# Modelling and forecasting the Maintenance Cost of Roads in Anambra State

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**Abstract**— This study dealt with evaluating the maintenance cost of roads in Anambra State using the times series approach. The objective of the present study to develop a time series model for estimating maintenance cost of roads in Anambra State. Secondary data set obtained from Consolidated Construction Company (CCC) form the year 2004 to 2013 was used to evaluate the analysis. The statistical tools used include the Kwiatkowski-Phillips-Schmidt-Shin test, Augmented Dickey-Fuller test, time series analysis and descriptive analysis. The findings of the study showed that the maintenance cost of roads has an increasing trend over time. The series was found to be stationary using the Kwiatkowski-Phillips-Schmidt-Shin test. Also, it was found that the series has no unit root at the first difference using the Augmented Dickey-Fuller test. It was concluded that the series was stationary overtime which implies that the model obtained can be used to make forecast for future behaviour of the process. Hence, five years forecast on the maintenance cost of roads in Anambra State was made and it was found that in the year 2018 all things being equal the maintenance cost of roads in Anambra State is expected to be about N237,226,028. This result implies that the maintenance cost of roads in Anambra State is expected be about N237,226,028 in the year 2018.

**Index Terms**— Forecast, Model, Maintenance cost, Roads, Stationary, Time series, Unit root
Maintenance cost of roads, Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD), and Mean Square Deviation (MSD), Time Series

## 1 INTRODUCTION

Roads are of vital importance in order to make a nation grow and develop. Especially in the third world, good maintained roads also will enhance poverty reduction by improving access between regional and rural communities and, ultimately, enhancing socio-economic growth and development. Road networks form vital links between production centres and markets. In addition its multiple function of providing access to employment, social, health and education services makes road network crucial in fighting against poverty by opening up more areas and stimulating economic and social development.

There is a problem, however, which is common throughout the world, the neglect of maintaining our roads. Building new roads cost money, but without maintaining the roads properly, they deteriorate very quickly. If nothing is done, roads with a design life of decades can need replacing or major repair work after just a few years.

That deterioration will very fast infect road transport in general where the costs will soar, which again will infect the economy of the transporters. The transporters will transfer their expenses to the customers and the economy of the whole country will suffer. As the road network deteriorates, the whole country loses major assets build up over years, assets created with vast amounts of money, time and effort.

Yet even small budgets for maintenance make a difference with proper planning and the right priorities. The situation in many countries concerning the road condition is not only urgent, it is critical. It is important to know the costs involved in road maintenance and the costs of not maintaining the roads. The money which is saved in the maintenance budget by not maintaining the roads, is ultimately paid by the users and the society. We can refer to it as the invisible tax, and the total cost to the economy is huge. Road maintenance activities can be classified based on the nature of each activity and the frequency at which they should be carried out. a. Routine Maintenance b. Recurrent Maintenance c. Periodic Maintenance d. Urgent Maintenance.

In most countries like Nigeria, it is believed to be a political benefit to be in favour of investing money in building new roads. However, maintenance does not have the same status or does not give the same opportunity to stake holders or decision makers to present themselves to the public. To this end, the main objective of this study is to develop a time series model for estimating maintenance cost of roads in Anambra State. We believe that the result of this study will help government in proper planning and providing appropriate budget allocation and attention to road maintenance in Anambra State.

## 2 METHODOLOGY

### 2.1 Time Series Analysis

Time series is an ordered sequence of values of a variable at equally spaced time intervals. Time series analysis accounts for the fact that data points taken over a period of time may have an internal structure (such as trend or seasonal variation) that should be accounted for. Time Series can be defined as a collection of observations $x_t$, each one being recorded at time t (where time could be discrete, t = 1,2,3,…, or continuous t > 0). In their contribution, [1] defined a time series as a collection of observations of well-defined data items obtained through repeated measurement over time.

Also, after fitting the time series model, the model was tested for staitionarity. A stationary time series is one whose statistical properties such as mean, variance or autocorrelation are all constant over time. Most time statistical forecasting methods

are based on the assumption that the time series can be rendered approximately stationary through the use of mathematical transformations ([2]; [3]). Stationarity of a processes implies that predictions of the statistical properties will be the same in the future as they have been in the past. In addition, the stationary assumption allows the straight forward calculation of the long run equilibrium distribution of the process [4]. In this study the augmented Dickey-Fuller test (ADF) will be employed in testing for unit root and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for testing Stationarity of the process.

The augmented Dickey-Fuller test is a test for a unit root in a time series sample data. The augmented Dickey-Fuller statistic, used in the test is a negative number. The more negative it is, the stronger the rejection of the hypothesis that there is a unit root at some level of confidence. The one classical procedure for testing for unit root is to test using augmented Dickey Fueller and with intercept. If the test statistic < critical value (i.e. less than the negative value) reject $H_o$. No unit root. Otherwise choose first difference and continue with until you reject Ho. The amount of differencing required to reject Ho=order of integration=number of unit roots.

The Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is used for testing the null hypothesis that the observed time series is stationary around a deterministic trend. Ref [5], proposed a test of the null hypothesis that an observed series is trend stationary (stationary around a deterministic trend). The series is expected as the sum of deterministic trend, random walk, and stationary error, and the test is the Lagrange multiplier test of the hypothesis that the random walk has zero variance. The KPSS type test are intended to compliment unit root test, such as the Dickey-Fuller tests. By testing both the unit root hypothesis and the stationarity hypothesis, the researcher can distinguish series that appear to be stationary, series that appear to have unit root, series for which the data are not sufficiently informative to be sure whether they are stationary or integrated and series that are fit to be used in predicting future behaviour of the data of interest.

The maintenance cost of roads was analyzed using that time series analysis with the main objective of designing a model that can be used in estimating the maintenance cost of roads given a time parameter. In time series analysis time parameter t is usually generic, in this research time here is observed as year. Hence, a trend analysis on the observed data will be performed and a corresponding model obtained. Also, the data will be tested for unit root and stationarity which will validate the use of the model for making forecasts. A five years forecast of the maintenance cost of roads using the designed model will be performed with aim of giving an idea of what maintenance of roads will cost in Anambra State all things being equal.

### 2.2 Source of Data

The source of data for this study was secondary source of data collection obtained from the records department of Consolidated Construction Company Uli Asphalt Plant Anambra State, Nigeria. The data comprises year and maintenance cost of road in Anambra State. The maintenance cost of road comprises of material cost, labour cost, overhead cost, transport cost for the production of binder and wearing for a the period 2004-2013.

### 2.3 Computing Package

The Eviews7 package was used to execute the time series analysis; the Kwiatkowski-Phillips-Schmidt-Shin test and the Augmented Dickey-Fuller test were also carried out.

### 2.4 Data Presentation

**Table 1: Summary of maintenance cost of roads and year code**

| Mcr | Year | Year code (t) |
|---|---|---|
| 57845868 | 2004 | 1 |
| 61211163 | 2005 | 2 |
| 83060565 | 2006 | 3 |
| 152240042 | 2007 | 4 |
| 201949343 | 2008 | 5 |
| 130670316 | 2009 | 6 |
| 182753103 | 2010 | 7 |
| 97130327 | 2011 | 8 |
| 141778801 | 2012 | 9 |
| 191931676 | 2013 | 10 |

Key: mcr represents maintenance cost of roads and year code(t) represents year

## 3. RESULTS AND DISCUSSION

### 3.1 Discussion of Results

The result of the time series analysis using table 1 obtained a Mean Absolute Percentage Error (MAPE) of 28.35, Mean Absolute Deviation (MAD) of 32704400, a Mean Square Deviation of 1.52 x 10^15 and the trend model,

$$Y_t = 68011964 + 11280938 \times t$$

The result of the stationarity test using the Kwiatkowski-Phillips-Schmidt-Shin test presented in table 2 revealed that the time series process of maintenance cost of roads in Anam-

bra state is stationary across the observed time period since the test the test statistic measure of 0.35 was obtained which falls on the acceptance region of the hypothesis. Table 3 showed the result of the unit root test using the Augmented Dickey-Fuller test statistic found that the series has unit root and is stationary over time since a t-statistic value of -1.87 was obtained with a p-value of 0.33 which falls on the acceptance region of the hypothesis assuming a 95% confidence level. It was found that the time series process has a unit root and the first difference analysis of the Augmented Dickey-Fuller test analysis found a test statistic measure of-3.64 with a p-value of 0.033 which implies that the series has no unit root at the first difference I(1) and stationary overtime which implies that the model obtained can be used to make forecast for future behaviour of the process.

Since, the series is stationary over the observed period and adequate for making future prediction, five years forecast on the maintenance cost of roads in Anambra State was made and it was found that in the year 2018 all things being equal the maintenance cost of roads in Anambra State is expected to be about N237,226,028.

Figure 1 revealed that the maintenance cost of roads has an increasing trend over time.

Figure 2 and 3 showed that the trend line generated a good fit for the observed data set on the maintenance cost of roads in Anambra State.

**Table 2: Summary of Kwiatkowski-Phillips-Schmidt-Shin test**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: MCR is stationary | | | | |
| Exogenous: Constant | | | | |
| Bandwidth: 1 (Newey-West automatic) using Bartlett kernel | | | | |
| | | | | LM-Stat. |
| Kwiatkowski-Phillips-Schmidt-Shin test statistic | | | | 0.351873 |
| Asymptotic critical values*: | | 1% level | | 0.739000 |
| | | 5% level | | 0.463000 |
| | | 10% level | | 0.347000 |
| *Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1) | | | | |
| | | | | |
| Residual variance (no correction) | | | | 2.57E+15 |
| HAC corrected variance (Bartlett kernel) | | | | 3.31E+15 |

**Table 3: Summary of Augmented Dickey-Fuller test**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: MCR has a unit root | | | | |
| Exogenous: Constant | | | | |
| Lag Length: 0 (Automatic - based on SIC, maxlag=1) | | | | |
| | | | | |
| | | | t-Statistic | Prob.* |
| | | | | |
| Augmented Dickey-Fuller test statistic | | | -1.872082 | 0.3284 |
| Test critical values: | 1% level | | -4.420595 | |
| | 5% level | | -3.259808 | |
| | 10% level | | -2.771129 | |
| | | | | |
| *MacKinnon (1996) one-sided p-values. | | | | |

**Table 4: Summary of Augmented Dickey-Fuller test at First Difference**

| | | | | |
|---|---|---|---|---|
| Exogenous: Constant | | | | |
| Lag Length: 0 (Automatic - based on SIC, maxlag=1) | | | | |
| | | | | |
| | | | t-Statistic | Prob.* |
| | | | | |
| Augmented Dickey-Fuller test statistic | | | -3.640206 | 0.0329 |
| Test critical values: | 1% level | | -4.582648 | |
| | 5% level | | -3.320969 | |
| | 10% level | | -2.801384 | |
| | | | | |
| *MacKinnon (1996) one-sided p-values. | | | | |
| Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 8 | | | | |

**Table 5: Forecasts of maintenance cost of roads in Anambra State**

| Year | Year code (t) | Forecast of mcr |
|---|---|---|
| 2014 | 11 | 192102277 |
| 2015 | 12 | 203383215 |
| 2016 | 13 | 214664152 |
| 2017 | 14 | 225945090 |
| 2018 | 15 | 237226028 |

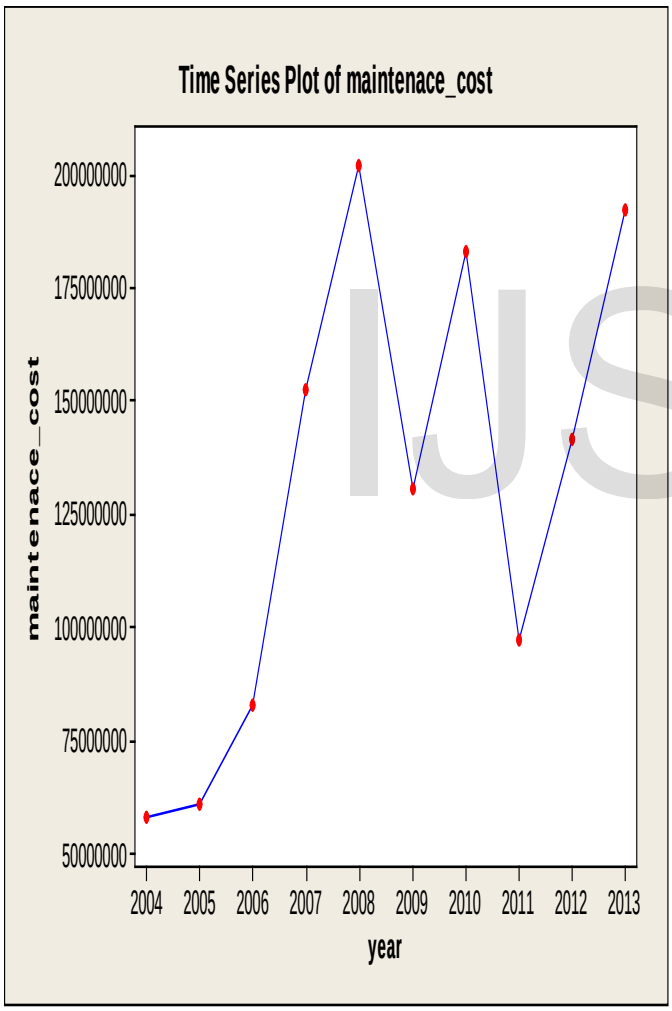


Fig. 1. Distribution of Maintenance cost of roads (2004-2013)

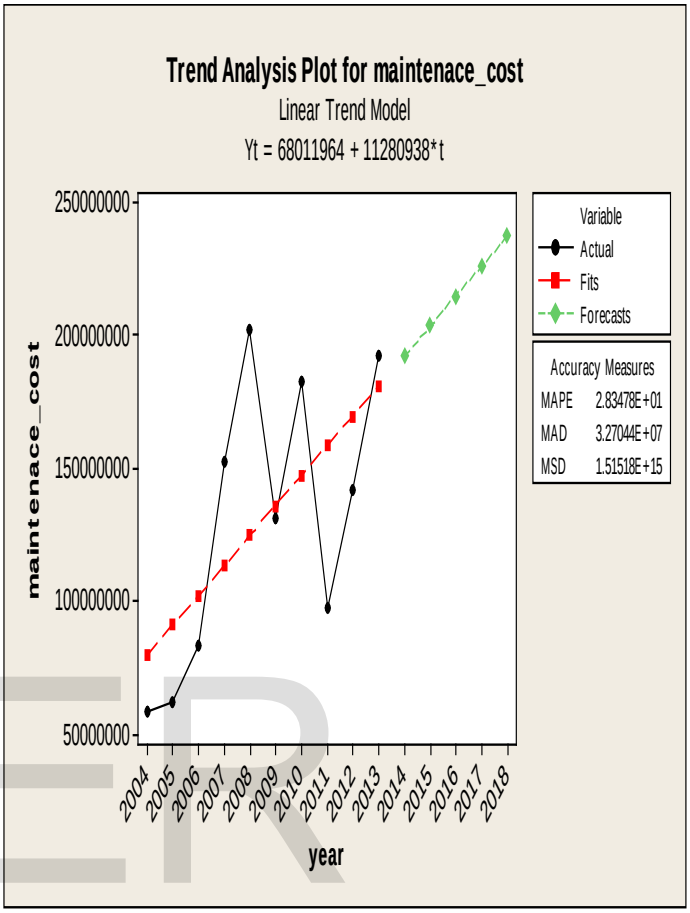


Fig. 2. Trend Plot of Maintenence Cost of roads (2004-2013) with (2015-2018) Forecast

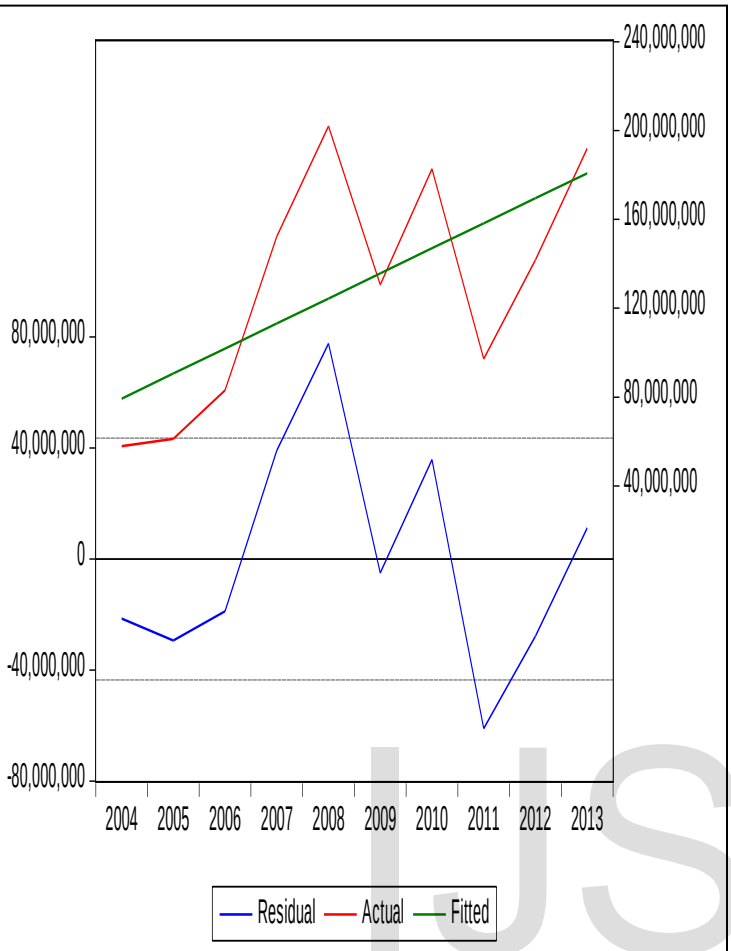


Fig. 3. Distribution of Actual, Fitted & Residua for Maintenance cost of raods in Anambra Statel

## 4 CONCLUSION

Results showed that the time series model on the maintenance cost of roads was stationary over the observed period. It was also found that the maintenance cost of roads has an increasing trend over the observed period. The designed model estimated that in the year 2018 all things being equal the maintenance cost of roads in Anambra State is expected to be about N237,226,028.

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