection, analysis, and model production. This research is focused on urban sites out of the CBD area and some criteria were used for site selection like the site should be mature at least two years old, occupy by at least (85%), the site should be clear, and no abnormal condition beside it. Also, most importantly the site should have an obvious and specific parking lot.

The sample size concept should be appropriate and reasonable to give the best representation to the study area. The 4th ITE manual stated that a minimum of four sites for an individual land-use type should be provided for the best analysis and outputs. However, for the studied ministries, the research excluded the ministries of service, health, military, and any ministry that does not accept the entry of ordinary citizens. Also, the data collection in ministries in Iraq is hard with many obstacles that require much official and government approvals therefore only three ministries were studied. All of them are achieved the above site selection criteria as shown in table 1, the selected ministries and their location.

| Site name                        | Location                                      |
|---------------------------------|-----------------------------------------------|
| Ministry of Science and Technology | Al-Rusafaa side. Karadaa district. Jadriyah region. |
| Ministry of Water Resources      | Al-Rusafaa side. Palestine street.             |
| Ministry of Culture              | Al-Karkh side. Haifa street.                   |

3.1. Ministry of Science and Technology

This Ministry was created in 2003. Its combination of several large buildings contains 12 departments. Besides, the Ministry contains scientific laboratories and industrial workshops. The Ministry has two gates for vehicles entering and exiting; the two gates are open on a local street. The ministry is located nearby Baghdad University, the oasis mall, and other government institutions. The ministry policy about the people who can be using its parking lot is strict and specific, were only for particular people. Public transportation does not reach the Ministry directly, far from it around 0.1 km. figure 1 shows the location of this Ministry.

3.2. Ministry of Water Resources

This ministry site has only one building, which represents the headquarters of the Ministry. The building is large and consists of 11 floors with a wide area. Near the ministry location, two government ministries
besides three other ministries are located close to it. As well as Al-Nakheel mall, which is far from the Ministry around 0.5 km. The Ministry is located directly on Palestine Street, and public transportation can reach it directly. Figure 2 shows the location of this Ministry.

![Figure 2. Ministry of Water Resources and its Surveyed Parking Areas](image)

3.3. Ministry of Culture

This ministry site consists of one large building, represents the headquarters of the Ministry. The building consists of six floors, and several gardens, and empty spaces. The Ministry is located on Haifa Street. Moreover, In front of it, the building of the Ministry of tourism and antiquities is located. The public transportation was limited to certain areas and can reach the Ministry directly. Also, the Ministry has several buses for employees' transportation. Figure 3 shows the location of this Ministry.

![Figure 3. Ministry of Culture and its Surveyed Parking Areas](image)

4. Methodology

1. Independent variables selection: The parking generation models and rates are used to predict the parking demand for a site, according to its land-use type. These models and rates are consist of independent variables, which vary with the land use type. The research selected two independent variables used to generate the model and rates are:
   - Gross Floor Area (GFA): is the area within the external walls of a building, excluding any area dedicated to the parking of vehicles including all common areas shared by customers when considers the joint retail areas.
The number of employees: the total number of employees that worked in the studied ministry building only. (The employees of sub-divisions affiliated with the ministry, but they have not worked in the ministry headquarter, are not counted).

2. Data collection using field Surveys: this step was done to collect two types of data:
First type: site’s properties data: it is the data about the selected independent variables Gross Floor Area (GFA) and No. of employees.

Second type: parking counts and inventories, the parking counts were done to calculate the car accumulation (parking demand) at each site. According to Garber and Hoel, 2014 [4], the parking demand is the accumulation of vehicles parked at a given site at any associated point in time. Therefore this survey is done in two steps:

A. Determination Counting periods and duration; this step is the major step in the counting of the parked vehicles accumulation for a particular site. Whereas every site has different times for parking demand, According to site land-use type, site activities, site work hours, etc. therefore, the ITE manual mentioned that the parking counts time must be connected with the study purpose. This study objective is to determine peak periods of parking demand (max accumulation), for each site on particular days. Parking counting time for institutional land use in this research is from 7 am – 3 pm. Besides, this study counts the parking demand for three days (Monday, Thursday, Wednesday) for each site.

B. Counting vehicles accumulation. This step is to count the parked vehicle accumulation at the sites, on a particular day. The ITE manual stated that the counting must cover the total site parking demand. This means all the parked vehicles related to the site, whether in the site, or parked vehicles out the site, in the public or private parking, or on streets. The Hourly surveys were conducted at each site during the period 7 pm – 3 pm.

3- Determine the Maximum Average Parking Demand.
This average is the average of three days of the maximum parked vehicle accumulation at each site, it represents the parking demand in this research, which then is used in analyzing to develop parking generation models and rates. whereas, two peaks of parking demand were obtained Am and Pm since the parking counting time is from 7 am to 3 pm, therefore this average is determined for two periods Am and Pm in this research.

5. Data Collection
As mentioned before in this research two types of data were collected, site properties data had shown in table 2 and parking counts and inventories data are shown in table 3. Table 2 presents the number of employees, total area, parking area, and Gross floor area (which is the total area without parking area) for each ministry.

| Ministry Name         | Total area. Per 100 m² | No. of parking Areas | Total Parking Area Per 100 m² | GFA Per 100 m² | No. of Employees |
|-----------------------|------------------------|----------------------|-------------------------------|----------------|-----------------|
| Science and Technology| 1040.7                 | 2                    | 75.48                         | 965.22         | 7745            |
| Water Resources       | 222.82                 | 3                    | 121.38                        | 101.44         | 1212            |
| Culture               | 192.25                 | 2                    | 74.00                         | 118.25         | 1845            |

GFA= Total area – parking area.

From table 2 the area and number of employees of the science and technology ministry are much bigger than the other two ministries and that because of the nature of studied sites. as science and technology ministry larger size than others where it contained several large department buildings and workshops, unlike the sites of water resources and culture ministry that were studied which contained only one or two large buildings, and the buildings represents the official headquarters of the ministry. That reason also made the science and technology ministry full with a number of employees more than the others.
The parking lot in table 2 means the legal parking lot in the study site and the water resources ministry has the largest area of the parking lot from the other ministries. The illegal parking spaces are not calculated but the illegally parked vehicles are counted in parking demand as shown in Table 3 below. The second type of collected data is the parking demand and supply for each ministry. As explained before the parking demand that used in this research is represents (the average of three days of max parking accumulation, that calculated in the period 7 am – 3 pm) therefore two peaks of parking demand are present for the morning and evening period. as for parking supply represents the legal parking supply spaces, within the sites only, These parking spaces usually be marked and striped, and they were counted manually. However, the parking supply information does not directly participate in parking model generation. But it gives more clarification about parking demand phenomena to a specified site in general. As well, it can be used for comparison purposes. Also, the ITE guide[7] and some references recommended providing such information. These parking counts were done in March, April, and May of the year 2019. Table 3 presents the number of parking supply spaces, the off-street, and on-street parked vehicles, parking demand and the ratio of demand over supply for two periods am and pm for each ministry.

**Table 3. Number of Parking Supply Spaces and Parking Demand for Each Ministry**

| Ministry Name          | Supply | Time | Off-street parking | On-street parking | Parking Demand* | D/S* |
|------------------------|--------|------|--------------------|-------------------|-----------------|------|
| Science and Technology | 150    | Am   | 390                | 238               | 628             | 4.23 |
|                        |        | Pm   | 376                | 227               | 603             | 4.14 |
| Water Resources        | 300    | Am   | 255                | 0                 | 255             | 0.87 |
|                        |        | Pm   | 268                | 0                 | 268             | 0.84 |
| Culture                | 82     | Am   | 121                | 183               | 304             | 3.7  |
|                        |        | Pm   | 120                | 192               | 312             | 3.6  |

*Parking Demand: on-street + off-street parking. *D/S: Demand / Supply.

From Table 3, the Water Resources Ministry has three parking lots, and it contained all the parked vehicles of ministry employees, so there were no parked vehicles outside. Also from Table 3 for all studied ministries, the differences between the morning and evening parking demand are very low, because of the nature of government permanence which is for 7 hours (8 a.m. to 3 p.m.), and to its restriction that prevents the employees from leaving during working hours, except for necessity. Also, from the field surveys, the government sites have a lack of sufficient supplied parking spaces, and they did not accommodate the parking demand. Therefore, parking demand is higher than the provided parking supply at all studied sites except in the Water Resources Ministry. However, in all studied sites the vehicles were parked on the sites randomly and taking advantage of any empty areas within the sites. The distribution of parking demand during the time of the day in the survey is shown in Table 4.

**Table 4. Time of Day Parking Demand Distribution of Ministries**

| Time Range | Ministry of Technology | Science and Technology | Ministry of Water Resources | Ministry of Culture |
|------------|------------------------|------------------------|-----------------------------|---------------------|
| 7 – 8      | 65 %                   | 67 %                   | 52 %                        |
| 8 – 9      | 94 %                   | 90 %                   | 84 %                        |
| 9 – 10     | 100 %                  | 95 %                   | 92 %                        |
| 10 – 11    | 98 %                   | 96 %                   | 100 %                       |
From Table 4 above, the parking demand variation of the ministries is somewhat stable with a little difference. Because of the nature of government work hours and its restriction, as stated before. Moreover, the type of ministries nature, which are not receiving many visitors.

6. Statistical Analysis

The descriptive statistics such as mean, standard deviation, coefficient of variation, maximum and minimum values, and range were calculated for each variable, as shown in Table 5 below.

| Variable                  | Mean | Standard deviation | Coefficient of Variation % | Maximum | Minimum | Range |
|---------------------------|------|--------------------|--------------------------|---------|---------|-------|
| No. of Employees          | 3601 | 3603               | 100                      | 7745    | 1212    | 6533  |
| GFA per 100 m²            | 395  | 494                | 125                      | 965.21  | 101.44  | 863.8 |
| Parking Demand (AM)       | 396  | 202.7              | 51.2                     | 628     | 255     | 373   |
| Parking Demand (PM)       | 394  | 182                | 46.2                     | 603     | 268     | 335   |

The results in Table 5 show that the GFA and number of employees have very high variation values, (CV > 100%), which indicates the high dispersion of data about the mean. Further, this high variation may affect the regression models and rates generation. On other hand, the parking demand for morning and evening periods has moderate variation values. Table 5 also shows the mean of max parked vehicles in the morning period is 405 vehicles approach to the mean of evening period 394 vehicles. This is closely related to the nature of official working hours in the ministries, as explained earlier. The employees are not allowed to leave until working hours are over or by using formal approval, besides the studied ministries’ nature is not service ministries or seeing high turnout from the citizens.

7. Develop Parking Generation Models

Regression analysis is a technique used to explore the relationship between two or more variables and build a model to describe this relationship. The regression analysis has many types; this research used the simple linear regression type based on the ITE guide. Moreover, one of the reasons to use the simple linear regression in model estimation is that ‘in the most situations when the new development is proposed there will be limited sources of information about a particular site or activity’; thus, using the equations that have one variable is better [5]. The linear regression analysis was used to produce models by using different independent variables. Also, all forms of models were investigated, but only the most appropriate models with the best fit of the regression line are presented, which are linear, exponential, power, and logarithm models.
The average of max parking accumulation for three days (parking demand) in the morning and evening periods was analyzed with the two variables, the number of employees and sites gross floor area to develop the parking generation models for the institutional land use, as in the following subsections.

7.1 Analysis Morning period with the Number of Employees as an Independent Variable
The employees are the base of work trips, especially in ministries, where the number of employees is usually to be very high. So, the number of employees is used to develop the parking generation models for institutional land use, as shown in Table 6.

Table 6. Parking Generation Models (AM) and Their Properties for Variable No. of Employees

| No. | Model Type | Model | $R^2$ | Adj. $R^2$ | F-test | P-value. | T-test | P-value. | RMSE |
|-----|------------|-------|-------|---------|--------|---------|--------|---------|------|
| 1   | Linear     | $P = 0.056 X + 193$ | 0.99  | 0.99    | 905.882 | 0.02    | 30.098 | 0.02    | 9.519 |
| 2   | Logarithm  | $P = 208\ln X - 1234.5$ | 0.99  | 0.98    | 106.522 | 0.06    | 10.321 | 0.06    | 27.64 |
| 3   | Power      | $P = X^{0.5} \times 7.7$ | 0.99  | 0.99    | 931.1   | 0.02    | 30.514 | 0.02    | 0.022 |
| 4   | Exponential| $P = e^{0.000132X} \times 227$ | 0.99  | 0.98    | 105.525 | 0.06    | 10.273 | 0.06    | 0.065 |

From Table 6, the developed models have high $R^2$ values equal to 0.99 which means the strong models for prediction and the high relationship between parking demand of ministries and their number of employees. The small sample size may cause biased $R^2$ values, but the adjacent $R^2$ values also are high (the adjacent $R^2$ value is the adjusted value of true $R^2$ due to the sample size and number of independent variables in the model). On other hand, the RMSE values are shown acceptable errors for all models, with the lowest errors for power and exponential models. In the same table 6, not all models are significant at 95% confidence interval, where only the linear and power models are significant (their P-value < 0.05), so they can be used for parking demand prediction. Small sample size and its variance have an effect on the model's significant, lower confidence interval (like 90 %) can be used here to produce more significant models. Figure 1 and 2 shows the developed model, which shows the regression line is a good fit for the data points. the points have a low deviation from the regression line.
7.2. Analysis for Morning Period with Site Gross Floor Area as an Independent Variable

The ministries’ gross floor area is also used as a second variable to develop the parking generation models for the morning period, as shown in Table 8 shows the developed models.

| No. | Model Type | Models | \( R^2 \) | Adj. \( R^2 \) | F-test | P-Value. | T-test | P-Value. | RMSE |
|-----|------------|--------|-----------|-------------|--------|----------|--------|----------|------|
| 1   | Linear     | \( P = 0.41 X + 234.5 \) | 0.99 | 0.98 | 91.522 | 0.06 | 9.567 | 0.06 | 29.8 |
| 2   | Logarithm  | \( P = 161\ln X - 476 \) | 0.99 | 0.99 | 275.04 | 0.038 | 16.58 | 0.038 | 17.25 |
| 3   | Power      | \( P = X^{0.4} * 47 \) | 0.98 | 0.97 | 64.315 | 0.08 | 8.02 | 0.07 | 0.084 |
| 4   | Exponential| \( P = e^{0.001X} * 251 \) | 0.97 | 0.94 | 34.775 | 0.1 | 5.897 | 0.1 | 0.113 |

From Table 8, the models have very high \( R^2 \) values 0.99 and 0.98, indicate to the strong relationship between the ministry parking demand and their gross floor area. Also, from the same Table, the RMSR values are acceptable values to low, especially in the power and exponential models, as their error is 0.021 and 0.098, respectively. Moreover, from the same table all the models, except the exponential models, are showing significance at a confidence interval of 0.95%. In summary, all the models recommended being used except the exponential model.

7.3. Analysis for Evening period (PM) with Number of Employees as an Independent Variable

Table 8 shows the produced models and their properties for variable No. of employees for an evening period for institutional land use.

| No. | Model Type | Model | \( R^2 \) | Adj. \( R^2 \) | F-test | P-Value. | T-test | P-Value. | RMSE |
|-----|------------|--------|-----------|-------------|--------|----------|--------|----------|------|
| 1   | Linear     | \( P = 0.05 X + 212.5 \) | 0.99 | 0.99 | 907.165 | 0.02 | 30.119 | 0.02 | 8.54 |
| 2   | Logarithm  | \( P = 186\ln X - 1070 \) | 0.99 | 0.98 | 106.47 | 0.06 | 10.318 | 0.06 | 24.83 |
| 3   | Power      | \( P = X^{0.443} * 11.4 \) | 0.99 | 0.99 | 608.899 | 0.026 | 24.676 | 0.026 | 0.025 |
| 4   | Exponential| \( P = e^{0.0011X} * 241 \) | 0.99 | 0.98 | 124.739 | 0.057 | 11.169 | 0.057 | 0.054 |

From Table 9 the developed models for the number of employees for the evening period have a very high \( R^2 \) equal to 0.99, indicates to the strong models and high relationship. The RMSE for the models shows low values that indicate the strong models for prediction, and the higher error is for the logarithm model (equal to 24.8) which is also considered acceptable. Furthermore, from the same Table 9, only
the linear and power models are significant at a confidence interval of 0.95%, so they are recommended use. Also, small sample size, data variation, and confidence level value are effect on models significant.

7.4. Analysis for Evening Period (PM) with Site Gross Floor Area (GFA) as an Independent Variable

The developed parking generation models and their properties for the variable GFA for the evening period for institutional land use are shown in Table 9 below.

Table 9. Parking Generation Models and Their Properties (PM) for site’s GFA

| No. | Model Type | Model | R² | Adj. R² | F-test | P-Value. | T-test | P-Value. | RMSE |
|-----|------------|-------|----|---------|--------|----------|--------|----------|------|
| 1   | Linear     | $P = 0.37 X + 250$ | 0.99 | 0.98 | 91.56 | 0.06 | 9.57 | 0.06 | 26.75 |
|     |            |       |     |         |        |          |        |          |      |
| 2   | Logarithm  | $P = 144.4\ln X - 388$ | 0.99 | 0.99 | 275.25 | 0.038 | 16.591 | 0.03 | 15.6 |
|     |            |       |     |         |        |          |        |          |      |
| 3   | Power      | $P = X^{0.34} \times 58$ | 0.98 | 0.97 | 73.25 | 0.07 | 8.559 | 0.07 | 0.071 |
|     |            |       |     |         |        |          |        |          |      |
| 4   | Exponential| $P = e^{0.001X} \times 263$ | 0.97 | 0.95 | 38.28 | 0.1 | 6.187 | 0.1 | 0.097 |

From Table 10, all the developed models are strong predictors as their $R^2$ values are very high 0.99 and 0.97 which means a strong relationship between the parking demand and GFA, also the small and convergent sample size may overestimate the $R^2$ values. As for RMSE of the models also show acceptable values, and the lower error is for the power model equal to 0.063. Furthermore, from Table 10 only the logarithm model is significant at a 95% confidence interval, it’s (p-value < 0.05). So, only the logarithm model is recommended to be used.

8. Parking Generation Rates

These rates are represented by the weighted mean; they are most predominately used across the world like the USA, UK, and other countries. The rates are used when the model is not efficient predictive of parking generation. The rates were produced for the two period’s morning and evening, and by using the same variables that were used to develop the models earlier. The statistical dispersion measurements for the weighted mean were also calculated and presented; these measurements illustrated the variation of the data and the differences between the data value and the mean. As the smaller dispersion the better rates. The parking generation rates and their dispersion measurements are shown in Table 11. For example, the parking generation rate for institutional land use for the morning period by using No. of employees is $= \frac{\text{total No. of employees/morning parking demand}}{\text{No. of employees}}$, which equal 0.11 vehicle (space) per employee. As for the rate, the range represents the parking generation rate for each ministry, the highest and lowest rates between them.

Table 10. Parking Generating Rates for Institutional Land Use

| No. | Period | Rates          | Range | Std. dev. | CV% | Rates Range |
|-----|--------|----------------|-------|-----------|-----|-------------|
| 1   | AM     | 0.11 space per employee. | 0.129 | 0.066 | 60 | 0.08 – 0.21 |
| 2   | PM     | 1 space per 100 m² of GFA | 2.017 | 1.164 | 116.4 | 0.62 – 2.64 |
9. Model Verification
Models validation or verification is essential in prediction models, to assess their predictive performance when predicting new data in the future. In general, the verification of models and rates are not used to indicate the model is right or wrong, but it only gives a picture of how the model or rate is work. Models and rates verification are checked by using a new and random sample selected from the studied land uses types. In this research, according to on studied sample size, 30% of the size difference is acceptable as an average. Only the good models are verified.

Table 11. New Data Used for Verify the Developed Institutional Models and Rates

| Ministry name.          | Employees | GFA       | Max Parking AM | Max Parking PM |
|-------------------------|-----------|-----------|----------------|---------------|
| Ministry of transportation | 2152      | 135.82    | 281            | 293           |

Table 12. Institutional Models Verification

| Period | No. | Variable             | Model                          | Predicted | Observed | Difference |
|--------|-----|----------------------|--------------------------------|-----------|----------|------------|
| Am     | 1   | No. of employees     | \( P = e^{0.000132X = 227} \) | 301       | 281      | 0.07       |
| AM     | 2   | GFA                  | \( P = 161\ln X – 476 \)     | 315       | 281      | 0.12       |
| PM     | 3   | No. of employees     | \( P = e^{0.00012X = 241} \) | 312       | 293      | 0.06       |
| PM     | 4   | GFA                  | \( P = 144.4\ln X – 388 \)   | 321       | 293      | 0.09       |

Table 13. Institutional Rates Verification

| Period | No. | Variable          | Rates | Predicted | Observed | Difference |
|--------|-----|-------------------|-------|-----------|----------|------------|
| AM     | 1   | No. of employees  | 0.11  | 236       | 292      | -0.19      |
|        | 2   | GFA               | 1     | 136       | 281      | -0.5       |
| PM     | 3   | No. of employees  | 0.11  | 236       | 314      | -0.25      |
|        | 4   | GFA               | 0.998 | 136       | 293      | -0.53      |

The verification in the Tables 12 and 13 showed that all the institutional models are verified, the differences are (< 30%). On another hand, the developed rates relied on the number of employees are also verified, while the rates relied on GFA show high differences but this result doesn’t have the poor, because of the small sample size that used in verification.

10. Recommended Models and Rates
The best models and rates are selected and recommended for each variable for the two periods AM and PM. The best models selected are based on \( R^2 \) values (the highest value), confidence level (significant at 95%), the model's error of estimate (the lowest error), residuals plot and test (normal distribution), and models and rates verification (differences < 30%). Relying on all the above criteria, the recommended models and rates for each land use are presented in Table 14.

Table 14. Recommended Models and Rates for Institutional Land Use
| Period | No. | Variable. | Models | \( R^2 \) | Rates | Range. |
|--------|-----|-----------|--------|----------|-------|--------|
| AM     | 1   | No. of employees | \( P = X^{0.5} \times 7.7 \) | 0.99 | 0.11 | 0.08 – 0.21 |
|        | 2   | GFA per 100 m²  | \( P = 161 \ln X - 476 \) | 0.99 | 1 | 0.66 – 2.57 |
| Pm     | 1   | No. of employees | \( P = X^{0.443} \times 241 \) | 0.99 | 0.11 | 0.078 – 0.22 |
|        | 2   | GFA per 100 m²  | \( P = 144.4 \ln X - 388 \) | 0.99 | 0.998 | 0.62 – 2.64 |

From the above Table, the models and rates are recommended for all independent variables, using any one of them is applicable although statistically, the models are more preferred.

11. Parking Supply Rates

It is the parking supply ratio according to the ITE manual is the number of spaces per independent variable. (Spaces per employee, spaces per 100 sq. m. of GFA, or any other variable). This ratio is based on the total supply spaces for the site (spaces provided by the site), rather than the occupied spaces. For example for the ministry of science and technology parking supply rate per 100 m² of GFA is \((144/965.22 = 0.15 \text{ space per person})\), per employee is \((144/7745 = 0.02 \text{ space per employee})\), and so on for other sites. The parking supply ratio for each site and independent variable is presented in Table 12 below.

**Table 15.** Parking Supply Rates for Studied Ministries

| Ministry Name              | Supply | GFA | Employees |
|----------------------------|--------|-----|-----------|
| Science and Technology     | 144    | 0.15| 0.02      |
| Water Resources            | 300    | 2.96| 0.25      |
| Culture                    | 82     | 0.69| 0.04      |

12. Rates Comparison and Discussion

Comparing the developed parking generation rates at this research with local regulations, international and regional parking generation rates, are done to determine if there is a difference between these rates. Table 16 displays the comparison with the ITE 5th edition rates and Palestine rates.

**Table 16.** Comparing Obtained Parking Generation Rates vs. Palestine and (ITE 5th) Rates

| Land-use type.              | The developed rates. | ITE 5th Rates | Palestine Rates. | Local regulation |
|-----------------------------|----------------------|---------------|-------------------|------------------|
| Institutional/ government offices | 1 space per 100 m² of GFA. 0.11 per employ | 3.22 spaces per 100 m² of GFA. 0.83 per employ | 1.55 spaces per 100 m² of GFA. 0.33 per worker | 3 spaces per 100 m² |

The displayed comparison in Table 16 shows there are large distances between the parking generation rates developed at this research and Iraqi regulation rates, where the obtained rates are lower than the local regulation rates. The comparison also shows that there are a lot of differences between the obtained parking rates and the ITE and Palestine rates, lower than them. This result is because most of the employees' trips are serviced by public transport, and this is the reason that leads to the number of lower spaces resulting from the developed models of this research. Also, this is what is agreed with Ewing et al. [15], where he found vehicle generation rates are less of ITE 10 manual developed values and show that vehicle ownership is lower in transit-served areas than those that are not transit-served.

13. Conclusions

Produce parking generation rates or models for all land uses are essential in the purpose of planning and management of transportation system. one of the predominant lands uses in Iraq is the government
ministries that contain a large number of employees and are located in vital areas in Baghdad city, therefore, provide the suitable parking spaces and area is one of the necessities ministry, transportation network, and safety. Two predominant variables were used to develop parking generation rates and models which are the number of employees and gross floor area. The two variables show a very high correlation with parking demand and produced models with ($R^2 > 99\%$). The statistical analysis for the two variables shows they have high variation. The simple regression is used for modeling where four forms for models were investigated (linear, power, exponential, and logarithm), the best forms are the exponential and power models as they produced high $R^2$ values, lower RMSE, and show significance at 95% confidence interval. The produced parking generation rates are (1 space for each 100 m$^2$ of GFA and 0.11 space for employees), they lower than international and regional rates because most of the employees are used public transportation for travel.

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