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Statistical Methods for Modelling Petroleum Products Consumption in Iraq

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Abstract

In this research there are models developed to consumption for three major petroleum products; Fuel oil, Gas oil and Gasoline for five years (2016-2020) based on two statistical methods; Autoregressive Integrated Moving Average (ARIMA) and Multi Linear Regression (MLR). The data collected for actual demand and consumption from 2005-2015 years, from different sources are used to estimate petroleum products consumption for Baghdad governorate (as a case study).These predicted models are affected by factors as population, urbanization rate, number of vehicles and electricity sector. The generated results by (ARIMA) are suitable to forecasting and more accurate, since it depends on Mean Absolute Percentage Error (MAPE) to determine forecasting accuracy the results showed that the error was equal to 8.1%, 15.93% and 10.57% for Gasoline, Gas oil and Fuel oil respectively. SPSS program version (23) is used to reveal these results, showing an increase in consumption of Fuel Oil and the stability of consumption to Gasoline and Fuel oil, in the same level of consumption in the past years resulting an increase in the gap between demand and produced quantity when compared to Doura refinery production quantity of these fuels. While the produced quantity of Fuel oil is greater than the predicted consumption required. These results are valuable to decision makers to select between different alternatives

as increase in production of light products (Gasoline, Gas oil) and reduce in Fuel oil production or importing these fuels, or the decision of implementing new refinery.

Keywords: Consumption, Statistical**,** ARIMA, MLR, MAPE, Fuel oil, Gas oil, Gasoline.

1. Introduction

Petroleum products are the major resource used to create energy where used in transport, commercial, domestic, industrial and other sectors. Therefore, petroleum products represent about 39% of global energy consumption also the consumption of petroleum products is expected to continue at the same rate by 2035. There is a need to set up a forecasting system for petroleum products consumption [1,2].

There are different methods, used to forecasting included quantitative and qualitative methods. Qualitative forecasting (also called subjective or judgmental forecasting) is the process of capturing the opinions, knowledge, and intuition of experienced people, and turning opinions, knowledge, and intuition into formal forecasts. Some of them as Delphi forecasting method, Grass Roots, Market Research, Panel Consensus and Historical Analogy methods [3,4]. Quantitative methods including time series methods and regression analysis methods that are applied when two conditions met are; numerical data in the past are available and these data are sensible to assume that some aspects of the past patterns will continue into the future [5]. Time series methods can be classified to Projection **(**Naïve approach), Moving Average, Exponential Smoothing, Holt's linear, Partial Adjustment Method (PAM), Autoregressive Integrated Moving average (ARIMA) method and other methods [6, 7]. In addition Artificial Intelligence (AI) methods are conducted to generate forecasting models, including Artificial Neural Networks (ANNs), fuzzy logic, genetic algorithm and other methods [8,9].
Several modeling methods have been used to understand the relationship between petroleum products consumption and other independent variables. During the last decade new method have are specifically for accurate prediction of the future energy needs. These include regression analysis methods and time series methods [2,8]. **Easmon, A (2008)** proposed a models that estimate the consumption for different petroleum products

(Liquefied Petroleum Gas (LPG) , Gasoline, Diesel, Kerosene and Fuel oil) in Ghana using Multi Linear Regression (MLR). Factors employed are Gross Domestic product GDP, price of petroleum products and the total population are used to forecasts these petroleum products up to 2020. Used Coefficient of Determination (R^2) to determine the forecasting accuracy. The Results showed an increase petroleum products consumption particularly in the transportation sector and the country's need to establish refineries to reach a production capacity of 115,000 Barrel Per Day (BPD)by 2020 year[10]. **Agyen, K. J. (2012)** proposed a models to forecast demand of petroleum products (Gas Oil, LPG and Premix Fuel) in Ghana by Box-Jenkins ARIMA modelling technique. Monthly data demand levels from January 1999 to December 2010 used to forecast for 12 next months. Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) are conducted to determine the stationary time series and select suitable coefficients for forecasting .The best fit model for National Gas Oil demand, National LPG demand and National Premix demand levels were found to be ARIMA(1,1,3), ARIMA(2,1,3) and SARIMA(3,1,0)(2,0,0) respectively. Used the Root Mean Square Percentage Error (RMSPE) to determine forecasting accuracy. The results showed that Box-Jenkins approach as time series analysis could find models that best fit the data for three petroleum products, and the demand pattern for premix fuel was found to be seasonal because of the market conditions in July, August and September [11]. **Al-Mansoori, M et al (2012)** proposed a models for Gasoline demand in UAE using ARIMA and (MLR) methods from 1995-2012 period, to forecast up to year 2020. Results show population, real income per capita, and number of vehicles had positive impacts on Gasoline consumption. Real gasoline prices, Human Development Index (HDI), and lagged factors had negative effects on Gasoline demand. An increase of Gasoline consumption in the coming years that caused an increase in environmental pollution .The aim of this study is reducing the environmental risk and increase awareness by the authorities that are concerned in decreasing Gasoline demand as this will help in enhancing sustainable development [12]. **Chai, J., et al (2012)** investigated a models for consumption mainly of Petrol and Diesel in China used in transportation sector. Where used Bayesian linear regression theory and Markov Chain Monte Carlo method (MCMC). Their demand-forecast model depend upon five factors are; urbanization level, per capita GDP, turnover of

Passenger in Aggregate and Turnover of Freight in Aggregate (TPA, TFA) and Civilian Vehicles Number (CVN). Results showed that urbanization is the most sensitive factor, followed by Civilian Vehicle Number (CVN).ARIMA method is used to forecasting and comparison the results between Bayesian Linear Regression and MCMC. Their results showed an increase in consumption of the above mentioned products because increased urbanization ratio and CVN. Also they stated that Bayesian linear regression theory and (MCMC) methods are more accurate in forecasting [13]. **Li, Z., et al (2014)** proposed statistical models to predict petrol demand for Australia's automobile up to year 2020 depending on eight methods conducted namely linear trend, quadratic trend, exponential trend, single exponential smoothing, Holt's linear, a Holt-Winters', Partial Adjustment Model (PAM), and (ARIMA) method. In order to identify the best forecast, with minimal error where used Mean Absolute Deviation (MAD) and (MAPE) to determine the forecasting accuracy. Forecasting models help to establish policy to reduce emissions from cars and CO_2 emissions. Results show increase in Gasoline consumption by (22.2%) in 2020 from 2000 and depending on quadratic trend model with less ratio (MAPE) from other models [14].

The aim of this research is generate models to predict consumption of three major petroleum products which are; Fuel oil, Gasoline and Gasoil for the years(2106-2020)based on collected data from (2005-2015) using two statistical methods are ARIMA and MLR in Baghdad governorate as a case study . The next paragraph offers theoretical background for the methods used and their relative formulas and equations, data collection and analysis. The generated results are discussed and final conclusions are revealed.

2. Theoretical Background

ARIMA is most common time series methods used according to the equation below. This method developed by statisticians George Box and Gwilym Jenkins often called as Box and Jenkins method. The Box-Jenkins method is not a specific forecasting method, but it is instead an iterative method to identify a fitting ARIMA model to the data set. The process of finding the suitable Box and Jenkins method include data analysis [15];-

$$Y_t=\theta_0+ \theta_1 Y_{t-1}+ \theta_2 Y_{t-2}+.....+ \theta_p Y_{t-p} +\varepsilon_t+ \delta_1\varepsilon_{t-1}+....+ \delta_q\varepsilon_{t-q} \quad ..... \quad (1)$$

AR: p = order of the autoregressive part

MA: q = order of the moving average part

ARIMA forecasting model involves four different but interrelated steps as shown in Fig (1).

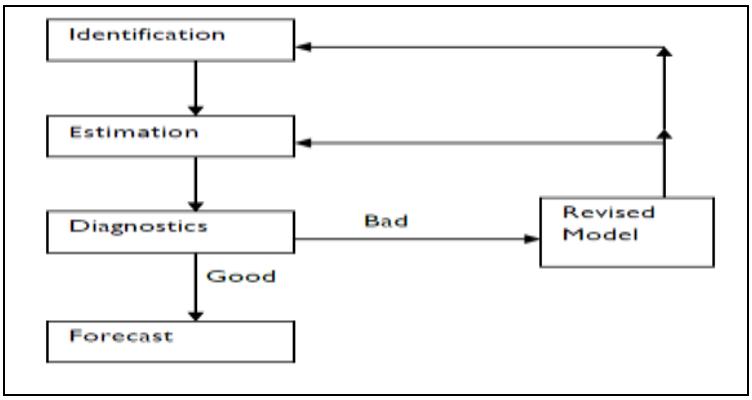

Fig. (1) ARIMA model Framework [7].

Multiple Linear Regression (MLR) is the oldest and most common methods used to analyze the dependency of a quantity on a set of independent variables according to the following equation [16];-

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\ldots+\beta_KX_K \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Multiple linear regression method is applied to identify unknown coefficients of β_0 to β_k. This procedure is done by minimizing the sum of the squares of the deviations of simulated data from the historical data [16].

To determine β coefficients using the following equations [16].

$$X=\begin{bmatrix}1 & x_{11} & x_{12} & \cdots & x_{1d}\\ 1 & x_{21} & x_{22} & \cdots & x_{2d}\\ \vdots & \vdots & \vdots & \cdots & \vdots\\ 1 & x_{n1} & x_{n2} & \cdots & x_{nd}\end{bmatrix} \qquad y=\begin{Bmatrix}y_1\\ y_2\\ \vdots\\ y_n\end{Bmatrix} \qquad \beta=\begin{Bmatrix}\beta_0\\ \beta_1\\ \vdots\\ \beta_d\end{Bmatrix}, \quad \ldots\ldots \quad (3)$$

Where X is independent variables, y is dependent variable and β is unknown coefficients.

$$\beta=(X^TX)^{-1}X^TY \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

There are two hypotheses used in MLR can be classified into Null Hypothesis (H0) proposed not relationship between the independent and dependent variables and Alternative Hypothesis (H1) proposed relationship between the independent and dependent variables by depending on P-value

is usually equal to the significance level where P value help the researcher to select the suitable hypothesis. The p-value used to determine the significance level, if the P-value is less than 0.05, the result is significant where is accept alternative hypothesis and reject null hypothesis [17,18] can be shown in table (1)

(Table1) P-Value to accept or reject the Null Hypothesis [17]

P-Value	Null Hypothesis
P-Value ≤ 0.05	Reject the H0
P-Value > 0.05	Accept the H0

There are number of parameters used to calculate forecasting accuracy. The most prominent Mean Absolute Deviation (MAD) , Mean Square Error (MSE) , Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) [19].

In this study (MAPE) are used to determine forecasting accuracy by comparison between the actual values and predictive values according to the equation below [19];-

$$MAPE = \frac{\Sigma ABS(\frac{A-F}{A})}{n} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

A: Actual value , **F**: forecasting value and **n** :sample size.

There are a large number of factors influencing the consumption of petroleum products in the future including population growth, the number of vehicles, the proportion of urbanization, high level of technological development, the economic situation, with volatility of prices of oil products and other factors. Therefore, there is considerable difficulty in predicting consumption and find a suitable relationship between independent factors help to predict consumption. There is need a forecasting system accurate used to determine demand patterns for petroleum products in order to be able to planning successful into the future [10].

2. Data Collection

The data in this study were collected from January 2005 to December 2015 from different sources. The information for population, number of vehicle and urbanization rate are collected from Iraqi Ministry of Planning (IMP). Fuels consumption in electrical power plants for Baghdad governorate is gathered from Iraqi Ministry of Electricity (IME). While local petroleum products consumption for (Gasoline, Gas oil and Fuel oil) in Baghdad governorate are collected from Iraqi Ministry of Oil (IMO). The collected data are used to predict consumption models for the above mentioned products using two different statistical methods are ARMIE, and MLR for the years 2016-20120. The gathered data are processed using Statistical Package for the Social Sciences (SPSS 23.0) software Ver.23 to obtain desired results (models and tables).

3. Results and Discussion

From December 2015 the results showed in Fig (2,3,4) and Table (2) by using ARIMA method . Where increase Fuel oil consumption in the next five years and remain Gas oil and Gasoline in same level from consumption.

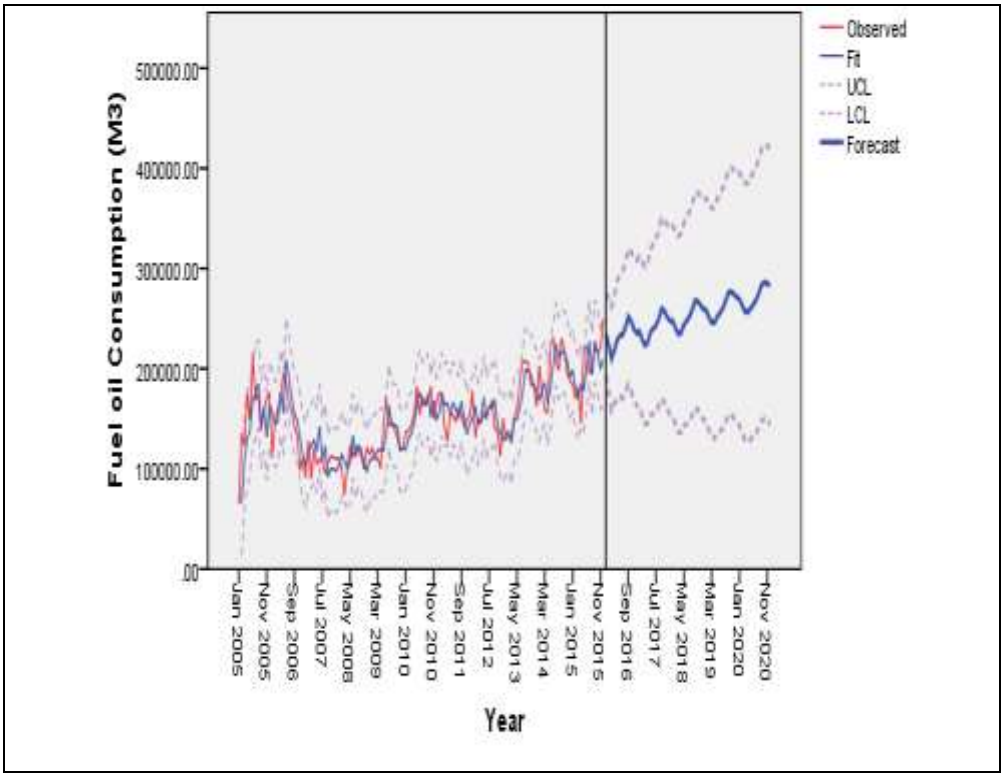

Fig (2) Forecasting of Fuel oil Consumption for (2016-2020) Yrs [20].

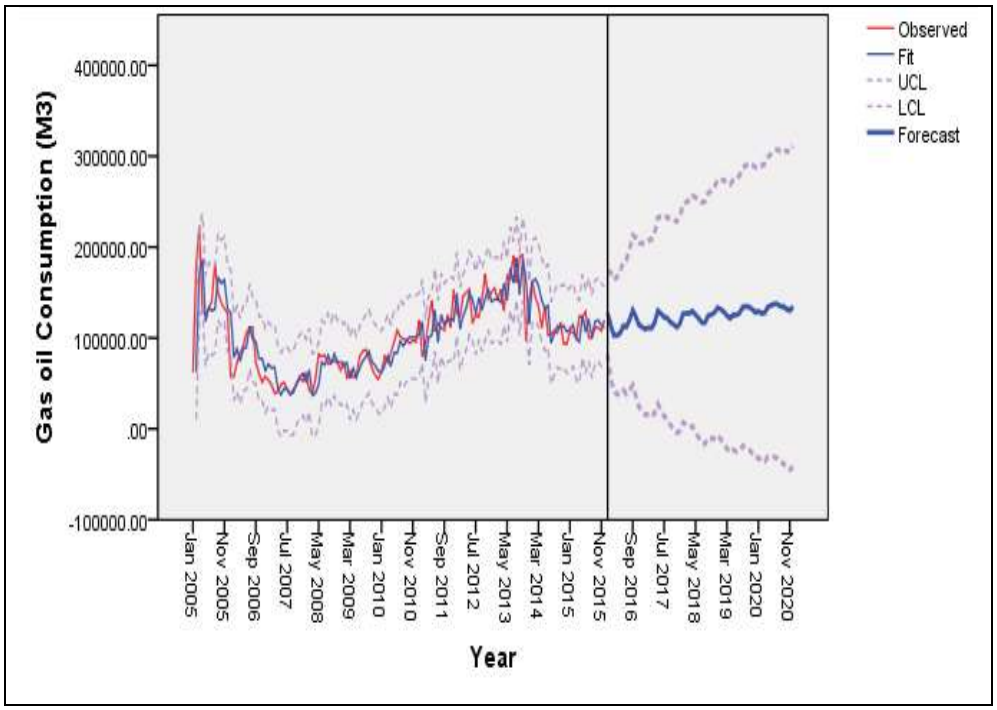

Fig (3) Forecasting of Gas oil Consumption for (2016-2020) Yrs [20].

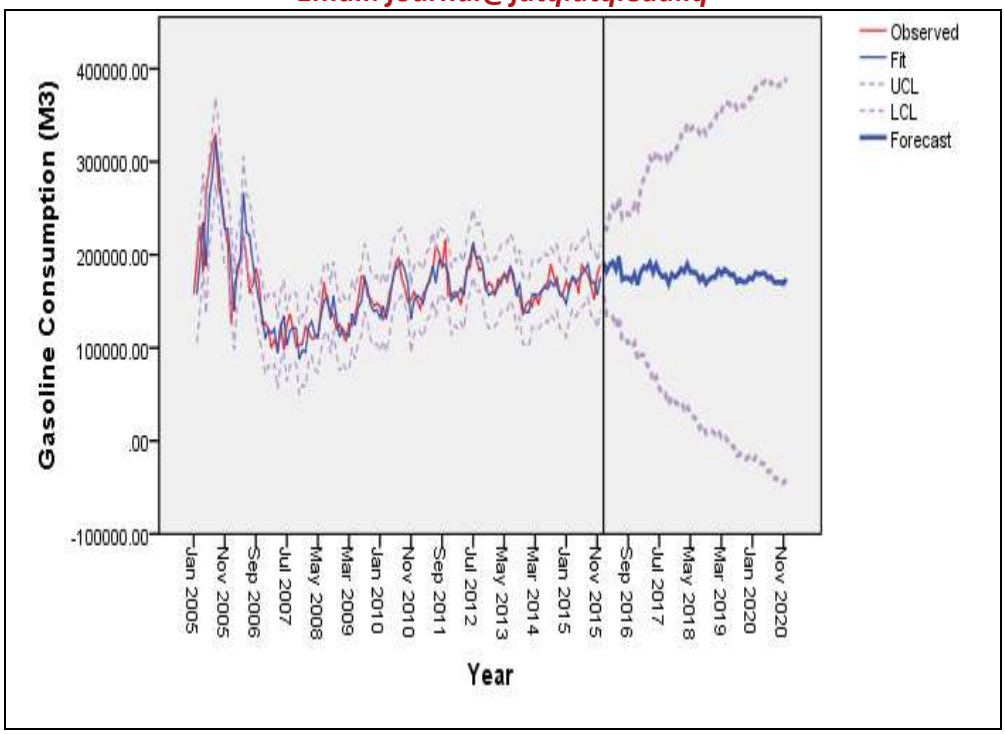

Fig (4) Forecasting of Gasoline Consumption for (2016-2020) Yrs [20].

Therefore Table (2) summarize the results as shown below,

Table (2) Fuel oil, Gas oil and Gasoline Consumption Using ARIMA Method [20].

Year	Fuel oil(M^3)	Gas Oil(M^3)	Gasoline(M^3)
2016	2797554	1377490	2179869
2017	2902655	1410018	2175559
2018	3019185	1502966	2145958
2019	3135769	1547763	2122873
2020	3252456	1594569	2098976

The second method used is MLR to find suitable relationship between dependent variables and independent variables, where used seasonal time series from 2005-2015 and forecasting to the next five years. Table (3) represent MLR estimates for Fuel oil consumption by effect two factors (Urbanization rate and Electricity sector). Urbanization rate is represented 85% from population growth. Where is show the statistical analysis such as Unstandardized Coefficients of the (MLR) Equation, Std. Error, Standardized

Coefficients, testing the significant of each factor effecting. Results show that Urbanization rate registered as the only factor accounting high significant effect at P<0.05, while other independent variables reported low significant effects at P>0.05. From Analysis of Variance (ANOVA) the p-value =0.00 less than 0.05 that describe relationship between independent variables (Urbanization rate and Fuel consumed in power stations) and dependent variables (Fuel oil consumption to Baghdad governorate)

Table (3) Regression Analysis for Fuel oil Consumption by (MLR) Method [20].

Regression Analysis						
Independent Variables	Unstandardized Coefficients		Standardized Coefficients	t-test	Sig.(p)	Index(*)
	B	Std. Error	Beta			
(Constant)	-542856.681	194437.140		-2.792	0.008	
X1	0.189	0.042	0.887	4.464	0.000	HS
X2	-0.271	0.190	-0.284	-1.428	0.161	LS
Dependent Variable: Fuel oil Consumption (M^3)						

(*) HS: Highly Significant at P<0.05; Low Significant at P>0.05.

The regression statistics for Fuel oil consumption can modeled as the equation (6) below:

$$Y_{Fuel\ oil\ Consumption} = -542856.681 + 0.189X_1 - 0.271X_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where X_1 and X_2 represent urbanization ratio, fuel used in power stations respectively.

Table (4) represent MLR estimates Gas oil consumption affected by four factors which are;- electricity sector, urbanization rate, numbers of vehicles and fuel consumed in generators. The results show that Electricity sector

registered as the only one factor accounting high significant effect at P<0.05 on consumption, while other independents variables are low significant at P>0.05. From (ANOVA) the p- value =0.01 less than 0.05 that describe relationship between independent variables (Fuel consumed in power stations, Urbanization rate, No of vehicles and Fuel consumed in Generators) and dependent variables (Gas oil consumption to Baghdad governorate). The regression statistics of Gas oil consumption can be modeled according to equation (7):-

$$Y_{Gas\ oil\ Consumption} = 1044613.3 + 0.681X_1 - 0.241X_2 + 1.395X_3 + 0.526X_4 \ldots..(7)$$

X_1, X_2, X_3 and X_4 represent fuel consumed in electrical stations, urbanization rate, number of vehicles and fuel consumed in generators respectively.

Table (4) Regression Analysis for Gas oil Consumption by (MLR) Method [20].

Regression Analysis						
Independent Variables	Unstandardized Coefficients		Standardized Coefficients	t-test	Sig.(p)	Index(*)
	B	Std. Error	Beta			
(Constant)	1044613.331	808717.122	-	1.292	0.204	
X1	0.681	0.372	0.607	1.831	0.003	HS
X2	-0.241	0.205	-1.079	-1.17	0.248	LS
X3	1.395	1.061	1.017	1.315	0.196	LS
X4	0.526	0.385	0.214	1.367	0.180	LS
Dependent Variable: Gas oil Consumption (M^3)						

Table (5) represented MLR estimates Gasoline consumption by affected two factors are; urbanization rate and numbers of vehicles. The results show that numbers of vehicles registered the only factor accounting high significant

effect at P<0.05, while other independents variables reported low significant effects at P>0.05. From Analysis of Variance (ANOVA) the p- value =0.045 less than 0.05 that describe relationship between independent variables (Urbanization rate and No. of vehicles) and dependent variables (Gasoline consumption to Baghdad governorate).

Table (5) Regression Analysis for Gasoline Consumption by (MLR) Method [20].

Regression Analysis						
Independent Variables	Unstandardized Coefficients		Standardized Coefficients	t-test	Sig.(p)	Index (*)
	B	Std. Error	Beta			
(Constant)	2186968.536	696856.466	-	3.138	0.003	
X1	-0.468	0.191	-1.999	-2.451	0.059	LS
X2	1.217	0.503	1.974	2.421	0.000	HS
Dependent Variable: Gasoline Consumption (M^3)						

The regression statistics Gasoline consumption can be modeled as in equation (8).

$$Y_{Gasoline\ Consumption} = 2186968.536 - 0.468X_1 + 1.217X_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

X_1 and X_2, represent urbanization rate, and number of vehicles respectively.

In this study, depended on (MAPE) to determine the error rate as in Table (6). That show the models generated by ARIMA method is appropriate to predict the consumption of petroleum products, since the error ratio is less for the three petroleum products.

Table (6) MAPE for (ARIMA / MLR) Methods [20].

Product	Fuel oil	Gas oil	Gasoline
MAPE/ARIMA Method	10.574	15.932	8.176
MAPE / MLR Method	14.38	24.76	16.78

Final detailed predicted consumption results by ARIMA and MLR for the three petroleum products is shown in Table (7) and Figs. (5,6,7). From these results an increase Fuel oil consumption for next five years. While Gas oil and Gasoline consumption level is remain almost steady as compared with previous years.

Table (7) Fuel oil, Gas oil and Gasoline Consumption by ARIMA and MLR methods [20].

Year	Fuel oil(M^3)		Gas Oil(M^3)		Gasoline (M^3)	
	ARIMA	MLR	ARIMA	MLR	ARIMA	MLR
2016	2797554	2521490	1377490	1678666	2179869	2501707
2017	2902655	2606628	1410018	1785873	2175559	2761094
2018	3019185	2741986	1502966	1953703	2145958	3020481
2019	3135769	2829438	1547763	2121077	2122873	3279868
2020	3252456	2955574	1594569	2280834	2098976	3553972

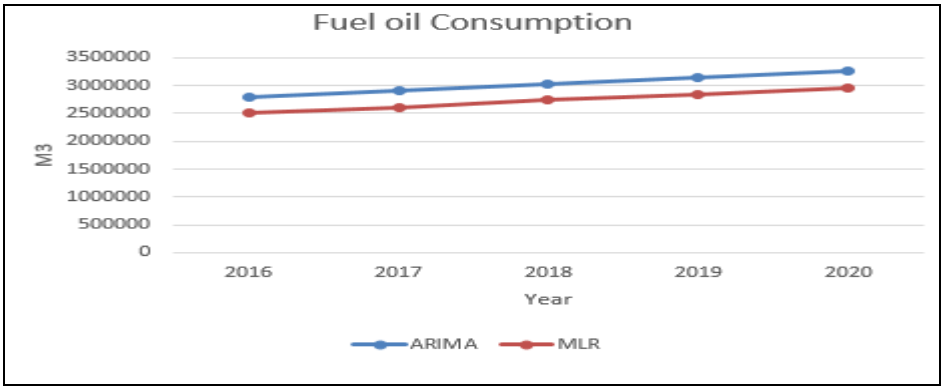

Fig (5) Forecasting Fuel Oil Consumption by ARIMA and MLR for (2016-2020) Yrs [20].

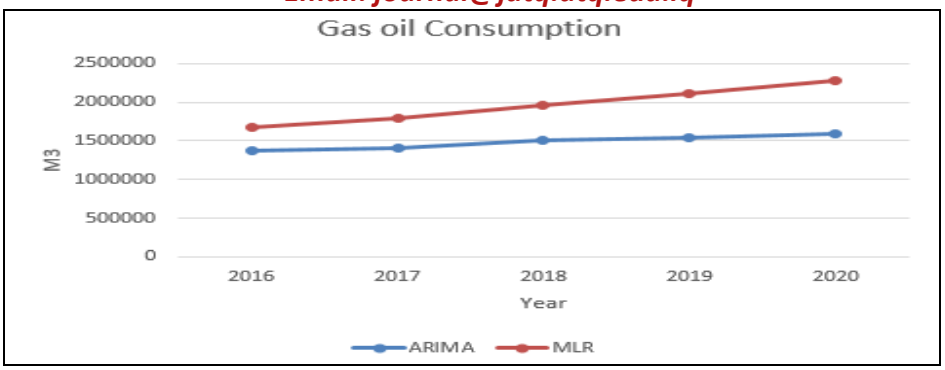

Fig (6) Forecasting Gas Oil Consumption by ARIMA and MLR for(2016-2020)Yrs [20].

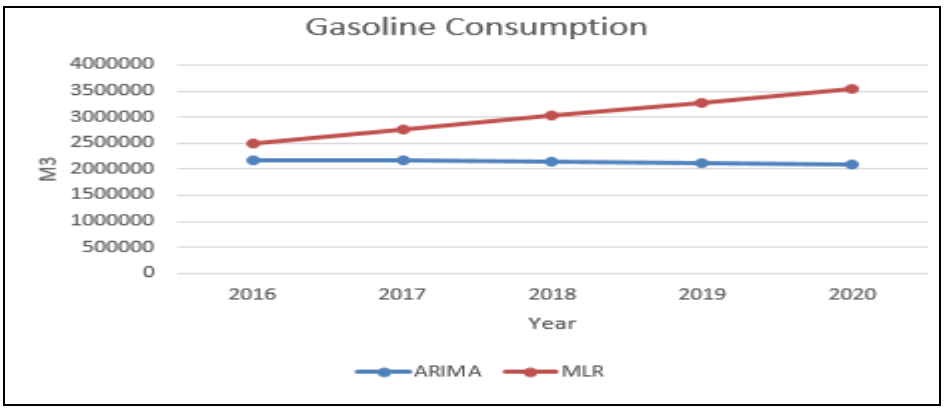

Fig (7) Forecasting Gasoline Consumption by ARIMA and MLR for 2016-2020) Yrs [20].

On comparing these results with the data collected for the previous period they show different trend that are not conform the actual consumption of the above mentioned products especially for Gasoline since the population and number of vehicles are increasing continues. Hence, other modeling techniques are recommended to be used that offer more compatibility to the local market demand.

4. Conclusions and Recommendation

The major conclusions from this research is

1. Increase in Fuel Oil consumption significantly in the next period as a result of its use in power stations in large quantities where the consumption can be reach to 3252456 M^3 in 2020.
2. Stable Gas and Gasoline in the same level of consumption as compared with previous years , where the consumption reach to 1594569 M3 and 2098976 M3 in 2020 for Gas and Gasoline consumption respectively.

3. ARIMA is most suitable method to forecasting Fuel oil, Gas oil and Gasoline consumption by time series analysis.

4. MLR method used to generate mathematical models to forecasting Fuel oil, Gas oil and Gasoline consumption using number of factors effecting consumption where MLR method less accuracy compared to ARIMA method.

It is recommended to;

1. Forecasting petroleum products consumption using other methods as non multi linear regression, fuzzy logic, Artificial Neural Networks (ANNs) and Genetic Algorithm (GA).
2. Use other influential factors on consumption, including economic factors and environmental factors to help in prediction and obtain better conforming results.
3. Forecasting models for other, Iraqi governorates, or petroleum products such as Kerosene, Liquefied Petroleum Gas (LPG) and Diesel.

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الطرق الاحصائية لنمذجة استهلاك المنتجات النفطية في العراق

ا. د. لمياء محمد داوود[1]

احمد عبد الرضا كريم [2]

الخلاصة : تهدف هذة الدراسة الى تطوير نموذج لتنبؤ استهلاك ثلاث منتجات نفطية رئيسية (البنزين وزيت الغاز وزيت الوقود) لمحافظة بغداد لخمس سنوات قادمة من عام 2016 الى 2020 باستخدام الطرق الكمية (الاحصائية) طريقة الانحدار الذاتى المتكاملة لمتوسط المتحرك وطريقة الانحدار الخطي المتعدد وبالاعتماد على البيانات التي تم جمعها عن الاستهلاك من عام 2005الى 2015من مصادر مختلفة لتقدير الاستهلاك لمحافظة بغداد. هنالك كثير من العوامل المؤثرة على الاستهلاك من ابرزها التعداد السكاني , نسبة التحضر , عدد المركبات و الوقود المستهلك في قطاع الطاقة الكهربائية. و النتائج التي تم الحصول عليها من طريقة الانحدار الخطي المتكامل للمتوسط المتحرك هي مناسبة لتنبؤ و اكثر دقة و ذلك من خلال الاعتماد على متوسط المطلق لنسبة الخطأ في تحديد دقة النماذج واظهرت النتائج ان نسبة الخطا تساوي 8.176%, 15.932%و 10.574% لنماذج تنبؤ كل من البنزين وزيت الغاز وزيت الوقود على التوالي. يتضح من النتائج زيادة في استهلاك زيت الوقود في الفترة القادمة مع بقاء الاستهلاك للبنزين و زيت الغاز بمستوى ثابت مع السنوات السابقة ادى ذلك الى زيادة الفجوه بين التجهيز والاستهلاك في خمس سنوات القادمة وذلك من خلال مقارنة انتاج مصفى الدورة مع الاستهلاك حيث ان كمية انتاج زيت الوقود اكبر من الكمية المطلوبة و نقصان انتاج البنزين و زيت الغاز . هذة النتائج ذات اهمية كبيرة لصناع القرار للاختيار بين عدة بدائل مختلفة مثل زيادة انتاج المنتجات الخفيفة (البنزين وزيت الغاز) والتقليل في انتاج زيت الوقود او استيراد هذة الانواع من الوقود او قرار في تنفيذ مصفاة جديدة .