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Trend Analysis of Crude Oil Prices in Ghana

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***Abstract* – Crude oil has become an integral part of the Ghanaian economy. It is an important commodity and its price volatility has an important effect on day-to-day activities. This project therefore seeks to determine the trend of crude oil prices in Ghana and also develop a model that will predict the prices of crude oil in Ghana. A three year monthly secondary data from January 2016 to December 2018 was downloaded from the official website of Bank of Ghana. Statistical Package for the Social Sciences (SPSS) software was used in the analysis of the data, different trends were exhibited in the years and also the analysis produced three models which are linear, quadratic and cubic. The results of the analysis showed that, the *p* values for the linear, quadratic and cubic regression models were significant at 5% level of significance. The coefficient of determination, R^2 for the cubic ($R^2 = 0.798$) was better than that of the linear and quadratic, hence the cubic regression model was considered as the best model.**

***Keywords* – Regression Analysis, Crude Oil Prices, Coefficient of Determination, Price Volatility.**

I. INTRODUCTION

Crude oil is a naturally occurring, unrefined petroleum product composed of hydrocarbon deposits and other organic materials found beneath the earth's surface [8]. Crude oil contributes significantly to the profitable areas of any economy manufacturing, agriculture and services [2]. It has become a fundamental piece of the Ghanaian economy. The development of the nation economy becomes weak against changes in price of crude oil, particularly when the country despite everything relies upon imported crude oil to meet her crude oil needs.

In Ghana, large amount of crude oil is utilized for the generation of electricity, manufacturing and transportation among other production exercises [1]. In the energy sector for example, aside from petroleum gas, light crude oil is the principal energy source that controls Ghana's warm plants to deliver power [3]. In almost all parts of the country, the usage of crude oil has become part of our day to day activities in the area of fuel transportation such as gasoline, diesel, and jet fuel.

Despite the fact that crude oil plays an important role to the country's economy, fluctuations in prices can significantly affects economic growth globally. Oil prices volatilities has enormous effect on both business and family units. It increases the cost of transportation and the charges of goods and services that are dependent on oil during either production or delivery to the market.

The prediction of oil price plays an essential role for example central banks and money related practitioners depends on oil prices in manufacturing imported variables for microeconomic risk assessment and projections. Moreover, prices of goods and services are dependent on oil price volatilities [6]. The economic strength of any country is affected with an unforeseen variation in oil prices and this is very critical for oil importing countries including Ghana. Crude oil is an important commodity and its price volatility has an important effect on day-to-day activities. There is a need to predict oil prices to help governments, organizations and individuals in their decision making and planning.

This project therefore seeks to analyze the trend of crude oil prices in Ghana and also to develop a model to predict crude oil prices in Ghana.

II. PRELIMINARIES

2.1. *Regression Analysis*

2.1. *Definition*

Regression analysis is a set of statistical methods for the estimation of relationships between a dependent variable and one or more independent variables [10]. It can be utilized to assess the strength of the relationship between variables as well as determining the other parameters. Various types include; Simple Linear Regression and Multiple Linear Regression.

2.1.1. *Simple Linear Regression*

Simple linear regression is a linear regression model with a single explanatory variable. That is, it concerns two-dimensional sample points with one independent variable and one dependent variable (conventionally, the x and y coordinates in a Cartesian coordinate system) and finds a linear function (a non-vertical straight line). Simple linear regression considers a single regressor or predictor X and a dependent or response variable Y [4]. Suppose that the true relationship between Y and X is a straight line and the observation Y at each level of X is random variable. The general linear regression model is given as;

$$Y = \beta_0 + \beta_1 X + \mathcal{E} \tag{1}$$

Where Y is termed as the dependent variable and X is termed as the independent or explanatory variable. The term β_0 and β_1 are the parameters of the model. The parameter β_0 is termed as intercept term and the parameter β_1 is termed as the slope parameter. These parameters are usually termed as the regression coefficients. The unobserved error component E accounts for the failure of data to lie on the straight line and represents the difference between the true and observed realization of Y].

2.1.2. *Multiple Linear Regression*

Multiple Linear Regression (MLR), also known simply as multiple regression, is a statistical technique that uses several explanatory variables to predict the outcome of a response variable [5]. The goal of MLR is to model the linear relationship between the explanatory (independent) variables and response (dependent) variable.

In essence, multiple regression is the extension of ordinary least-squares (OLS) regression that involves more than one explanatory variable.

Multiple regression allows you to determine overall fit of the model and the relative contribution of each of the predictors to the total variance. The model variance. The model for multiple linear regression is;

$$Y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n \tag{2}$$

2.1.3. *Statistical Tools*

2.1.4. *Coefficient of Determination* (R^2)

Coefficient of determination is a measure of how much of the variability in one variable can be "explained by" variation in the other variable [9]. For example, if the correlation of determinants between two variables, is $r^2 = 0.64$, then 64% of the variability in one variable can be explained by the other variable.

2.1.5. *Correlation Coefficient*

The correlation coefficient is a statistical measure of the strength of the relationship between the relative movements of two variables. The correlation coefficient, denoted by *r* indicates how closely data in a scatterplot fall along a straight line. The closer that the absolute value of *r* is to one, the better that the data are described by a linear equation [7].

Correlation is a measure of the association between two random variables, say X and Y. There are several types of correlation coefficients, but the one that is most common is the Pearson correlation *(r).* This measures the strength and direction of the linear relationship between two variables.

III. MAIN RESULT

3.1. *Graph Trend of Crude Oil Prices*

Figure 1 below shows a graph of the prices of crude oil, crude oil prices are the observations on the y-axis against equally time interval on the x-axis. It also shows the pattern and the behavior of the data.

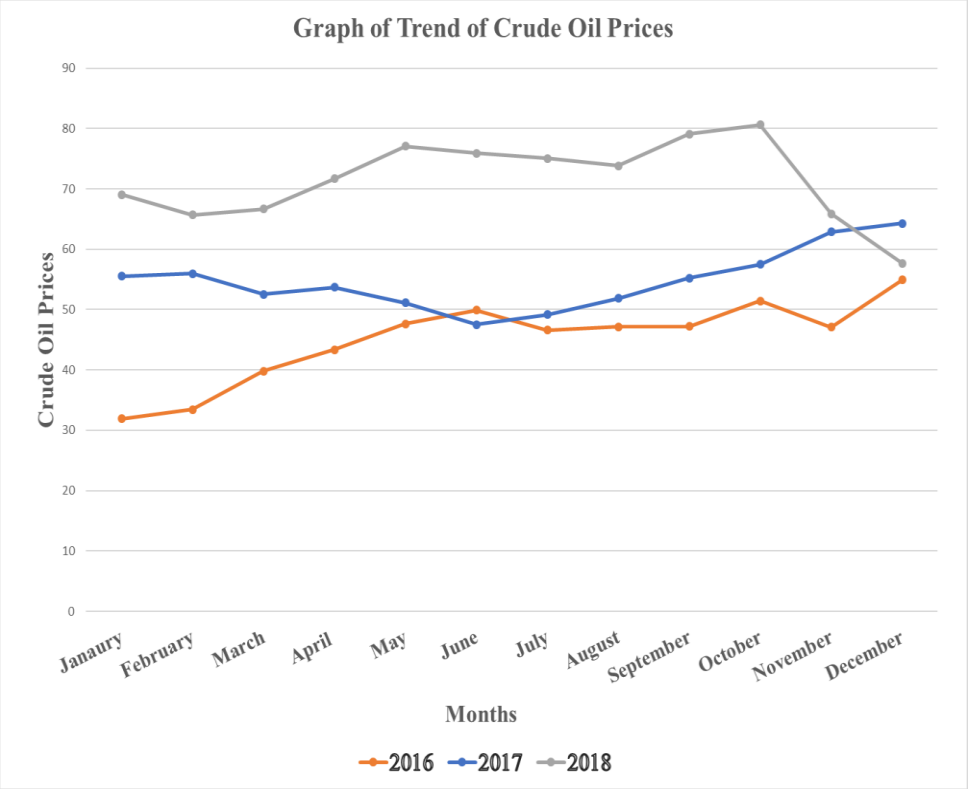

Fig. 1. Graph Trend of Crude Oil Prices.

From Figure 1, the prices of crude oil in all the three years appears to exhibit trends but not a linear one. The possibility of quadratic and cubic trends is therefore considered.

According to Figure 1, it was realized that from January 2016 to June 2016 the prices of crude oil was increasing and started declining from June to July, there again increased slowly from July to October, decreased in November and finally increased in December. In 2017, the prices decrease from January to June and started inclining from June to December. 2018 and also exhibited an oscillatory pattern signifying that the prices of crude oil do not follow any trend.

The model that best represents the trend of crude oil prices is giving by equation (3).

$$Y_t = 112.575 + (-2.346t) + 6.110t^2 + (-3.702t^3) \quad (3)$$

A linear equation can be written as:

$$Y = \beta_o + \beta_1 t \quad (4)$$

Where,

Y = Prices of crude oil

β_o = Intercept on the crude oil prices axis

β_1 = Slope of crude oil prices

t = Independent variable (time in months)

3.2. *Analysis of Linear Model*

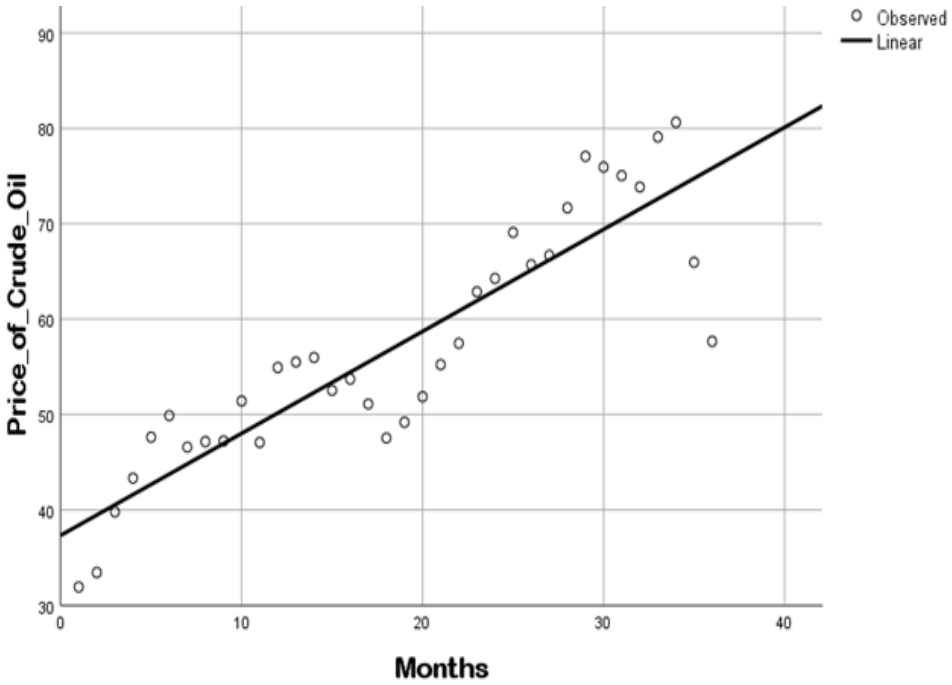

Fig. 2. Graph of Linear Model.

Table 1. Summary of Linear Model.

Model	Constant	*R*	R^2	Sig
Linear	37.333	0.890	0.793	0.000

Table 2. Summary of Linear Model Coefficient.

Model	β_0
Linear	0.890

The actual linear regression model is formulated as:

$$Y_t = 37.333 + 0.890t \quad (5)$$

From the linear model indicated in Figure 2, there is a positive relationship between the prices of crude oil (y_t) and the period (t) such that a unit increase in time would increase y_t by 0.890 units, and also a constant value of 37.333.

Table 1 and 2 present the summary of linear model estimates. The R^2 value of 0.793 suggests that 79.3% variation in crude oil prices is explained by time (t). The significant value of 0.000 < 0.05 level of significance so the null hypothesis is rejected, which shows that the linear regression is significant.

3.3. *Analysis of Quadratic Model*

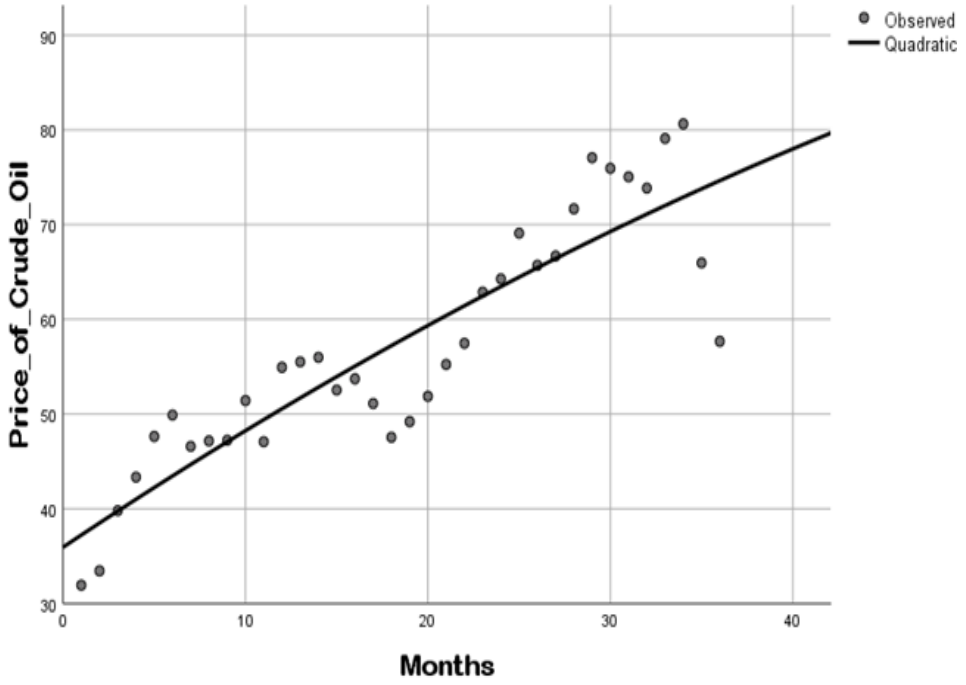

Fig. 3. Graph of Quadratic Model.

Table 3. Summary of Quadratic Model.

Model	Constant	R	R^2	Sig
Quadratic	35.938	0.892	0.795	0.000

Table 4. Summary of quadratic model coefficients.

Model	β_0	β_1
Quadratic	1.074	-0.189

The Quadratic model is giving as:

$$Y_t = 35.937 + 1.074t + (-0.189)t^2 \quad (6)$$

The quadratic model in Fig 3 suggests that, keeping t^2 constant, a unit increase in (t) would increase the price of crude oil by 1.074 units and also keeping (t) constant would decrease the price of crude oil by 0.189 units. The R^2 value of 0.795 suggests that 79.5% of variation in crude oil prices is explained by time (t). The significant value of 0.000 < 0.05 level of significance meaning we reject the null hypothesis and also indicating that the quadratic regression model is significant.

3.4. *Analysis of Cubic Model*

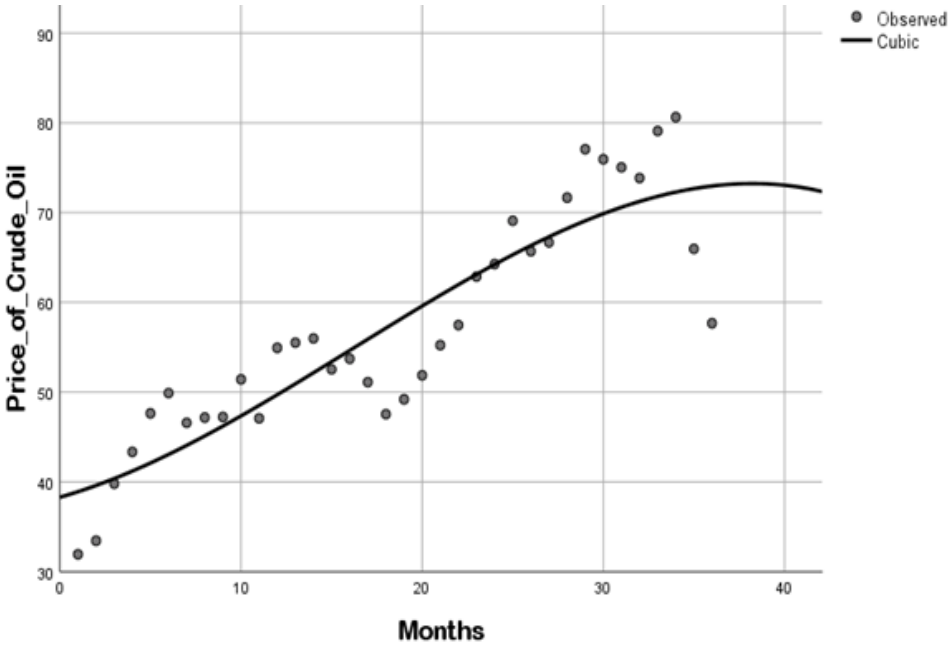

Fig. 4. Graph of Cubic Model.

Table 3. Summary of Cubic Model.

Model	Constant	R	R^2	Sig
Cubic	38.287	0.894	0.798	0.000

Table 4. Summary of Cubic Model Coefficients.

Model	β_0	β_1	β_2
Cubic	0.480	1.322	-0.947

The cubic regression model is given as:

$$Y_t = 38.287 + 0.480t + 1.322t^2 + (-0.947t^3) \quad (7)$$

The cubic regression model in Figure 4 suggests that keeping t^2 and t^3 constant, a unit increase in time (t) would increase the price of crude oil by 0.480 units. The R^2 value of 0.798 suggests that 79.8% of variation in crude oil prices is explained by time (t). The significant value of 0.000 < 0.05 level of significance meaning we reject the null hypothesis and also indicating that the cubic regression model is significant.

3.5. *Best Model Selection*

Under this section the R^2 values of the three models were examined and the one with the highest value of R^2 would be selected as the best model.

Table 5. Summary of R^2 Values.

Model	R^2
Linear	0.793
Quadratic	0.795

Model	R^2
Cubic	0.798

Considering table 5 above, by comparing the R^2 value of the three models, the cubic model gives the highest value of 0.798 suggesting that it is adjusted the best model to fit the data.

IV. CONCLUSION

In this study, the pattern of crude oil prices was examined and a model was developed to predict crude oil prices in Ghana. The significant values of all the three models were significant showing that the prices of crude oil do follow a uniform trend. The cubic model was chosen as the best model since it has the highest R^2 value.

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