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MODELLING THE NIGERIAN PORTS AUTHORITY REVENUE GENERATED SERIES WITH AND WITHOUT OUTLIERS

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Abstract: This study examined the Nigerian Ports Authority (NPA) revenue generated monthly series spanning January, 2007 to December, 2019 inclusive. The objective of the study is to define a good model and a perfect fit for the NPA revenue generated series by comparing the forecast of the transformed series with outlier and without outliers using the forecast evaluation criterion. Bartlett's power transformation technique was employed. Outlier detection methods initiated were: Modified Z score test, Median Absolute Deviation (MAD), Standard deviation, Range test and Tukey methods. Outliers were treated using the mean imputation method. Box and Jenkins technique was employed for model building. The results showed that (i) normality and variance stability was achieved (ii) MAD, Range and standard deviation tests proved effective in outlier detection (iii) ARIMA (1, 1, 3) model, perfectly described the behaviour of the NPA revenue generated series for the transformed series without outliers. (iv) The forecast evaluation criterion of the transformed data without outliers has a perfect fit when matched with the transformed data with outliers hence, ARIMA (1, 1, 3) is the most suitable model.

Keywords: Bartlett's Power Transformation; Outlier Detection Methods; Series with/without Outliers; Box and Jenkins Technique; Forecasts.

1. Introduction

Revenue generation process begins with data collection. Important data are paramount to revenue administrative structure's capability to provide accurate and actionable information. A system must collect and store historical data for inventory, prices, demand and other causal factors. Statistical data that discloses the facts of products offered, their prices, competition and customers' behaviour must be collected, stored and analyzed. Thus, Revenue can be seen as the gross or net income which a company actually receives at a specified period of time (daily, quarterly, monthly, yearly). Examples of revenue generated includes taxation, fees, fines, inter-governmental grants or transfers, securities, sales, mineral and resource rights (Oseni, 2013).

Nigerian Ports Authority (NPA) is a federal government agency that governs the operation of sea ports in Nigeria, established in 1954 under the ports act of 1954 and started its operations in April, 1955. The statutory functions of NPA include dredging and contract dredging of water ways, repairs and maintenance of buoys, provision and operation of cargo handling facilities, pilotage and towage services, navigational lighting of the ports and other subsidiary services, supply of water and fuel to vessels anchorage and mooring buoys, ensure safety and security at water channels and regulation of concessionaires' operation. "The major seaports controlled by NPA (excluding oil terminals) includes Tin Can Island (Apapa), Roro (Lagos), Rivers port, Delta port (Warri), Calabar ports, Container Terminal (Lagos), Federal lighter Terminal (Onne) and Federal Ocean Terminal (Onne). Rivers Ports, the source of data for this study, was established in the East of the Niger and is the second oldest port in the nation state. It was conceptualized as the primary gateway for the exportation of coal from Enugu which was commissioned for business by Lord Frederick Lugard in 1913. A concise history of the NPA and Nigerian seaports can be found in Bello (2001), Igbokwe (2009), Adeniyi (2015), and Anthony (2016).

Nigerian seaports provide key platforms for trade facilitation. About 90% imports and exports pass through these seaports. The NPA revenue is mainly generated from imports, export, ports' charges, tariffs, throughput fees, berth renting, cargo inspection, Estate rent, jetty licenses, custom duties, mandatory fees from vessel lifting Nigerian crude oil, corporate tax, VAT, etc. (Igbokwe, 2009; Christiana, 2013). The revenue generated and collected by NPA is in foreign currency which enhances the country's foreign reserve. As a business enterprise, it is definite that from time to time, the revenue generated will experience gains and losses depending on its source' nature and development. Therefore, the behaviour of the generated revenue can be examined using time series analysis. Time series is the collection of an ordered series of observations at equally spaced intervals. The importance of analyzing time series data is to determine the historical pattern or study the dynamics of the series thereby explaining the erratic nature of the series or growth of a company/an economy, forecast future unanticipated trends and articulate policies. Time series analysis can be applied in budgeting analysis and control, sales forecasting, economic planning/forecasting, financial risk management, utility studies, geosciences and metrology, yield projections, census analysis, medicine, process and quality control, workload projections, inventory studies (Chatfield, 2004).

The problem commonly encountered in time series data analysis is the existence of outliers and structural changes. Enormous changes in series' trends are at times caused by outliers, detected as variation from predicted series using distance or model based analysis. Thus, an outlier is a point whose standardized residual falls outside the interval. Outliers are caused by a shift in the mean or variances of the process, changes in system behaviour, fraudulent behaviour, human error (gross recording error), instrument error (measurement error) or simply through natural deviations in populations. It can also originate from misspecifications based on wrong distributional assumptions (Alfred *et al.,* 2015). Studies have shown that outliers had been a global problem in time series analysis. If the series are not randomly distributed, outliers decrease normality, causing Type 1 and Type II error [Burman and Otto (1965), Seo (2006), Tolvi, (1998)]. From primeval times, outliers have been studied extensively with numerical data to be precise and diverse methods have been proposed by so many researchers trying to curb outlier problems in time series. In this regard, statistical detection and treatment of outliers is imperative for model building especially, in the search for a good model to provide a perfect fit to generated data.

Revenue generation is very significant to the life of an organization. Hence, close attention must be paid to the behaviour of the data collected over time to certify that its growth is sustained. Most often, the nature of the revenues generated and its fluctuations over time are due to some economic shocks. Outliers do occur in time series and this can hinder its study and consequent modelling for economic policies. Therefore, in analyzing time series of financial data such as revenue generated, one should ensure the treatment of outliers before modelling and forecasting is done. Empirical studies have shown that modelling revenue generated series enables forecasting of future trends. Etuk *et al.* (2014) modelled the monthly internally generated revenue of Mbaitoli Local Government Area of Imo state, Nigeria from 2001 – 2006. The time series plot showed a parallel trend and a 12 monthly seasonality. The autocorrelation function follows a sinusoidal pattern of 12-month periodicity that was not significant. The differenced and stationary series on modelling, yielded a horizontal pattern and the correlogram (i.e. seasonality of 12-month periodicity) indicated the presence of a seasonal autoregressive component of order one. SARIMA model (0, 0, 0) x (0, 1, 1) was accepted. Similarly, Emelogu

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(2010), Oliveira *et al.* (2012) and Mustapha (2015) used time series analysis to study the trend behaviour of the collected revenues with a view to forecasting future trends respectively. Their results were remarkable.

The aim of this study is to define a good model for a perfect fit to the NPA revenue generated series by comparing the forecast of the transformed data (with outliers) and (without outliers), using Nigeria Ports Authority (NPA) revenue generated data from 2007 – 2019.

This study will serve as a guideline for evaluation of port performance of the maritime industry. This exploration covers the operations of the Nigerian Ports Authority revenue generated series from January, 2007 to December, 2019 and is limited to Rivers Port only due to time and financial constraints, organizational secrecy in information dispensation, difficulty in data collection, etc.

2. Theoretical foundation

2.1 Data Transformation

Transformation is the application of a deterministic mathematical function to each point in a data set, typically applied to data that appear closely to meet the assumptions of statistical inference procedure and improve interpretability. It is often connected with non-stationary time series data The reasons for transformation include to achieve variance stability, choice of models, normalizing (many statistical methods require to follow a particular kind of distribution which is usually the normal distribution), reducing outliers' effect, making the measurement scale more meaningful and linearizing the relationship (Akpanta and Iwueze, 2009). An effective way to stabilize the variance across time is to apply common transformations $\left[\log Y, \sqrt{Y}, \frac{1}{Y}, Y^2, \frac{1}{Y^2}, \frac{1}{\sqrt{Y}}\right]$ to the systematic observations.

Transformation techniques have been applied by many researchers to achieve one or more of the above stated reasons for transformation [Makridakis and Hibon (1997), Akpanta and Iwueze (2009), Okororie *et al.* (2013), Iwueze *et al.* (2013)]. The motives for transformation in this study are for normality and variance stability. Two techniques, Bartlett's transformation and power transformation were applied to the data. The transformation was based on the link between the mean and variance or standard deviation over several groups. Practically, the tentative time series was fragmented $\{Y_t, t = 1, 2, ..., n\}$ sequentially into m equal groups and compute their means $\{\bar{Y}_i, i = 1, 2, ..., m\}$ and standard deviations $\{\hat{\sigma}_j, j = 1, 2, ..., m\}$ for the groups. We then reverted the natural logarithm of the group standard deviations $\{\hat{\sigma}_j, j = 1, 2, ..., m\}$ against the natural logarithms of the group means $\{\bar{Y}_i, i = 1, 2, ..., m\}$ to determine the slope, β, of the relationship (Akpanta and Iwueze, 2009):

$$Log_e \hat{\sigma}_i = \alpha + \beta \log_e \bar{X} + \varepsilon_i \qquad (1)$$

where: α = the intercept; β = the slope; $\log_e \bar{X}$ = Log of the mean and $\log_e \hat{\sigma}$ = Log of standard deviation.

The appropriate transformation was initiated based on the slope value, β as presented in table 1. Furthermore, the power transformation is expressed as:

$$X_t = \begin{cases} \log_e Y_t, & \beta = 1 \\ Y_t^{(1-\beta)} & \beta \neq 1 \end{cases} \qquad (2)$$

Table 1: The Bartlett Transformation Technique for the values of β

S/No	1	2	3	4	5	6	7
β	0	$\frac{1}{2}$	1	$\frac{3}{2}$	2	3	-1
Transformation	No Transformation	$\sqrt{X_t}$	$Log_e X_t$	$\frac{1}{\sqrt{X_t}}$	$\frac{1}{X_t}$	$\frac{1}{X_t^2}$	X_t^2

[Source: Akpanta and Iwueze (2009)]

2.2 Outliers

An outlier is a numerical observation that deviates extensively from the other data points. "Outliers are recognised as uncharacteristic, inappropriate, deviants or anomalies" (Chandola *et al.*, 2009). Generally, outliers are categorized into three phases viz. Point outliers, Contextual outliers and Collective outliers (Rana and Gautam, 2014). Point outlier is the easiest type of outlier and is a particular observation that deviates so greatly from the rest of the data. When an observation deviates so much from a data set of which there exist a sudden spike in a time series data with respect to categories, it is termed contextual outliers. For instance, a dwarf adult is an outlier in a group of tall adult persons (Rana and Gautam, 2014). Then, when a cluster of correlated series deviates greatly from the entire data set, it is known as Collective outliers. For example, an unusual and rapid oscillation over time of the sale of greeting cards. Outliers and its diverse types was first introduced by Fox (1972) in time series such as additive outlier, temporary outliers, Level shifts, Innovative Outliers and seasonal level shifts.

Quite a number of works had discussed outliers and their methods of detection. López (2016) posits that detecting and correcting outlier effect is very crucial since it manipulates the choice of models, parameter estimate, forecasts and seasonal adjustments. Hausitore (2012) conceived that an additive outlier affects solitary observation, innovational outlier affects numerous observations. Level shift refers to the change in mean of the series by a certain magnitude while variance change refers to change in variance of the series by a certain magnitude. For further studies on outliers and their detection see Burman and Otto (1988), Chen and Liu (1993), Clark *et al.* (2002), Seo (2006), Biu *et al*. (2014), Al-khazaleh *et al.* (2015) and Sadam (2015).

In this work, Modified Z score test, Median Absolute Deviation test, Standard deviation test, Range test and Tukey test were methods used to spot outliers in the transformed series.

2.2.1 Modified Z Score Test

The modified z scores with an absolute value greater than 2 is labelled as potential outliers.

$$M_i = \frac{0.6745(x_i - \tilde{x})}{MAD} \qquad (3)$$

where: x_j - observations; $\tilde{x}$ - Median of the series; 0.6745 is constant and MAD – Median Absolute Deviation (Iglewicz *et al.*, 1993).

2.2.2 Range Test (R_T)

Range test calculates the amount of standard deviations which differs from the mean. This good rule states that if, $\left(\frac{abs|x - \overline{X}|}{\hat{\sigma}} > 2.\right)$ then x is anticipated to be an outlier.

It is articulated as:

$$R_T = \frac{x_t - \overline{X}}{\hat{\sigma}} \qquad (4)$$

where: x_t = Observations, $\overline{X}$ = Overall Mean, and $\hat{\sigma}$ = Overall standard deviation.

2.2.3 Standard Deviation Test:

This is a simple typical method to ascertain outliers in a data set. Two standard deviations differ from the mean is detected as potential outliers.

The STD test is expressed as**:**

$$\bar{X} \pm 2\hat{\sigma} \quad (5)$$

where: $\bar{X} = \frac{\sum_{t=1}^{N} X_t}{N}$; $\hat{\sigma} = \sqrt{\frac{1}{N}\sum_{t=1}^{N}\left(X_t - \bar{X}\right)^2}$; that is $\bar{X}$ = mean and $\hat{\sigma}$ = Standard Deviation (Olewuzi, 2011).

2.2.4 Median Absolute Deviation (MAD) Test

MAD is a measure of central tendency, expressed (Christophe *et al.*, 2013) as:

$$MAD = bM_i\left(\left|x_i - M_i(x_i)\right|\right) \quad (6)$$

The decision criterion $M \pm 2(MAD)$

where, x_i = observations; $M_i(x_i)$ = Median of the series and b = 1.4826 (constant)

2.2.5 Tukey Test

Tukey (1977) test known as the box plot method – a simple graphical tool to display facts such as median, lower quartile, upper quartile, lower extreme and upper extreme of a data set. The fences are located at a distance 1.5(IQR) below Q_1 and above Q_3 which is expressed as:

$$Q_1 - 1.5(IQR) \quad \text{and} \quad Q_3 + 1.5(IQR) \quad (7)$$

A value between lower bound and upper bound is a possible outlier (Hubert and Vandervieren, 2007). Given X_t, t = 1, 2, 3… n, the first quartile (Q_1) and third quartile (Q_3) respectively are:

1) If n is even: $First\ Quartile(Q_1) = X_{t=\frac{n}{4}}$ and

$Third\ Quartile\ (Q_3) = X_{t=\frac{3(n)}{4}}$

2) If n is odd: $First\ Quartile(Q_1) = X_{t=\frac{n+1}{4}}$ and

$Third\ Quartile\ (Q_3) = X_{t=\frac{3(n+1)}{4}}$

where, Interquartile range (IQR) = $Q_3 - Q_1$; 1.5 = threshold or constant; x_t = Observation in the time series and n = Number of observations.

2.3 Forecasting

Forecasting is a statement about what will happen in the future based on the information or data that is available now. Forecasting is categorized into in sample and out sample forecast. Suppose the forecast sample is $j = T+1, T+2, \cdots, T+h$ and denote the actual and forecasted value in period t as y_t and $\hat{y}_t$ respectively. The four forecast evaluation measures are:

Root Mean Squared Error (RMSE) =

$$\sqrt{\sum_{t=T+1}^{T+h}\frac{(\hat{y}_t - y_t)^2}{h}} \quad (8)$$

Mean Absolute Error (MAE) =

$$\sum_{t=T+1}^{T+h}\frac{|\hat{y}_t - y_t|}{h} \quad (9)$$

Mean Absolute Percentage Error = 100 x

$$\sum_{t=T+1}^{T+h}\left(\frac{\left|\frac{\hat{y}_t - y_t}{y_t}\right|}{h}\right) \quad (10)$$

Theil's Inequality Coefficient, U =

$$\frac{\sqrt{\sum_{t=T+1}^{T+h}(\hat{y}_t - y_t)^2/h}}{\sqrt{\sum_{t=T+h}^{T+h}\frac{\hat{y}_t^2}{h}} + \sqrt{\sum_{t=T+1}^{T+h}\frac{y_t^2}{h}}} \quad (11)$$

where, $\hat{y}_t$ = the forecast value, y_t = the actual value and $(\hat{y}_t - y_t)$ - is the error forecast.

This statistic provides a measure of the distance of the actual values from the forecasted values.

2.4 Test for Stationarity

In time series analysis, a unit root test is used to investigate if a time series random variable is non-stationary or stationary and possesses a unit root. In this study, the Augmented Dickey Fuller test was used.

2.4.1 Augmented Dickey Fuller (ADF) Test

ADF test is a frequent method used to test for the existence of unit roots. The main drive of the unit root literature concentrates on whether time series are affected by transitory or permanent shocks. ADF model is primarily concerned with the estimate of α. To test for unit root, the hypothesis is:

H_0: $\alpha = 1$

H_1: $\alpha < 1$.

To construct a test of H_0, the $AR_{(p)}$ model considered is written as:

$$\Delta y_t = \mu + \beta_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_p \Delta y_{t-p+1} + \varepsilon_t$$

$$\{\varepsilon_t\} \sim WN(0, \sigma^2) \qquad (12)$$

where: Δ denoted the first difference, y_t is the data being tested, μ is a constant, βt is the coefficient on the time trend, t is the time trend variable, p is the lag order of the AR process and k is the number of lags added to the model to certify that the residuals, ε_t are white noise. AIC, BIC and SIC are used to determine the optimal lag length (k). If $\alpha \geq 1$, y_t is a non-stationary series and the variance of y increases with time and approaches infinity. If $\alpha < 1$, y_t is a trend – stationary series. Dickey and Fuller (1979) derived the limit distribution as $n \to \infty$ of the t-ratio,

$$\hat{t}_\alpha = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \qquad (13)$$

under the unit root assumption from which a test of the null hypothesis (H_0) can be constructed.

where, $\hat{\alpha}$ is the estimate of α and $SE(\hat{\alpha})$ is the coefficient standard error. (Glynn et al, 2007).

3. Materials and Methods

Records of monthly revenue generated by the NPA (Rivers Port) spanning January, 2007 to December, 2019 was obtained from the NPA statistical bulletin [Nigerian Ports Authority Annual Report, Rivers Port. (2007 – 2019)]. Time series plot of the data was generated. The data were transformed using Bartlett's power transformation techniques as discussed in section 2. Outliers were detected and treated using Modified Z score test, Range test, Standard deviation, Median Absolute Deviation test and Tukey method. Plots of the transformed data with and without outliers were obtained. The generated series were tested for stationarity using ADF test and the non-stationary series made stationary by differencing. Plots of the differenced series, the autocorrelation (ACF) and partial autocorrelation (PACF) were obtained. ARIMA(p,d,q) model was fitted to the transformed series with, and without outliers. Akaike information criterion (AIC) was used to determine the best suitable model. Ljung – Box Chi-squared Test for Serial Correlation was used to check for model adequacy. Estimation of the model parameters and other statistical analysis were done using EVIEWS statistical software.

4. Results

The series plot of Nigerian Ports Authority (NPA) revenue generated (Figure 1) and the results obtained by comparing the forecast of the transformed data with outlier and the transformed series without outliers using the forecast evaluation are presented below.

4.1 Transformation Using Bartlett Technique

Transformation procedure was done by regressing the log of the standard deviations against log of the averages using the Bartlett technique and the results are shown in Table 2.

Table 2: Twelve-Monthly Overall Means and Standard Deviations with its Natural Logarithms of the Series (₦ Million).

Year	$\bar{X}$	$\hat{\sigma}$	Log($\bar{X}$)	Log$(\hat{\sigma})$
2007	166357471.7	51193583.94	18.92965	17.75112
2008	141816245.9	54812071.39	18.77004	17.81942
2009	111840538.6	73405218.92	18.53258	18.11151

2010	163898105.2	109284184.2	18.91476	18.50946
2011	144180890.5	35347102.58	18.78658	17.38073
2012	79350466.85	19722821.82	18.18938	16.79729
2013	58485778.82	20901607.76	17.88429	16.85534
2014	57917146.52	13936507.36	17.87452	16.45002
2015	47043413.78	27527927.7	17.66658	17.13071
2016	33334943.65	22179736.68	17.32212	16.91469
2017	38770693.02	23072518.8	17.47318	16.95415
2018	39728054.95	30184856.13	17.49757	17.22285
2019	55120669	28417356.54	17.82504	17.16251

$$\text{Log}(\hat{\sigma}) = 4.184 + 0.7242\,\text{Log}(\bar{X}) \qquad (14)$$

Since β = 0.7242 lies in between 0 and 1, equation (2) called the power transformation was applied. From equation (2),

$$X_t = Y_t^{1-\beta}$$
$$X_t = Y_t^{1-0.7242}$$
$$X_t = Y_t^{0.276}$$

Thus, $X_t = Y_t^{0.276}$ is the transformation applied to the actual series (X_t).

4.1.2 Justification for the Transformation

The transformation procedure was repeated to justify that the variance is constant in the series. Table 3 shows the repeated twelve-monthly overall means and standard deviations (and its natural logarithms) of the Series (X_t).

Table 3: Repeated transformation of Twelve-Monthly Overall Means and Standard Deviations with its Natural Logarithms of the Series (₦ Million).

Year	$\bar{X}$	$\hat{\sigma}$	Log($\bar{X}$)	Log$(\hat{\sigma})$
2007	184.0983	16.22631	5.21547	2.786634
2008	175.2526	19.40491	2.243665	2.965526
2009	157.607	36.54137	5.060104	3.598445
2010	170.7781	21.14911	2.232432	3.051598
2011	177.6618	11.66696	5.179882	2.456761
2012	150.6277	10.12829	2.177905	2.315332
2013	137.1888	15.75407	4.921358	2.757099
2014	138.0858	9.40683	2.140149	2.241436
2015	127.2839	20.21158	4.84642	3.006256
2016	120.7637	19.61822	2.081936	2.976459
2017	120.0159	21.09754	4.787624	3.049157
2018	119.8871	22.68261	2.078772	3.121599
2019	132.9254	21.96277	4.889788	3.089349

Figure 2 shows the Fitted Line Plot of the Repeated Ln $(\hat{\sigma})$ and ln $(\bar{X})$ of the Series

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The regression equation is ln(std) = 4.298 - 0.2770 ln(Mean)
S = 0.414335 R-Sq = 1.4% R-Sq(adj) = 0.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	0.02672	0.026722	0.16	0.701
Error	11	1.88841	0.171673		
Total	12	1.91513			

Since $R^2_{adjusted} = 0.0\%$ and β = -0.2770, we conclude that there is constant variance in the series.

4.1.3 Test of Significance of βeta (β) After Transformation

The slope of the regression line is not precisely 0.0 however -0.2770 is closer to 0.0, we test for the significance of β = 0.0 using t-test.

The hypothesis testing is achieved b computing the t test for β

H_0: β = 0.0

H_1: β ≠ 0.0

$$t = \frac{\hat{\beta} - \beta}{SE(\hat{\beta})} = \frac{-0.2770 - 0.0}{0.476} = \frac{-0.2770}{0.476} = -0.5819$$

$$t_{1-\frac{\alpha}{2}, n-1} = t_{1-\frac{0.05}{2}, 13-1} = t_{0.975,\ 12} = 2.179$$

Decision rule: Since t_{cal} = -0.5819 < t_{tab} = 2.179 and t_{cal} = -0.5819 > t_{tab} = -2.179, we do not reject the null hypothesis and conclude that the power transformation is adequate for the revenue generated series.

4.2 Outlier Detection and Treatment of the Transformed Series (X_t)

The methods of outlier detection techniques discussed in section 2 were employed. Of the five methods, only the modified Z score method did not detect the presence of outlier in the transformed series. The results are presented below and Table 4 gives a summary of the number of outliers detected by each method.

4.2.1 Median Absolute Deviation

Given $b = 1.4826$, $Median \ (Q_2) = 145.85$ and Median $|x_i - Q_2| = 24.36$

$$MAD = b \times M(|x_i - Q_2|) = 1.4826 \times 24.36 = 36.12$$

$$Lower \text{ bound} = 145.85 - 2(36.12) = 73.61$$

$$Upper \ \ bound = 145.85 + 2(36.12) = 218.09$$

Using the interval (73.61 – 218.09), two outliers were obtained (November, 2005 and April, 2011).

4.2.2 Range Test (R_T) Method on X_t

Using this good rule of thumb method, two outliers were detected (November, 2005 and April, 2011).

4.2.3 Standard Deviation on X_t

Given that $\bar{x} = 147.19$ and $\hat{\sigma} = 31.67$

$$= 147.19 \pm 2 \times (31.67)$$

$$= 147.19 - 63.34 < x < 147.19 + 63.34$$

$$= 83.85 < x < 210.53$$

For the 2SD method, the interval is between 83.85 and 210.53 thus, two outliers were detected (November, 2005 and April, 2011).

4.2.4 Tukey Method on X_t

Given $Q_1 = 122.36$, $Q_3 = 171.75$ and IQR = 49.40

$$Lower\ bound = 122.36 - 1.5 \times (49.40) = 122.36 - 74.1 = 48.26$$

$$Upper\ bound = 171.75 + 1.5 \times (49.40) = 171.75 + 74.1 = 245.85$$

Using this method, one outlier was detected (November, 2005).

Table 4: Summary of Outliers Detected by each Method

Outlier Detection Method	Z score Test	STD Test	MAD	Range Test	Tukey Test
Number of Outliers	0	2	2	2	1

(See Appendix A for details)

The outlier series was treated using Mean imputation method thus, replacing the outlier value with the mean value (147.19) in the transformed series. (see Appendix A).

Figures 3 and 4 show the plots of the transformed series with and without outliers, respectively. Figures 5a, b, c presents the time series, ACF and PACF plots of the first difference of the transformed series with outliers, respectively. Figures 6a, b, c presents the time series, ACF and PACF plots of the first difference of the transformed series without outliers respectively.

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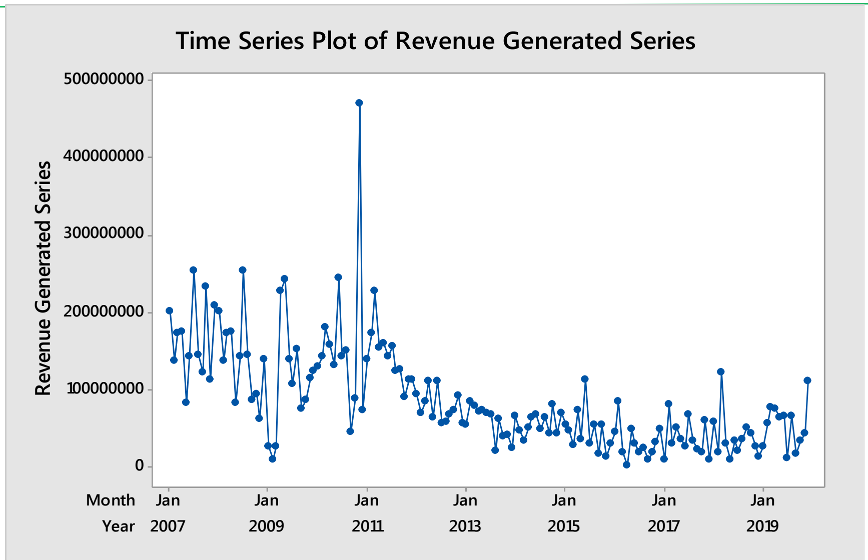

Figure 1: The Time Series Plot of the Actual Series (X_t)

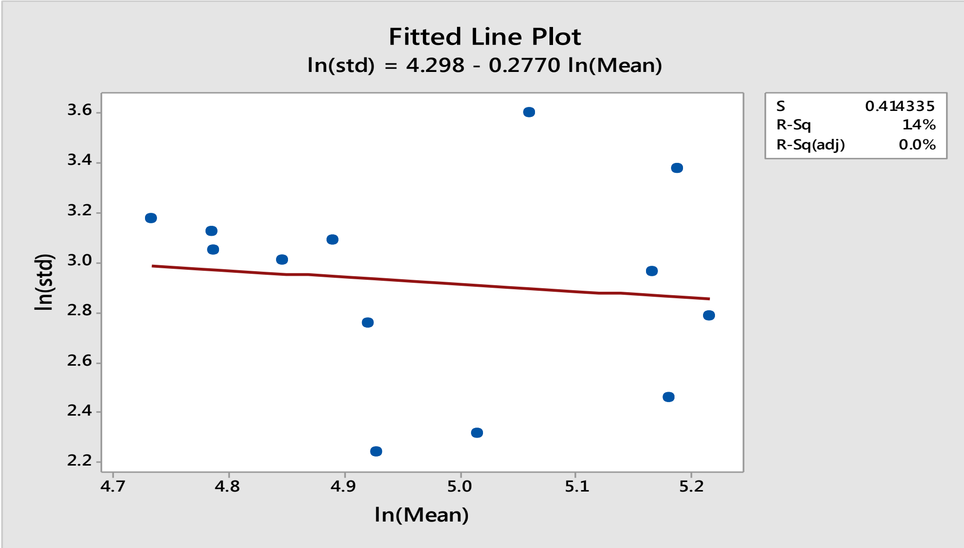

Figure 2: The Fitted Line Plot of the Repeated Ln $(\hat{\sigma})$ and ln $(\bar{X})$ of the Series

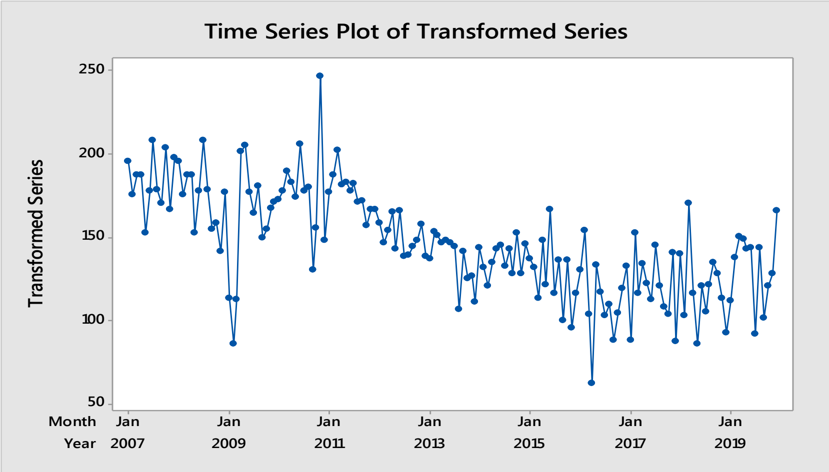

Figure 3: The Time Series Plot of the Transformed Series (W_t) with outliers

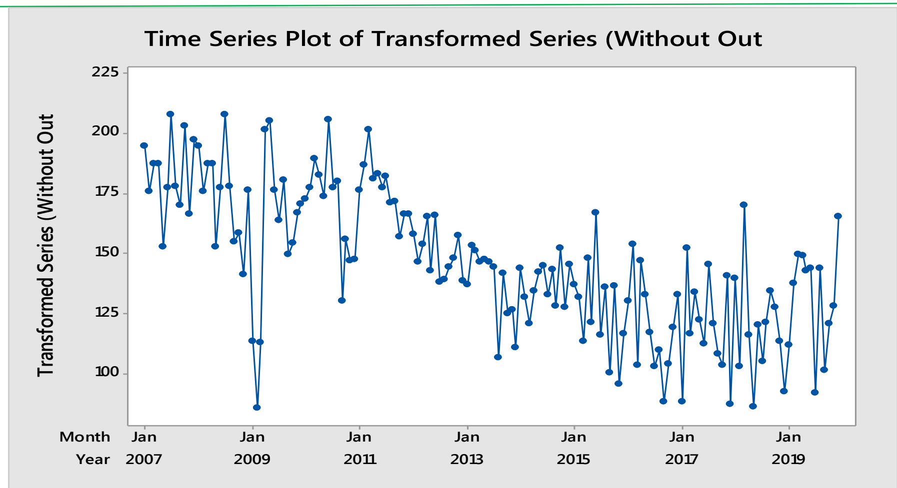

Figure 4: Time Series Plot of the Transformed Series (Without Outliers)

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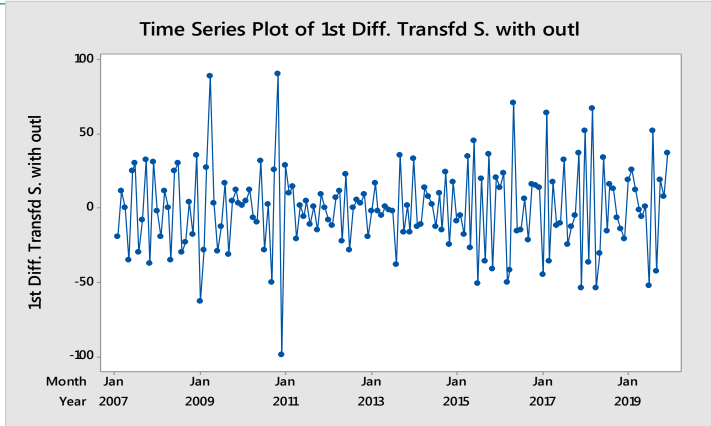
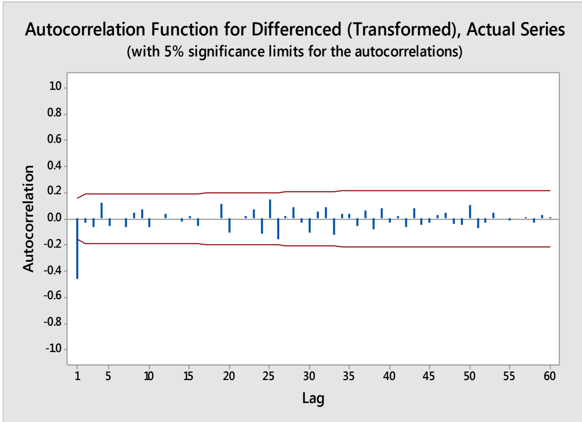




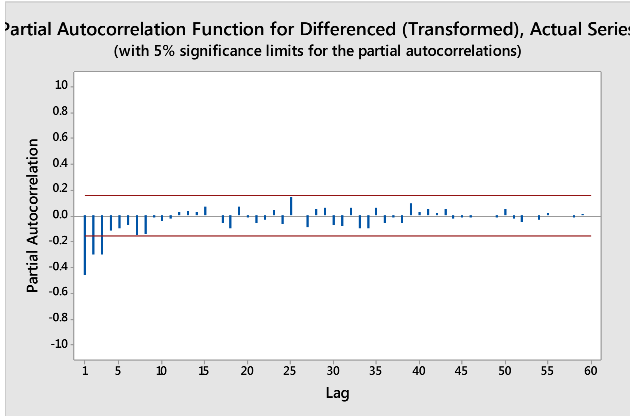
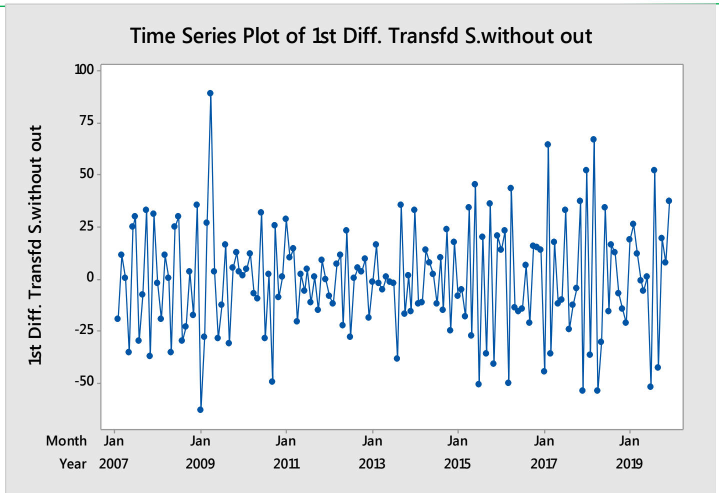
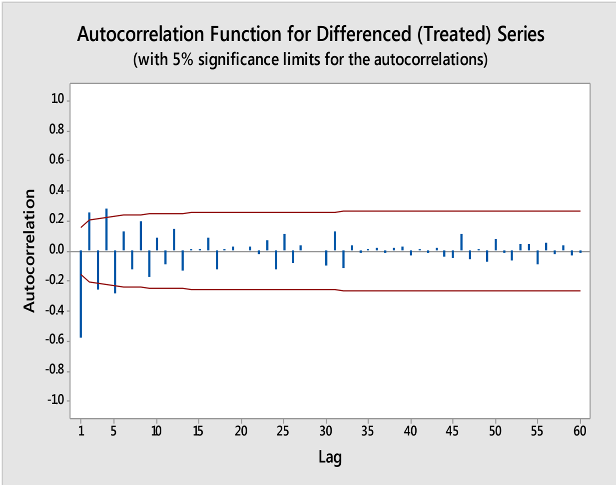


Figure 5a: Time Series Plot of the First Difference Transformed Series (with outliers) **Figure 5b: ACF of the First Difference Transformed Series (with outliers)**
Figure 5c: PACF of the First Difference Transformed Series (with outliers)





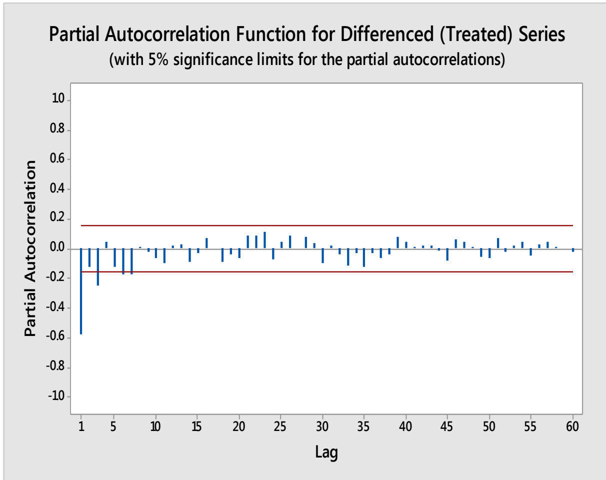


Figure 6a: The Time Plot of the First Difference Transformed Series (without outliers) Figure 6b: ACF of the First Difference Transformed Series (without outliers) Figure 6c: PACF of the First Difference Transformed Series (without outliers)

Table 5: ADF test for Transformed series with outliers

Null Hypothesis: TRANSFORMED_SERIES has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.483327	0.1215

Table 6: ADF Test for Transformed Series Without Outliers

Null Hypothesis: TRANSFORMED_TREATED SERIES has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.850656	0.3549
Test critical values:	1% level	-3.474874	
	5% level	-2.880987	
	10% level	-2.577219	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TRANS_TREATED)
Method: Least Squares
Date: 10/08/17 Time: 12:02
Sample (adjusted): 9 156
Included observations: 148 after adjustments

Test critical values:	1% level	-3.473672
	5% level	-2.880463
	10% level	-2.576939

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TRANSFORMED_SERIES)
Method: Least Squares
Date: 10/08/17 Time: 11:59
Sample (adjusted): 5 156
Included observations: 152 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TRANSFORMED_SERIES(-1)	-0.180145	0.072542	-2.483327	0.0141
D(TRANSFORMED_SERIES(-1))	-0.567264	0.093544	-6.064141	0.0000
D(TRANSFORMED_SERIES(-2))	-0.387640	0.095015	-4.079755	0.0001
D(TRANSFORMED_SERIES(-3))	-0.286770	0.079645	-3.600616	0.0004
C	25.66811	10.82162	2.371929	0.0190

R-squared	0.382771	Mean dependent var	-0.145692
Adjusted R-squared	0.365976	S.D. dependent var	29.12107
S.E. of regression	23.18783	Akaike info criterion	9.157474
Sum squared resid	79038.32	Schwarz criterion	9.256944
Log likelihood	-690.9680	Hannan-Quinn criter.	9.197882
F-statistic	22.79033	Durbin-Watson stat	2.025989
Prob(F-statistic)	0.000000		

Tables 5 and 6 show results of the Augmented Dickey Fuller (ADF) unit root test for the transformed series with and without outliers respectively. The results show that both series were not stationary at 5% level of significance.

4.3 ARIMA Model Building of the Transformed Series with Outliers and without Outliers, respectively

Order of ARIMA model was established using the ACF and PACF of the differenced transformed series (with outliers) and (without outliers). Given ARIMA (p, d, q), let p = 3 and q = 3. Using the AIC, the most suitable model for both series are shown in Table 7.

Table 7: Comparison of ARIMA Models of the Transformed Series with and without Outliers

S/N	Model Form	AIC Values	
		Transformed Series (With Outliers)	Transformed Series (Without Outliers)
1	**ARIMA (0,1,1)**	**9.0908**	8.9719
2	ARIMA (0,1,2)	9.1031	8.9772
3	ARIMA (0,1,3)	9.1161	8.9685
4	ARIMA (1,1,0)	9.3340	9.1158
5	ARIMA (2,1,0)	9.2724	9.1073
6	ARIMA (3,1,0)	9.1740	9.0388
7	ARIMA (1,1,1)	9.1032	8.9745
8	ARIMA (1,1,2)	9.1162	8.9889
9	**ARIMA (1,1,3)**	9.1233	**8.9530**
10	ARIMA (2,1,1)	9.1160	8.9718
11	ARIMA (2,1,2)	9.1245	8.9552
12	ARIMA (2,1,3)	9.1163	8.9659
13	ARIMA (3,1,1)	9.1199	8.9705
14	ARIMA (3,1,3)	9.1358	8.9762

Results of the diagnostic check for adequacy of the models are presented in Tables 8 and 9.

Table 8: Transformed series (with outliers)

Lag	χ^2 calculated	Degree of Freedom	χ^2 tabulated
12	5.3	11	19.69
24	10.9	23	35.18
36	20.9	35	49.81
48	26.1	47	64.01

Table 9: Transformed series (without outliers)

Lag	χ^2 calculated	Degree of Freedom	χ^2 tabulated
12	2.5	7	14.069
24	13.3	19	30.147
36	22.6	31	45.00
48	27.2	43	59.32

Since χ^2 calculated < χ^2 tabulated, we do not reject the null hypothesis and conclude that no serial correlation exists in the residuals of both series at lag 12, 24, 36, 48….

4.4 Forecasting

Table 10 shows results of the forecasting criteria used to determine the forecast performance of the transformed series with and without outliers. From the results, it is obvious that the transformed series without outliers performed better in terms of forecasting future trends of the NPA generated revenue.

Table 10: Forecast Evaluation on Transformed Series with and Without Outliers

Forecast Evaluation	Transformed Series With Outliers	Transformed Series Without outliers
RMSE	24.3191	**22.8235**
MAE	20.5903	**19.9970**
MAPE	410.9298	**380.1576**
Theil U Coefficient	0.5073	**0.4935**

5. Discussion

From Figure 1, one can see that for the years under review, the NPA generated revenue witnessed increased fluctuation from 2007 to 2011 when the revenue rose speedily to its peak. This could be due to improved super structures, low turn round time and increased berthing facilities, and introduction of concessionaire (Private firms) into ports operation. Thereafter, there was steady decrease in the NPA revenue series from 2011 to 2019 despite the private operators' involvement in the operations of the ports. Factors considered to be responsible for the decrease in revenue include high turn round times, low exportation of goods, mal-administration, increased custom and excise duties, ban on importation of goods such as second hand cars, frozen foods, rice, etc. Figure 1 shows a slight downward trend with no evidence of seasonality in the ACF plot, although the variance does seem to change which indicates that the series is non-stationary. Furthermore, the measures of skewness (1.84), and kurtosis (6.32) of the original series indicates that the series may not have come from a normal population and the variance may not be stable hence, making the data transformation necessary. The Bartlett's power transformation helped in scaling down the measurement, achieving normality and variance stability thus, making the transformed series stationary and analyzable.

The transformation procedure was repeated to confirm that the data has constant variance. The fitted line plot of the repeated natural log $(\hat{\sigma})$ and log (μ) of the series is shown in Figure 2. Since $R^2_{adjusted} = 0.0\%$ and β = -0.2770, it means that the series now has constant variance. The Test of significance of Beta (β) after transformation was performed, indicates that the power transformation was adequate for the revenue generated series.

The transformed series (Figure 3) had outliers which were detected and removed. The MAD, Range and Standard deviation methods were more effective in detecting outliers in the NPA revenue generated series (See Table 4). The ACF plot shows that the autocorrelation up to lag 50 (autocorrelation = 0.082822) are all positive, after which there is a sequence of negative autocorrelations from lag 55 to lag 120. This is a typical behaviour of non-stationary time series. The lines on the graph at around 0.4, indicate that values outside these dotted lines are significantly different from zero. Apart from lag 1 with PACF (0.607317), lag 2 (0.364996) and lag 4 (0.211536) the autocorrelation all lie inside the dotted lines which means there is effectively little serial correlation left and a downward trend in the transformed series (without outliers). Order of ARIMA model was established using the ACF and PACF of the transformed, differenced series with outliers and without outliers. The transformed series with outliers ARIMA Model (0,0,1) [AIC = 9.0906] and transformed series without outliers ARIMA model (1,0,3) [AIC = 8.9528] were selected as the prime fitted model using its smallest AIC values (Table 7). The forecast evaluation in Table 10 discloses that the transformed series without outliers performed better than the transformed series with outliers since its RMSE, MAE and MAPE have smaller values. The forecast measure Theil U coefficient indicates that the model of the transformed series without outliers had a better fit than the transformed series with outliers since Theil U statistics = 0.4935 is nearer to zero (0) than one (1). This finding agrees with Arimie, *et al.* (2020) that the presence of outlier impacts negatively on modelling.

6. Conclusion

This study on modelling of the NPA revenue generated series with and without outliers was conducted with a view to developing a good mathematical model that could be applied to control future economic policies and decision making in the organization. Using Box-Jenkin's methodology on the transformed series with outliers and without outliers respectively, ARIMA (0, 1, 1) or MA (1) model, $X_t = \varepsilon_t - 0.8271\varepsilon_{t-1}$ and ARIMA (1, 1, 3) or ARMA (1, 3) model,

$$X_t = \mu - 0.8234\, y_{t-1} + \varepsilon_t + 0.1083\varepsilon_{t-1} - 0.6067\varepsilon_{t-2} - 0.2170\varepsilon_{t-3}$$

were found to be appropriate for use by the organization with the ARIMA (1, 1, 3) model being more appropriate to produce a better forecast. It was therefore, concluded that ARIMA (1, 1, 3) model is adequate to forecast expected future revenue of the Nigerian Ports Authority if the above stated methodology is followed.

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APPENDIX A

Revenue Generated Series and Outlier Detection Methods

Year	Months	Actual Series	Transformed Series	MADe	Tukey	Z score	Range	STD
2007	January	201741057	195.19	195.19	195.19	0.9354	1.5392	195.19
2007	Feburary	138397402	175.92	175.92	175.92	0.574	0.9281	175.92
2007	March	173919760	187.36	187.36	187.36	0.7886	1.291	187.36
2007	April	175247788	187.76	187.76	187.76	0.796	1.3035	187.76
2007	May	83055087	152.81	152.81	152.81	0.1406	0.1952	152.81
2007	June	143968055	177.85	177.85	177.85	0.6101	0.9892	177.85
2007	July	253623397	207.91	207.91	207.91	1.174	1.9426	207.91
2007	August	145071792	178.22	178.22	178.22	0.6172	1.0011	178.22
2007	September	123456789	170.47	170.47	170.47	0.4717	0.7551	170.47
2007	October	234001678	203.34	203.34	203.34	1.0883	1.7978	203.34
2007	November	113458900	166.54	166.54	166.54	0.3981	0.6306	166.54
2007	December	210347956	197.45	197.45	197.45	0.9779	1.611	197.45
2008	January	201741057	195.19	195.19	195.19	0.9354	1.5392	195.19
2008	Feburary	138397402	175.92	175.92	175.92	0.574	0.9281	175.92
2008	March	173919760	187.36	187.36	187.36	0.7886	1.291	187.36
2008	April	175247788	187.76	187.76	187.76	0.796	1.3035	187.76
2008	May	83055087	152.81	152.81	152.81	0.1406	0.1952	152.81
2008	June	143968055	177.85	177.85	177.85	0.6101	0.9892	177.85
2008	July	253623397	207.91	207.91	207.91	1.174	1.9426	207.91

2008	August	145071792	178.22	178.22	178.22	0.6172	1.0011	178.22
2008	September	87715511	155.13	155.13	155.13	0.184	0.2687	155.13
2008	October	95751419	158.93	158.93	158.93	0.2552	0.3891	158.93
2008	November	62582277	141.34	141.34	141.34	-0.0747	-0.1688	141.34
2008	December	140721406	176.73	176.73	176.73	0.5892	0.9538	176.73
2009	January	28480127	113.75	113.75	113.75	-0.5921	-1.0437	113.75
2009	Feburary	10305757	85.94	85.94	85.94	-1.1137	-1.9257	85.94
2009	March	27791705	112.99	112.99	112.99	-0.6065	-1.0679	112.99
2009	April	227465349	201.76	201.76	201.76	1.0587	1.7476	201.76
2009	May	242538225	205.36	205.36	205.36	1.1262	1.8618	205.36
2009	June	140733193	176.74	176.74	176.74	0.5893	0.9539	176.74
2009	July	107718865	164.17	164.17	164.17	0.3537	0.5555	164.17
2009	August	152414485	180.67	180.67	180.67	0.663	1.0786	180.67
2009	September	77188826	149.76	149.76	149.76	0.0832	0.0982	149.76
2009	October	87046306	154.8	154.8	154.8	0.1779	0.2583	154.8
2009	November	115469295	167.35	167.35	167.35	0.4132	0.6562	167.35
2009	December	124934328	171.03	171.03	171.03	0.4822	0.7728	171.03
2010	January	130099082	172.95	172.95	172.95	0.5182	0.8338	172.95
2010	Feburary	143307035	177.62	177.62	177.62	0.6059	0.982	177.62
2010	March	182284325	189.81	189.81	189.81	0.8345	1.3685	189.81
2010	April	159766469	183.03	183.03	183.03	0.7073	1.1535	183.03
2010	May	132364954	173.77	173.77	173.77	0.5337	0.8599	173.77
2010	June	244440265	205.81	205.81	205.81	1.1345	1.8759	205.81
2010	July	143321564	177.63	177.63	177.63	0.606	0.9822	177.63
2010	August	150499131	180.04	180.04	180.04	0.6512	1.0586	180.04
2010	September	46734400	130.4	130.4	130.4	-0.2798	-0.5156	130.4
2010	October	89462795	155.98	155.98	155.98	0.1999	0.2955	155.98
2010	November	470516053	246.54	**246.54**	**246.54**	1.8987	**3.1679**	**146.66**
2010	December	73981189	148.01	148.01	148.01	0.0505	0.043	148.01
2011	January	141031071	176.84	176.84	176.84	0.5912	0.9572	176.84
2011	Feburary	173377643	187.2	187.2	187.2	0.7856	1.2859	187.2
2011	March	228343371	201.98	201.98	201.98	1.0627	1.7544	201.98
2011	April	154341054	181.29	181.29	181.29	0.6748	1.0984	181.29
2011	May	160659567	183.31	183.31	183.31	0.7126	1.1624	183.31
2011	June	143420270	177.66	177.66	177.66	0.6066	0.9832	177.66
2011	July	157513663	182.31	182.31	182.31	0.6939	1.1308	182.31
2011	August	125245699	171.14	171.14	171.14	0.4844	0.7765	171.14
2011	September	127486649	171.98	171.98	171.98	0.5001	0.8032	171.98
2011	October	92312311	157.33	157.33	157.33	0.2253	0.3385	157.33
2011	November	113253364	166.46	166.46	166.46	0.3965	0.6279	166.46
2011	December	113186024	166.43	166.43	166.43	0.396	0.6271	166.43

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2012	January	94721536	158.45	158.45	158.45	0.2464	0.3741	158.45
2012	Feburary	71502994	146.63	146.63	146.63	0.0246	-0.001	146.63
2012	March	85155082	153.87	153.87	153.87	0.1604	0.2286	153.87
2012	April	111187527	165.62	165.62	165.62	0.3807	0.6012	165.62
2012	May	65684909	143.24	143.24	143.24	-0.0391	-0.1085	143.24
2012	June	112758533	166.26	166.26	166.26	0.3927	0.6216	166.26
2012	July	58102339	138.47	138.47	138.47	-0.1284	-0.2597	138.47
2012	August	59136460	139.15	139.15	139.15	-0.1158	-0.2382	139.15
2012	September	68220639	144.74	144.74	144.74	-0.0108	-0.0608	144.74
2012	October	74167491	148.12	148.12	148.12	0.0525	0.0462	148.12
2012	November	93026898	157.67	157.67	157.67	0.2316	0.3491	157.67
2012	December	58541196	138.76	138.76	138.76	-0.123	-0.2505	138.76
2013	January	56193227	137.2	137.2	137.2	-0.1523	-0.2999	137.2
2013	Feburary	84891376	153.74	153.74	153.74	0.1579	0.2245	153.74
2013	March	80644344	151.58	151.58	151.58	0.1174	0.1559	151.58
2013	April	71737350	146.76	146.76	146.76	0.0271	0.0032	146.76
2013	May	73848946	147.94	147.94	147.94	0.0492	0.0406	147.94
2013	June	71325554	146.53	146.53	146.53	0.0227	-0.0041	146.53
2013	July	68123537	144.68	144.68	144.68	-0.0119	-0.0626	144.68
2013	August	22554541	106.66	106.66	106.66	-0.725	-1.2685	106.66
2013	September	63446201	141.87	141.87	141.87	-0.0646	-0.1518	141.87
2013	October	40488795	125.34	125.34	125.34	-0.3747	-0.6761	125.34
2013	November	42415378	126.96	126.96	126.96	-0.3444	-0.6248	126.96
2013	December	26160095	111.12	111.12	111.12	-0.6415	-1.1272	111.12
2014	January	67151729	144.11	144.11	144.11	-0.0226	-0.0808	144.11
2014	Feburary	48792611	131.96	131.96	131.96	-0.2506	-0.4662	131.96
2014	March	35524872	120.9	120.9	120.9	-0.458	-0.8169	120.9
2014	April	52708147	134.8	134.8	134.8	-0.1973	-0.3761	134.8
2014	May	64892533	142.76	142.76	142.76	-0.048	-0.1237	142.76
2014	June	69010657	145.2	145.2	145.2	-0.0022	-0.0462	145.2
2014	July	50277423	133.06	133.06	133.06	-0.23	-0.4314	133.06
2014	August	65866785	143.35	143.35	143.35	-0.037	-0.1051	143.35
2014	September	44469043	128.63	128.63	128.63	-0.3131	-0.5719	128.63
2014	October	82810137	152.69	152.69	152.69	0.1382	0.1912	152.69
2014	November	43657219	127.98	127.98	127.98	-0.3253	-0.5926	127.98
2014	December	69844602	145.68	145.68	145.68	0.0068	-0.031	145.68
2015	January	56190410	137.2	137.2	137.2	-0.1523	-0.3	137.2
2015	Feburary	48740317	131.92	131.92	131.92	-0.2513	-0.4674	131.92
2015	March	28623862	113.91	113.91	113.91	-0.5891	-1.0387	113.91
2015	April	74725364	148.42	148.42	148.42	0.0582	0.0559	148.42
2015	May	36135046	121.47	121.47	121.47	-0.4473	-0.7989	121.47

2015	June	114417531	166.93	166.93	166.93	0.4053	0.6429	166.93
2015	July	30755361	116.19	116.19	116.19	-0.5464	-0.9664	116.19
2015	August	54928940	136.34	136.34	136.34	-0.1684	-0.3272	136.34
2015	September	18103149	100.39	100.39	100.39	-0.8428	-1.4675	100.39
2015	October	55287984	136.59	136.59	136.59	-0.1638	-0.3194	136.59
2015	November	15388255	95.99	95.99	95.99	-0.9253	-1.607	95.99
2015	December	31224746	116.68	116.68	116.68	-0.5373	-0.951	116.68
2016	January	46811730	130.46	130.46	130.46	-0.2787	-0.5137	130.46
2016	Feburary	85204352	153.89	153.89	153.89	0.1608	0.2294	153.89
2016	March	20522481	103.92	103.92	103.92	-0.7765	-1.3554	103.92
2016	April	3217607.7	62.34	**62.34**	62.34	-1.5564	**-2.6742**	**146.66**
2016	May	50605111	133.3	133.3	133.3	-0.2255	-0.4239	133.3
2016	June	32105711	117.58	117.58	117.58	-0.5204	-0.9225	117.58
2016	July	19988440	103.17	103.17	103.17	-0.7906	-1.3793	103.17
2016	August	25069557	109.82	109.82	109.82	-0.6659	-1.1684	109.82
2016	September	11514149	88.61	88.61	88.61	-1.0637	-1.8411	88.61
2016	October	20817131	104.33	104.33	104.33	-0.7688	-1.3424	104.33
2016	November	33834956	119.29	119.29	119.29	-0.4883	-0.8681	119.29
2016	December	50328099	133.09	133.09	133.09	-0.2293	-0.4302	133.09
2017	January	11461343	88.5	88.5	88.5	-1.0658	-1.8446	88.5
2017	Feburary	82810137	152.69	152.69	152.69	0.1382	0.1912	152.69
2017	March	31224746	116.68	116.68	116.68	-0.5373	-0.951	116.68
2017	April	51847629	134.19	134.19	134.19	-0.2088	-0.3955	134.19
2017	May	37151892	122.41	122.41	122.41	-0.4298	-0.7693	122.41
2017	June	27458688	112.61	112.61	112.61	-0.6135	-1.0798	112.61
2017	July	69421011	145.44	145.44	145.44	0.0022	-0.0387	145.44
2017	August	35858617	121.22	121.22	121.22	-0.4521	-0.807	121.22
2017	September	24111934	108.65	108.65	108.65	-0.6879	-1.2056	108.65
2017	October	20551562	103.96	103.96	103.96	-0.7757	-1.3541	103.96
2017	November	62253013	141.13	141.13	141.13	-0.0785	-0.1753	141.13
2017	December	11097744	87.72	87.72	87.72	-1.0805	-1.8695	87.72
2018	January	60177030	139.82	139.82	139.82	-0.1032	-0.217	139.82
2018	Feburary	20056875	103.27	103.27	103.27	-0.7888	-1.3762	103.27
2018	March	123076861	170.32	170.32	170.32	0.469	0.7505	170.32
2018	April	31065775	116.51	116.51	116.51	-0.5403	-0.9562	116.51
2018	May	10488857	86.36	86.36	86.36	-1.1059	-1.9124	86.36
2018	June	35363203	120.75	120.75	120.75	-0.4608	-0.8217	120.75
2018	July	21586288	105.38	105.38	105.38	-0.7491	-1.3092	105.38
2018	August	36460136	121.77	121.77	121.77	-0.4417	-0.7893	121.77
2018	September	52514331	134.66	134.66	134.66	-0.1999	-0.3805	134.66
2018	October	43674576	127.99	127.99	127.99	-0.3251	-0.5921	127.99

2018	November	28588040	113.87	113.87	113.87	-0.5899	-1.0399	113.87
2018	December	13684688	92.93	92.93	92.93	-0.9826	-1.704	92.93
2019	January	26880732	111.95	111.95	111.95	-0.6258	-1.1007	111.95
2019	Feburary	57385107	138	138	138	-0.1373	-0.2747	138
2019	March	77892443	150.13	150.13	150.13	0.0903	0.1101	150.13
2019	April	76074468	149.16	149.16	149.16	0.072	0.0792	149.16
2019	May	65553704	143.16	143.16	143.16	-0.0405	-0.111	143.16
2019	June	67039136	144.05	144.05	144.05	-0.0239	-0.0829	144.05
2019	July	13203069	92.02	92.02	92.02	-0.9997	-1.733	92.02
2019	August	66997199	144.02	144.02	144.02	-0.0244	-0.0837	144.02
2019	September	18956923	101.67	101.67	101.67	-0.8187	-1.4268	101.67
2019	October	35540492	120.92	120.92	120.92	-0.4577	-0.8164	120.92
2019	November	44503088	128.65	128.65	128.65	-0.3126	-0.571	128.65
2019	December	111421668	165.71	165.71	165.71	0.3825	0.6043	165.71