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Forecasting the production of jute based on time series models in Bangladesh

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Abstract
Jute is called the Golden Fiber of Bangladesh. Bangladesh is currently the second largest producer of jute fiber. In terms of world export of jute fiber, Bangladesh's share is more than 70%, which makes Bangladesh the largest exporter of jute fiber in the world. The global demand for jute and allied products has seen a steady increase driven be a fresh comeback for biodegradable fiber as people now look for eco-friendly products replacing synthetics. The main purpose of this project is to forecast the production of jute in Bangladesh. Here, we applied different methods of time series and analyze the yearly jute production data in Bangladesh over the period 1972-1973 to 2016-2017. We applied Box-Jenkin's methodology to identify the actual model based on different model selection criterion. In this research, we found that ARIMA (1, 1, 1) model is suitable for the forecasting the jute productions in Bangladesh. Comparing between the original series and forecasted series, we found that the production of jute is predicted to gradually increasing.

Keywords: golden fiber, box-jenkin's methodology, arima model, forecasting

1. Introduction
Bangladesh is currently the second largest producer of jute fiber, now over taken by India. After the country's independence, more than 80% of total foreign currency in Bangladesh was earned from jute and jute related goods. But after 80's, the earning rate of foreign currency from jute industry has gradually declined. The sector provides about 10% of the total employment in the economy and 12% of GDP. About 90% of jute products produced in Bangladesh is exported (Rahman, 2007) [7]. Foreign exchange earnings of Bangladesh come mostly from jute. Beside, jute is a good source of revenue for the governments in the form of taxes, levies, sales and custom duties on jute goods (Alam, *et al*., 2009) [1]. Bangladesh is famous for jute production and earned a big amount of foreign currency by exporting jute and jute products to different countries. At one stage, Jute was only the vital sector in Bangladesh from which major portion of foreign currency is to come and help Bangladesh's economy and a large number of manpower were employed there. Bangladesh was recognized as one of the best jute producing and exporting countries of the world (Bangladesh Bank, 2014) [6]. Over the last 20-25 years it did slide down to the seventh position. Now it regained to come to the forth position (Rahman & Salim, 2013) [8]. Jute is called the Golden Fiber of Bangladesh. The Jute Area, popular for highest quality of jute fiber is located in Bangladesh. Therefore, Bangladesh is able to supply the highest quality of jute fiber in the world. Jute is grown mainly in Bangladesh for fiber rather than for seed. In Jute, use of quality seeds of improved variety alone contributes 223.54kg of extra fiber per hectare i.e. an increase of about 17% (BBS, 2010) [5]. It is one of the cheapest and the strongest of all natural fibers and considered as fiber of the future. Jute is second only to cotton in world's production of textile fibers. India, Bangladesh, China and Thailand are the leading producers of Jute. It is also produced in southwest Asia and Brazil. India is the largest producer of jute goods in the world, while Bangladesh is the largest cultivator of raw jute (Ministry of Finance, 2010) [4].

In Bangladesh, almost 3 million farming households are involved in jute cultivation. Jute harvesting takes place at a time when marginal farmers and farm workers are faced with shortage of their food stocks. The cash derived from sales of jute fiber and the wages received by workers are an important contribution to food security for this vulnerable segment of the population. Rapid employment generation is vital to poverty reduction in Bangladesh. Economic growth driven by sectors that are labor-intensive by nature has greater potential for job creation. The fact that the jute sector is so labor-intensive has played important strength, given the country's large rural underemployment. The global demand for jute and allied products has seen a steady increase driven by a fresh comeback for biodegradable fiber as people now look for ecofriendly products replacing synthetics. Bangladesh produces around 30% of the total world production of jute and exports around 40% of its total produce as raw jute. Thus, it is necessary to estimate the behaviors of jute production and forecast the future production of jute in Bangladesh.

1.1 Objectives of the study

The main objective of this study is to forecast the future production of Jute in Bangladesh. Here we study time series analysis on production of Jute. On the basis of this analysis the study attempts to-

1. To fit accurate model of Jute production of Bangladesh.
2. To check the model adequacy for different fitted model for Jute production of Bangladesh.
3. To forecast future production, obtain form Jute of Bangladesh.
4. To see the forecasting performances of the selected ARIMA models.

2. Materials and Methods

For forecasting purposes, one of the important types of data used in empirical analysis is time series data. The empirical work based on time series data assumes that the underlying time series is stationary. The time series analysis based on the stationary time series data. In this section we briefly discuss on stationary and non-stationary time series. A stochastic process is said to be stationary if its mean and variance are constant over time. Otherwise it will be non-stationary. Why are stationary time series so important? Because if a time series is non-stationary, we can study its behavior only for the time period under consideration. Each set of time series data will therefore be for a particular episode. As a consequence, it is not possible to generalize it to other time periods. Therefore, for the purpose of forecasting, such (non-stationary) time series may be of little practical value. How do we know that a particular time series is stationary? There are several tests of stationary. Here we used graphical and analytical recognized test. Graphical test: if we depend on common sense, it would seem that the time series depicted in figure is non-stationary, at least in the mean value. Here we applied most widely used popular formal test over the past several years are Autocorrelation function (ACF), Partial Auto-correlation function (PACF) and Augmented dickey-fuller test (Brockwell, *et al*., 2002 & Box, 1994) [2, 3].

2.1 Auto correlation function (ACF)

For a stationary process, auto correlation function (ACF) is the process of k and the parameter of the process. The ACF is a useful device for describing a time series process. One of the characteristics of a stationary process is an autocorrelation function. Mathematically the auto-correlation function is,

$$\rho_k = \frac{\dfrac{\sum (Y_t - \bar{Y})(Y_{t+k} - \bar{Y})}{n}}{\dfrac{\sum (Y_t - \bar{Y})}{n}}$$

2.2 Partial Auto-correlation function (PACF)

Alternative valuable technique to scrutinize serial dependencies is to observe the partial autocorrelation function (PACF) - an extension of autocorrelation, where the dependence on the intermediate elements (those within the lag) is removed. Mathematically the partial auto-correlation function is,

$$\phi_{p+1,p+1} = \frac{r_{p+1} - \sum_{j=1}^{p} \phi_{pj} r_{p+1-j}}{1 - \sum \phi_{pj} r_j}$$

Where, $\phi_{p+1,j} = \phi_{pj} - \phi_{p+1,p+1}\phi_{p,p-j+1}$

2.3 Augmented dickey-fuller test

For theoretical and practical reasons the Dickey Fuller test is applied to regression model of the following form:

$$\Delta y_t = \delta y_{t-1} + u_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (a)$$
$$\Delta y_t = \beta_1 + \delta y_{t-1} + u_t \dots\dots\dots\dots\dots\dots\dots\dots\dots (b)$$
$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + u_t \dots\dots\dots\dots\dots\dots (c)$$

Where t is the time or trend variable. In each case the null hypothesis is that $\delta = 0$, that is there is a unit root. The difference between (a) and the other two regression lines are in the inclusion of the constant (intercept) and the trend term. If the error term u_t is auto correlated, one modified (c) as follows:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta y_{t-1} + \varepsilon_t \dots\dots\dots\dots (d)$$

Where $for\ example, \Delta y_{t-1} = (y_{t-1} - y_{t-2}), \Delta y_{t-2} = (y_{t-2} - y_{t-3})\ etc.$ i.e. one uses lag difference terms.

The null hypothesis is still that $\delta = 0$ or $\delta = 1$, i.e., a unit root exists in y (i.e. is non-stationary) when the Dickey Fuller test is applied to models like (d), it is called augmented Dickey-Fuller (ADF) test. The ADF the test statistic has same asymptotic distribution as the DF statistic, so the same critical values can be used.

2.4 Model selection

Here, we applied Box-Jenkin's Methodology to identify the appropriate model for analyzing and forecasting the production of Aman rice in Bangladesh. The Box-Jenkin's Methodology is shown below:

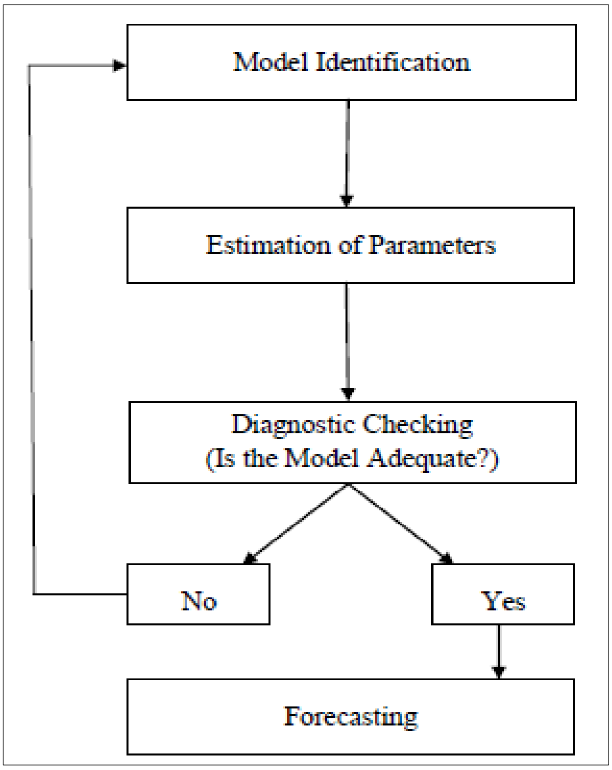

Fig 1: Box-Jenkin's Methodology

2.5 Forecasting

A planning tool that helps management in its attempts to cope with the uncertainty of the future, relying mainly on data from the past and present and analysis of trends. Predictions of future events and conditions are called forecasts, and the act of making such predictions is called forecasting (Brockwell, *et al*., 2002 & Box, 1994) [2, 3].

3. Result and Discussion

We have used the secondary data regarding Jute production in Bangladesh which are collected over the period 1972-1973 to 2016-2017. From Department, Bangladesh Bank. Here we applied different techniques for analyzing the data and the results of this data are shown below:

3.1 Checking non-stationary of original jute production by time series plot

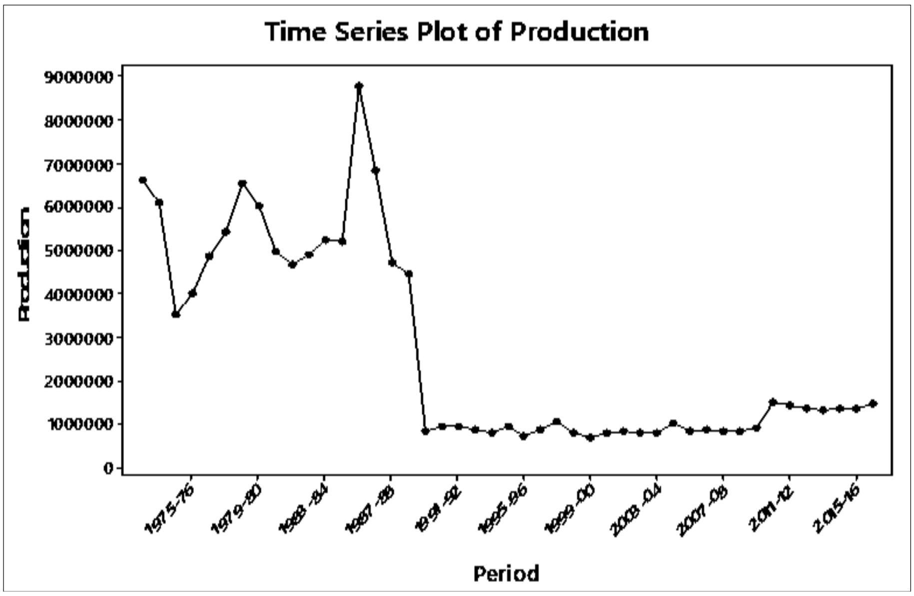

Fig 2: Time series Plot of original Jute production

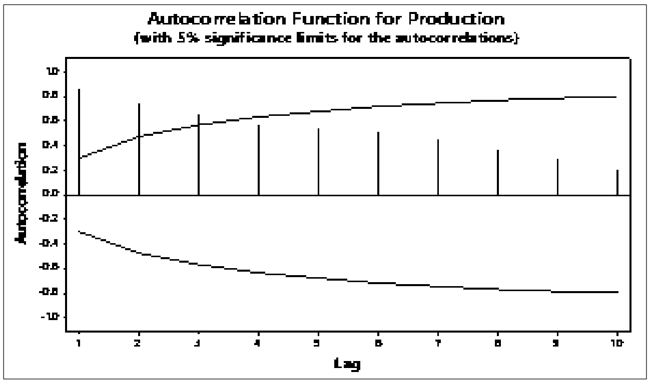

Fig 3: ACF Plot of Original Jute Production

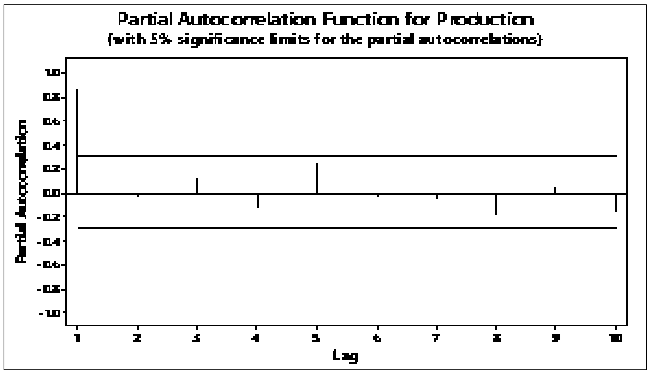

Fig 4: PACF Plot of Original Jute Production

From Figure 2, it is clear that the yearly jute production in Bangladesh fluctuated over the study period 1972-2017. The jute production started at about 6624 thousand tone's in 1972-73 and reached a peak in 1985-86 of around 5194 thousand tones then it dropped dramatically up to the period 1989-90 and the production reached to around 835 thousand tones. After the period 2003-04 there was an upward trend in the jute production in Bangladesh, i.e., the variance is unstable which indicates the jute production data series is not stationary. From Figure 3 & 4 we observed that the series is non-stationary.

Table 1: ACF & PACF of Jute production

	Q-Stat	Critical value
ACF	139.7304	18.307
PACF	41.22662	18.307

From Table 1 we showed that the calculated values are garter than the tabulated values. Therefore we conclude that the series is non-stationary.

Table 2: Unit root test of Jute production

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.859071	0.0606
Test critical values:	1% level	-2.618579	
	5% level	-1.948495	
	10% level	-1.612135	

From Table 2 we observed that -1.85(ADF value) >-1.94 (Negative Critical Value) accept the null hypothesis. So, the production is non-stationary.

3.2 Checking stationary by time series plot of Jute production with natural log

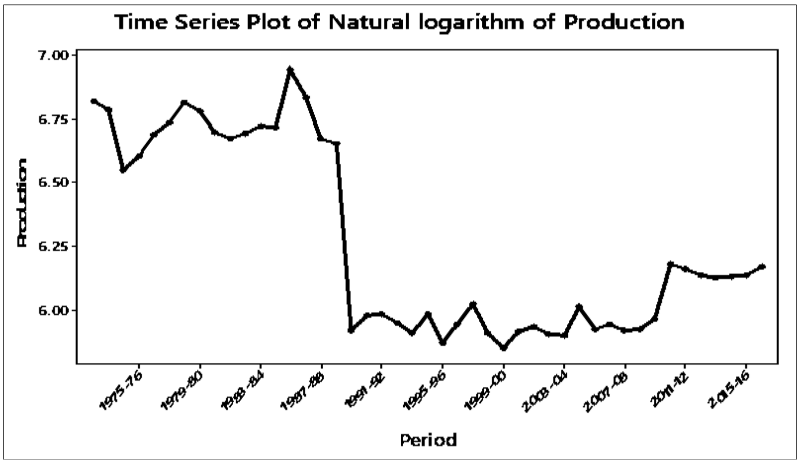

Fig 5: Time series Plot of log transform of Jute Production

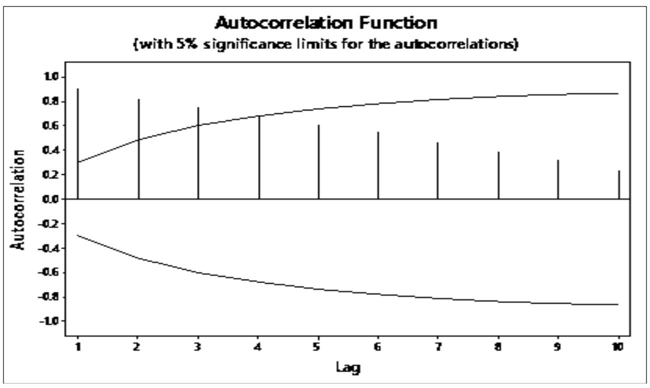

Fig 6: ACF Plot of natural log of Jute Production

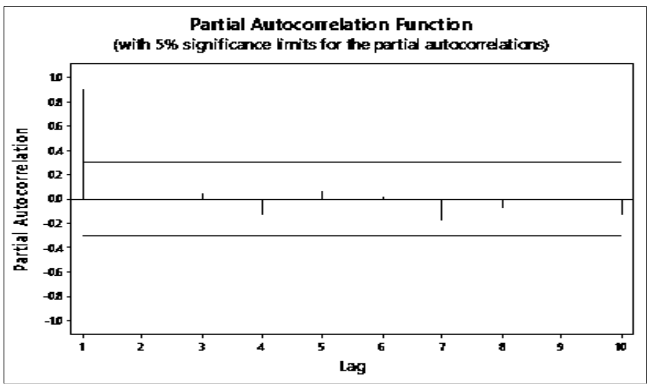

Fig 7: PACF Plot of natural log of Jute Production

From Figure 5-7 we observed that the Jute production on log transform is non-stationary.

Table 3: ACF & PACF of Jute production on log transform

	Q-Stat	Critical value
ACF	163.6805	18.307
PACF	69.24003	18.307

From Table 3 we showed that the calculated values are garter than the tabulated values. Therefore we conclude that the series is non-stationary.

Table 4: Unit root test of Jute production with natural log

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.802333	0.3627
Test critical values:	1% level	-2.618579	
	5% level	-1.948495	
	10% level	-1.612135	

From the above Table 4 we observed that -0.802 (ADF value) >-1.94(Negative Critical Value) accept the null hypothesis. So, the production of natural log is non-stationary.

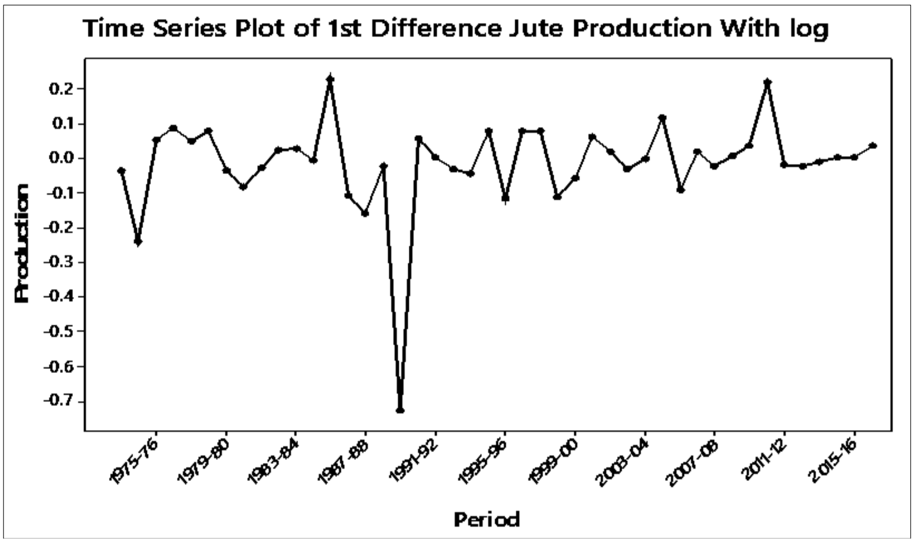

Fig 8: Plot of first difference jute production with log

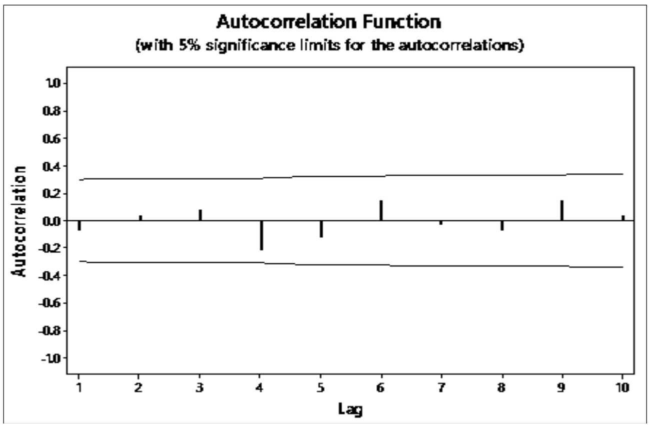

Fig 9: ACF plot of first difference Jute Production with log

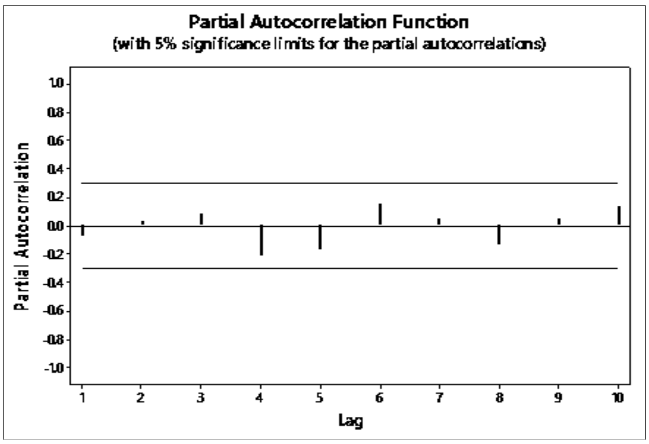

Fig 10: PACF plot of first difference Jute Production with log

From Figure 8-10, we observed that the series of jute production based on 1st difference of natural log is stationary.

Table 5: ACF & PACF of Jute production on log transform

	Q-Stat	Critical value
ACF	10.42215	18.307
PACF	13.6778	18.307

From Table 5 we showed that the calculated values are less than the tabulated values. Therefore we conclude that the series is stationary.

Table 6: Unit root test of 1st difference Jute production with log

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.853563	0.0000
Test critical values:	1% level	-2.619851	
	5% level	-1.948686	
	10% level	-1.612036	

From Table 6 we showed that -6.85(ADF value) < -1.94 (Negative Critical Value). We can reject the null hypothesis. So, the production is stationary.

3.3 Model Selection of Jute Production

Let us consider the different types of tentative models as much as possible from which we select the best model using the model selection criterion. Since the characteristics of a good ARIMA model is parsimonious ignoring the higher order of p and q, the tentative models on the basis of model selection criterion are as follows:

Table 7: Different significant ARIMA Model

Model	MaxAPE	NBIC	RMSE
ARIMA(1,1,1)	445.667	28.041	1079108.334
ARIMA(1,1,2)	434.668659	28.078019	1052838.763
ARIMA(2,1,1)	434.112	28.075	1051221.670
ARIMA(2,1,2)	395.854829	28.156782	1049033.92

Using the tentative procedure, it is clear that ARIMA (1, 1, 1) model with NBIC = 28.041 is the best selected model for forecasting the jute production in Bangladesh. The estimates of the parameters of the fitted ARIMA (1, 1, 1) model are shown in the given table. Also, the value of the most useful "forecasting criteria" of the fitted model is shown in given Table 7.

3.4 Diagnostic checking

To check the diagnosis, we should follow the residual ACF & PACF for the selected models those are displayed as sequentially-

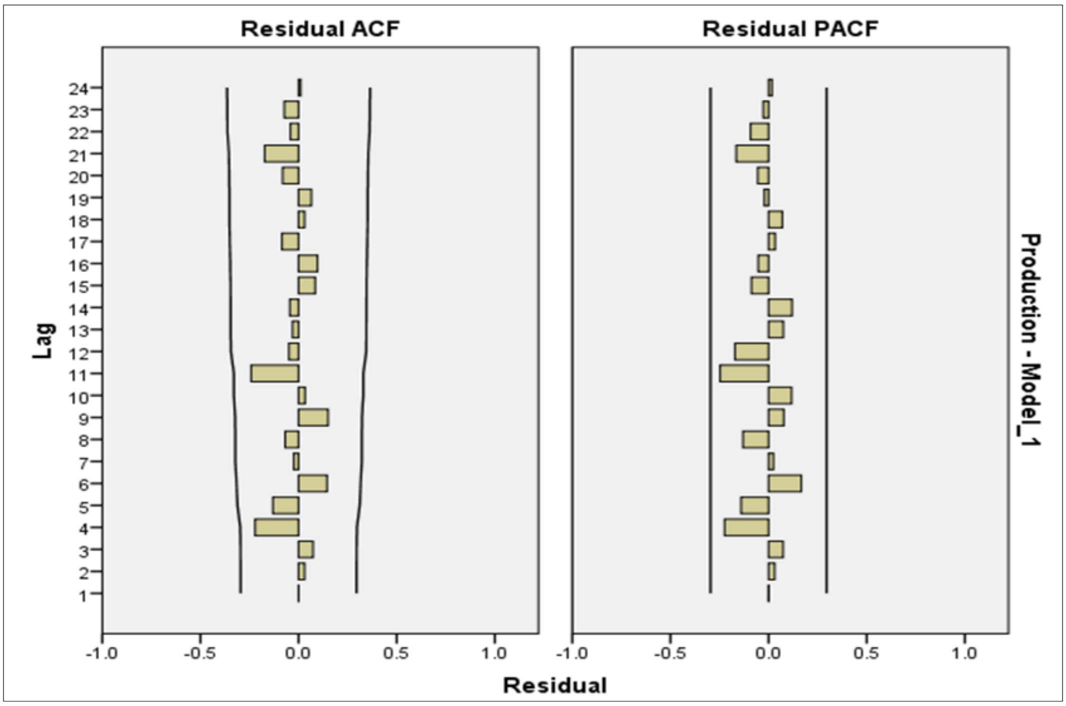

Fig 11: Residual ACF, PACF of ARIMA (1, 1, 1)

3.5 Parameter estimation

Now we have to estimate the parameters of best fitted model ARIMA (1, 1, 1). The estimated values of the parameters are displayed in the following Table 8:

Table 8: Significance Test of the parameters of ARIMA (1, 1, 1) model for jute production in Bangladesh

ARIMA Model Parameters								
					Estimate	SE	T	Sig.
Production-Model_1	Production	Natural Logarithm	Constant		-.034	.047	-.734	.467
			AR	Lag1	-.168	2.236	-.075	.940
			MA	Lag1	-.100	2.258	-.044	.965

From the above Table 8, we observed that the p-values corresponding to coefficients are approximately less than 0.05, which leads to the conclusion that the parameters are significant.

3.6 Forecasting

By using the best fitted model ARIMA (1, 1, 1), the forecasted jute production along with 95% confidence level for ten years are shown in Table 9. The graphical comparison of the original series and the forecasted series is shown in Figure 12. It is observed that the forecasted series (blue-color) fluctuated from the original series (red) with a very small amount which shows the fitted series has the same manner of the original series (Figure 12). Therefore, the forecasted series is really a better representation of the original jute production series in Bangladesh.

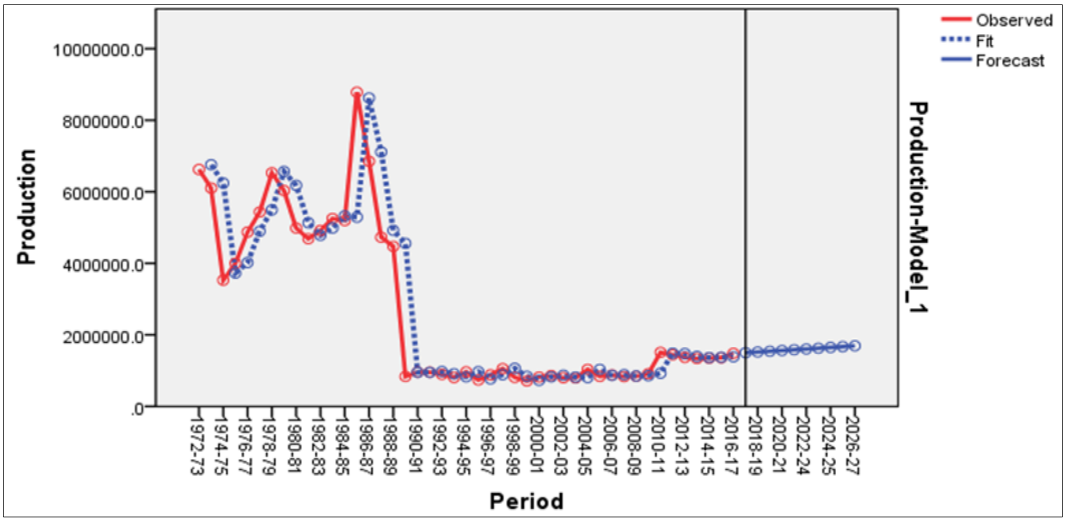

Fig 12: Plot for Forecasts for Jute production for Bangladesh

We have already fitted an ARIMA (1, 1, 1) model for the forecasting of yearly data of jute. Now to see the performance of this model in the out of sample forecasting, the forecasted value of jute production data for the year 2017-18 to 2026-2027 will be derived using this model. Then we compare the forecasted value with the actual value, which is available from 2017-18 to 2026-2027. The Table 9 gives the forecasted value obtained by ARIMA (1,1,1) model along with the forecasting errors in the test set. The following table contains the forecasted values under the period 2017-18 to 2026-27.

Table 9: Forecasted jute value in Bangladesh for the period 2017-18 to 2026-27

Period	Forecasted	LCL	UCL
2017-18	1501067.2	734981.4	2754591.2
2018-19	1521737.4	558053.2	3397401.4
2019-20	1542058.6	443999.2	3986404.1
2020-21	1562757.5	364172.2	4539667.9
2021-22	1583716.1	304388.7	5072613.3
2022-23	1604958.8	257918.8	5591303.7
2023-24	1626486.0	220825.1	6099333.4
2024-25	1648302.0	190634.2	6598797.1
2025-26	1670410.6	165688.9	7090995.9
2026-27	1692815.8	144828.0	7576746.7

4. Conclusion
The best selected Box-Jenkins ARIMA model for forecasting the jute productions in Bangladesh is ARIMA (1, 1, 1). From the comparison between the original series and forecasted series shows the same manner indicating fitted model are statistically well behaved to forecast jute productions in Bangladesh i.e., the models forecast well during and beyond the estimation period which reached at a satisfactory level. Thus, this model can be used for policy purposes as far as forecasts the jute production in Bangladesh.

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