

FORECASTING COTTON LINT EXPORTS IN NIGERIA USING THE AUTOREGRESSIVE INTEGRATED MOVING AVERAGE MODEL

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ABSTRACT

Nigeria was a major global exporter of cotton lint to international market during the colonial and post-colonial era till late 70s when the country fully embraced oil exports to the detriment of the non-oil sector, cotton lint exports inclusive. However, Nigeria is gradually emphasizing agricultural exports again to earn huge foreign exchange, the oil sector having left the country in economic crises. This study utilized time series model particularly, Autoregressive Integrated Moving Average (ARIMA) to make forecasting of cotton lint exports in Nigeria by using 46 yearly observations (1970-2015). The model went through series of investigative and diagnostic tests in order to observe the usefulness of the model. The fitting of the selected ARIMA (2,1,2) model to the time series data, means fitting ARIMA (2,1,2) model of one first order difference. Smaller RMSE, MAE as well as Theil Inequality coefficient are actually preferred and justified that ARIMA (2,1,2) model was justified as adequate for the forecasting of cotton lint exports in Nigeria with AIC value of 20.96771, SIC value of 21.04881, MAPE value of 6751.231, RMSE of 93303.67 and R² of 0.330951. A thirty-year period ahead of cotton lint exports is predicted. The observations signify a rising trend in exports hence; it will be available especially in the future for foreign trade in the next thirty years. The outcome from the study is valuable for trade organisations and investors in assessing the precariousness of the market structure.

Keywords: ARIMA model, Cottonlint, Export, Forecasting, Nigeria

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INTRODUCTION

Essentially, cotton is a major agricultural produce that is important in Nigerian domestic sector as well as foreign trade. It is an important annual cash crop which requires four to six months of growth and production. Cotton was basically one of the foremost exports crops in Nigeria in the 60's and 70's contributing largely to the nation's Gross Domestic Product (GDP) until its production and exports were abandoned for oil exploration. The neglect of the export of cotton over the years is worrisome considering the fact that it is a key agricultural crop that is produced in most parts of Nigeria. Cotton lint is one of the two products got from cotton crop, the other being cotton seed. Cotton lint is regarded as "white gold" owing to its

position as a huge foreign exchange earner to countries involved in the export of the produce. In enhancing a sustainable increase in cotton lint export in Nigeria, it is necessary to be acquainted with how the industry will actually perform in the future. In others words, it is important to ascertain possible expectations in cotton lint export in the country. This can be calculated using the application of a range of forecasting models which are obtainable in time series literature. Forecasting as a matter of fact is as old as man, dating back to the days of the early man when fortune telling, astrology as well as predictions which were based on animal sacrifices were then used as methods of forecasting (Stephen, 1998). It is regarded as the process of making prediction of future events which are usually based on relevant variables which has known past values. Forecasting today, has become relevant in the agricultural sector of the economy especially in the area of economic forecasting where agriculture is believed to have some features which are common with business and macro-economic forecasting. It is necessary in agricultural exports, yield, incidence of diseases and others.

This paper is set out to discuss the future of Cotton lint Exports in Nigeria using annual time series data for thirty years from 1970-2015. The sets of data used are obtained from Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS). Autoregressive Integrated Moving Average (ARIMA) model is applied in examining the forecasting trends and performance. ARIMA models are extensively useful in diverse sectors of trade and industry forecasting, for instance in forecasting the production of palm oil in Nigeria from 2014-2024 by Akarue (2015), in forecasting the volume of cocoa and rubber exports in Nigeria by Mesike (2010), predicting inflation by Olajide *et al.* (2012), in forecasting prices of coriander for a mandi in Rajasthan by Verma *et al.* (2016), in forecasting international tourists influx to India for the period 2007-2010 and also to Thailand by Baloch *et al.* (2009) as well as in discussing about tourist travel forecasting based on ARIMA methodology by Chaitip *et al.* (2009). ARIMA model has actually proved its potency of precise short- and long-term forecasting, though inadequacy of the model might arise in fifty or more observations. Therefore, there is no doubt that ARIMA model is quite a popular forecasting tool for time series observations. However, best fitting ARIMA model should be given the required attention by following the necessary steps of predicting the consistency of the model which is based on the principle of parsimony.

This study attempts to put together a forecast by making use of ARIMA model that is based on time series data of cotton lint exports. The accuracy of the forecast without doubt has significant bearing on the policy deliberations of the Nigerian government and other

stakeholders in foreign trade. Economic development, rising high rate of unemployment and insecurity challenges in Nigeria necessitates the study of forecasting models.

The broad objectives of the study are as follows:

I. To check whether the series of observations under consideration are stationary or not. If the observations are not stationary, the data are to be transformed into stationary using suitable transformation.

II. To select the best ARIMA model following the principle of parsimony and selection criteria.

III. To make a forecast on the export of cotton lint from Nigeria for a thirty-year period (2016 through 2046) using ARIMA forecasting method.

MATERIALS AND METHODS

The Study Area

This study was carried out in Nigeria, situated in the Western part of Africa Continent. It is located between latitudes 7,6219°N and longitude 6.9743°E and has a population of 140,003,542 people [National Population Census (NPC), 2006]. It has a land area of 923,770km². The total estimated irrigated land which is 9570 km², is made up of arable land, pasture, forest reserve, settlements and uncultivated area estimated at 35%, 15%, 10%, 10% and 30% respectively [Federal Ministry of Environment of Nigeria (FMEN), 2001]. Nigeria has two main distinct seasons: wet season between late April and October with a short break in August and dry season between November and early April. The rainfall pattern varies from the Southern part to the Northern part. Nigeria is basically referred to as an agrarian nation due to its vast cultivable land as well as the suitable climatic conditions that favours the production of crops and livestock including cotton. A large proportion of the population (about 75%) are directly or indirectly involved in agriculture mostly at the subsistence level [Iyoha and Itsede, (2003); Asikadi (2010) and Akenbor (2012)].

Data Collection Method

The data set used for this study was time series data collected from secondary sources which include various issues of National Bureau of Statistics (NBS), Central Bank of Nigeria

(CBN), Federal Ministry of Agriculture and Water Resources (FMAWR), International Centre for Trade and Sustainable Development (ICTSD) as well as World Bank.

Method of Data Analysis

In achieving the objective of this study, ARIMA forecasting method was used in analysing the collected data.

Model Specification

The Box and Jenkins (1970) procedure is to a large extent the milestone of the modern approach being applied today to time series analysis.

When an observed time series is given, the Box and Jenkins procedure helps to build an ARIMA model. As a matter of fact, the procedure basically focuses on Stationary processes when passing by opportune preliminary transformations of the series of data. Thus, in making forecasts from past time series value, the procedure applies ARIMA or ARMA models to determine the best fit of a time series. The specific and general forms of ARIMA model may be expressed as follows;

Let Y_t be a variable with discrete time series that can take different values over a given time period. The corresponding AR (p) model of Y_t series, which is the generalizations of autoregressive model, can be expressed as:

$$AR(p) : Y_t = \{_0 + \{_1 Y_{t-1} + \{_2 Y_{t-2} + \dots + \{_p Y_{t-p} + v_t \dots \dots \dots (1)$$

Where, Y_t is the response variables (value of export of cotton lint) at time t,

$Y_{t-1}, Y_{t-2}, \dots, Y_{t-p}$ is the respective variables (value of export of cotton lint) at different time lags;

$\{_0, \{_1, \{_p$ Are the coefficients; and v_t is the error factor.

Likewise, the MA (q) model is the generalizations of moving average model and specified as:

$$MA (q) : Y_t = \mu_t + v_t + \partial_1 v_{t-1} + \dots + \partial_q v_{t-q} + v_t \dots \dots \dots (2)$$

Where,

μ_t = constant mean of the series;

$\partial_1 \dots \partial_q$ = coefficients of the estimated error term;

v_t = error term.

A combination of Equations (1) and (2) was arrived at in ARIMA Models, with the general form:

$$Y_t = \{_0 + \{_1 Y_{t-1} + \{_2 Y_{t-2} + \dots + \{_p Y_{t-p} + v_t + \partial_1 v_{t-1} + \dots + \partial_q v_{t-q} + vt \text{ -----} \quad (3)$$

If Y_t is stationary at level or $I(0)$ or at first difference $I(1)$, it indicate the order of integration, which is called ARIMA model. To identify the order of p and q the ACF and PACF is applied. The details of the estimation and forecasting process are discussed below.

Basically, the Box-Jenkins method involves four steps namely Identification; Estimation; Diagnostic checking as well as Forecasting.

Model identification actually involves the determination of the orders (p , d , and q) of the AR and MA which are the components of the model. Basically, it seeks to provide answers for whether data is stationary or non-stationary. Again, it seeks to find the order of differentiation (d), which could have made the data stationary. This is achieved by using plots of autocorrelation function (ACF) and the partial autocorrelation function (PACF) to determine the orders of the initial model, and also Augmented Dickey- Fuller (ADF) tests.

The second stage is the estimation, once the appropriate value of p and q have been identified, the parameters of the autoregressive and moving average terms included in the model was then identified.

The third stage was to carry out a diagnostic test in checking if the model is a good one through the use of tests on the parameters and residuals of the model. It should also be noted that when the model is rejected, this is a very useful step as it helps to obtain information on how to improve the model.

The fourth stage is the forecast and control. When the model is able to pass through the diagnostics step, then of course, it can be used to carry out an interpretation on a phenomenon, forecast.

RESULTS AND DISCUSSION

Developing an ARIMA Model for Cotton Lint Export Forecasting

As mentioned earlier the four basic steps in making forecast was also employed, these are model identification, model estimation, model validation and then forecasting.

Unit Root Test for the Cotton Lint Export Series

A stationary series must be obtained before it can be used to specify and estimate a model. The unit roots test will help us to determine the stationarity of a series. In carrying out this analysis the graphical and the Augmented Dickey-Fuller (ADF) was used to test for the stationarity of the Cotton Lint Export Series.

Stationarity check using the graphical methods

The preliminary understating about the nature of time series data showed is that there is no consistency in the variables over a period. The Figure 1 shows that the variable (cotton lint export) is not stationary, thus there is a need to carry out differencing the variable.

Stage 1: Model Identification

The first step here is to compute the series correlogram which actually consists of values of ACF and PACF. Taking into cognizance the Ljung-Box Q-statistics, the ACF and PACF patterns were observed and thereafter, determine the parameter values p and q for ARIMA model. Gujarati and Porter (2009) noted that the Autocorrelation Function (ACF), Partial Autocorrelation Function (PACF) as well as the resulting correlograms which are basically the plots of the ACFs and PACFs against the lag length are the key tool in the identification stage. Autocorrelation function is actually a constructive tool used in finding out if a time series is stationary or non-stationary. ACF and PACF are actually used in the determination of auto-regression and moving average orders of the models. The result of the time plot graph; the level of cotton lint appears stationary at levels. However, before deciding on the stationarity of the time series, it is necessary to carry out the Augmented Dickey-Fuller (ADF) test of stationarity. 20 lags of autocorrelation and partial autocorrelation were generated. The ACF died out after lag 2 (AR) and PACF died out slowly after lag 2(MA). Thus, the p and q values for the ARIMA ($p, 1, q$) model were set at 2 and 2 respectively. So, the ARIMA model was temporarily set to be ARIMA (1, 1, 1). From the correlogram of the series at levels, it seems an AR (1), or AR (2) might be adequate, while MA (1), or MA (2) might also be adequate. This therefore suggests the possibility of the following combinations of ARIMA: ARIMA (1,1,1), ARIMA (1,1,2), ARIMA (2,1,1), to ARIMA (2,1,2). It should be noted that from these possible ARIMA combinations, the AIC and SIC criteria were employed in the selection of the most desirable ARIMA model.

It is important to note here that in the selection of the best suitable model for forecasting out of the four models in Table 1, it is better to choose the one with lowest SIC (Schwarz

Information Criterion) and AIC (Akaike Information Criterion) value. It is clearly observed in the table that the lowest AIC and SIC values are for the ARIMA (2,1,2) model with ($p=2$, $d=1$ and $q=2$) and hence this model can be the best predictive model for making forecasts for future values of our time series data.

Stage 2: Model Estimation

After the identification of the ARIMA model, the next step is the estimation of the parameter coefficients. The parameter estimation of the model was conducted using the EViews software. The ARIMA (2,1,2) was adjudged the most suitable model for forecasting cotton lint export in Nigeria with AIC value of 20.96771, SIC value of 21.04881, MAPE value of 6751.231, RMSE of 93303.67 and R^2 of 0.330951. The results are as shown in Table 2.

In Table 2, ARIMA (2,1,2) results indicate that the coefficients of AR (2), and MA (2) were highly significant at 1% levels. The AIC (20.97) and SIC (21.05) were lower in values when compared to ARIMA (1,1,1), ARIMA (1,1,2), and (2,1,1). The adjusted R-squared of ARIMA (2,1,2) which is 0.3150 (31.50%) was also the highest when compared to ARIMA models indicating that ARIMA (2,1,2) goodness of fit for forecasting is also preferred. From the t-statistics for the coefficient variables AR (p) and MA (q) in Table 2, the null hypothesis that the coefficients are equal to zero is rejected. The value for R-squared was 0.33095 (0.33 to 2 decimal places) which implies that about 33.09% of the variation in cotton lint export in Nigeria is explained by past values of cotton lint export and the past errors. The D-W statistic of 1.627701 showed that there was little or no evidence to accept the presence of serial correlation in the model.

The results showed that the coefficient of cotton lint export expectation was negative and positive and both are significant both in the lag(s) one and two. This is consistent with the theoretical expectation.

Stage 3: Diagnostic Checking

In ensuring that the identified model is actually appropriate for analysis or not diagnostic checking is necessary. It actually involves the carrying out of diagnostic checking on the residual term which has been obtained from ARIMA model. When the estimation of the parameters for ARIMA (2,1,2) model is done, it became necessary to also do an examination of the statistical properties of the estimated ARIMA model as regards checking the adequacy of the model. Thereafter, ARIMA (2,1,2) was adjudged as the model most suitable for the forecasting of cotton lint export in Nigeria, with AIC value of 20.97, SIC value of

21.05, MAPE value of 6751.231, RMSE of 93303.67 and R^2 of 0.3309. It was quite necessary to also examine the statistical properties of the ARIMA model that has been estimated so as to check for its adequacy. Hence, the specification error, serial correlation, and heteroscedasticity of ARIMA (2,1,2) were tested.

The results reported in Table 3 shows that the model was properly specified on the ground of the Ramsey RESET and Serially Correlated based on the Breusch-Godfrey serial correlation LM tests that were carried out. The Autoregressive Conditional Heteroscedasticity (ARCH) test shows that there is no presence of volatility clustering in cotton lint export in Nigeria. In Figure 4, the Jarque-Bera (JB) test used for the residual from ARIMA (2,1,2) model, indicates that the model is normally distributed at 1%.

The histogram and normality test are plotted. The mean value of the residuals is -390.44 and the standard deviation is 8348.502. The values of skewness and kurtosis are 1.19 and 3.85 respectively. Jarque-Bera test shows that the residuals series do not reject the null hypothesis of normally distributed at 5% significance level.

Stage 4: Forecasting

After going through the identification, estimation and diagnostic stages the next stage is to make forecast for cotton lint export. The fitting of the selected ARIMA (2,1,2) model to our time series data, means fitting ARIMA (2,1,2) model of one first order difference. During forecasting stage RMSE, MAE and Theil Inequality coefficient values were calculated from ARIMA (2,1,2) model as shown in Table 4. The closer the actual values and forecast values are to each other, the smaller the forecast error that will be obtained. Hence, smaller RMSE, MAE as well as Theil Inequality coefficient are actually preferred. These forecast measures are provided in Table 4 and shows that ARIMA (2,1,2) model is adequate for the forecasting of cotton lint export in Nigeria. This is however at variance with Adebayo *et al.*, (2014) that forecasted stock markets for Nigeria and Botswana using ARIMA and concluded that the best model is ARIMA (1,1,4) for Nigeria and ARIMA (3,1,1) for Botswana respectively.

From Table 5 it can be concluded that the model is relevant for forecasting cotton lint export in Nigeria. This is because the values are less than 5 percent.

The next stage is the fitting of the chosen ARIMA (2, 1, 2) model to make forecast for the time series future values. Table 5 reveals the forecast for the next 30 years. In the case of this analysis the ARIMA (2, 1, 2) model, with Adjusted R^2 of 0.315022 (31.5%), the forecasted

values for year 2016 is 21,250.62 tonnes, year 2017 is 23,465.95 tonnes and for year 2046 is 330,571.11 tonnes.

Results presented in Table 5 showed that the export of cotton lint would increase over time between 21,250.62 tonnes and 330,571.11 tonnes for the period under forecast, 2016-2046. This means that there will be an increase in the quantity of cotton lint export hence, it will be available especially in the future for foreign consumption in the next thirty years.

CONCLUSION

The time series data showed that the variable (cotton lint exports) is not stationary, thus there was the need to carry out differencing the variable. This present study actually utilized Autoregressive Integrated Moving Average (ARIMA) model in obtaining predictions of Nigerian cotton lint exports for thirty years. ARIMA (2,1,2) results indicate that the coefficients of AR (2), and MA (2) were highly significant at 1% levels and has better forecasting results than other models. The observations signify a rising trend in exports hence; it will be available especially in the future for foreign trade in the next thirty years. Suffice it to say here that the validity of the forecasted export values can be checked as soon as the lead period data are available. If the available actual export data are found to be different from the forecasted data, then the revision of the forecast model becomes necessary. The outcome from the study is valuable for trade organisations and investors in assessing the precariousness of the market structure.

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APPENDICES**Table 1: ARIMA Models for Forecasting Cotton Lint Export in Nigeria**

Variables	ARIMA (1,1,1)	ARIMA (1,1,2)	ARIMA (2,1,1)	ARIMA (2,1,2)
AR(1)	1.012167 Se= (0.031002) t= (32.64874)	0.654091 Se= (0.114378) t= (5.718661)		
AR (2)			0.668463 Se= (0.128427) t= (5.205005)	1.099083 Se= (0.019128) t= (57.45883)
MA (1)	-0.784432 Se= (0.084422) t= (-9.291841)		0.604844 Se= (0.136198) t= (4.440931)	
MA (2)		0.281935 Se= (0.156222) t= (1.804710)		-0.971277 Se= (0.021139) t= (-45.94823)
R ²	0.290140	0.222455	0.272787	0.330951
R ² Adj	0.273632	0.204372	0.255472	0.315022
AIC	21.03945	21.13052	21.05107	20.96771
SIC	21.11975	21.21082	21.13217	21.04881
DW	1.706707	2.196341	2.076175	1.627701
RMSE	29084.37	13841.00	14216.5	93303.67
TIC	0.554	0.775	0.753	0.743

AIC=Akaike Information Criterion
SIC=Schwarz Information Criterion

DW=Durbin-Watson statistics

Table 2: Parameter Estimated along with standard error results, significant values and diagnostic criteria of the ARIMA (2,1,2) Model

Parameter	Parameter Estimate	Standard Error	t-Statistics	Prob.
AR (2)	1.099083	0.019128	57.45883	0.0000
MA (2)	-0.971277	0.021139	-45.94823	0.0000
R ²	0.330951			
R ² ad	0.315022			
AIC	20.96771			
SIC	21.04881			
DW	1.627701			
RMSE	93303.67			
MAE	80409.51			
MAPE	6751.231			
TIC	0.542			

Table 3: ARIMA (2,1,2) Diagnostic Test

TEST	F-STATISTIC	P-VALUE
Specification Error: Ramsey RESET test	4.013877	0.0258
Serial Correlation: Breusch-Godfrey serial correlation LM test	1.404770	0.2573
Autoregressive conditional Heteroscedasticity: ARCH LM test	1.099856	0.3004

Source: Authors' Calculations.

Table 4: Forecasting Performance of ARIMA (2,1,2)

Forecast Performance	ARIMA (2,1,2)
RMSE	93303.67
MAE	80409.51
Theil Inequality Coeff.	0.542

Source: Authors' Calculations.

Table 5: 30-Year Forecasting for Cotton Lint Export

S/N	Year	Export (000) tones	S/N	Year	Export (000) tones
1	2016	21,250.62	16	2032	88,073.32
2	2017	23,465.95	17	2033	96,799.73
3	2018	25,790.87	18	2034	106,390.78
4	2019	28,346.15	19	2035	116,932.14
5	2020	31,154.61	20	2036	128,517.79
6	2021	34,241.35	21	2037	141,251.76
7	2022	37,633.93	22	2038	155,247.25
8	2023	41,362.65	23	2039	170,629.46
9	2024	45,460.83	24	2040	187,535.78
10	2025	49,965.07	25	2041	206,117.23
11	2026	54,915.60	26	2042	226,539.47
12	2027	60,356.65	27	2043	248,985.53
13	2028	63,336.81	28	2044	273,655.60
14	2030	72,909.80	29	2045	308,770.00
15	2031	80,133.60	30	2046	330,571.11

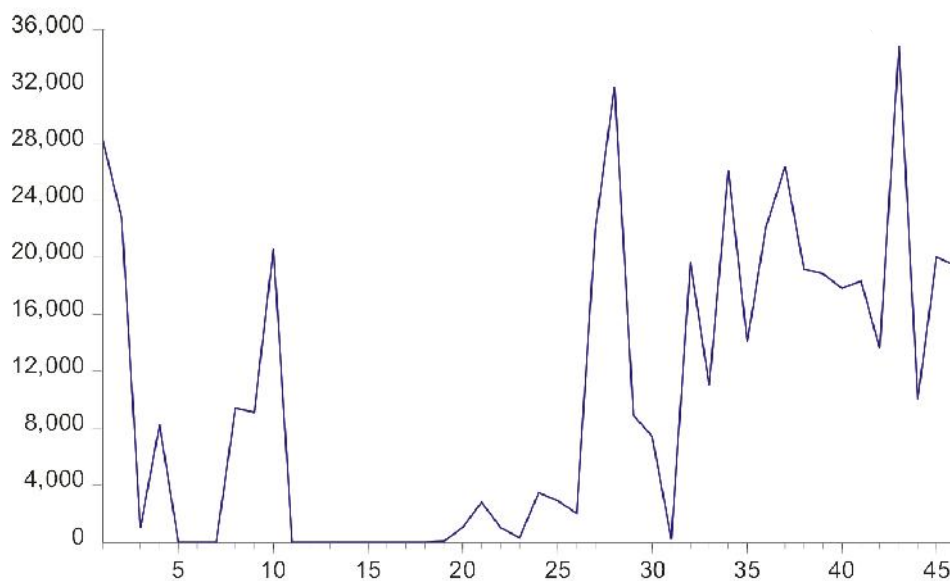


Figure 1: Graph of cotton lint export at levels (1970-2015).

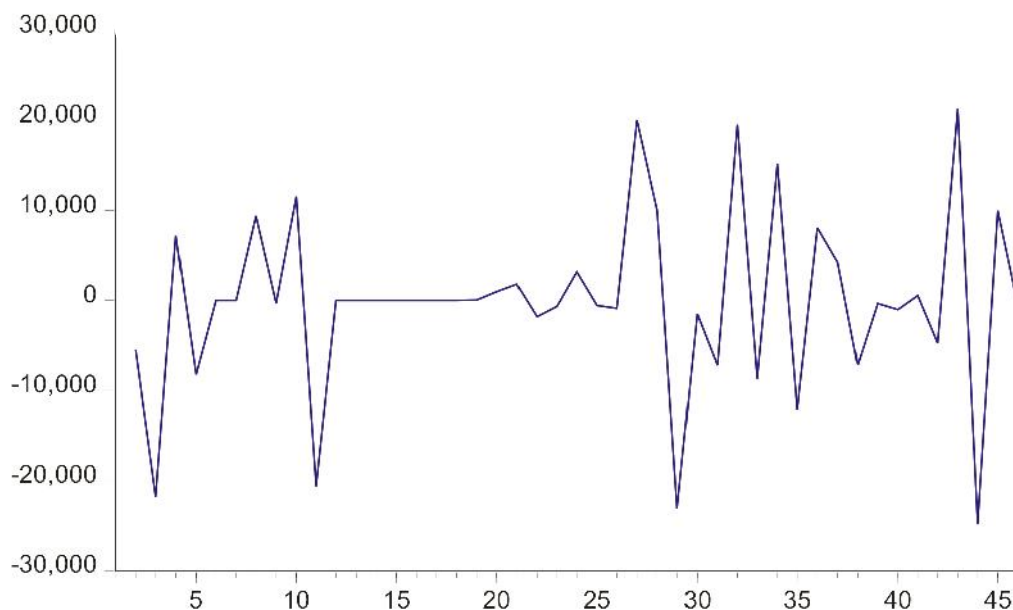


Figure 2: Graph of cotton lint export at first difference (1970-2015).