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Modeling of Tea Production in Bangladesh Using Autoregressive Integrated Moving Average (ARIMA) Model

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Abstract

In the present paper, different Autoregressive Integrated Moving Average (ARIMA) models were developed to forecast the tea production by using time series data of twenty-four years from 1990-2013. The performance of these developed models was assessed with the help of different selection measure criteria and the model having minimum value of these criteria considered as the best forecasting model. Based on findings, it has been observed that out of eleven ARIMA models, ARIMA (1,1,2) is the best fitted model in predicting the production of tea in Bangladesh and the forecasted value of tea production in Bangladesh, for the year 2014, 2015 and 2016 as obtained from ARIMA (1,1,2) was obtained as 65.568 Million Kilogram, 67.867 Million Kilogram and 60.997 Million Kilogram.

Keywords: ARIMA; Time series; Tea; Modeling; Forecast

Introduction

Tea serves as the most important and popular drink for two-thirds of the world population not only because of its attractive aroma and taste but also because of its many pharmacological effects, like suppressing tumor cell growth, reducing cardiovascular diseases, anti-obesity and decrease the risk of atherosclerosis says Wang et al. [1] and Dhekale et al. [2]. The role of Bangladesh tea industry in global context is insignificant. It is only 1.68% of the global tea production and 0.58% of the world tea export. It seems that its export is gradually declining. If this trend continues, Bangladesh will turn into a tea importing country by 2015 discussed by Monjur [3] and Baten et al. [4]. As a result; international comparisons of the tea industry's efficiency have been of great interest to firms in the industry as well as policymakers. The large tea producing countries like India and Sri Lanka produce more than Bangladesh, where India and Sri Lanka's production level is 16 and 12 times higher than Bangladesh discussed in BCS [5]. It was found that in 1998, on an average only 1,145 kg of tea was produced per hectare in Bangladesh. Whereas, in the same year, production level per hectare in India and Sri Lanka was 1708 and 2030 kg respectively found Monjur [3] and Majumder [6].

In Bangladesh, on average the area of a tea estate is around 337 hectares. At present there are very few newly established smallholding tea gardens operating in the north-western part of Bangladesh. They have very significant contribution to the tea industry of Bangladesh. The first tea garden was established in 1857 at Malnicherra discussed Monjur [7] and Khisa and Iqbal [8], two miles away from Sylhet town, situated in the north-eastern part of Bangladesh. The British companies were the pioneer of tea plantation in Bangladesh. By 1903, there were 15 European planters in Northern Sylhet, 102 in Southern Sylhet and 26 in Habiganj district of Sylhet discussed Sana [9]. At present Bangladesh has 162 tea gardens and among them Sterlink companies operate 28 gardens and 128 gardens are operated by Bangladeshi owners (National Tea Company, Bangladesh Tea Board, Private limited companies and proprietary owners). Besides, six gardens are operated by smallholders which are situated in the north-western part of Bangladesh discussed Huque [10].

Tea cultivation in Bangladesh is spread over the hilly zones on the eastern part mainly in four districts (Sylhet, Moulvibazar, Habiganj and Chittagong). About 96% annual productions (of which 63% is of Moulvibazar district) is contributed by greater Sylhet obtained from 93% (of which 62% is of Moulvibazar district) of plantation area discussed. Islam et al. It is to be noted that Sterling companies produce about 50% of annual crop from about 42% of plantation area discussed BBS [12].

Materials

In the present study, time series secondary data on production (Million Kilogram) of tea in Bangladesh were considered for the period 1990 to 2013 from Bangladesh Tea Board (BTB) [13], Ministry of Commerce, and Government of People's Republic of Bangladesh. The time series secondary data were analyzed with the help of various ARIMA models. .

Methods

ARIMA is one of the most traditional methods of non-stationary time series analysis. In contrast to the regression models, the ARIMA model allows time series to be explained by its past or lagged values and stochastic error terms. The models developed by this approach are usually called ARIMA models because they use a combination of autoregressive (AR), integration (I)-referring to the reverse process of differencing to produce the forecast and moving average (MA) operations discussed by Box [14].

The ARIMA model is denoted by ARIMA (p,d,q) where "p" stands for the order of the auto regressive process, 'd' is the order of the data stationary and 'q' is the order of the moving average process. The general form of the ARIMA (p,d,q) can be written as which discussed Judge et al. [15]

$$\Delta^d y_t=\delta+\theta_1\Delta^d y_{(t-1)+}\theta_2\Delta^d y_{(t-2)}+\ldots\ldots\ldots\ldots\ldots+\theta_p y_{(t-p)+}e_{(t-1)}\alpha e_{(t-1)}-\alpha_2 e_{(t-2)} \alpha_q e_{(t-2)} \quad (1)$$

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Where, Δ^d denotes differencing of order d, i.e., $\Delta y_t=y_t-y_{t-1}$, $\Delta^2 y_t=\Delta y_t-\Delta y_{t-1}$ and so forth, y_{t-1}.......... y_{t-p} are past observations (lags), δ,θ_1........ θ_p are parameters (constant and coefficient) to be estimated similar to regression coefficients of the Auto Regressive process (AR) of order "p" denoted by AR (p) and is written as,

$$Y=\delta+\theta_1 y_{t-1}+\theta_2 y_{t-2}\dots\dots\dots+\theta_p y_{t-p}+e_t \qquad (2)$$

Where, e_t is forecast error, assumed to be independently distributed across time with mean θ and variance $\theta_2 e$, e_{t-1}, et_{-2}......... e_{t-q} are past forecast errors, α_1.........α_2 are moving average (MA) coefficient. While MA model of order q (i.e.) MA (q) can be written as,

$$Y_t=e_t-\alpha_1\alpha_{t-1}-\alpha_1\alpha_{t-2}\dots\dots\dots\alpha_q\,\alpha_{t-q} \qquad (3)$$

Seasonal ARIMA model is to be denoted by ARIMA (p,d,q)(P,D,Q), where P denotes the number of seasonal autoregressive components, Q denotes the number of seasonal moving average terms and D denotes the number of seasonal differences required to induce stationarity discussed Box et al. [16]. The steps which are followed in order to define an ARIMA model as stated by Box and Jenkins:

a) Identifying a model

b) Estimating the parameters of the model

c) Diagnostic checking

In the present paper, time series yearly data on production (Million Kilogram) of tea in Bangladesh were considered so there is no seasonal variation in the data which means non-seasonal ARIMA (p,d,q) models are applicable only. Comparison among family of different parametric combination of ARIMA (p,d,q) was done on the basis of minimum value of selection criteria which are Root Mean Squared Error (RMSE), Mean percentage error (MPE), Mean absolute percentage error (MAPE), Mean absolute error (MAE), Maximum absolute percentage error (MAPE), Maximum absolute standard error (MASE) and Bayesian information criteria discussed Kumari et al. [17] and Rahman et al. [18].

Result and Discussion

In Figure 1, from the autocorrelation (ACF) and partial autocorrelation (PACF), it is clear that there is no significant spike in the original series which also indicates that there are no significant effects of Auto-Regressive and Moving Average in the original series, that is, the tea production series is stationary without any difference.

After making the series stationary, different parametric combinations of ARIMA (p,1,q) model were tried to analyze the twenty-four years' data (1990 to 2013) of tea production and the best fitted model is accepted on the basis of minimum value of all selection criteria as mentioned above in methodology. The results of performance of developed ARIMA (p,1,q) model is presented in Table 1. It exposed the performance of eleven ARIMA models out of which ARIMA (1,1,2) was best out of all. ARIMA (2,1,2) and ARIMA (2,1,1) ranks second and third respectively while remaining ARIMA models are not as good as these three.

Therefore, it was concluded that the appropriate model for forecasting the production of tea in Bangladesh during 2013 was ARIMA (1,1,2) having minimum value of all selection criteria as compared to remaining ten models.

Table 2 shows the forecasted value of tea production using the best fitted model ARIMA (1,1,2). The forecasted value of tea production

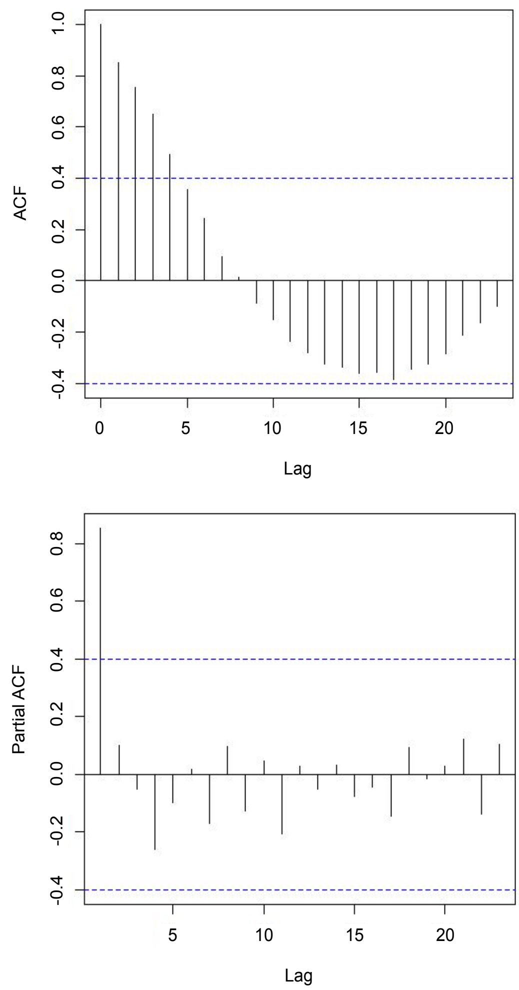

Figure 1: Autocorrelation and partial autocorrelation graph.

Models	Model selection criteria					
	RMSE	MAE	MPE	MAPE	MASE	BIC
ARIMA (0,1,0)	4.350	3.421	4.491	8.798	.9585	137.01
ARIMA(0,1,1)	4.335	3.474	4.815	8.924	.9734	139.99
ARIMA(0,1,2)	3.999	3.388	4.316	8.781	.949	140.03
ARIMA(0,1,3)	3.770	3.102	4.126	7.865	.869	140.79
ARIMA(1,1,0)	4.326	3.497	4.958	8.991	.979	139.91
ARIMA(1,1,1)	4.226	3.422	4.523	8.907	.959	142.43
ARIMA(1,1,2)	3.095	2.465	2.073	6.462	.691	136.1
ARIMA(2,1,0)	4.206	3.330	3.803	8.978	.933	141.85
ARIMA(2,1,1)	3.759	2.824	1.464	7.788	.791	140.7
ARIMA(2,1,2)	3.103	2.494	2.151	6.563	.699	138.96
ARIMA(3,1,0)	3.793	3.232	2.687	8.271	.906	140.84

Table 1: Performances of different ARIMA (p,d,q) models of tea production in Bangladesh.

in Bangladesh, for the year 2014, 2015 and 2016 as obtained from ARIMA (1,1,2) was 95% confidence interval obtained as 65.568 Million Kilogram, 67.867 Million Kilogram and 60.997 Million Kilogram with Upper production limit (UPL) and Lower production limit (LPL) are 72.021 Million Kilogram and 59.115 Million Kilogram, 74.799 Million Kilogram and 60.934 Million Kilogram, 78.47 Million Kilogram and 60.997 Million Kilogram respectively.

Year	Forecast	LPL	UPL
2014	65.56755	59.11452	72.02057
2015	67.86658	60.93385	74.79931
2016	69.73192	60.99701	78.46682

Table 2: Forecast of tea production in Bangladesh using ARIMA (1, 1, 2) during 2014 to 2016.

Conclusion

This paper aimed to modeling the production of tea during 2013 in Bangladesh, by Autoregressive Integrated Moving Average (ARIMA) Approach. On basis of results obtained it is concluded that ARIMA (1,1,2) model having minimum value of all measures of selection criteria was found to be the appropriate model amongst all for predicting the tea production in Bangladesh. The model showed a good performance in case of explaining variability in the data series and also, it's predicting ability. The forecasting of tea can help tea garden owners as well as the policy makers for future planning.

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