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Comparative Analysis of Three Time Series Trend Models on Gross Domestic Product in Nigeria

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Abstract
This work fitted three time series trend models namely, linear trend model, quadratic trend model and exponential trend model on Gross Domestic Product of Nigeria using an annual data from 1982 to 2012. It was found out that the exponential trend model had the least MAPE and fitted the data appropriately. The exponential trend model was used to make a five year for forecast of Nigeria's Gross Domestic Product, which showed that the country's Gross Domestic Product will be on the rise within the next five years.
Keywords: Model, Forecast, Time Series and Linear Trend

1.0 Introduction

The time series analysis as a statistical method deals with analyzing past data and modeling it to obtain estimates of the future. To make any forecast about the future, past observations of a phenomenon must be obtained. Therefore, time series can be defined as series of observations collected over a period time order.

This can be represented mathematically, $Y = f(t)$ where the values $Y1, Y2 \cdots\cdots\cdots\cdots Yn$ are of variable Y at times $t1, t2 \cdots\cdots\cdots\cdots tn$. In time series, there are different kinds of movements namely, secular trend, seasonal variation, cyclical variation and irregular variation.

Therefore, the concept of time series analysis has been applied very well in forecasting macroeconomic variables. Christ (1951), in his work, indicated that when structural changes are taking place in an economy, econometric models are not superior to time series approaches. In this study, three time series models will be used to evaluate the movement of Gross Domestic Product in Nigeria. These are , linear trend model, quadratic trend model and exponential trend model with the aim of determining the best model that fits the Gross Domestic Product in Nigeria and more so, to make forecast of Nigeria's Gross Domestic Product. In this regard, the research question is, does the Gross Domestic Product in Nigeria follow the linear trend model? Providing an answer to this question will assist in structuring the methodology for this study. The annual data (1982 – 2012) of Nigeria's Gross Domestic Product used for this study was obtained from the National Bureau of Statistics, Abuja.

2.0 Method

2.0.1 Model Specification

The three models to be used in this study are the linear trend model, quadratic trend model and exponential trend model

The linear trend model:

$$Y_t = \beta_0 + \beta_1 T_t + \mu_t \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

Linear forecasting model:

$$Y_t = \beta_0 + \beta_1 T_t \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2)$$

The quadratic trend model:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 T_t^2 + \mu_t \quad \cdots\cdots\cdots\cdots\cdots (3)$$

Quadratic forecasting model:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 T_t^2 \quad \cdots\cdots\cdots\cdots\cdots\cdots (4)$$

The exponential trend model:

$$Y_t = \beta_0 \beta_1^T \mu_t \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (5)$$

Exponential forecasting model

$$Y_t = \beta_0 \beta_1^T \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (6)$$

Where

$\beta_0 =$ Estimated Y intercept

$\beta_1 =$ Estimated linear effect on Y

$\beta_2 =$ Estimated quadratic effect on Y

Decision Rule: the best fit model will be the one with the minimum accuracy measures (MAPE, MAD and MSD).

Mean Absolute Percentage Error (MAPE) – This expresses accuracy as a percentage of the error, because this number is a percentage, and it measures the accuracy of fitted time series values.

$$\text{MAPE} = \frac{\sum\left|\left(y_t - \hat{y}_t\right)/ y_t\right|}{n} x100 \quad \left(y_t \neq 0\right) \qquad \text{..... (7)}$$

Where y_t is the actual value, $\hat{y}_t$ is the estimated value, and n is the number of observations.

Mean Absolute Deviation (MAD) – This measures the accuracy of fitted time series values. It expresses accuracy in the same as the data. This helps to theorize the error also.

$$\text{MAD} = \frac{\sum\left|y_t - \hat{y}_t\right|}{n} \qquad \text{..... (8)}$$

Where y_t is the actual value, $\hat{y}_t$ is the estimated value, and n is the number of observations.

Mean Squared Deviation (MSD) – This is calculated using the same denominator, n, regardless of the model. This is to enable comparison of MSD values across models. This makes MSD a more sensitive of a usually largest forecast error than MAD.

$$\text{MSD} = \frac{\sum\left|y_t - \hat{y}_t\right|^2}{n}$$

Where y_t is the actual value, $\hat{y}_t$ is the estimated value, and n is the number of observations.

3.0 Results

3.0.1 The time series plot of the data:

The time series plot of the data in fig. 1 below, displayed the GDP of Nigeria for thirty one years (1982 – 2012). The plot shows trend movement with no seasonal variation. This means we shall model the data by fitting a general time series trend model to the time series data in order to know the model that fits best and make forecasts.

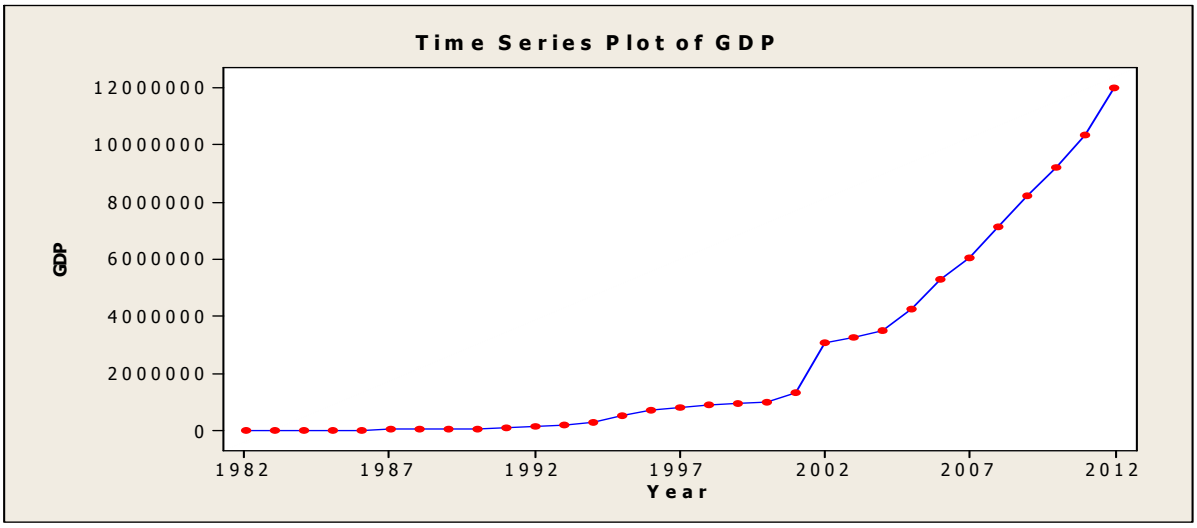

Fig.1 Time series plot of the data and Minitab 16 output

3.0.2 The Linear Trend Model:

The estimated linear trend model of equation (2) is given as $Y_t = -2763227 + 332694T_t$. The plot of the linear trend model in fig.2 shows that it does not fit the data.

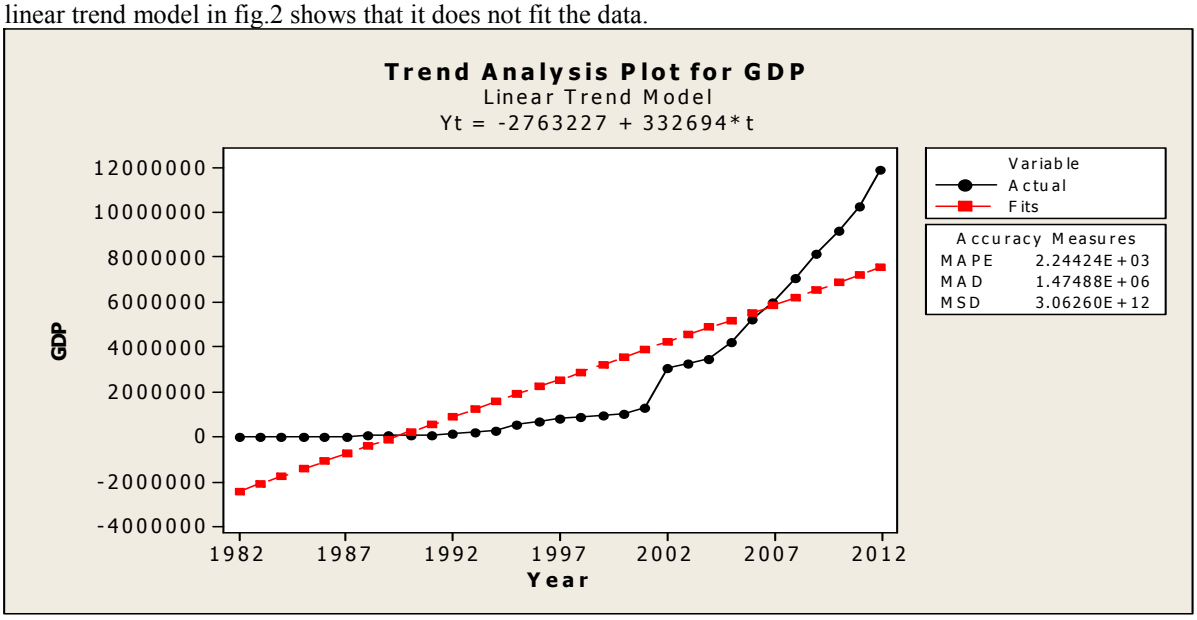

Fig.2 Time series plot of the linear trend model and Minitab 16 output

Table 1: Accuracy measures of linear trend model

Accuracy Measures	
MAPE	2.24424E+03
MAD	1.47488E+06
MSD	3,06260E+12

Authour's computation and Minitab 16 output

The accuracy measures of the linear trend model in table 3 show that MAPE has a value of 2.244E+3 while other measures are quite large.

3.0.3 The Quadratic Trend Model:

The estimated quadratic trend model of equation (4) is given as $Y_t = 1359472 - 416888T_t + 23424T_t^2$.
The plot of the quadratic trend model in fig.3 shows that it does not fit the data.

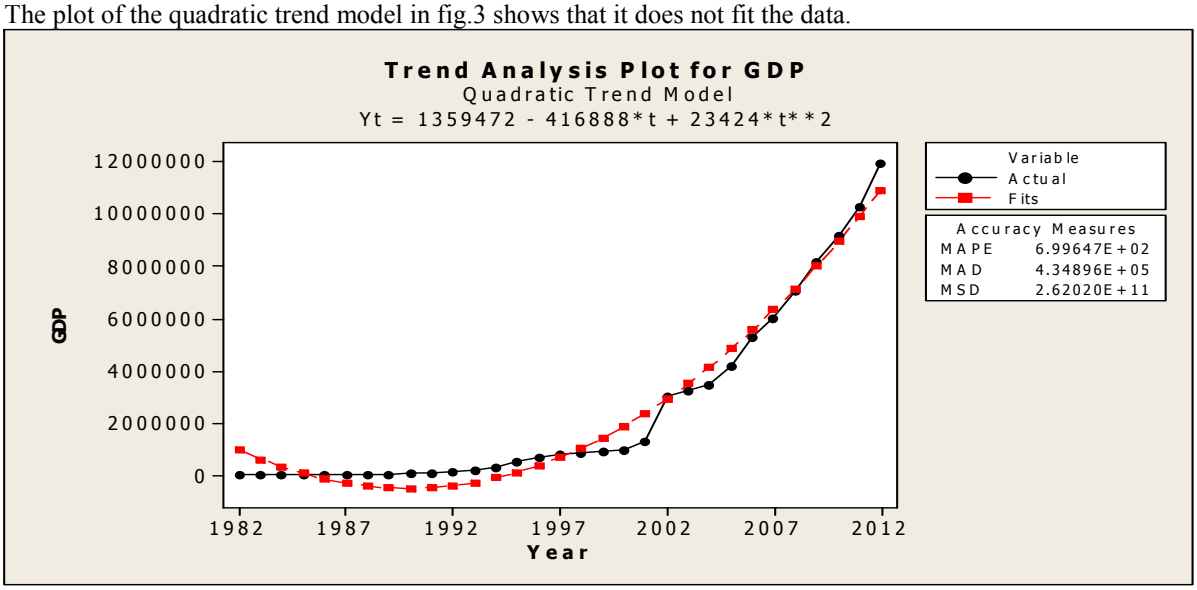

Fig.3 Time series plot of the quadratic trend model and Minitab 16 output

Table 2: Accuracy measures of quadratic trend model

Accuracy Measures	
MAPE	6.9964E+02
MAD	4.34889E+05
MSD	2.62020E+11

Authour's computation and Minitab 16 output

The accuracy measures of the quadratic trend model in table 2 show that MAPE has a value of 6.9964E+02 while other measures are quite large.

3.0.4 The Exponential Trend Model:

The estimated exponential trend model of equation (6) is given as. $Y_t = 8801.95(1.28647)^T$. The plot of the exponential trend model in fig. 4 shows that it fits the data with minor deviation.

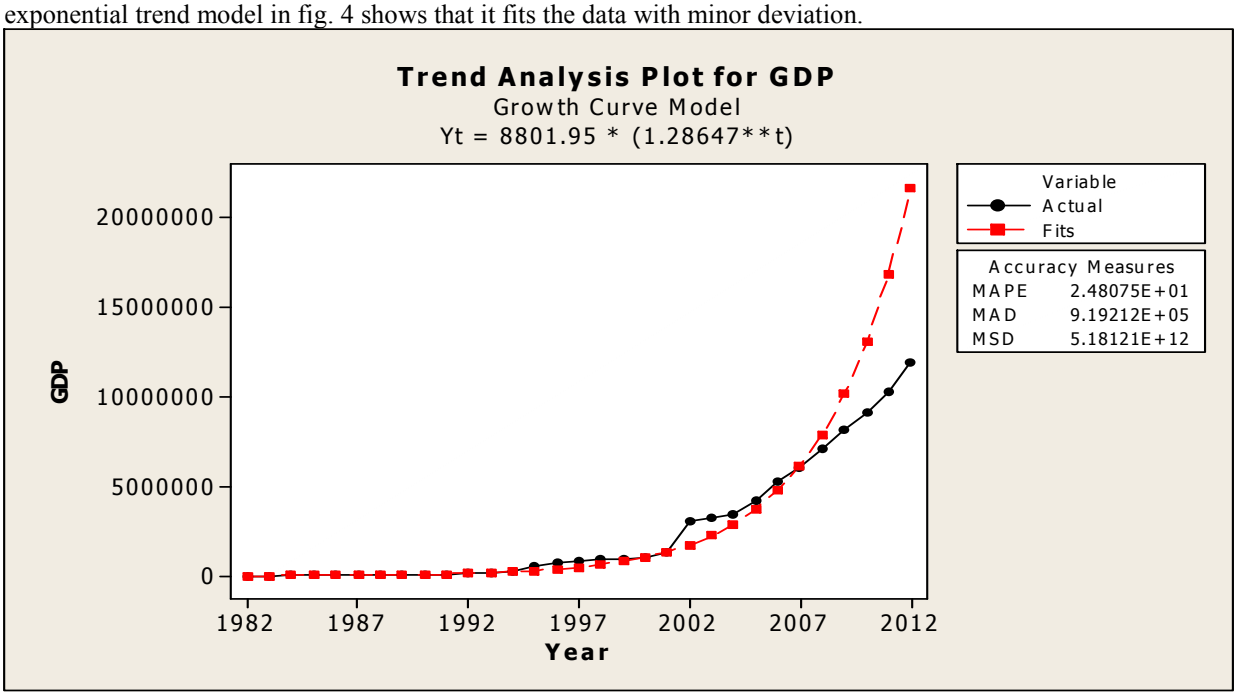

Fig.4 Time series plot of the exponential trend model and Minitab 16 output

Table 3: Accuracy measures of exponential trend model

Accuracy Measures	
MAPE	2.48075E+01
MAD	9.19212E+05
MSD	5.18121E+12

Authour's computation and Minitab 16 output

The accuracy measures of the exponential trend model in table 3 show that MAPE has a value of 2.48075E+01 while other measures are quite large.

3.0.5 Comparing the Accuracy Measures:

Table 4: Comparative accuracy measures

Model	MAPE	MAD	MSD
Linear	2.24424E+03	1.47488E+06	3,06260E+12
Quadratic	6.9964E+02	4.34889E+05	2.62020E+11
Exponential	2.48075E+01	9.19212E+05	5.18121E+12

Authour's computation and Minitab 16 output

Comparing the accuracy measures of these three models in table 4, both the MAD and MSD are quite large for all the models. Nevertheless, specifically using MAPE which is a more effective measure of the three accuracy measures, the exponential model has the smallest MAPE measure of 2.48075E+01 when compared to other models, therefore, it shows that Gross Domestic Product of Nigeria does not follow a linear trend model; rather, it follows an exponential trend model. To this end, a five year forecast of Nigeria's Gross Domestic Product will

be computed using the exponential trend model.

3.0.6 Five Year Forecast of Nigeria's Gross Domestic Product

The exponential trend model forecast of Nigeria's Gross Domestic Product shows that the country's GDP will be on the rise as this can be confirmed in table 5 below.

Table 5: Five year forecast of Nigeria's GDP using exponential trend model

Period	2013	2014	2015	2016	2017
Forecast(Naira'M)	27.884,371	35,872,388	46,148.727	59.368,922	76,376,298

Authour's computation and Minitab 16 output

4.0 Conclusion

The fitting of appropriate trend model to the Gross Domestic Product of Nigeria (1982-2012) showed that exponential trend model was the best fit model for the data and with the smallest MAPE. Since the exponential trend model was the best fit, it was used to make forecast of Nigeria's GDP. It clearly showed that Nigeria's GDP will be on the rise within the next five. This confirms the current GDP figures recently released by the National Bureau of Statistics, Nigeria on the rebasing of Nigeria's GDP which in on the increase.

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