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ORIGINAL STUDY

Forecasting the Demand for Asphalt Concrete in Karbala Governorate

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Abstract

The challenge of forecasting asphalt concrete demand in the Karbala governorate is the subject of this study. Population and number of vehicles in Karbala are considered among the independent (explanatory) variables taken into consideration. These explanatory variables ' historical data have been gathered and examined. The historical data of each explanatory variable has been linked to the historical demand for asphalt concrete in the governorate using regression techniques in the Statistical Package for the Social Sciences (SPSS) program version 26.

A model to forecast the governorate's demand for asphalt concrete has been developed based on these factors. The forecasts have been determined for the years 2023−2032. According to the analysis, the demand for asphalt concrete in the Karbala governorate in 2032 will be 1,718,227 Tonne.

Keywords: Forecasting, Asphalt concrete, Demand, Regression analysis, Population, Number of vehicles

1. Introduction

Asphalt concrete supply should meet instant demands; makers of asphalt concrete must forecast their product demand effectively. A reliable forecast means a lesser risk of making the incorrect option, which results in more effective organizational management [1]. Forecasting the asphalt concrete product demand is beneficial for planners in various ways, including identifying the production levels, estimating projected revenue, planning the renovation of the production process, purchasing raw and other materials, and locating the asphalt concrete plant optimally [2].

Forecasting can be divided into two categories: qualitative and quantitative. Individual, subjective estimation based on personal experience and intuition, blended with expert judgments and market surveys, is typical of qualitative forecasts. There are formal ways for obtaining such forecasts, which range from utilizing sales staff estimations or a sales force composite to using Delphi-style methodologies to get a consensus among a panel of forecasters [3]. External influences are used in statistical forecasting to explain the variable being forecasted. It tries to characterize the level of variation in one variable (such as asphalt concrete demand) in relation to other factors in an objective manner (Population and the number of vehicles, for example). The rationale is clearly described, and the processes are mathematical in such procedures, which openly define how the forecast is determined [4].

Forecasting plays a crucial role in the development of plans for the future. Before investing in inputs, it is critical for organizations to determine what degree of activities they are intending. Forecasting is a method of estimating future events by systematically combining and projecting forward facts from the past in a predetermined manner. Forecasting the future demand for asphalt concrete is an important aspect of the process [5].

The purpose of this paper is to discuss the issue of forecasting asphalt concrete demand in the Karbala governorate. The population of Karbala and the

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number of vehicles are considered to be independent (explanatory) variables. These explanatory variables' historical data have been gathered and analyzed. Regression techniques in the (SPSS) software version 26 connected records from every explanatory variable to the historical demand for asphalt concrete in the Karbala governorate.

2. Study objectives

Investigating the governorate's supply of asphalt concrete and developing an asphalt concrete demand forecasting model will help the Karbala government, the asphalt concrete sector, and decision-makers. As a result, the primary objectives of this research are as follows:

- Examine the existing and future supply of asphalt concrete, concentrating on the essential issues that could hinder an efficient supply of this critical building material.
- Provide an asphalt concrete demand forecasting model that will enable asphalt concrete plants to optimize sales potential, government planners to make better decisions and thus manage resources more effectively, and final projects to have adequate asphalt concrete supply.
- Define the general characteristics of the asphalt concrete industry and market. As a result, the economies of scale in the production and distribution of asphalt concrete and the plant sites required to meet that scale will be investigated.

3. Materials and methods

Real data have been used from the Central Statistical Organization of Iraq (CSO) to evaluate population and vehicle ownership in the Karbala governorate [6]. The increase in the population and the percentage of their ownership of private vehicles leads to an increase in the number of daily trips, as mobility is a basic need for humans because everyone travels either for food or entertainment [7]. There is a need closely related to the transportation of raw materials to the manufacturing unit or finished goods to the consumer, which increases pressure on the existing road network and increases the need for its continuous expansion and rehabilitation due to this pressure [8].

Forecasting asphalt concrete demand comprised several analytical phases, including multiple regression analysis, developing the mathematical model, and determining the demand ratio for each sub-district. A multiple regression analysis was initially conducted using the (SPSS) software version 26; then, develop the demand model that interprets expectations demand for asphalt concrete in Karbala governorate according to the factors discussed; The conceptual model for numerous analyses done in this study is shown in Fig. (1).

4. Development and application of model

To forecast asphalt concrete demand, it must rely on a model that “helps to explain” variations in asphalt concrete demand due to changes in other variables to forecast asphalt concrete demand. Furthermore, forecasting the demand for asphaltic concrete needs forecasting the explanatory variables. Applying a multiple regression model entails specifying the model's structure that is, determining which variables to use or what type of relationship to utilize and analyzing the model's constants utilizing available records.

4.1. Data preparation

Information regarding the demand for asphalt in Karbala governorate for the previous six years (2016−2021) has been obtained from the Iraqi Ministry of Oil/Oil Products Distribution Company, which expresses the actual consumption of asphalt in Karbala governorate [9]. The amount of asphalt concrete has been estimated because the asphalt concrete mix consisted of 5% asphalt and 95% of aggregate [10]. Data on the population and the number of registered vehicles have been taken from the (CSO). Table 1 shows the demand for asphalt concrete, population and the number of registered vehicles in Karbala governorate.

The population increased from 113,6220 in 2016 to about 1309005 in 2021, while the number of registered vehicles increased from 128,585 in 2016 to about 176,104 in 2021.

The data for 2020 were excluded from the analysis because the consumption of asphalt concrete in Karbala governorate this year does not reflect the true demand due to the abnormal conditions caused by the Corona pandemic.

To estimate the population and the number of registered vehicle rates, it is essential to know that the annual growth rate for the population and the number of registered vehicles were (2.57% and 5.4%) respectively [6]. For years for which no historical data are available, equation (1) has been used to estimate the population and the number of registered vehicles [11]

$$P_t = P_o\,(1 + i)^n \tag{1}$$

Where:

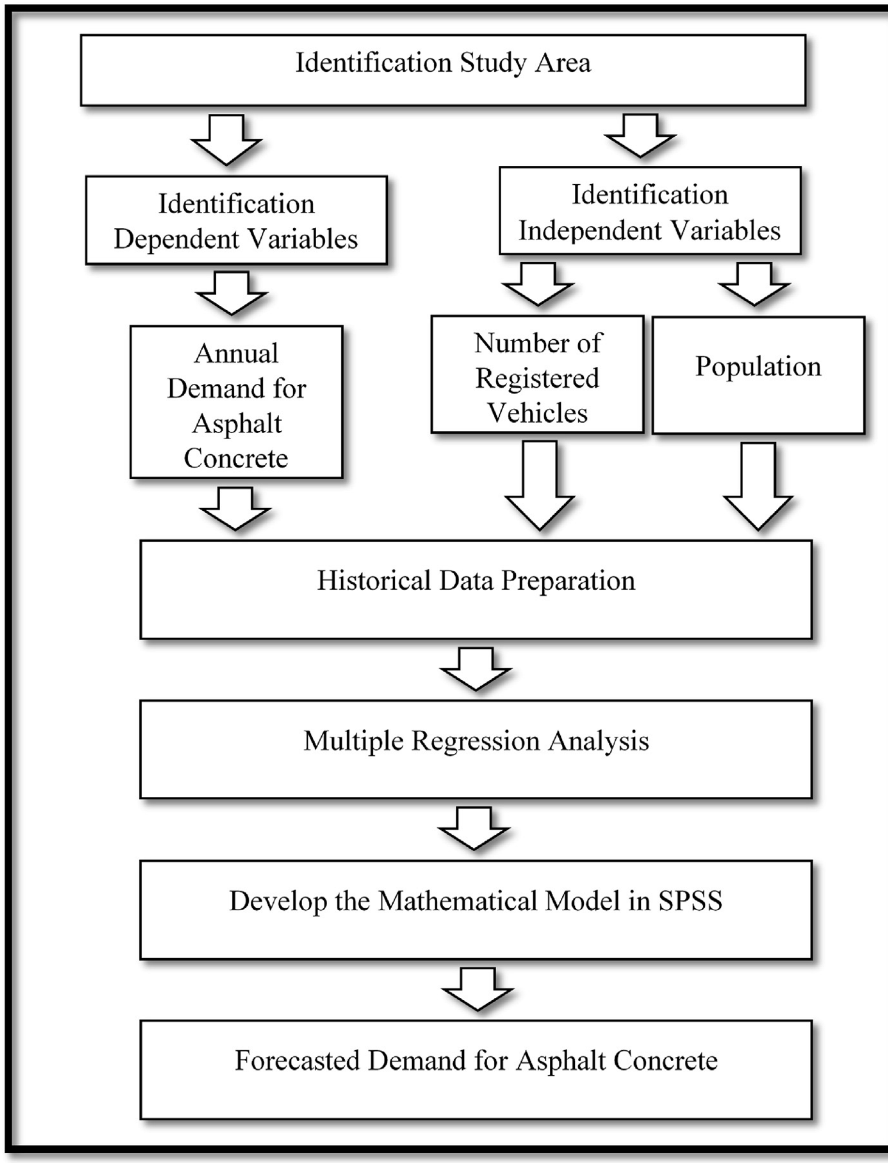

Fig. 1. Conceptual model for asphalt concrete demand forecasting analysis.

P_t = is the future population/number of vehicles by the end of n years

P_o = is the population/number of vehicle values before n years

i = the annual growth rate

n = analyses period in years

Table 1. Model variables data [6,9].

No.	Year	Demand Tonne	Population No.	Vehicle No.
1	2016	236637	1136220	128585
2	2017	255430	1147245	136084
3	2018	172702	1228732	150400
4	2019	380140	1250806	159424
5	2020	83440	1279575	168033
6	2021	478360	1309005	176104

4.2. Statistical regression of asphalt concrete demand model

The (SPSS) software is used to develop a proper relationship between asphalt concrete demand and the selected variables. SPSS is a collection of computer software used to analyze many types of social science data [12]. SPSS can execute a wide variety of statistical operations, one of which is a basic and multiple regression model.

Regression models are highly effective methods for forecasting a dependent variable using a number of indicators. They are frequently used in a variety of circumstances [13]. A linear model is used to express the connection between a responder variable Y and explanatory variables X [13]

$$Y = a + a1x1 + a2x2 + a3x3 \quad (2)$$

Where: a, a1, a2, and a3 are constants referred to as regression coefficients or parameters for the equation.

Two presumptions define linear models:

- The model presupposes that the dependent and independent variables have a linear relationship.
- The residuals (ϵ) are distributed normally and are distributed independently and identically.

4.2.1. Variables selection

Due to a lack of documented historical data on which to develop a statistical model for forecasting the Karbala governorate's future asphalt concrete demand, several specialists, including academics and researchers with expertise in the subject of study, were interviewed to ascertain their perspectives on the variables that should be used to create the statistical forecasting model. As a result, the independent variables listed below have been adopted:

- Population
- Number of registered vehicles

And the dependent response variable is the annual demand for asphalt concrete.

4.2.2. Scatter plots

The Scatter Plot is a graph of data that enables visual examination of the data's overall pattern; these plots are shown in Fig. (2) and (3).

It may be possible to alter the variables x and/or y in such a way that the resulting relationship approaches linearity. A linear regression model can then be developed for the changed variables, and the modified data can be analyzed appropriately [14]. Excel has been used to find the better possible relationship between the dependent variable (the asphalt concrete demand per year) and independent variables (population and number of registered vehicles).

4.2.3. Statistical approach for removing abnormal data

According to Barnett and Lewis (1994), an outlier deviates from the other observations. The most frequently used statistical tools for identifying outliers are as follows [15]:

- Histogram
- Chauvenet's Criterion
- Grubbs Test
- Box Plots

Due to its ease of use in the statistical program SPSS, the Box Plots tool has been adopted to perform this test. A box plot is a graphical representation of the conduct of data in the center and ends of distributions. The median, lower and higher

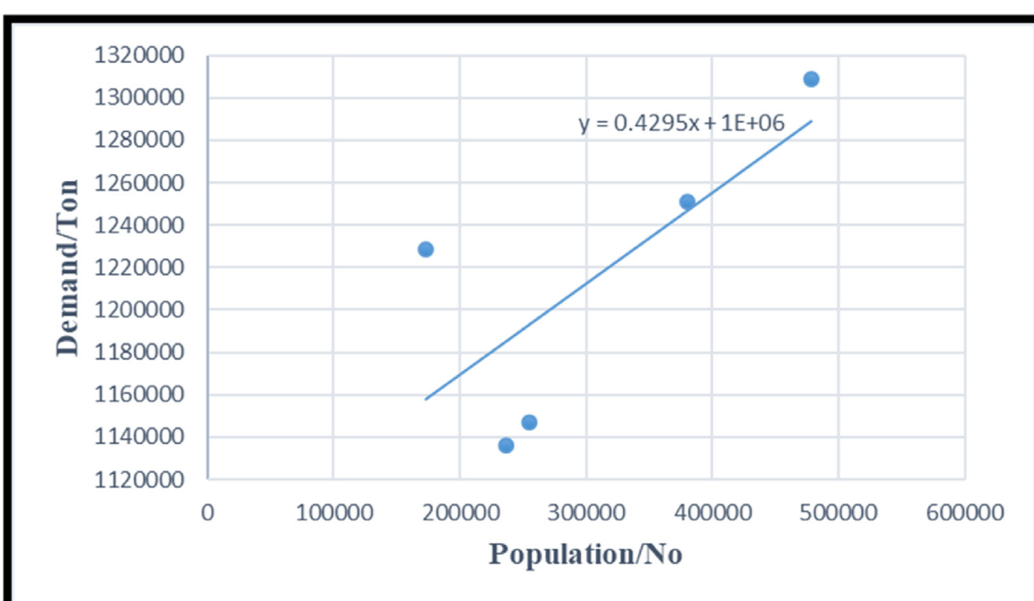

Fig. 2. Scatter plot of independent variables (Population).

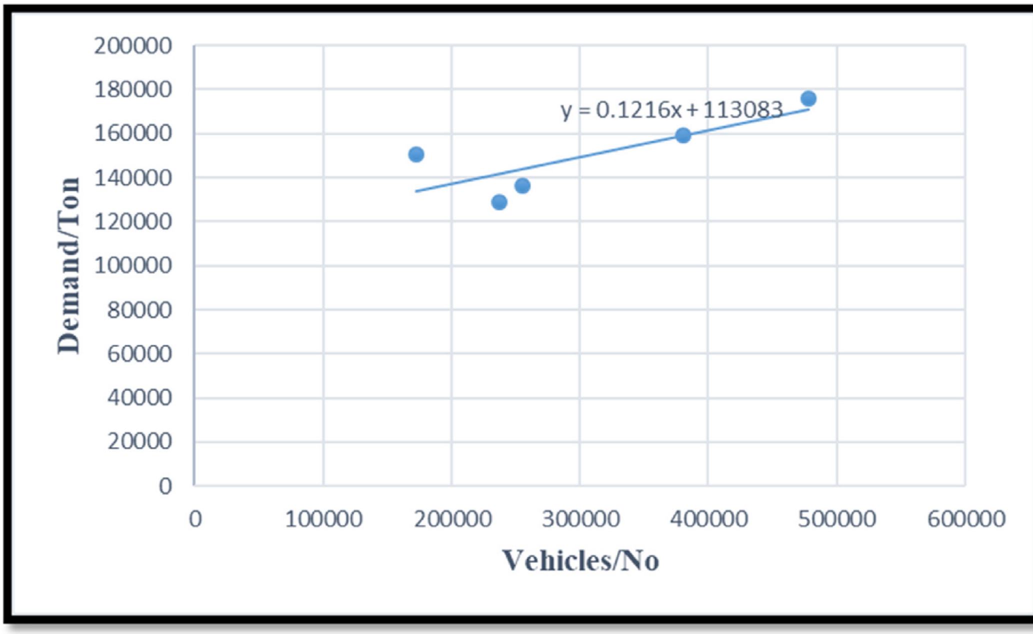

Fig. 3. Scatter plot of independent variables (Number of registered vehicles).

quartiles (25th and 75th percentiles) are used in the box plot. Because Q1 denotes the lower quartile and Q3 the higher quartile, the difference (Q3 - Q1) denotes the interquartile range between the first and third quartiles. Any data that seems to diverge significantly from the others is so rejected [15].

Figure 4 illustrates how to use a Box Plot to inspect for outliers; no data have been found that deviated

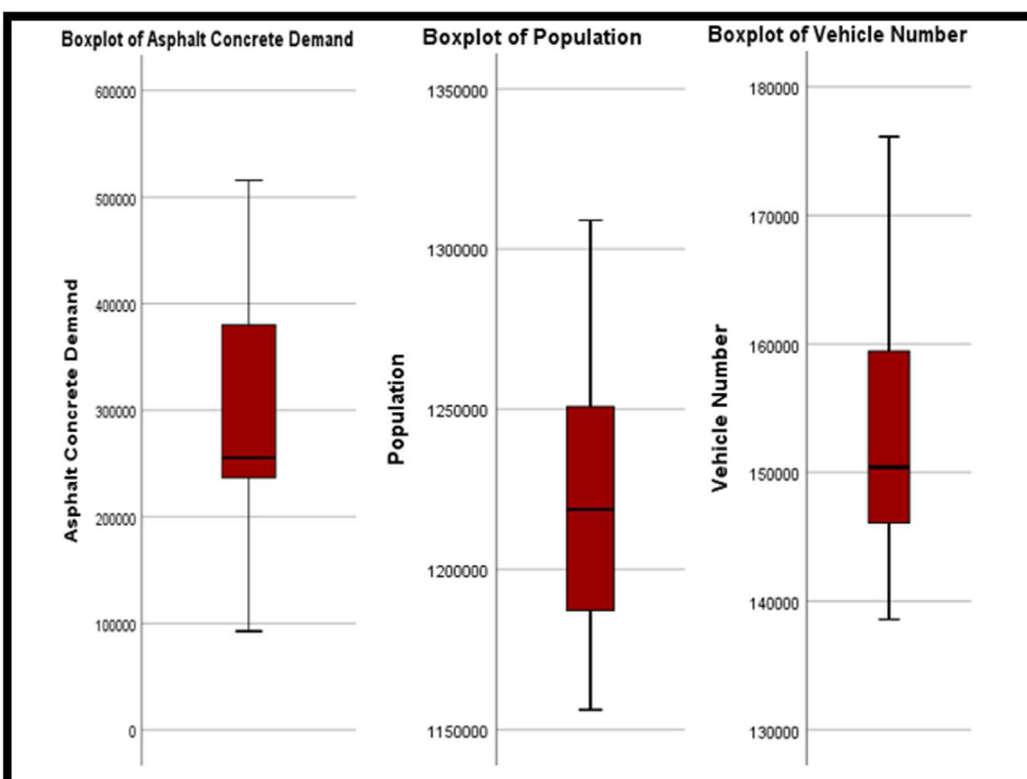

Fig. 4. Box plot for inspecting outlier.

significantly from the other data, so none of these data have been rejected.

4.2.4. Multi collinearity

Multi collinearity occurs when there are strong correlations between two or more independent variables in a multiple regression model, for example, $r = 0.90$ or above. Multicollinearity can result in heavily biased or misleading results when a researcher or analyst determines how well each independent variable can be used to predict or understand the dependent variable in a statistical model, but multicollinearity has little effect on the overall fit of the regression equation. Additionally, forecasting and prediction will be unchanged [16]. Correlations between dependent and independent variables are shown in Table 2.

4.2.5. Normality test

To determine the normality of the data, the Shapiro–Wilk statistical test (W) (1965) is utilized. For medium and small samples out to $n = 2000$, Shapiro-W Wilk's is recommended [17].

$$W = \frac{\left(\sum_{i=1}^{n} a_i x_{(i)}\right)^2}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \tag{3}$$

W is the correlation coefficient between the input data and the ideal standard scores.

SPSS was used to conduct the test. As a general rule, a variable is considered to be generally normal if its skewness and kurtosis values are between −1.0 and + 1.0. The following are the test hypotheses:

Null Hypothesis: H_o is normally distributed

Alternative Hypothesis: H_1 is not normally distributed

Table 3 include the results of this test for each variable.

4.2.6. Analyses of regression model

Iterative regression analysis uses the outputs to diagnose, confirm, criticize, and possibly adjust the inputs. This procedure must be repeated until an acceptable output is achieved. A suitable output is a model that meets the assumptions and fits the data relatively well [18].

Based on equations (3)–(2), the relation between the dependent variable and the independent variables to develop a regression model for forecasting the demand for asphalt concrete in the Karbala governorate are as follows:

$$\text{Asphalt Concrete Demand} = a_0 + b_1{*}\text{Population} + b_2{*}\text{Vehicles Number} \tag{4}$$

Multiple linear regressions are performed to build the optimal model at the 0.95 level of confidence. Table 4summarizes the results of standard multiple regression (4).

Thus the results indicate equations (3)–(5):

$$\text{Demand} = 2863084.063 - 5.193{*}\text{Population} + 24.968{*}\text{Vehicle Number} \tag{5}$$

The last test will be the accuracy of equation (5) in estimating the total demand for asphalt concrete in

Table 4. Summary of the standard multiple regression results (Res.).

R Square	**0.805**
F Value	4.123
F (Significance of Population)	0.082
F (Significance of Number of Vehicle)	0.055
Beta of Population	−3.071
The beta of the Number of Vehicles	3.834
Constant	2863084.063
B of Population	−5.193
B of Number of Vehicle	24.968

Table 2. Correlation matrix.

	Asphalt Concrete Demand	Population	Vehicles Number
Asphalt Concrete Demand	–	0.726	0.792
Population	0.726	–	0.991
Vehicles Number	0.792	0.991	–

Table 3. Shapiro–Wilk test.

Normality Test: Shapiro–Wilk Test

	For Asphalt Concrete Demand Variable	For Population Variable	For Vehicles Number Variable
Test Statistic	0.937	0.927	0.974
Alpha	0.05	0.05	0.05
Signification	0.646	0.573	0.898
Decision Rule	If Significance <0.05, reject the H_o.		
Conclusion	Accept the H_o.		

the Karbala governorate for years not covered by historical data. The model's accuracy may deteriorate as the prediction date gets about further. As the date approaches explanatory factors or independent variables, estimations may become less accurate.

4.2.7. Residuals analysis

Residuals are the undefined portion of the dependent variable; they represent the gap between the observed and predicted values; big residuals indicate a poor fit to the model. For least-squares residuals, these vertical distances are referred to as the ordinary. One of the residuals' properties is that its sum is zero. This implies that the sum of the distances above the line is equal to the sum of the distances below the line [18].

The residuals variable must satisfy the following primary requirements:

- Residuals have a normal distribution,
- The distribution of residuals has a mean of zero.

The distribution of the standardized residual, the normal P–P plot of the regression standardized residual, and the regression standardized predicted versus standardized residual have been shown in Fig. (5)–(7).

4.2.8. Independence of residual

The Durbin Watson test is used to determine whether there is sequential correlation between the residuals, i.e., the presumption of error independence, which needs that the residuals or prediction errors do not follow the same pattern from situation to situation. Durbin Watson values fall within a range of values (0–4). If (the D-W) statistic is less than 2, the residuals are not correlated [18]. The results of this test are shown in Table 5.

4.2.9. Model limitation

Like with all forecasting models, the model's most significant limitation is that the precision of the input determines the correctness of the output. For example, if the real number of vehicles is significantly fewer than the expected number, the actual value of asphaltic concrete demand will be far less than the forecasted value. Another restriction is that the explanatory variables have been the only variables that could be foreseen with any degree of certainty at the time of this study. This is, without a doubt, a critical limitation. It's not impossible that the model could have been made more sophisticated in other conditions with more explanatory variables available and that the forecasts would have been different from those reported here.

5. Asphalt concrete forecasting

A report published by the Canadian University of Toronto in 2012 determined the service life of the asphalt concrete plant at 10 years. Estimates of the government's actual population and number of

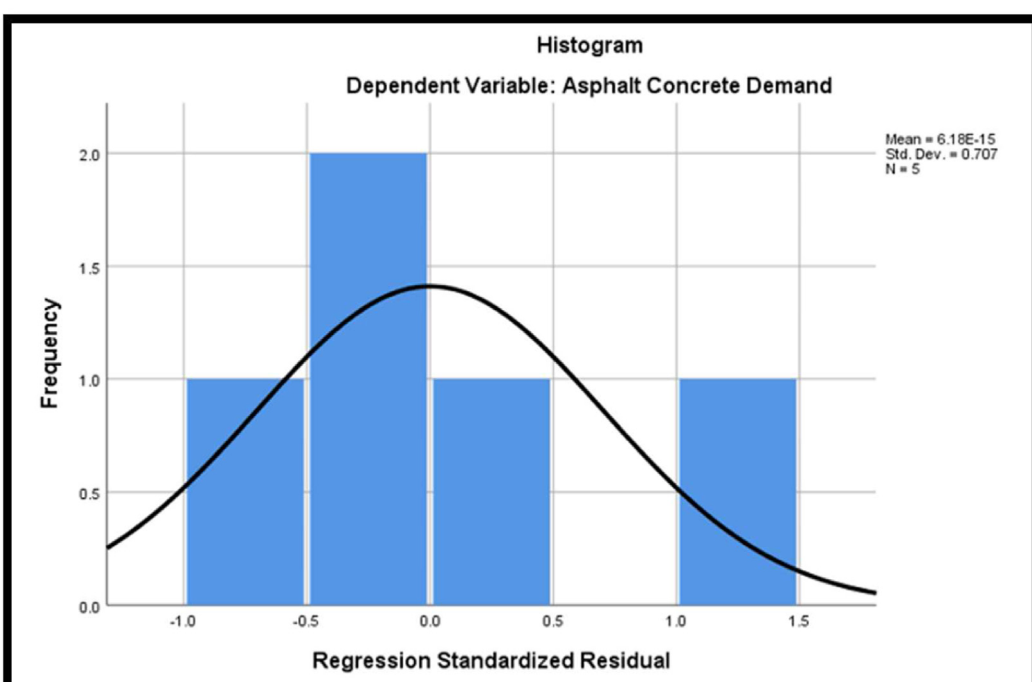

Fig. 5. The standardized residual distribution (Histogram).

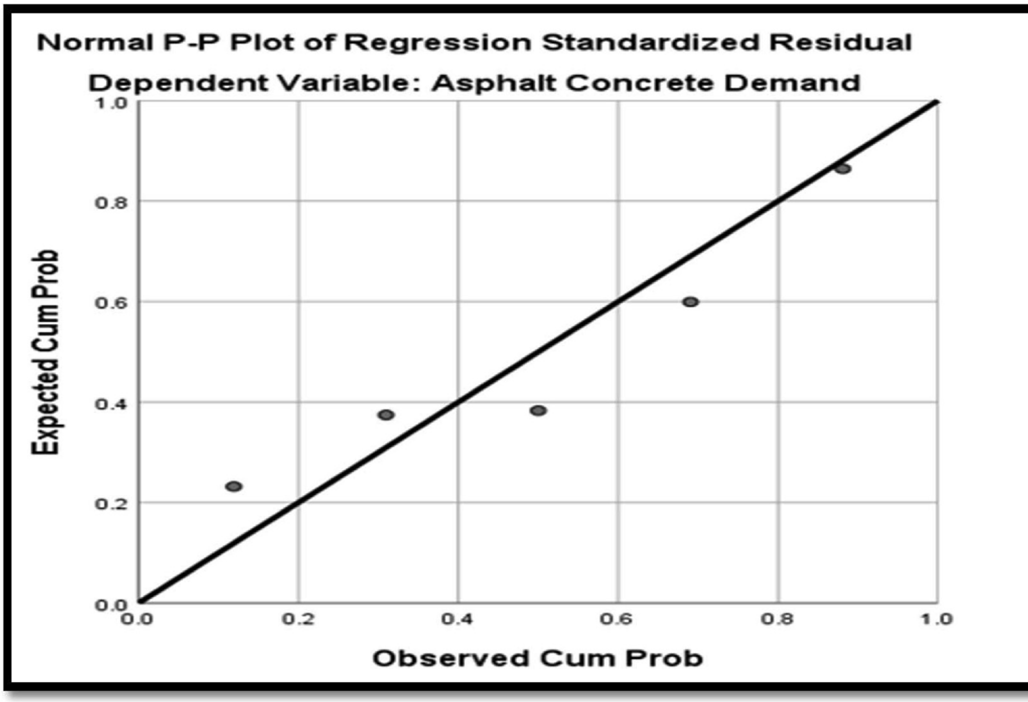

Fig. 6. The standardized residual distribution (Normal P–P Plot).

Vehicles for the years 2023–2032 were examined, estimated, and summarized in Table 6 in accordance with equation (1). These estimations are used to predict the asphalt concrete demand in the Karbala governorate using equation (5).

The ultimate test of the model represented in equation (5) was its accuracy in estimating the quantity demanded asphalt concrete in the Karbala governorate for years not covered by historical data. However no demand prediction is likely to

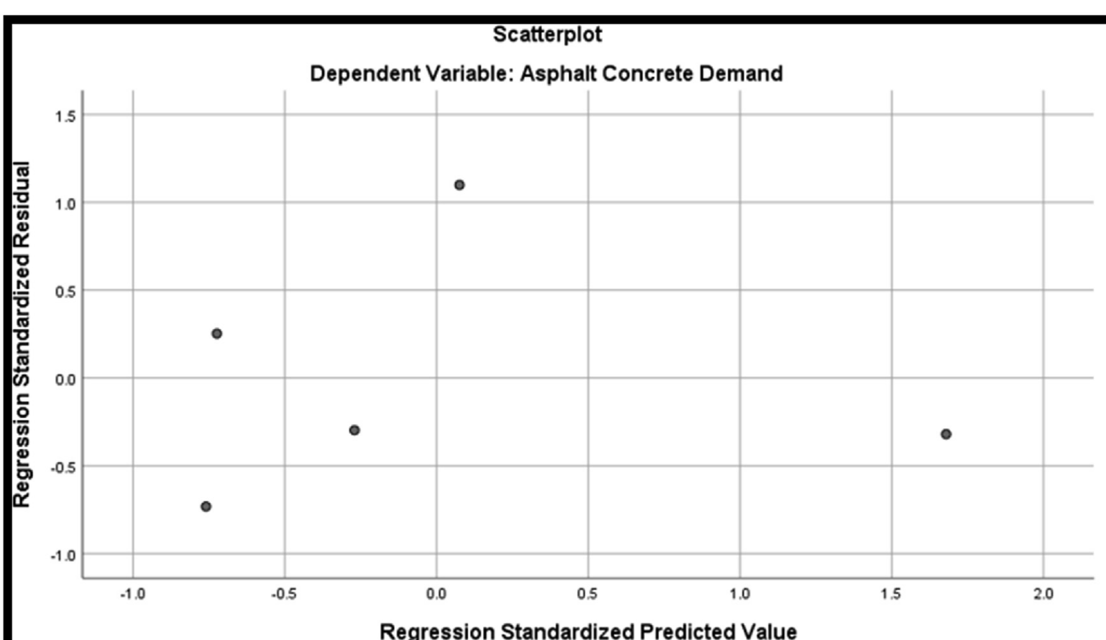

Fig. 7. The standardized residual distribution (Scatterplot).

Table 5. Durbin–Watson test.

Model	R	R Square	Adjusted R Square	D-W
1	0.897	0.805	0.610	1.891

Table 6. Annual demand for asphalt concrete in Karbala governorate.

No	year	population No.	Vehicle No.	Demand Tonne
1	2023	1,377,152	195,637	596198
2	2024	1,412,545	206,201	676164
3	2025	1,448,848	217,336	765662
4	2026	1,486,083	229,072	865325
5	2027	1,524,275	241,442	975848
6	2028	1,563,449	254,480	1097950
7	2029	1,603,630	268,222	1232400
8	2030	1,644,843	282,706	1380018
9	2031	1,687,116	297,972	1541656
10	2032	1,730,475	314,062	1718227

completely match actual demand, the model is projected to be reasonably accurate for at least the next two years, provided that actual estimates of population growth and number of vehicle growth are highly agreed upon.

Forecasts have been calculated assuming that the annual population growth rates were 2.57% and the estimated growth rate number of vehicles was 5.4%.

Karbala population for the year 2023 will be 1,377,152, and vehicle number 195,637. Substituting these values in the model (4) led to an estimate of asphalt concrete demand for 2023, which amounted to 596,198 tons. This estimate is about 24.6 %over the 2021actual asphalt concrete demand; the increase in actual asphalt concrete demand in 2021 is about 25.8% over the 2019 actual asphalt concrete demand. Thus, the slight increase in actual population and vehicle number in 2023 will result in a similar increase in asphalt concrete demand for the same time. The results can be seen as a reflection of the model's reliability (5). Table 6 and Fig. (8) Show the annual demand for asphalt concrete in the Karbala governorate from 2023 to 2032.

6. Conclusion

According to the findings of this study, the governorate of Karbala requires new asphalt concrete plants, with the capacity and locations of these plants being determined as precisely as possible in order to meet the increased demand in the governorate's numerous districts.

All of the forecasts in this report are contingent on expectations of actual government spending. Asphalt concrete demand should be at a different level if actual government expenditures develop differently for one reason or another.

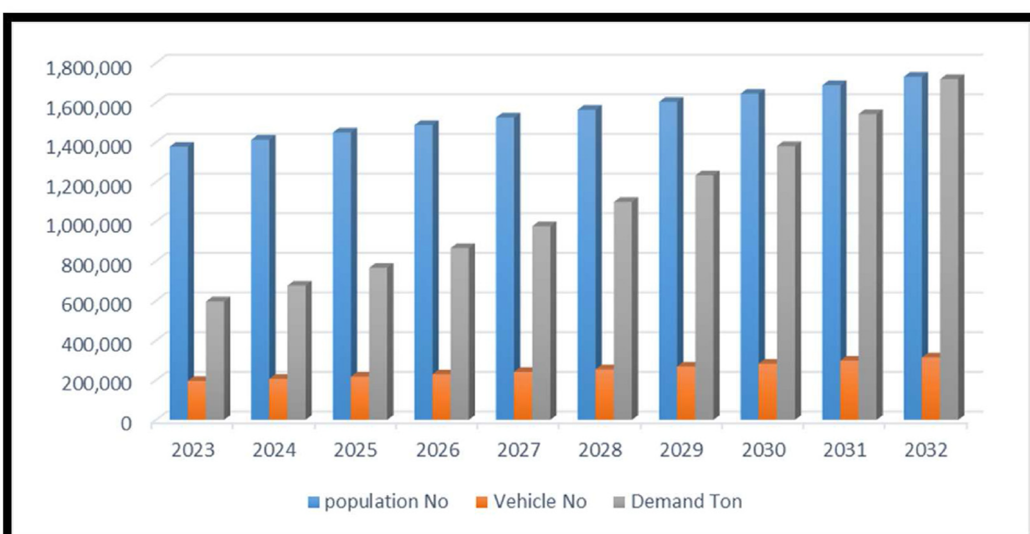

Fig. 8. Annual demand for asphalt concrete in Karbala governorate from 2023 to 2032 (Res.).

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