OPEN ACCESS

International Journal Of Modern Engineering Research (IJMER)

A Statistical Model for the Projection of Flow of Cargo Traffic at the Tema Port

Joseph Ackora-Prah[1], Richard Owusu[2], Bonuedi Seshie Christian[3], Francis Atiso[4], Daniel Gyamfi[5]

[1,2,3] Kwame Nkrumah University of Science and Technology, Kumasi
[4]Christian Service University College, Kumasi
[5]University of Energy and Natural Resources, Sunyani
Corresponding Author: Ackora-Prah

ABSTRACT: *Maritime activities could be seen as a life-wire of any developing economy. Shipping of bulky goods for over a relatively long distance for international exchange through seaports has become the most effective mode of transportation for developing economy. However, there is an unprecedented growth of cargo traffic at the port of Tema, Ghana over the years as a result of developing energy sector, increasing domestic consumption of foreign goods which has engendered increasing delays in loading, offloading and cargo clearance. In this paper, a model for the flow of cargo traffic at the Tema port is presented. The data collected is subjected to the Jacque-Bera normality test to investigate the normality. The ACF and PACF is used to determined the pattern of the series while the ADF test and Ljung-Box Q' are used to ascertain the fact established from the ACF and PACF. The results of this study show that imports are the major contributor of cargo traffic at the port followed by exports and transit. The model for projection indicates that forecasted values will show increasing trend in the cargo traffic.*

KEYWORDS: *Model, Autoregressive Integrated Moving Average Model(ARIMA), Port*

Date of Submission: 27-12-2018 Date of acceptance: 12-01-2019

I. INTRODUCTION

The Ghana Ports and Harbours Authority (GPHA) was incorporated by PNDC Law 160 which merged three organizations in 1986 namely Ghana Ports Authority, Ghana Cargo Handling Company and Takoradi Lighterage Company [4]. The GPHA is a statutory public corporation mandated to plan, build, manage and control ports in Ghana in collaboration with other institutions. Since its establishment in 1986, the GPHA has operated the two ports at Tema and Takoradi.

Ports in Ghana are struggling to keep up with the demands of the expanding economy, which are being fuelled by the rapidly developing energy industry and increasing domestic consumption. However, new investments being channelled into the maritime services sector should ease some of the pressure, (Oxfordgroup.com, 2013). Domestic maritime trade is served by two ports: Tema, around 25 km east of Accra, the capital; and Takoradi, 230 km to the west. The Tema Port has increasingly served as an outlet for Ghana's landlocked neighbours, Burkina Faso, Niger and Mali, especially as shippers begun to shift over from the Port of Abidjan in 2011, following the spate of post-electoral violence in neighbouring Cote d'Ivoire, (Oxfordgroup.com, 2013). GDP growth of nearly 7% has spurred a rise in imports to feed infrastructure and energy developments but also engendered increasing delays in loading, offloading and cargo clearance as freight volumes climb, (Oxfordgroup.com, 2013). In 2012 the Tema and Takoradi facilities handled 19.4 m tonnes of cargo, comprising 4.4m tonnes of exports and 15m tons of imports and trans-shipments, according to data issued by the Ghana Shippers Authority in April 2013. This figure was an 8 percent increase over the 2011 total, with imports rising by 9.7 percent and exports up by more than 4 percent. (Oxfordgroup.com, 2013).

The amount of cargo handled by the Tema and Takoradi ports continues to increase over the years both from within the country and outside the sub-region. For example, the amount of transit and transhipment cargo handled by the ports increased from 145,000 tons in 2000 to 888,000 tons in 2002 [3]. This called for the dredging of the Tema Port to a depth of 11.5meters to enhance its capacity to handle bigger vessels as a result of increase in transit cargo from landlocked countries such as Mali and Burkina Faso [3]. The activities of port operations however transcend the domain of physical expansion and construction. It includes a number of tasks such as information and documentation of cargo, which comprise the value of the cargo, the vessel that ferried it and points of origin and destination [6]. There were several requests from some larger vessels to berth at Ghana ports but only a few had access, which even led to heavy congestion at the ports. The country's current economic dispensation is attracting investors so there is the need to strategise in order to handle the situation (B & FT, February 2013). The study seeks to determine the traffic of the various trade categories and to develop a statistical model for projection.

II. PRELIMINARY CONCEPTS

An autoregressive model (AR) is simply a linear regression of the current value against one or more prior values of the series. A common approach for modelingunivariate time series is the autoregressive, AR(p) model:

$$Y_t = \delta + \varphi_1 Y_{(t-1)} + \varphi_2 Y_{(t-2)} + \cdots + \varphi_p Y_{(t-p)} (1)$$

The AR(p) process with mean zero is given as:

$$Y_t = \sum_{p=1}^{N} \emptyset_p Y_{t-p} + \varepsilon_t \ (2)$$

Where $\emptyset_p$ are the autoregression coefficients, Y_t is the series under investigation, and N is the order of the filter which is generally very much less than the length of the series. The noise term or residue, ϵ_t, is almost always assumed to be Gaussian white noise.

A moving average (MA) model is conceptually a linear regression of the current value of the series against the white noise or random shocks of one or more prior values of the series. The random shocks at each point are assumed to come from the same distribution, typically a normal distribution, with location at zero and constant scale. The distinction in this model is that these random shocks are propagated to future values of the time series. Fitting the MA estimates is more complicated than with AR models because the error terms are not observable. In time series analysis, the moving-average (MA) model is a common approach for univariate time series models. The notation MA(q) refers to the moving average of order q:

$$Y_t = \mu + \epsilon_t + \theta_1 \epsilon_{(t-1)} + \cdots + \theta_q \epsilon_{(t-q)} (3)$$

Where μ is the mean of the series, the $\theta_1, \theta_2, \ldots, \theta_q$ are the parameters of the model and the$\epsilon_{(t)}, \epsilon_{(t-1)}, \ldots,$ $\epsilon_{(t-q)}$ are white noise error terms. This can be equivalently written in terms of the backshift operator **B** as:

$$Y_t = \mu + \left(1 + \theta_1 B + \theta_2 B^2 + \cdots + \theta_q B^q\right)\epsilon_t . (3)$$

The autocorrelation function (ACF) measures the degree of correlation between neighbouring observations in a time series. The autocorrelation function at lag p is defined as:

$$Y$$
$$Y$$
$$(\quad |t + k - \mu_Y)$$
$$Y$$
$$Y$$
$$(\quad |t - \mu_Y)^2 E(\quad |t + k - \mu_Y)^2$$
$$Y$$

$$Y$$

$$cov$$
$$\sqrt{E} =$$

$$\underline{(\quad |t - \mu_Y)}$$

$$E$$
$$\rho_t =$$

ACF plot is used to check the order of MA and the ACF cuts off at lag q. The approximate 95% confidence interval for the partial autocorrelations are at $\frac{-1}{N} \pm \frac{2}{\sqrt{N}}$and are often further approximated to$0 \pm \frac{2}{\sqrt{N}}$, where N is the size of the sample. Hence any value lying outside this interval is said to be significantly different from zero.

Partial Autocorellation Function (PACF) is an extension of autocorrelation, where the dependence on the intermediate elements (those within the lag) is removed. PACF measures the degree of association between $Y_t$and $Y_{(t+p)}$when the effect of other time lags on Y are held constant.

In statistics and econometrics, an Augmented Dickey-Fuller test (ADF) is a test for a unit root in a time series sample. It is an augmented version of the Dickey's Fuller test for a larger and more complicated set of time series models. The augmented Dickey-Fuller (ADF) statistic 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 Autoregressive Integrated Moving Average Model (ARIMA) is generally referred to as an ARIMA(p,d,q) model where parameters p, d, and q are non-negative integers that refer to the order of the autoregressive, integrated, and moving average parts of the model respectively. ARIMA models form an important part of the Box-Jenkins approach to time-series modelling. If a non-stationary time series which has variation in the mean is differenced to remove the variation, the resulting time series is called an integrated time series. It is called an integrated model because the stationary model which is fitted to the differenced data has to be summed or integrated to provide a model for the non-stationary data. Notationally, all AR(p) and MA(q) models can be represented as ARIMA models: for example an AR(1) can be represented as ARIMA(1,0,0); that is no differencing and no MA part. The general model is ARIMA (p,d,q) where p is the order of the AR part, d the degree of differencing and q the order of the MA part. An example of ARIMA (p,d,q) is the ARIMA(1,1,1) which has one autoregressive parameter, one level of differencing and one MA parameter given by:

$$W_t = \nabla^d Y_t = (1-B)^d Y_t = \sum_{i=1}^{p} \emptyset_i \, W_{(t-1)} + \sum_{j=1}^{q} \theta_j \epsilon_{t-j} \ (6)$$

$$W_t = \mu + \emptyset_1 W_{(t-1)} + \theta_1 \epsilon_{(t-1)} + \varepsilon_t ------GeneralARIMAmodel(7)$$

$$W_t = \mu + \emptyset_1 W_{(t-1)} + \theta_1 \epsilon_{(t-1)} + \varepsilon_t (8)$$

$$(1-B)Y_t = \mu + \emptyset_1 (1-B) Y_{t-1} + \theta_1 \epsilon_{(t-1)} + \varepsilon_t (9)$$

$$Y_t - Y_{t-1} = \mu + \emptyset_1 Y_{t-1} + \emptyset_2 Y_{t-2} + \theta_1 \epsilon_{(t-1)} + \varepsilon_t (10)$$

$$t-1$$

$$Y_t - Y$$

$$Y_t - Y_{t-1} = \mu + \emptyset_1$$

In practice, most time series are non-stationary and the series is differenced until the series becomes stationary. An AR, MA or ARIMA model is fitted to be differenced.

III. METHODOLOGY

The target population for the study is the various economic trade activities or categories that constitute the volume of traffic and throughput of Tema Port of Ghana from period of 2005 to 2014. These various trade categories are: import; export; transit in; transit out; national coastal; transhipment in; transhipment out; shift via quay. Data collected for analysis was mainly from Secondary source which constituted an economic time series data of the flow of traffic for the various trade categories. The data was collected from the Port Monitoring and Control of the Port Operations Department of Tema port and rearranged using Microsoft Excel 2013 for easy analysis. The data collected was checked using the Jacque-Bera normality test to investigate the normality. Time series analysis was employed in the study. Graphical and quantitative means were used in the interpretation. The graphical method make use of ACF and PACF to determine the pattern of the series and the ADF test and Ljung-Box Q' were also used to ascertain the fact established from the ACF and PACF. R console (3.0.3) and gretl software were mainly employed for the data analysis of the data.

IV. ANALYSIS

4.1 Test for Normality

The test result were mainly from R console software and little from gretl software. The significant value (α) used in the study is 0.05. The data collected was subjected to a normality test using the hypothesis,

Null hypothesis, H_0: the data is not normal
Alternative hypothesis, H_1: the data is normal
From the output in table 1, the p-value for Jarque-Bera Test shows that the Volume of Traffic monthly data from 2005 to 2014 is normally distributed.
Table 1: Test for Normality

Jarque-Bera Normality Test	
STATISTIC:	
X-squared:	7.202
Asymptotic p Value:	**0.0273**

4.2 General Flow of Cargo Traffic

The ACF plot below (figure 1) shows a tapering/exponential pattern, indicating that after lag 4 (that is the lag values recorded were 0.510, 0.339, 0.366, and 0.207 respectively), most of the lags were below the 95 percent confidence bound and some were closer to zero as well as the lags in the PACF also were around zero after lag 1, 2, and 14.

The non-stationarity of the series can be affirmed from the slow decaying or tapering pattern of the ACF plot and very dominant significant spark at lag 1 (0.787) of the PACF plot as shown in the correlogram above.

Table 2: ADF Test for Flow of Cargo Traffic

Augmented Dickey Fuller (ADF) test for Volume of Traffic (in Metric Tonnes)

Test	**Constant**		**Constant and Trend**	
ADF	Test Statistic	p-value	Test Statistic	p-value
	-0.831512	0.8097	-2.6762	0.2466

Augmented Dickey Fuller (ADF) Test:
Null hypothesis, H_0: the data is not stationary
Alternative hypothesis, H_1: the data is stationary

The result from the ADF test as shown in the table 2 above confirms the existence of unit roots under the condition where either a constant or a trend is included. The p-value in both cases is greater than the significant value of 0.05 which confirms the presence of serial correlation in the series. This has lent credence to the earlier assertion in the series plot which shows a non-stationarity of the series. That is the variance of the series is dependent on time (t).

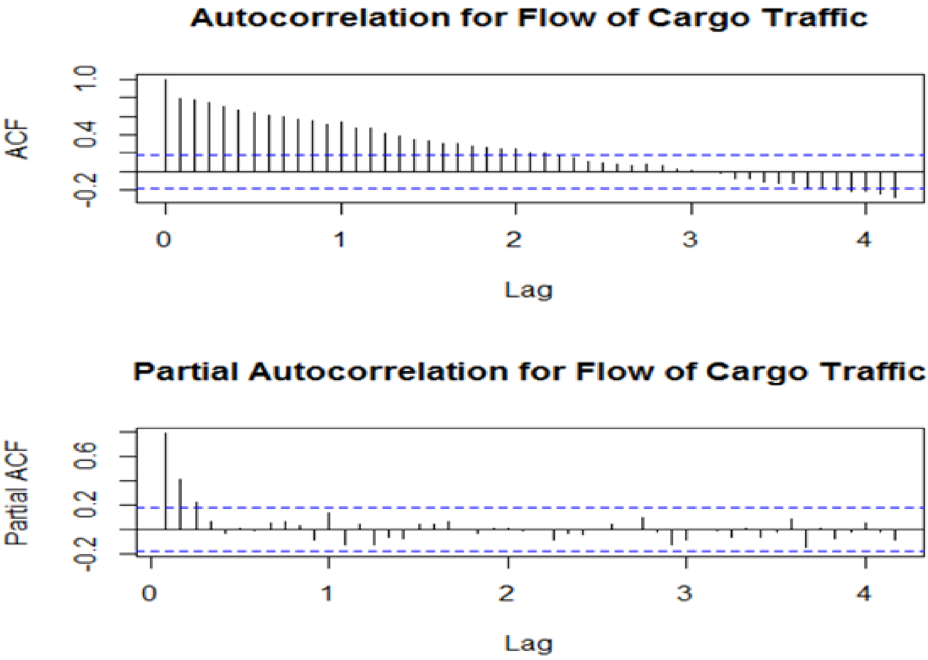


Figure 1: Correlogram of the Series for the Flow of Cargo Traffic

Detrended Cargo Traffic

The p-value of 0.8097 from the Augmented Dickey Fuller test suggested that the data is not stationary; hence the data need to be transformed as in the Box-Jerkin method. This transformation helps to stabilize the variance by detrending the trend in the series. The transformed series plot is exhibited in figure 3.

From the series, the irregular variation in the series has been stabilized which can also be affirmed from the correlogram (figure 3).

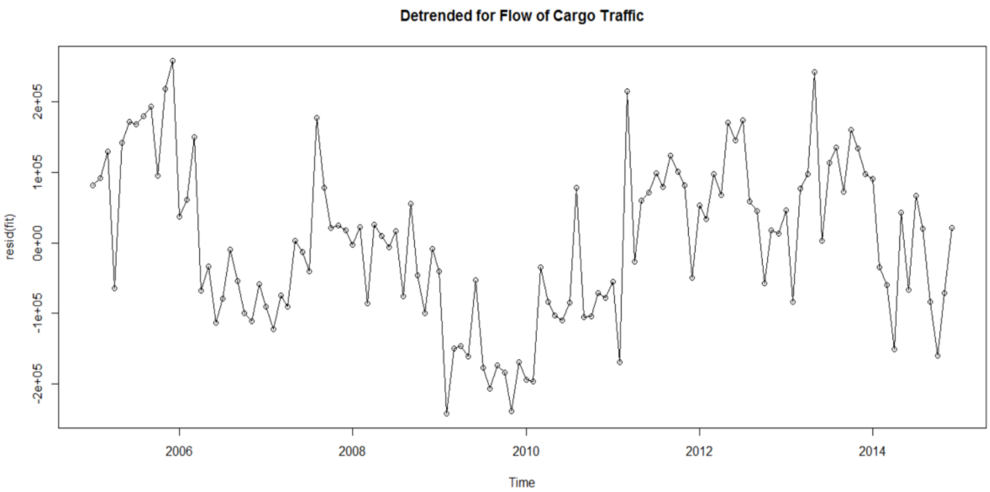


Figure 2: Detrended Series of Flow Cargo Traffic

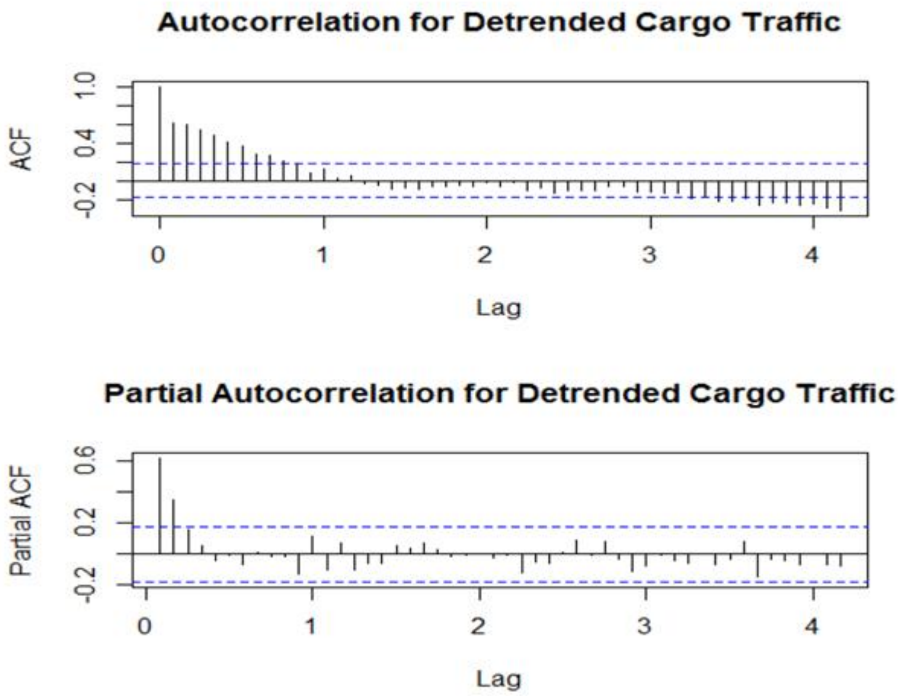


Figure 3: Detrended ACF and PACF Correlogram

4.3 First Difference of Cargo Traffic

The transformed (detrended) series has exhibited non-stationarity which can be affirmed from the correlogram, hence the series has to be differenced to achieve stationarity. The first differencing result to a stable stationary series with another ADF test p-value of 0.01 supporting that there are no presence of unit roots in the series (reject the null hypothesis that stated that the series is not stationary). Therefore, the series has constant variance as shown in figure 4, so there is no need for to consider further differences.

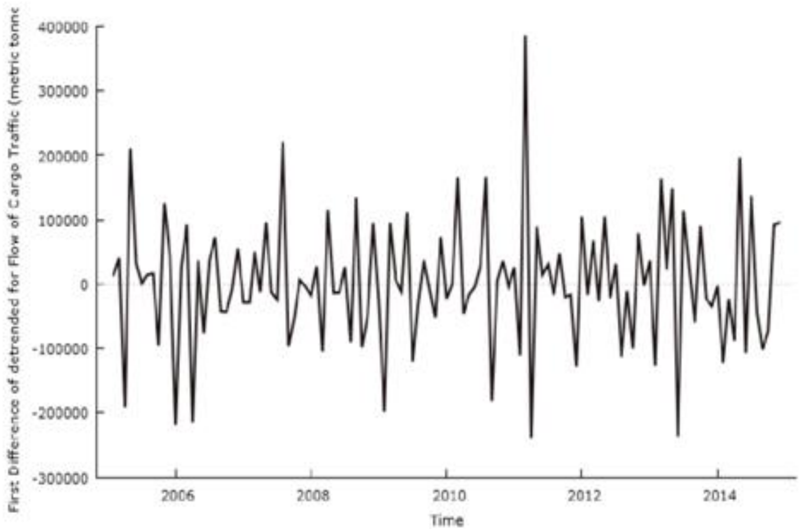
Table 3: ADF Test for Difference Series

ADF test for Volume of Traffic (in Metric Tonnes)

Test	**Constant**		**Constant and Trend**	
ADF	Test Statistic	p-value	Test Statistic	p-value
	-4.03292	0.001248	-4.13088	0.005605

Source: Survey, May 2015

Figure 4: First Difference Series Plot of Flow of Cargo Traffic



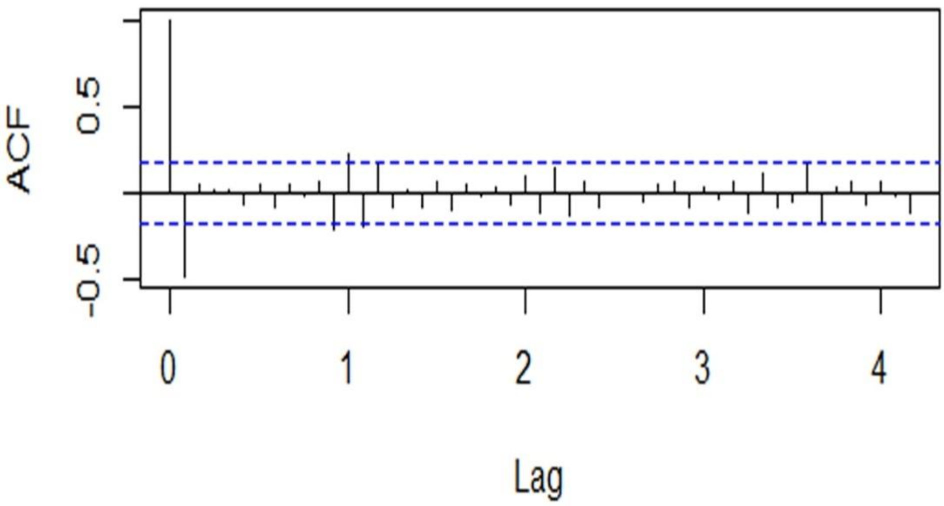


Figure 5: ACF Correlogram for the First Difference of the Series

Following the Box-Jenkins approach of modelling ARIMA model, the ACF plot (figure 5) suggested that lag 1 is the most significant lag that cut out of the significant bound, suggesting moving average of order 1, MA(1). The pattern is sinusoidal because the lags converges to zero in the ACF plot. The PACF in figure 5 and 6 also suggested that lag 1 and lag 2 were the most significant lags among the rest, suggesting Autoregressive of order 2, AR(2).

4.4 Model Identification and Diagnosis

The following candidate models were developed and fitted as shown in the table 4 below: From the table 4, ARIMA(2, 1, 1) is the best model because it has the least AIC and BIC values. Therefore, the model for forecasting is given below: The residual analysis of the series plots as illustrated in figure 7 was used to check the adequacy of the model above. From the ACF residual plot/correlogram for the ARIMA(2 ,1,1), we show that all correlations are within the threshold limits (significant bound) indicating that the residuals are behaving like noise (almost all the lags are within the confidence bound). Therefore we can conclude that there are no serial correlations in the series, hence the series is stationary. A portmanteau test returns a large p-value, also suggesting the residuals are white noise. The Normal Q-Q plot of standard residuals which is a normal probability plot also does not look bad, so the assumptions of normal distributed residuals looks good because majority of the points lying on the line. The time series plot of the standardized residuals mostly indicates that there is no trend in the residuals, no outliers, and in general, no changing variance across time. The bottom plot gives p-values for the Ljung-Box-Pierce statistic for each lag up to 20. These statistic consider the accumulated residual autocorrelation from lag 1 up to and including the lag on the horizontal axis. The dashed line is at 0.05 of which all p-values are above it.

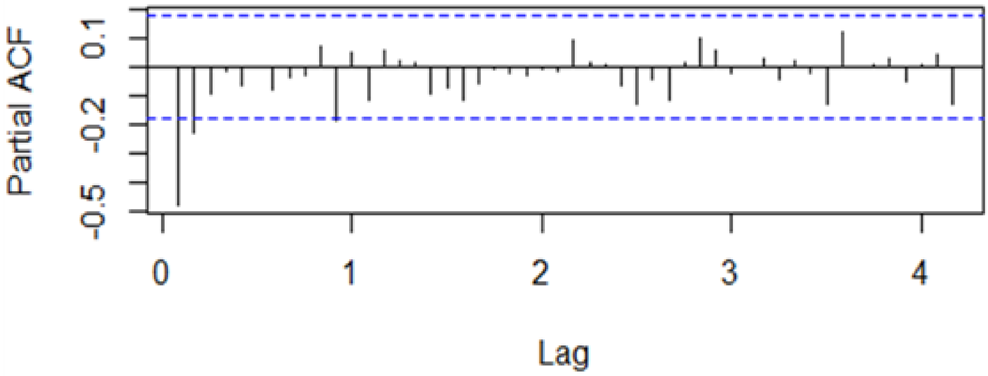


Figure 6: PACF Correlogram for the First Difference of the Series.

Table 4: Six Candidates ARIMA Models

ARIMA Model	AIC	AICc	BIC
ARIMA(0,1,0)	25.07863	25.09572	24.07863
ARIMA(0,1,1)	24.01437	24.03205	23.03773
ARIMA(1,1,0)	24.47451	24.49218	23.49786
ARIMA(1,1,1)	23.76991	23.78847	22.81662
ARIMA(2,1,0)	24.19936	24.21792	23.24607
ARIMA(2,1,1)	**23.72572**	**23.74547**	**22.79578**

Source: Survey, May 2015

ar random
ult of some
vory Coast
detrending
n the other
A (2, 1, 1).

ncrease for
the plan to
ighbouring
ansit-in and

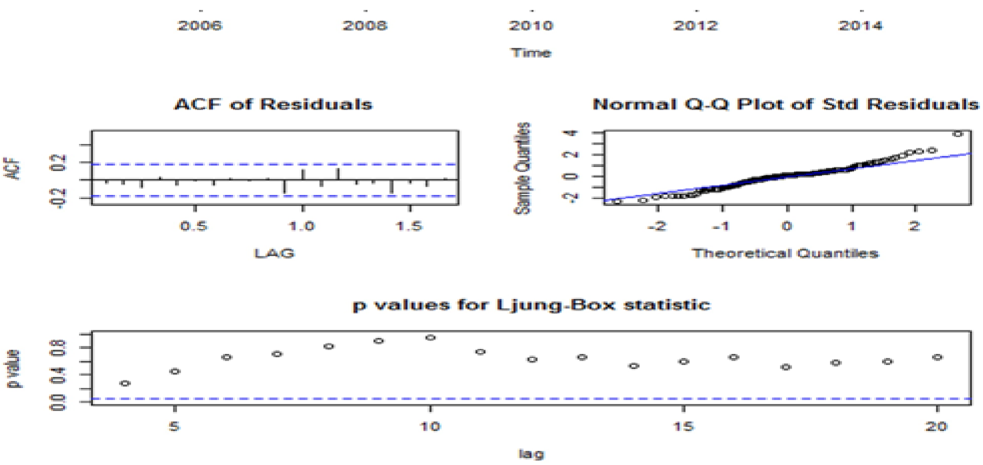


Figure 7: Model Diagnosis

VI. CONCLUSION

We indicate that Import, Export, and Transit are the major causes of cargo traffic at the port in order of ranking. It is clear from the series that the plot pattern is with irregular fluctuations with an existence of upward trend especially between 2010 and 2014. When the data is transformed and differenced to achieve stationarity, the best candidate model is ARIMA(2,1, 1). However, the best diagnosed statistical model deemed best fit for projection of flow of cargo traffic at the port was:

$$0, \sqrt{0.0248}$$

$$Y_t = 0.4093Y_{t-1} + 0.3542Y_{t-2} - 0.2365Y_{t-3} + \epsilon_t - \epsilon_{t-1}, \epsilon_t ND^{)}$$

REFERENCES

[1]. Budnik V. A., Shkurko, Y. L. (2014). Controlling tariffs for Ccargo handling in the sea ports of Ukraine. Transportation Science, 1, 100–107.
[2]. Eshun A. (2013). Trends in Transport and Logistics on the Tema-Ougadougou-Bamako Corridor. USAID No. 15.
[3]. Galley, N. P. (2006). Ghana Ports and Harbours Authority. GPHA News Letter.
[4]. Ghana Ports and Harbours Authority (2006). Ports Newletter, 1(3).
[5]. Ghana Ports and Harbours Authority. (2007). Ghana Shippers Review. Fiona Press Ltd, Accra, Ghana.
[6]. Ghana Ports and Harbours Authority. (2008). GPHA Handbook. GHPA Press, Tema, Ghana.
[7]. Ghana Ports and Harbours Authority. (2015). Ghana Shippers Review. GHPA Press, Tema, Ghana.
[8]. Gyebi-Donkor, E. (2006). Tema Port Newsletter: The evolution of Tema. GHPA Press, Tema, Ghana 1(2).
[9]. Goss L. (1990). Economic Policies and Seaports. Clfine Press, France.
[10]. [10.] Luguje, D. (2007). Ports Development Indicators. Helsinki Press, Finland.
[11]. Merk, O., Dang, T. (2012). Efficiency of world ports in container and bulk cargo (oil, coal, ores, and grain), OECD Regional Development Working Papers, OECD Publishing. http://dx.doi.org/10.1787/5k92vgw39zs2-en.
[12]. Oduro, K. (1999). The performance of Takoradi Harbour in Cargo Handling. A special study submitted to the Department of Planning, Kwame Nkrumah University of SCience and Technology, Kumasi-Ghana.

Ackora-Prah" A Statistical Model for the Projection of Flow of Cargo Traffic at the Tema Port" International Journal of Modern Engineering Research (IJMER), vol. 08, no. 11, 2018, pp 16-23