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Production Behavior and Forecasting of Some Selected Winter Vegetables of Bangladesh

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ABSTRACT

Vegetables are valuable sources of numerous vitamins and minerals. The winter seasons of Bangladesh are very rich in growing different colored vegetables. Being an overpopulated country, identifying the production behavior of winter vegetable adequately and forecast the production process is important to meet the future demand of these growing populations. This study aimed to forecast the production process of some selected winter vegetables such as Bean, Cabbage and Cauliflower grown in Bangladesh. The time series data over the period 1961-2017 are used for this empirical study and the Box Jenkins ARIMA methodology has been utilized with a view to identify production behavior and forecast. The estimated best fitted Box-Jenkins ARIMA model for Bean, Cabbage and Cauliflower are (0,2,1), (1,2,3) and (0,2,1) respectively. The classical model diagnostic test confirmed the power of fitness of the estimated model. Additionally, AIC and BIC of models are observed and the residuals are examined thorough ACF, PACF and QQ plots. Finally, the future production of winter vegetables is forecasted up to 10 years from the best selected model. The performances of ARIMA models provide reasonable fit to the observed data for the prediction during and beyond the assessment period 1961 to 2017. This information on future production would be helpful for policy maker in decision making on the necessities of the storage facility, import and/or export and so on.

Introduction

Bangladesh is primarily an agricultural country where agriculture sector plays a vital role in stimulating the economic growth. Agriculture is the single largest producing sector of this economy by contributing about 13.82 % to the total Gross Domestic Product (GDP) of this country as well as accommodates around 40.6% of the labor force in 2016-17. Though the main agricultural commodities of Bangladesh are rice, wheat, pulse, jute but vegetables are considered as an essential part of agriculture by contributing 9.23% of the agricultural Gross Domestic Product (BBS, 2019). Vegetables can be identified as a significant one for this economy for its impressive contribution in raising the foreign exchange earnings and occupies an important position among the items exported from Bangladesh. Bangladesh earned US $ 41.11 million from export of agricultural products in 2003-2004, which contributed 0.54% to total export earnings (BER, 2008). The importance of vegetable can be realized from the economic and nutritional point of view and vegetables are generally labor-intensive crops offering a considerable promise for generating rural employment opportunities (Kaynath and Shamima, 2020). There is a great opportunity for unemployed rural people specially for women of Bangladesh to be independent by producing vegetables in even a small amount of land or homestead area within a short time period and more than one crop can be grown within a crop season. As well as major problems faced by our country such as unemployment, poverty and malnutrition can be solved by vegetable production in a short period of time (Akter *et al.,* 2011). Climate and soil of Bangladesh are very much suitable for growing vegetables round the year and there are a large number of vegetables having different varieties, which can be grown throughout the year. However, the largest numbers of vegetables are grown in the winter season. Major winter vegetables are tomato, brinjal, rabi pumpkin, water gourd, cauliflower, cabbage, radish, bean, green spinach etc. Among the entire winter vegetables, three most commonly used vegetables were selected, namely bean, cabbage and cauliflower for time series modelling. The bean is an excellent source of dietary proteins that play an important role in human

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nutrition by complementing other foods such as wheat and other cereals (Butt and Batool, 2010) and also rich in carbohydrate, fat, vitamins and minerals (Islam and Karim, 1997). Cabbage (*Brassica oleracea* L. var. *capitata*) is an important and nutritious leafy vegetable for a winter season in Bangladesh. Among all the vegetables produced in the country, cauliflower dominates a major share in terms of total cropping area and production (Islam *et al.,* 2020). As well as Cabbage and cauliflower are the important source of vitamin A, C, and K, iron, and calcium, etc., which are important to the consumer as a nutritional value (Hoq *et al.,* 2014).

In order to maintain proper nutritional status of the people, nutritive vegetables like bean, cabbage and cauliflower are very important which is one of the main goals of SDGs (Sustainable Development Goal) of Bangladesh to achieve food security and ensure improved nutrition. Basically, lack of capital, inadequate supply of good quality seeds, unavailability and high price of insecticides and fertilizers are very lavish problem of farmers in Bangladesh. The appropriate future prediction model is essentially providing an idea regarding the necessary demand of these essential factors which may help to overcome these difficulties. In addition, supply of vegetables increases in a large extent during the winter season yet farmers faced several problems, including loss of production due to inadequate storage facilities, lack of marketing facilities, lack of transportation (Hoq *et al.,* 2014). At this stage, the Government may decide to export surplus vegetables after meeting domestic requirements or they can store surplus vegetables to reduce economic loss. Therefore, proper planning and policy based on the growth and trend of winter vegetable production in Bangladesh would save farmers and contribute to the economy. Thus, it is necessary to estimate the behaviors of winter vegetables and forecast the future production of vegetables in Bangladesh.

Box-Jenkins ARIMA model have been expansively applied in the field of forecasting economic time series, inventory and price modeling. However, in agricultural crop production process, this approach widely applied in forecasting the production of major crops, for example rice, wheat, jute, tea, palm oil and soybean etc. Nevertheless, very limited application of ARIMA found in forecasting vegetables or winter vegetable productions. Rachana *et al.* (2010) used ARIMA models for forecast pigeon pea production in India. Mutavdžic *et al.* (2013) forecasting the major vegetables such as potato, paprika and tomato production and Mutavdžic *et al.* (2014) forecast beans, cucumber and cabbage and kale production in the Republic of Srpska. Bharath (2020) applied ARIMA model for forecasting garden pea and cauliflower in Himachal Pradesh. In addition, the tomato (Hossain and Abdulla, 2015), potato (Hossain and Abdulla, 2016) and onion (Hossain *et al.,* 2017) production of Bangladesh were forecasted according to ARIMA approach. However, Sharmin *et al.* (2018) and Ghimira *et al.* (2018) performed growth and trend analysis of winter vegetable production, but the growth model fails to explain the actual scenario of annual growth rate until the annual growth rate is fixed over time. However, best fitted fits time series model is necessary for growth model to estimate annual growth rate (Gujarati, 2003).

The aim of this research is to concentrate two important topics. Primarily, determining the appropriate ARIMA model of some selected winter vegetables of Bangladesh utilizing Box-Jenkin's methodology. Secondly, with the best fitted ARIMA model, forecast the annual production of winter vegetables in next ten years. In fact, this study attempts to select the ARIMA model with best precision that can be forecast the univariate production time series of selected winter vegetables with greater accuracy.

Materials and Methods

The Box-Jenkins models established by George Box and Gwilym Jenkins is one of the breakthroughs of the contemporary approach to time series analysis. Both stationary or non-stationary with or without seasonal elements can appropriately grasp with this method. For a given time, series data the generalized model of the non-stationary ARMA model denoted by ARMA(p,q) can be written as

$$Y_t = \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \cdots + \Phi_p Y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-1} - \cdots - \theta_p e_{t-p} \qquad (1)$$

Where, Y_t is the original series and for each t assuming e_t is independent of $Y_{t-1}, Y_{t-2} Y_{t-3}, \ldots\ldots, Y_{t-p}$. $\Phi_1, \Phi_2, \ldots\ldots, \Phi_p$ is a white noise series with zero mean and variance σ^2 .The autoregressive series is of order p is denoted by AR(p) and can be defined as

$$Y_t = \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \cdots + \Phi_p Y_{t-p} + e_t \qquad (2)$$

The moving average process of order q can be denoted by MA(q) and expressed as

$$Y_t = \theta_1 e_{t-1} - \theta_2 e_{t-1} - \cdots - \theta_p e_{t-p} \qquad (3)$$

Therefore, ARMA model is a combination AR and MA process. A time series Y_t is said to follow an integrated autoregressive moving average (ARIMA) model if the d^{th} difference $W_t = \nabla^d Y_t$ is a stationary ARMA process. If the series W_t follows an ARMA (p, q) model, then it can be said that the series Y_t is an ARIMA (p,d,q) process. Usually, $d = 1$ or at most $d = 2$ is considered as reasonable choice. Therefore, a ARIMA (p,1,q) process can be defined as

$$W_t = \Phi_1 W_{t-1} + \Phi_2 W_{t-2} + \cdots + \Phi_p W_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_p e_{t-p} \quad \text{.............(4)}$$

Where $W_t = Y_t - Y_{t-1}$

The following five steps are applying in Box and Jenkins approach

1. **Preliminary analysis**: construct conditions in such a manner that the original data follow stationary stochastic process.
2. **Identification**: The orders of the ARIMA model are identified to have a clear idea about the number of parameters to estimate. The performance of empirical autocorrelation functions actively playing a vital role to recognize the model.
3. **Estimate**: Estimation of, the parameters of the tentative ARIMA model identified in step-2 are estimated according to maximum likelihood approach.
4. **Diagnostics**: Parameters and residuals of the model are checked after applying some test to find a perfect model the series.
5. **Forecasting**: Finally, suitable model after diagnostic checking can be used toforecast the future series.

Diagnostic Tests of Residuals

Ljung-Box test

Ljung-Box (Ljung and Box,1978) test is very popular diagnostic statistical tool to check the lack of fit of a time series model. This test applied to the residuals after fitting ARIMA model to check the assumption of no autocorrelation of residuals. However, if there are very small autocorrelations exists, it could be concluding that the specific model reveals insignificant lack of fit. The null hypothesis, $H_0: \rho_1(e) = \rho_2(e) = \rho_3(e) = \cdots = \rho_k(e) = 0$ is tested by the Ljung-Box statistics,

$$Q^* = N(N+1)\sum_{k=1}^{k}(N-k)\rho_k^2(e) \quad \text{.................(5)}$$

Where, N is the number of observations used to estimate the model. The Q^* asymptotically follows the Chi-square distribution approximately with degrees of freedom $(k-q)$, where q is the number parameters estimated in the model. The null hypothesis is rejected if $Q^* > \chi^2_{1-\alpha,h}$ shows lack of fit, concluding auto-correlation exists.

The Box-Pierce Test

The Box-Pierce test statistic is the simplest form of the Ljung–Box statistic. The Box-Pierce test also applied to examine if residuals are white noise or not and can be defined as:

$$Q = N\sum_{k=1}^{k}\rho_k^2(e) \quad \text{................................(6)}$$

Q-statistic follows a chi-square distribution with $(k - q)$ degrees of freedom where q is the number of parameters estimated.

Jarque-Bera Test

The normality assumption is tested applying Jarque-Bera test (1978) can be defined as

$$JB = \frac{n}{6}\left(s^2 + \frac{(k-3)^2}{4}\right) \quad \text{...................................(7)}$$

Where, n is the sample size and k is the number of estimated parameters. The statistic JB follows asymptotic chi-square distribution with degrees of freedom 2. The test statistics applied to test the hypothesis of zero skewness and zero excess kurtosis.

Model selection criteria

The time series model describes the production system so that assess the performance of the best fitted model, is very challenging and critical task. Perfectly fitted observed data sometimes may fail to predict future values correctly due to model complexities. Therefore, it is essential to evaluate adequacy of the time Series model before forecasting. Among many estimators of evaluating the forecast errors of time series or econometric model, Root Mean Square Error (RMSE), Mean absolute percentage error (MAPE) mean absolute scaled error (MASE) are used to identify the best models for in this study.

Root Mean Square Error Percentage (RMSPE)

Root Mean Square Error Percentage (RMSPE) is estimated by the following equations

$$RMSPE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^f - Y_t^a}{Y_t^a}\right)^2} \quad \text{..................(8)}$$

where Y_t^f is the forecast value in time t and Y_t^a is the actual value in time t.

Mean absolute scaled error (MASE)

Mean absolute scaled error (MASE) is a measure of the accuracy of forecasts calculated by the following equations

$$MASE = mean\left(\frac{|e_j|}{\frac{1}{T-1}\sum_{t=2}^{T}|Y_t - Y_{t-1}|}\right) \quad \text{........................(9)}$$

where the e_j is the forecast error for a given period j calculated from the difference between actual and forecasted value for that period.

Mean absolute percentage error (MAPE)

Mean absolute percentage error (MAPE) is defined as

$$MAPE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|} \qquad (10)$$

where F_t is the forecast value in time t and A_t is the actual value in time t.

The production data of some selected vegetables used in this study are collected from the website of the Food and Agriculture Organization, (www.fao.org) for the period 1961 to 2017. All analysis was performed by statistical package R.

Results and Discussion

Bean

The average bean production of Bangladesh during the study period was 48413.67 metric tons and the maximum production was 137495 metric tons obtained in 2017 whereas the minimum production was 15034 metric tons in 1961. The time series plot of bean production presented in Figure 1 over the study period, 1961 to 2017 shows the steady increasing trend. Thus, the variance of bean production over the period was not stable which confirms the data series was non-stationary. To convert the original non-stationary data series into stationary, difference method was applied. The second difference data series plot showed in Figure 1 more stable in variance. The Augmented –Dickey-Fuller (ADF) test of second difference series showed that $\Pr(|t| > -5.9609) = 0.01$ suggested the series was stationary conditions at 1% level of significance. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root test with $\Pr(|t| > 0.04435) = 0.1$ also suggests that the second difference series satisfied the stationary conditions at 10% level of significance. The Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots of difference data presented in Figure 1 laid down fast or cut off fast. The correlogram showed a significantly positive spike at lag 1, revealing a non-seasonal MA component of one order. Although the autocorrelation at lag 8 and 9 just exceeded the significant limits, but rest all coefficients fall within the limits. The partial auto-correlation function (PACF) for lags 1 to 20 of the second difference time series exceeded significant limits at lag 1 and lag 7 but other test suggest that the series is stationary. The best suitable ARIMA model for bean production is selected based on the lowest BIC (Bayesian Information Criterion) and AIC (Akaike Information Criterion) values. ARIMA (0,2,1) was found to be the best from seven candidate ARIMA models obtained by applying the tentative procedure and Table 1 represents the estimated parameters with model summary and forecasting criteria. The *ma1* coefficient is highly significant and it can be said that one year moving average lag had significant effects on bean production.

Table 1. Summary statistics and forecasting criteria of ARIMA (0,2,1) model for bean production

Coefficients	Estimates	SE	z-Stat	p-value
ma1	-0.834	0.0747	-11.17	< 2.2e-16
AIC	1072.35			
BIC	1076.36			
Forecasting criteria	RMSE	MAPE	MASE	
	3884.10	5.440	0.850	

Now, to check the adequacy of the estimated model several diagnostic methods were applied. Normality assumptions were checked by "Jarque-Bera" test and found that the $\Pr(|\chi^2| > 29.69) = 3.571e^{-07}$, which strongly suggests to accept the normality assumption of the residuals of the fitted ARIMA (0,2,1). Moreover, the normal QQ plot for the fitted ARIMA (0,2,1) model were presented in Figure 2 which also agreed with the test. Box-Ljung and Box-Pierce test suggested no autocorrelation among the residuals of the fitted ARIMA (0,2,1) models at 5% level of significance with $\Pr(|\chi^2| > 0.52451) = 0.4689$ and $\Pr(|\chi^2| > 0.49784) = 0.4804$ respectively. The ACF and PACF of the residuals had no significant pattern concluded no autocorrelation among the residuals. Therefore, the fitted ARIMA (0,2,1) model was the best fitted model and adequately used to forecast the bean production in Bangladesh.

Cabbage

Total 99915.33 metric tons cabbage was produced on average in Bangladesh annually, maximum 311650 metric tons cabbage was harvested in 2017 whereas the minimum production was 31738 metric tons in 1961. The cabbage production time series plot in Figure 3 clearly reveals an increasing trend from 1961 to 2017 except 2009 to 2014 but the plot of second difference series showed more stable in variance. The ADF test $\Pr(|t| > -5.0061) = 0.01$ suggested the second difference series was stationary at 1% level of significance as well as KPSS unit root test with $\Pr(|t| > 0.036088) = 0.1$ provided necessary evidence of stationary at10% level of significance. The correlogram in Figure 3 showed a significantly positive spike from lag 1 to lag 5, PACF in Figure 3 crossed significant limits at lag 2 ,5 and lag 7. Since other test confirmed stationary condition as well as the ACF and PACF plots were better than the original and first difference series, the second difference series was considering here for modelling data.

The ARIMA (1,2,3) model was selected for cabbage production from fourteen candidates and estimated parameters with model summary and forecasting criteria was presented in Table 2. The autoregressive parameter labelled *ar1* was highly significant and it might be said that one-year autoregressive average lag had significant effects on cabbage production and three years moving average lag have significant effects on cabbage production.

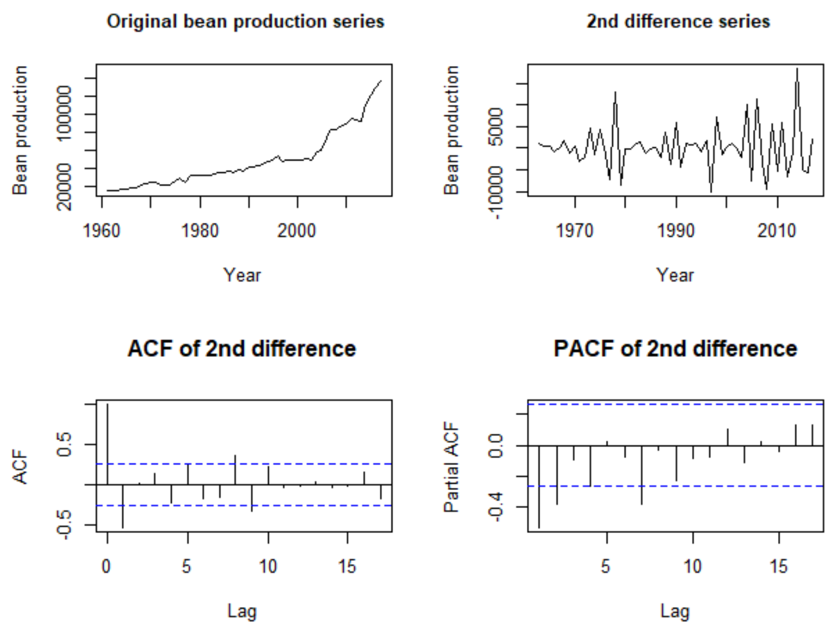

Figure 1. Time series plot of original series, 2nd differenced ACF and PACF of 2nd differenced bean production in Bangladesh

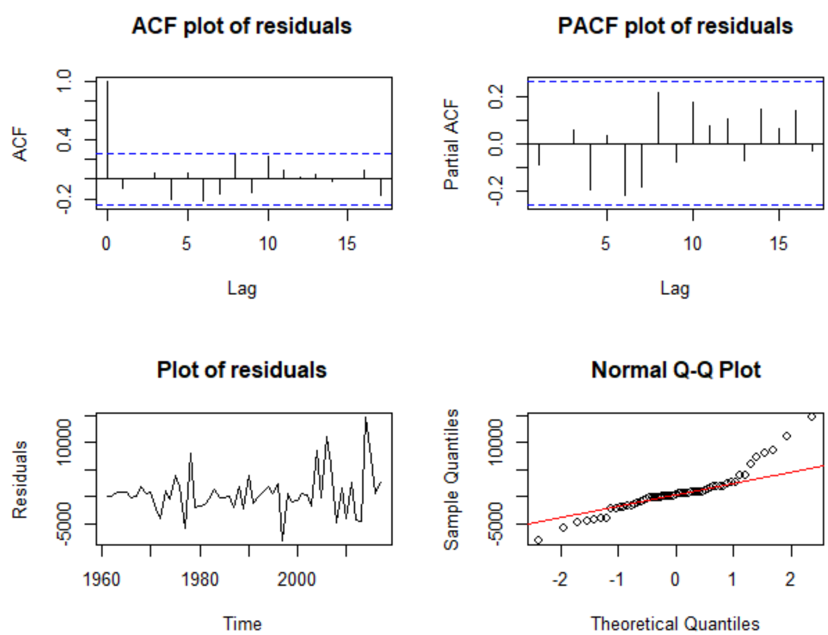

Figure 2. Diagnostic plots of residuals of ARIMA (0,2,1)

Table 2. Summary statistics and forecasting criteria of ARIMA (1,2,3) model for cabbage production

Coefficients	Estimates	SE	z-Stat	p-value
ar1	-0.681	0.166	-4.1032	4.075e-05
ma1	0.266	0.166	1.5969	0.110
ma2	-0.276	0.145	-1.9343	0.0531
ma3	-0.739	0.087	-8.456	< 2.2e-16
AIC	1152.66			
BIC	1162.7			
Forecasting Criteria	RMSE	MAPE	MASE	
	7513.72	4.806	0.654	

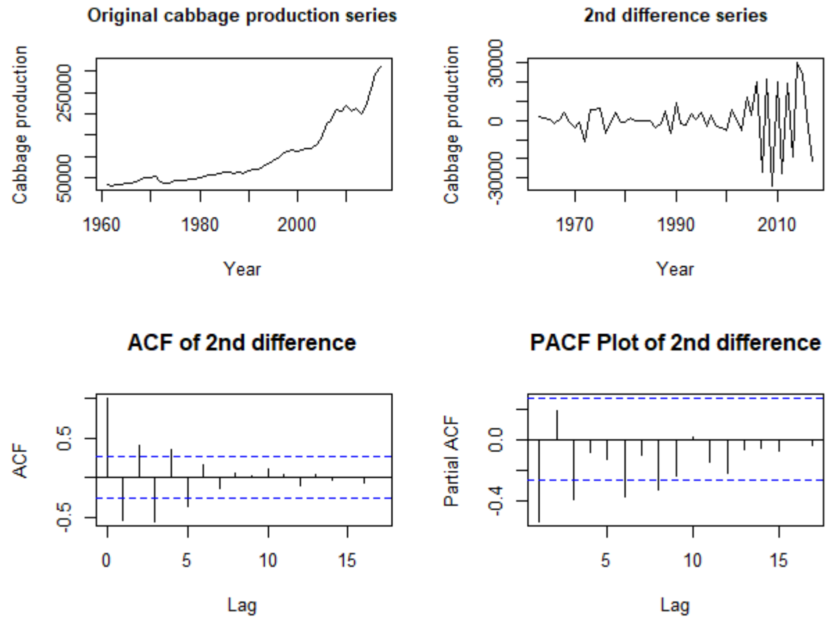

Figure 3. Time series plot of original series, 2nd differenced ACF and PACF of 2nd differenced cabbage production in Bangladesh

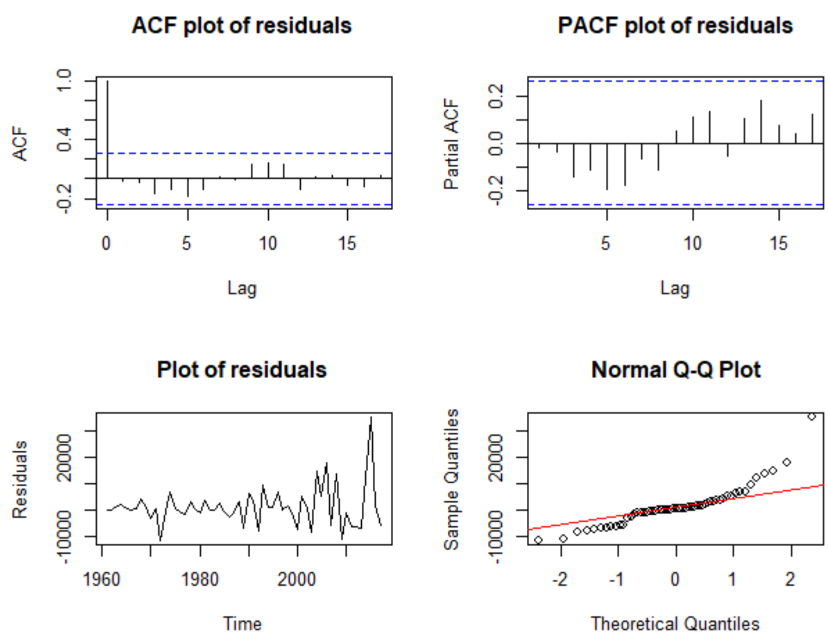

Figure 4. Diagnostic plots of residuals of ARIMA (1,2,3)

The "Jarque-Bera" normality test revealed $\Pr(|\chi^2|125.98) = 2.2e^{-16}$, and QQ plot in Figure 4 both were strongly suggested to accept the normality assumption of residuals. Both Box-Ljung and Box-Pierce test suggested that no autocorrelation among the residuals at 5% level of significance with $\Pr(|\chi^2| > 0.026804) = 0.87$ and $\Pr(|\chi^2| > 0.02544) = 0.873$ respectively. The ACF and PACF of the residuals had no significant pattern and hence there was no autocorrelation among the residuals. Therefore, the fitted ARIMA (1,2,3) model was the best fitted model and adequately used to forecast the cabbage production in Bangladesh.

Cauliflower

There are 82772.32 metric tons cauliflower was produced annually in Bangladesh. The maximum production was recorded 2,77,500 metric tons in 2017 whereas the minimum production was 26,170 metric tons in 1962. The upward trend of cauliflower production presented in Figure 5 over the study period motivated to convert the original data series applying difference methods and the second difference data series plot showed in more stable in variance. The ADF test showed that $\Pr(|t| > -3.7194) = 0.0312$ satisfied the stationary conditions at 5% level of significance and KPSS unit root test with $\Pr(|t| > 0.0643) = 0.022$ also satisfied the stationary conditions at 5% level of significance. The correlogram in Figure 5 showed a significantly positive spike at lag 1 and 5 as well as the PACF exceed significant limits at lag 1, 2 and lag 8. The second difference series was preferred since the other test suggested stationary conditions and the ACF and PACF plots are better than the original and first difference series. The ARIMA (0,2,1) was selected from seven candidates for cauliflower production based on the lowest AIC and BIC, Table 3 represented the estimated parameters with model summary and forecasting criteria. The moving average parameter labelled *ma1* found highly significant and one-year moving average lag had significant effects on cauliflower production.

Table 3. Summary statistics and forecasting criteria of ARIMA (0,2,1) model for cauliflower production

Coefficients	Estimates	SE	z-Stat	p-value
ma1	-0.8786	0.0643	-13.672	<2.2e-16
AIC	1194.82			
BIC	1198.83			
Forecasting criteria	RMSE	MAPE	MASE	
	11794.19	5.092649	0.913952	

The "Jarque-Bera" normality test $\Pr(|\chi^2| > 2602) = 2.2e^{-16}$ and the normal QQ plot strongly suggested to accept the normality assumption regarding the residuals of the fitted ARIMA (0,2,1). Box-Ljung and Box-Pierce test suggested no autocorrelation among the residuals at 5% level of significance with $\Pr(|\chi^2| > 0.01655) = 0.8976$ and $\Pr(|\chi^2| > 0.01744) = 0.8949$ respectively. Moreover, the ACF and PACF in Figure 6 provided a good evidence of no autocorrelation of the residuals. Therefore, the fitted ARIMA (0,2,1) model was the best fitted model and adequately used to forecast the cauliflower production in Bangladesh.

Forecasting and comparison between original series

The best fitted ARIMA (0,2,1) was applied to forecast the bean production of Bangladesh and Figure 7 showed the original series along with fitted and forecasted series. There was an upward production tendency observed in the fitted model for bean and adequately matched with original production series over the period 1961 to 2017. Moreover, the sample forecasting part of beans also showed an upward trend which illustrated that the future production will increase from present and around 203390 tons bean will produce in 2027 according to ARIMA model. It can be said that if the present growth rate continues than the bean production will increase by 47.92% by 2027.

Figure 8 illustrated the cabbage production along with the predicted values according to best fitted ARIMA (1,2,3). The figure also accompanying the 10 years ahead forecasted series of cabbage production with respective ARIMA. As predicted series showed a little deviation from the original series it could be said that the ARIMA model perfectly captures the real scenario of the original series. Moreover, the upward trend of sample forecasted series illustrated that the annual production will increase and the expected annual production will approximately 412060 tons. Hence, the cabbage production of Bangladesh will rise by 32.21%, according to the ARIMA (1,2,3) model in 2027.

The cauliflower production of Bangladesh along with predicted and forecasted series over the study period were displayed in Figure 9. A very small amount of predicted value was fluctuating from the original series, which concluded that the ARIMA (0,2,1) model was the better representation of cauliflower production of Bangladesh. According to ARIMA (0,2,1) the average annual production will 410912 tons which means that the production will increase by 47.92% from the production of 2017. The best selected ARIMA model for forecasting the tomato and potato productions of Bangladesh were found ARIMA (0,2,1) and ARIMA (0,2,1) respectively (Hossain and Abdullah, 2015) and (Hossain and Abdullah, 2016). These models predicted tomato and potato production precisely and projecting minimum forecasting error. Furthermore, the production of garden pea followed ARIMA (2, 2, 0) and production of cauliflower followed ARIMA (0, 2, 1) in Himachal Pradesh (Bharath, 2020). Similar analysis conducted for forecasting the production parameters of beans, cucumber and cabbage and kale production in Republic of Srpska where bean followed ARIMA (1,0,0) and cabbage ARIMA (1,1,0) (Mutavdžic *et al.,* 2014). Therefore, this Box Jenkins approach adequately models the production series as well as forecast the future production with minimum error. Therefore, the beans, cabbages and cauliflowers production series had upward trend and would support to forecast the expected winter production from 2018 to onward. At this stage, the other related factors which may affect the future production process should be identified and take proper actions to control these factors. Furthermore, farmers need proper training on risk management and new farming mechanism and crop planning policy to adopt extreme climate hazards. Excess use of insecticides, chemical fertilizers are a major problem which is very harmful to public health, the awareness regarding this issue must be increased among the farmers. The care giver, provider also arranges training program on food processing, storage facility to reduce the financial loss of farmers. Proper supply facility of winter vegetables over the country is a safeguard of the price to upward, as well as it fulfils the demand of proper vitamins and minerals of low-income peoples.

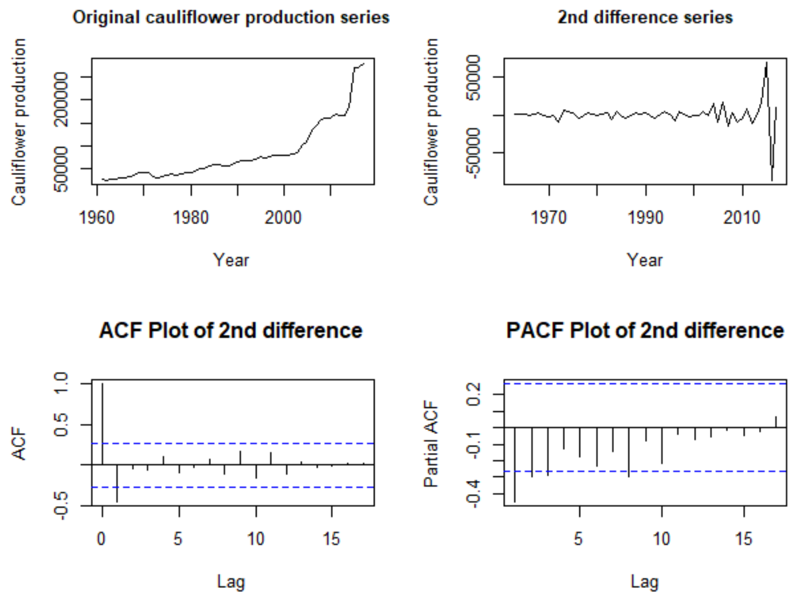

Figure 5. Time series plot of original series, 2nd differenced ACF and PACF of 2nd differenced cauliflower production in Bangladesh

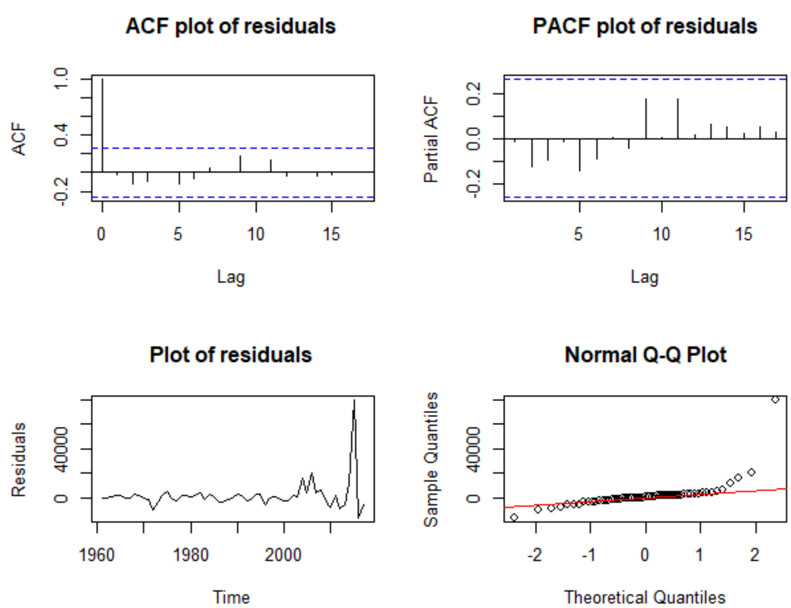

Figure 6. Diagnostic plots of residuals of ARIMA (0,2,1)

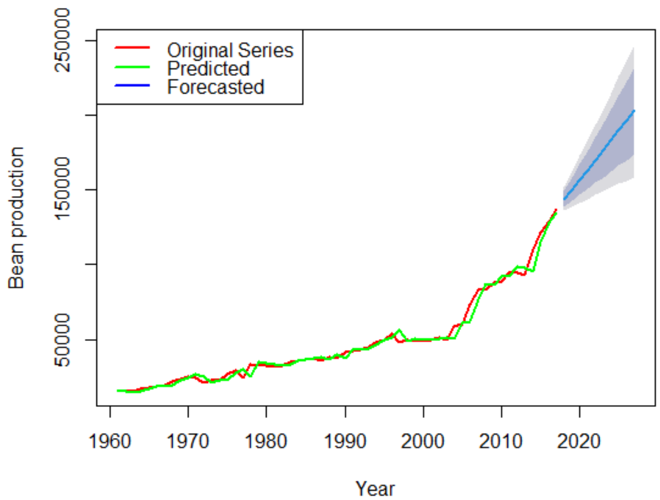

Figure 7. Graphical Comparison between Original and Forecasted series of bean

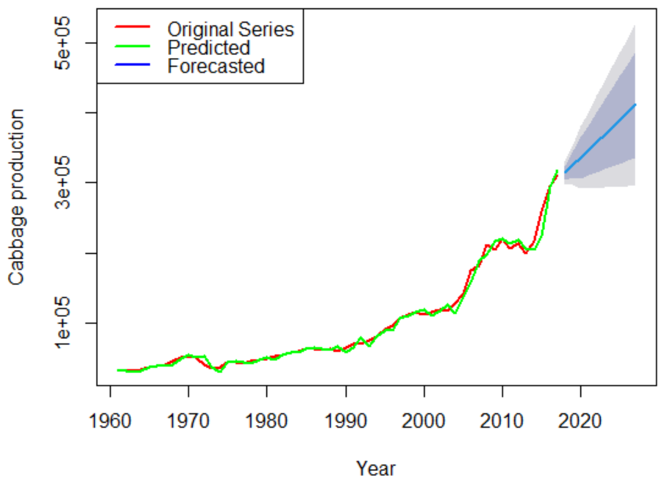

Figure 8. Graphical Comparison between Original and Forecasted series of cauliflower

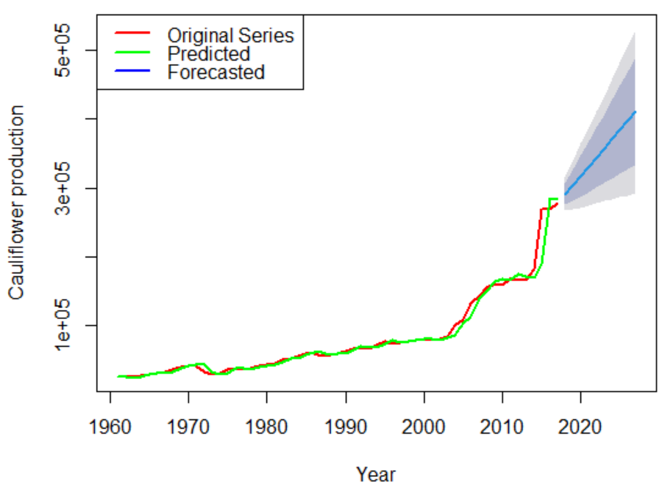

Figure 9. Graphical Comparison between Original and Forecasted series of cabbage

Conclusion

Vegetables are very essential for their nutritional value and health benefits. Appropriate ARIMA models could identify the production pattern efficiently and forecast the future production with minimum forecasting error. In this respect, the present study explored the production pattern of some selected winter vegetables in the light of Box-Jenkins approach, found bean production of Bangladesh followed ARIMA (0,2,1). As well as, the cabbage production was ARIMA (1,2,3) and finally ARIMA (0,2,1) was for cauliflower. This model adequately describes the real situation and statistically suitable to forecast the selected winter vegetables. The model projected that the production of beans, cauliflowers and cabbages will be increasing in near future if the current growth rate continues. Best selected ARIMA models were applied to forecast the production of selected vegetables for the next 10 years. According to the model, the beans and cauliflowers production will increase by approximately 48% and cabbages increase by 33%. Therefore, policymaker and care provider could take a decision regarding future native demand of increased population. Moreover, after developing proper storage facility, it might be possible to export surplus winter vegetables.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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