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Trend Analysis of Export Commodity Prices in Ghana: A Case Study in Cocoa Transport

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Abstract

The exports of many African countries are concentrated in a relatively small number of primary commodities, commodities whose world prices are extremely volatile, and which, in many cases are now at historically low levels. The descriptive statistics of prices of Export commodities showed a mean of 1806.2 Ghana cadies, maximum and minimum values of 2378.00 and 1406.00 Ghana cedi respectively. Prices of Export commodities for the entire period was positively skewed and platykurtic in nature with a coefficient of variation (CV), 15.4 percent. The unit roots test showed that the prices do not fluctuate with constant variation about a fixed point given an indication of a non-stationary series. The ACF plot also shows a slow decay and the PACF plot have a significant spike at lag 1. The non-stationarity of the series was further confirmed by the p-values of KPSS and ADF test, as their p values were compared with alpha value of 0.05. The series was then differenced and the ACF plot in Figure 4.3 shows significant spikes at lag 1, 10 and 11. The PACF plot also showed significant spike at lag 1. KPSS and ADF tests also carried out shows that the differenced series was stationary. The Ljung-Box test revealed that, the residuals of the model were free from serial correlation at lags 12, 24, 36, and 48 since the *p*-values of test statistic exceeds the 5% significance level at all these lags.

Keywords: export commodity, cocoa, ARIMA, Ljung-Box, smoothing, ARCH-LM

INTRODUCTION

The exports of many African countries are concentrated in a relatively small number of primary commodities, commodities whose world prices are extremely volatile, and which, in many cases are now at historically low levels. Fluctuations in commodity prices induce fluctuations in real national incomes and pose problems for macroeconomic management, Angus S (1993). Booms in government revenue can lead to hastily –executed investment programs that involved low-returns and irreversible projects, or too good but over-ambitious projects that are abandoned when revenue falls. In extreme cases, the expenditures so induced have exceeded the windfall gain, leading to an accumulation of debt, and to subsequent cutbacks in more easily controlled but more useful expenditures, such as health or education. Far from stabilizing revenue fluctuations, government responses may actually exacerbate them; even to the extent that windfall price increases hurt sellers as well as buyers. Indeed, Gelb (1988) concludes that 'the decade of the oil windfalls had involved the global economy in a massive, negative-sum gain.' This work seeks to look at the experience of dealing with commodity price variability, and discusses the nature of the policy problem, whether it is a result of that in which commodity prices fluctuate, or whether the problems can be traced to internal political and fiscal arrangements. In an attempt to establish the facts, and to cast some light on some of the mechanisms, the study looks at the econometric evidence on the effects of commodity price fluctuations on output and its components.

Long-term declines in the prices of many primary commodities relative to other products, combined with high price volatility have been long-standing issues in international trade. A large number of poor countries depend on one or few commodities for their export earnings. Negative trends in the secular terms of trade, uncertainty arising from price variability, and difficulties in achieving economic diversification have all contributed to persistent development challenges and low incomes in such countries. This study will focus on export taxes in the field of commodities.

The objectives of the study are to:

1. develop a time series model for forecasting export commodity prices in Ghana.

2. investigate the pattern of export commodity prices.
3. predict the export commodity prices in the future.
4. ascertain the general economic implications of export taxes.

METHODOLOGY

Time series analysis

Time series is an ordered sequence of values of a variable at equal spaced time interval. It is also a set of observations on a variable measured at a successive point. This could be daily, weekly, monthly, quarterly etc. It must be noted that, these observations are record at regular intervals of time. There are some major reasons that time series analysis seeks to achieve:

1. To forecast or predict to some future events.
2. To help control some future event(s) or help policy makers in formulating policies.
3. To remove the seasonally effects in the series.

Nature of Forecasting and its Applications

A forecast is simply predictions of some future events. Forecast is very important because prediction of future events is a critical input in many planning and decision making process with application to areas such as operation management , finance and risk management, marketing, economic planning,

Smoothing

Smoothing always involves some form of local averaging of data such that the non-systematic components of individual observation cancel each other out. The most common technique is the moving average smoothing, which replaces each element of the series by either the simple or weighted average of n surrounding elements, where n is the width of the smoothing ''window''.

Medians can be used instead of means. The main advantage of median as compared to moving average smoothing is that its results are less biased by outliers (within the smoothing window). Thus, if there are outliers in the data (e.g., due to measurement error), median smoothing typically produces smoother or at least more ''reliable'' curves than moving average based on the same window width. The main disadvantage of median smoothing is that in the absence of clear outliers it may not produce smooth curves like moving average and it does allow for weighting.

Exponential Smoothening Model

The exponential smoothening model uses weighted average of time series values as forecast. It is a special case of the weighted moving average in which we select only the weight of the most recent observation. The weight for other observation moves further into the past. The basic exponential smoothening model is given:

$$F_{t+1}=\alpha Y_t + (1-\alpha)F_t \quad (1)$$

Where;

F_{t+1} =forecast for period t+1, Y_t = Actual value in period t, F_t =Forecast for period t, α = smoothening constant (0≤α≤1). This shows that the forecast for period t+1 is a weighted average of the actual value in period t and the forecast for period t. The smoothness constant α is selected depending on the degree of smoothness required and the smaller the smoothness and vice versa.

Autocorrelation Function (ACF)

The autocorrelation sometimes called the lagged or serial correlation. It is the correlation between the successive values of a time series variable. Let $Y_1, Y_2, \dots\dots, Y_n$ be a time series of finite length then the sample autocorrelation is given by:

$$\rho(k) = \frac{E[(Y_1-\mu)(Y_{1+K})}{Var(Y_1)};\ k = 0, 1, 2 \dots \quad (2)$$

$$\rho_{(k)}=C_k/C_0 \quad (2.1)$$

The correlogram (autocorrelogram) displays graphically and numerically the autocorrelation function (ACF), that is serial correlation coefficients (and their standard errors) for consecutive lags in a specified range of lags (e.g., 1 through 30). Ranges of standard errors for each lag are usually marked in correlograms but typically the size of auto correlation is of more interest than its reliability because we are usually interested only in very strong (and thus highly significant) autocorrelations.

Partial Autocorrelation

The partial autocorrelation coefficient measures the degree of association between yt-k when the effects of order time lags are somehow partial out with the purpose of identifying the appropriate orders of an autoregressive process. To estimate the partial autocorrelation coefficient; we estimate the following sequence models:

$$\left.\begin{array}{l} Y_t = A_{11}Y_{t-1} + \varepsilon_t \\ Y_t = A_{21}Y_{t-1} + A_{22}Y_{t-2} + \varepsilon_t \\ Y_t = A_{31}Y_{t-1} + A_{32}Y_{t-2} + A_{33}Y_{t-3} + \varepsilon_t \\ Y_K = A_{K1}Y_{t-1} + A_{K2}Y_{t-2} + A_{K2}Y_{t-3} + A_{K4}Y_{t-4} + \cdots \dots \dots \dots .. + \varepsilon_{t-K} \end{array}\right\} \quad (3)$$

The sequence $A_{11},\ A_{22},\ A_{33},\ \dots \dots \dots \dots \dots A_{KK}$ are referred to as the partial autocorrelation coefficient which is the last autoregressive coefficient of the AR (P) model. The PACF is a collection of the partial autocorrelation coefficient and it is zero for lags greater than the order of the process in an autoregressive process.

ANALYSIS AND DISCUSSION OF RESULTS

Preliminary Analysis

This section explains the descriptive statistics of the data on the prices of export commodities in Ghana. The maximum and minimum values for the prices of export commodities for the entire period were 2378.00 and 1406.00 Ghana cedi respectively as shown in Table 1.

Table 1: Descriptive Statistics for export commodity prices

Variable	Mean	CV	Minimum	Maximum	Skewness	Kurtosis
Commodity	1806.20	15.45	1406.00	2378.00	0.45	-0.92

Table 2 displays the monthly descriptive statistics for prices of Export commodities. As seen from Table 2, the maximum price occurred in June, while the minimum value was recorded in December. Also, the coefficient of variation (CV) revealed that the largest variability occurred in February and the highest average price also occurred in February. Again, it was observed that the Export prices were negatively skewed for the months of February, March and September while it was positively skewed for the rest of months. Moreover, the Export prices for the months of May, June, July, October and November were found to be leptokurtic while that of January, February, March, April, August, September and December were platykurtic in nature.

Table 2: Monthly Descriptive Statistics of export commodities prices

Month	Mean	CV	Minimum	Maximum	Skewness	Kurtosis
January	1824.00	19.70	1447.00	2287.00	0.18	-1.95
February	1852.00	20.73	1429.00	2234.00	-0.08	-2.91
March	1831.00	19.55	1436.00	2203.00	-0.09	-2.88
April	1786.00	18.14	1456.00	2248.00	0.56	-0.78
May	1777.00	18.92	1499.00	2318.00	1.35	1.30
June	1786.00	20.31	1490.00	2378.00	1.41	1.84

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July	1832.00	18.24	1550.00	2353.00	1.12	0.56
August	1811.10	9.96	1633.40	2061.00	0.38	-1.14
September	1806.30	7.35	1659.10	1966.60	-0.02	-2.33
October	1808.00	12.47	1557.00	2145.00	0.80	0.31
November	1779.00	13.01	1569.00	2132.00	0.97	0.22
December	1783.00	19.42	1406.00	2248.00	0.36	-1.50

A time series plot of the prices of export commodities depicts that the series fluctuates with time in an increasing and decreasing manner as shown in Figures 1.

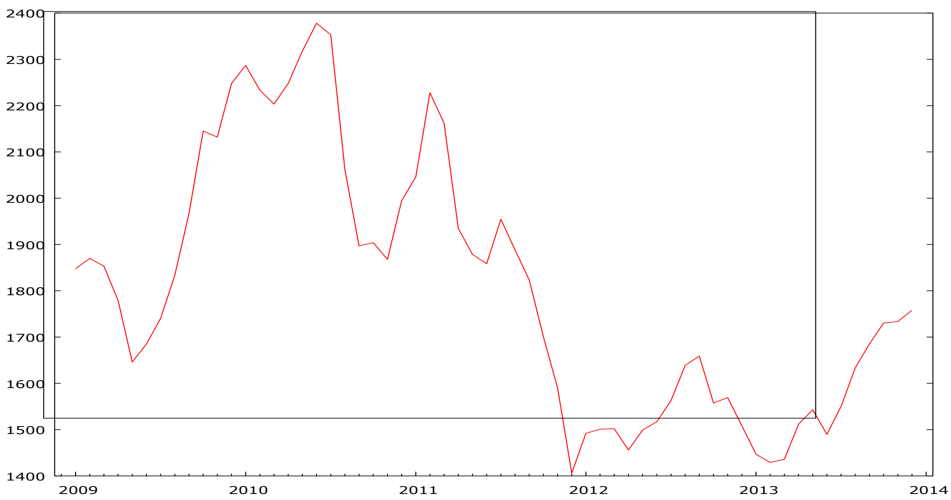

Figure 1: Time series plot of the prices of Export commodities

The nature of trend characterising the export prices over time was investigated by assessing the Linear and Quadratic time trend model. The results, as shown in Table 3 indicates that, the prices of the export commodities were best modelled by a linear time trend based on minimum AIC and BIC values.

Table 3: Trend Analysis of the Prices of Export Commodities

Model	AIC	BIC
Linear	818.29*	822.88*
Quadratic	818.70	824.58

*: Means best based on the selection criteria

The parameters of the best trend model for the prices of the export commodities were estimated as shown in Table 4. It is seen that, the parameters of the trend model were significant at the 5% level.

Table 4: Estimated parameters of the Linear trend Model

Variable	Coefficient	Standard Error	T-statistic	P-value
Constant	2113.27	57.15	36.98	0.00**
Time	-10.07	1.63	-6.18	0.00**

**Means significant at 5% significance level.

Thus, the estimated trend model of the export prices is given as;

$$Export\ price = 2113.27 - 10.07t \qquad (4)$$

FURTHER ANALYSIS

Test for Unit Roots

The time series plot of the export prices as in Figure 4.1 showed that, the prices do not fluctuate with constant variation about a fixed point, thus gives an indication of non-stationary of the series. This is also seen from the ACF and the PACF of the export price as shown in Figure 2. The ACF plot shows a slow decay and their PACF plot have a significant spike at lag one (1). This gives a graphical indication that the series was not stationary.

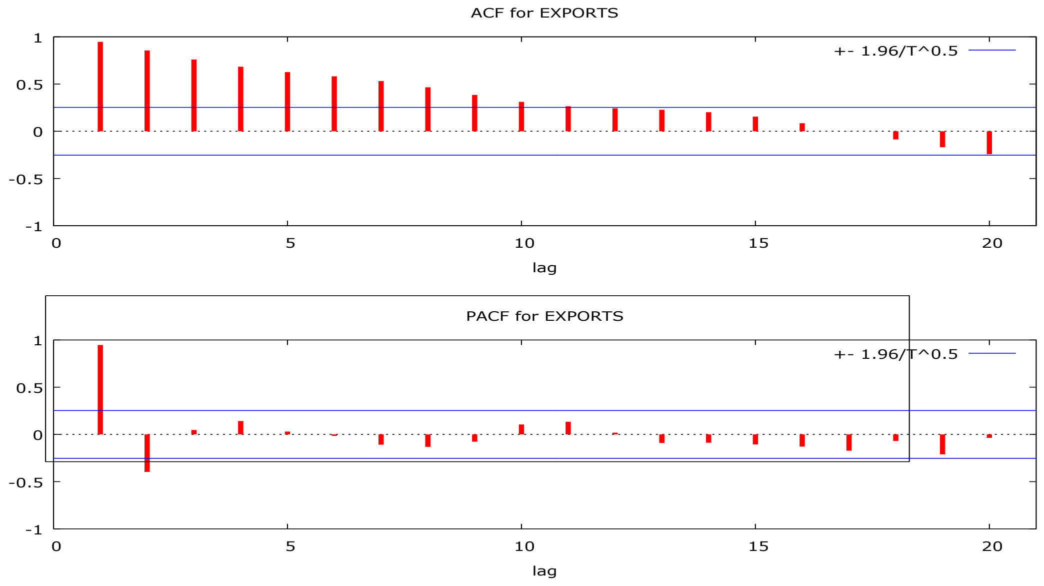

Figure 2: ACF and PACF plots of the prices of export commodities

To further confirm the non-stationarity of the series, the KPSS and ADF test for unit root were carried out on the original data. Using the KPSS test, the results in Table 5 revealed that the calculated value was greater than the critical value at 5% level of significance. The null hypothesis of stationarity was therefore rejected indicating the series was not stationary.

Table 5: KPSS test of the export prices

Test	Test Statistic	Critical value
KPSS	0.88	0.47

The ADF test also confirms the existence of unit root with only a constant term and a constant with a trend. This affirmed the presence of unit root in the series since the *p*-value was greater than the 0.05 level of significance as illustrated in Tables 6.

Table 6: ADF test of the export prices

Test	Constant		Constant+ Trend	
	Test Statistic	P-value	Test Statistic	P-value
ADF	-1.84	0.36	-2.41	0.37

The series was then differenced and then tested for stationarity. The KPSS and ADF tests for the export prices revealed that, the differenced series was now stationary since the *p*-value for the ADF test is less than the 5% significance level and the test statistic being less than the critical value in the case of the KPSS test as shown in Tables 7 and 8 respectively.

Table 7: KPSS test for the differenced series

Test	Test Statistic	Critical value
KPSS	0.10	0.47

Table 8: ADF test for the differenced series

Test	Constant		Constant + Trend	
ADF	Test Statistics	P- value	Test Statistics	P - value
	-5.14	0.00	-5.09	0.00

Fitting an ARIMA Model for the prices of export commodities

Table 9 displays the various tentative models that were identified for the prices of export commodities after obtaining the order of integration. The Box-Jenkins approach was also used to determine the order of the Autoregressive and Moving Average components based on the ACF and PACF plots. The ACF plot in Figure 4.3 shows significant spikes at lag 1, 10 and 11. The PACF plot also showed significant spike at lag 1. Among these possible models ARIMA (1, 1, 1) was chosen as the appropriate model that fit the data well because it has the minimum values of AIC, BIC and HQIC compared to other models.

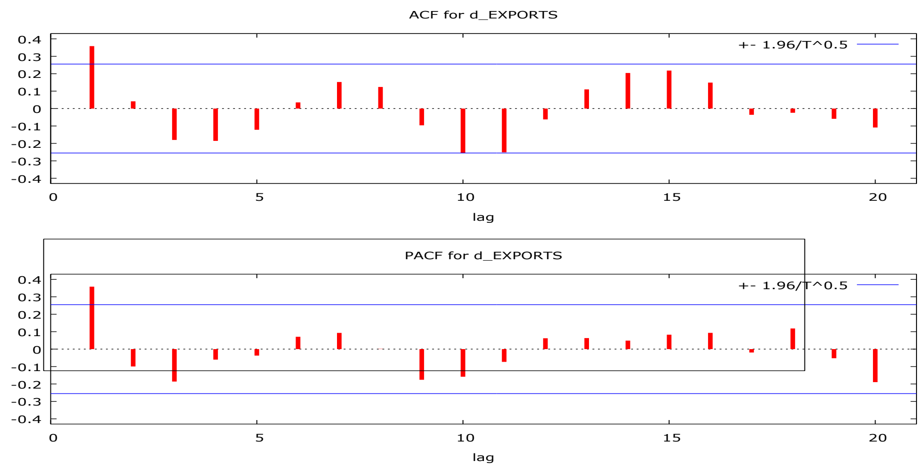

Figure 3: ACF and PACF plot of differenced series

Table 9: Tentative ARIMA models for the prices of export commodities

Model	AIC	BIC	HQIC
ARIMA(1, 1, 0)	544.69	553.83	548.11
ARIMA(1, 1, 1)	518.26*	531.06*	523.05*
ARIMA(0, 1, 1)	522.08	531.22	525.50

*: Means best based on the selection criteria

Table 10 displays the parameter estimates of the ARIMA (1, 1, 1) model. Observing the *p*-values of the parameters of the model, it can be seen that both the Autoregressive and Moving Average components were highly significant at the 5% level. The model appears to be the best model among the proposed models.

Table 10: Estimates of parameters for ARIMA (1, 1, 1)

Variable	Coefficient	Standard error	*z*-statistic	*P*-value
ϕ_1	0.39	0.13	2.93	0.00
θ_1	0.87	0.30	3.31	0.00

The estimated ARIMA (1, 1, 1) model for the prices of export commodities can be expressed in terms of backshift operator as;

$$(1 - 0.39B)(1 - B)y_t = (1 + 0.87B)\varepsilon_t \quad (5)$$

To ensure that, the fitted ARIMA (1, 1, 1) model is adequate, both the Ljung-Box and ARCH-LM tests were performed. The Ljung-Box test as shown in Table 11 revealed that, the residuals of the model were free from serial correlation at lags 12, 24, 36, and 48 since the p-values of test statistic exceeds the 5% significance level at all these lags. This indicates that the mean of the residuals of the model were finite. Further, the ARCH-LM test also shown in Table 4.11 revealed that, the residuals of the model was free from conditional heteroscedasticity, since the ARCH-LM test fails to reject the null hypothesis of no ARCH effect in the residuals of the equation at the 5% significance level. This shows that the residuals of the models were uncorrelated, thus have zero mean and have a constant variance over time; hence are white noise series.

Table 11: Ljung-Box Test and ARCH-LM Test of ARIMA (1, 1, 1) Model for export prices

	Ljung-Box Test		**ARCH-LM Test**	
Lag	**Test statistic**	**P-value**	**Test statistic**	**P-value**
12	15.8664	0.527	25.163	0.422
24	38.271	0.251	31.117	0.161
36	21.432	0.905	20.208	0.862
48	58.693	0.288	53.618	0.471

Since the diagnostic tests revealed that the ARIMA (1, 1, 1) model was adequate for forecasting the export commodity prices, the model was therefore used to forecast the prices beyond the period under consideration. Figure 4.4 clearly revealed that the export commodities prices were going to be stable in future.

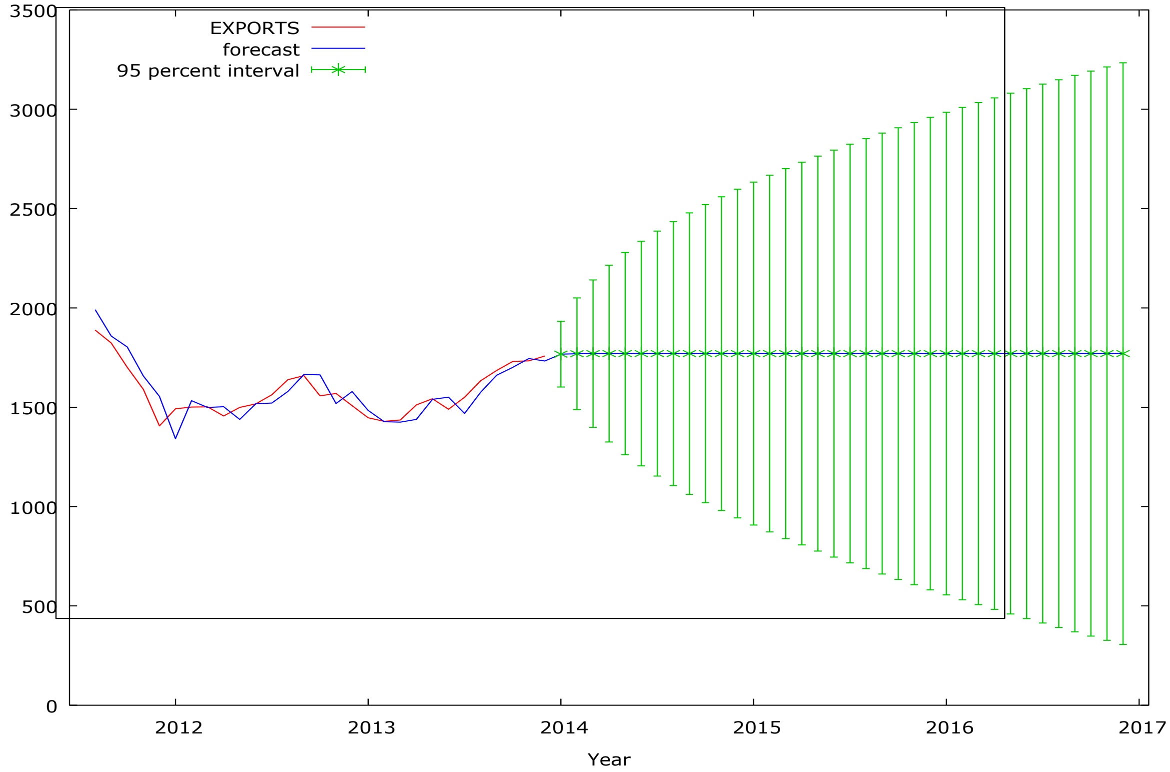

Figure 4: Forecast of export commodity prices

DISCUSSIONS

The descriptive statistics performed on the data (prices of Export commodities) under consideration displayed by Table 4.1 showed a mean of 1806.2Ghana cadies, maximum and minimum values of 2378.00 and 1406.00 Ghana cedi respectively. Also the prices of Export commodities for the entire period was positively skewed and platykurtic in nature with a coefficient of variation (CV), 15.4 percent. Table 4.2 displays the monthly descriptive statistics for prices of Export commodities. The maximum price occurred in June, while the minimum value was recorded in December. The largest variability based on CV occurred in February and the highest average price also occurred in February, the Export prices were negatively skewed for the months of February, March and September and positively skewed for the rest of the months. Moreover, Export prices for the months of May, June, July, October and November were found to be leptokurtic while that of January, February, March, April, August, September and December were platykurtic in nature.

A trend analysis test was performed on the prices of export commodities, and the best trend model was chosen based on the trend selection criteria (AIC and BIC). The linear trend model emerged the best model with the least values of AIC and BIC displayed in Table 3. The parameters of the best trend model for the prices of the export commodities were estimated as shown in Table 4 and the full model displayed by equation 4.

A time series plot of the prices of export commodities displayed by Figure 1 depicts that the series fluctuates with time in an increasing and decreasing manner confirming non stationarity within the data set. This is also seen from the ACF and the PACF of the export price as shown in Figures 2. The ACF plot showed a slow decay and their PACF plot have a significant spike at lag one (1). This gives a graphical indication that the series was not stationary. The KPSS and ADF test for unit root were also carried out on the original data. Using the KPSS test, the results in Tables 5 revealed a high test statistic. Therefore, the null hypothesis of stationarity was therefore rejected indicating the series was not stationary. The ADF test also confirms the existence of unit root with only a constant term and a constant with a trend having *p*-values greater than the 0.05 level of significance as shown in Table 6. The series was then differenced. The differenced series shows stationarity as the KPSS and ADF tests carried out shows that, the p-value for the ADF test is less than the 5% significance level and the test statistic was less than the critical value in the case of the KPSS test as shown in Table 7 and 4.8 respectively

The Box-Jenkins approach was used to determine the order of the Autoregressive and Moving Average components based on the ACF and PACF plots. The ACF plot in Figure 4.3 shows significant spikes at lag 1, 10 and 11. The PACF plot also showed significant spike at lag 1. Among these possible models, ARIMA (1, 1, 1) was chosen as the appropriate model that fit the data well because it has the minimum values of AIC, BIC and HQIC compared to other models shown in Table 9. The estimated parameters of ARIMA (1, 1, 1) model showed to be significant, since their p-Values are less than the significant values, 0.05 displayed in Table 10. The model is shown by equation 5, expressed in terms of backshift operator.

To ensure the adequacy of the fitted ARIMA (1, 1, 1) model, both the Ljung-Box and ARCH-LM tests were performed. The Ljung-Box test as shown in Table 11 revealed that, the residuals of the model were free from serial correlation at lags 12, 24, 36, and 48 since the p-values of test statistic exceeds the 5% significant level at all these lags, indicating finite mean of the residuals. Furthermore, the ARCH-LM test also shown in Table 11 revealed that, the residuals of the model were free from conditional heteroscedasticity, since the ARCH-LM test fails to reject the null hypothesis of no ARCH effect in the residuals of the equation at the 5% significance level indicating the presence of white noise in the series.

The adequate ARIMA (1, 1, 1) model was therefore used to forecast the export commodity prices beyond the period under consideration and the forecast showed by Figure 4 clearly revealed that the export commodities prices were going to be stable in the future.

CONCLUSIONS

The trend analysis of export commodity prices carried out has shown the following outcomes, the data has shown a mean of 1806.2Ghana cadies, maximum and minimum values of 2378.00 and 1406.00 Ghana cedi respectively. Also the prices of Export commodities for the entire period was positively skewed and platykurtic in nature with a coefficient of variation (CV), 15.4 percent.

A trend analysis test was performed on the export commodity prices data and the best model was chosen, based on the trend selection criteria (AIC and BIC). The linear trend model emerged the best model with the least values of AIC and BIC and is used to model the trend in the export commodities prices. From the analysis, the test for unit roots showed that the prices do not fluctuate with constant variation about a fixed point given an indication of a non-stationary series. The ACF plot also shows a slow decay and their PACF plots have a significant spike at lag 1. The non-stationarity of the series was further confirmed by the KPSS and ADF test. The series was then differenced and KPSS and ADF tests carried out shows that the differenced series was stationary. Also, the diagnostic tests revealed that the ARIMA (1, 1, 1) model was adequate for forecasting the export commodity prices. The model was therefore used to forecast the prices beyond the period under consideration and the result clearly revealed that the prices of the export commodities were going to be stable in the future.

RECOMMENDATIONS

1. Government should pay much attention to the areas of export commodities in the country especially the major ones such as cocoa and gold. Since that is our major source of income
2. Support to farmers and other areas responsible for production of raw materials should be supported financially in order to improve on export commodities. Measures should be put in place to properly monitor the free distribution of fertilizers and other farm implements to make sure the items reach the targeted farmers. This will help reduce or curb low yields and post-harvest lost.
3. Quality production of export commodities should be considered in order to avoid fluctuations in prices of export commodities by putting measures in place to curb practises that reduce quality of the commodities before their exportation
4. Exporting raw materials seem not to generate enough income for the nation. I therefore, recommend that government and other stakeholders in the cocoa sector give more value to the cocoa by processing the raw material before its exportation since it is one of the major export commodities in the country.
5. Transporting cocoa beans after harvest to the appropriate storage facilities like the ‘‘depots’’ is always very challenging. This mainly is due to the deplorable nature of most roads leading the farms to the various depots. Government should endeavour to upgrade the existing roads and construct new roads in these places where needed.

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