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Research Article

Growth, Production Instability and Price Forecasting of Onion in Bangladesh

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ABSTRACT

Onion is an essential and popular spice crop which is widely cultivated and consumed in Bangladesh. Every year the country needed to import onion for fulfilling the domestic demand. Onion price has been largely influenced by import price and frequent fluctuation. The objectives of the research were to analyze the onion production behavior, instability, and forecasting of price using secondary data. The study used deterministic growth models and coefficient of variation for analyzing the growth rate and instability. Among different growth models, cubic model was identified as the best-fitted model. The average growth rate was 7.85%, and in instability analysis the coefficient of variation was 71.10%, which implies that onion production was unstable during the period of 1970-2022. Seasonal Autoregressive Integrated Moving Average (SARIMA) model was used to forecast onion price. The finding reveals that SARIMA (1, 0, 2) $(1, 1, 1)_{12}$ model identified as the best model to forecast the onion price in Bangladesh. The results show that onion price followed seasonal trend, and the highest price was in October and November. These findings will support to develop appropriate policies regarding the increase of domestic supply through increased production and storage facilities, reducing post-harvest losses, and price stabilization.

Introduction

Onion is an essential vegetable crop that is cultivated and consumed all over the world (Mishra et al. 2013). In Bangladesh, it is most important and popular spice in daily diet. It is a good source of nutrition, flavour, and medicinal value. In addition, net return from onion production is significantly higher than that of its competing crops due to high commercial value (Mila et al. 2022). The demand for onion is gradually increasing because of the increasing population, changing consumption behavior, and various ways of using in foods. The country has advantageous agro-climatic environment for onion production. Onion is grown all over the country, particularly Pabna, Kushtia, Jenaidah, Magura, Meherpur, Rajshahi, Faridpur, Rajbari, Madaripur, Shariatpur, Dianjpur and Rangpur are major producing districts. The annual production was 2547 thousand tons covering 503 thousand acres of land in 2022-23 (BBS, 2023), while the annual demand was 2600 thousand tons. Moreover, onions are semi-perishable crop, around 1 million tons were damaged during harvesting and storage (Akter et al. 2023). To meet the demand, every year the country needed to import between 0.9 to 1.1 million tons of onion, primarily from India and other neighbouring countries (Mila and Parvin, 2019; Mila et al. 2023). As a result, the import price of onion largely dominates the domestic onion market price. The price fluctuation largely depends on India, if India implements any export restriction on onion than the price has surprisingly increased in Bangladesh (Akter et al., 2023). Also multiple intermediaries are exist in the marketing system. Therefore, there is a significant difference between producer and consumer price (Mila et al., 2023). Unexpected changes in price has become a major source of concern. In Bangladesh, the onion price has dramatically increased at the end of 2019. And the price has frequently fluctuated in every year. The onion price variation has direct impact on consumers' real earnings and forces them to adjust their consumption expenditure (Mila and Parvin, 2019). It is difficult for the low-income group of people to afford this price. Therefore, it is important to increase domestic production for reducing reliance on import and assisting consumers in balancing their food baskets as well. This is only possible through having an actual information about the growth rate, fluctuation of onion production,

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nature of price variation and forecasting the future price. This attempt will support the government formulating proper production and marketing policies so as to stability in the domestic demand and supply. Additionally, the study will provide useful information to farmers, processors and traders for onion production and developing market strategies.

In literature, one or both of regression and time series models are frequently applied for prediction. In stochastic time series analysis, Autoregressive Integrated Moving Average (ARIMA) model which is known as Box –Jenkins methodology allows to forecast the future indications of a time series using its own current and previous values (Box and Jenkins, 1978). ARIMA models are very popular and powerful among stochastic time series models to forecast agricultural productions (Hazarika and Phukon, 2024; Mishra, 2013). Cyclical behavior is usually implied by estimated model parameters in traditional linear autoregressive integrated moving average (ARIMA) models. In Bangladesh, ARIMA models were used to forecast rice production (Awal and Siddique 2011), fish production (Haque et. al. 2005), shrimp export (Haque et al. 2006), area and production of onion (Mila and Parvin, 2019; Rana et al. 2021), potato production (Rahman et al. 2022), maize production (Mohammad et al. 2023) and jute production (Yasmin and Moniruzzaman, 2024). Also used to forecast inflation rate of the economy of Bangladesh (Islam, 2017). Seasonal Autoregressive Integrated Moving Average (SARIMA) model is an extension of ARIMA which explicitly use for time series data considering the seasonal components. Very few studies have used SARIMA model to forecast considering seasonal variation. Choudhury et al. (2008) forecasted dengue incidence in Dhaka using SARIMA model. However, agricultural products particularly onion price is highly fluctuated by seasonality. Therefore, the study was undertaken to assess the growth rate and variability in onion production using deterministic growth models, and forecast the onion price using SARIMA model.

Material and Methods

Data sources

The study was conducted using yearly production and monthly price data. Onion production data for the period of 1970 to 2022 were collected from yearly publications of the Bangladesh Bureau of Statistics (BBS, 2023). Onion price data for the period of January, 2000 to December, 2021 were collected from the Department of Agricultural Marketing (DAM, 2022).

Analytical methods

To examine the nature, changes and instability of production the study used various descriptive statistical measures such as average, standard deviation and the coefficient of variation.

Growth models for onion production

The deterministic growth models are frequently used to describe the behaviour of variables with change in time. In the study, we have used five deterministic growth models. In linear, exponential, and compound models the growth rates are independent of time. The main difference in between the exponential and compound models are the value of the coefficients and their interpretation. The forecasted values obtained by these models can be used with other forecasts to get appropriate forecasts.

Table 1. Deterministic growth models with their mathematical forms

Models	Mathematical forms
Linear	$Y_{t=}\ \alpha+\beta t+\epsilon$
Quadratic Model	$Y_{t=\alpha+\beta t+\gamma t^2+\epsilon}$
Cubic Model	$Y_t\ =\alpha+\beta t+\gamma t^2+\delta t^3\ +\epsilon$
Compound Model	$Y_{t=}\ \alpha\beta^{t\epsilon^{\epsilon}}$
Exponential Model	$Y_{t}=\alpha e^{\beta t\epsilon}$

To identify the best model various available model selection criteria such as R^2, Adjusted R^2, Akaike Information Criterion (AIC), Mean Squared Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percent Error (MAPE) were used.

$$R^2 = 1 - \frac{Error\ sum\ of\ square}{Total\ sum\ of\ square}$$

Adjusted $R^2 = 1-(1-R^2)[n-1/n-k]$

$$AIC = nlog(MSE) + 2k$$

$$MSE = \frac{1}{n-k}\sum \epsilon_t^2$$

$$RMSE = \sqrt{\frac{1}{n-k}\sum \epsilon_t^2}$$

$$MAE = \frac{1}{n}\sum_{t=1}^{n} .\ \hat{\epsilon_t}$$

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} .\ \hat{\epsilon_t}\ \times 100$$

Where, n is the number of observations $Y_{(t)}$ is the observed value and, $\hat{\epsilon_t}$ is the difference between the observed and estimated values and k is the number of parameters in the statistical model.

Instability in onion production

Growth rate analysis is given the rate of growth over the period. But without knowing instability it is not possible to decide about the production was unstable or stable over the period. So, it is important to know about the instability index in production as well as growth rate. To study the instability in onion production, the coefficient of variation was calculated using the following formula

$$\text{Coefficient of variation} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

However, for time series data the coefficient of variation does not explain the variation appropriately (Hasan et al. 2008). Therefore, in the study, we have used the coefficient of variation around the trend (CVt) proposed by Cuddy and Delly (1978). The formula is as follows:

$$\text{CV}_t = \text{Coefficient of variation} \times \sqrt{(1 - \text{R}^2)}$$

SARIMA model for forecasting onion price

ARIMA (Autoregressive Integrated Moving Average) model

In time series econometrics, the ARIMA models are very popular and widely used process. These models are based on the assumption of stationary. However, some of time series are non-stationary and integrated. When a time series are integrated of order one i.e., I (1), then its first differences are I (0), that is stationary. Similarly, when a time series is I(2); then its second difference is I (0). If we differentiate a time series d times and use the ARMA (p, q), then the model is ARIMA (p, d, q) where, p is the number of autoregressive terms, d is the number of times the series need to be differentiate and q is the number of moving average terms. The ARIMA (1, 1, 1) process can be written as,

$$\Delta Y_{t=} \ \rho \Delta Y_{t-1} + \varepsilon_t + \theta \varepsilon_{t-1}$$

Where,

$\Delta Y_t = Y_t - Y_{t-1}$ And $\Delta Y_t = Y_{t-1} - Y_{t-2}$ are the first differences of Y(t)

ARIMA (p, d, q) is,

$$\Delta^d Y_t = \rho_1 \Delta^d Y_{t-1} + \cdots\cdots\cdots + \rho_p \Delta^d Y_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots\cdots\cdots + \theta_q \varepsilon_{t-q}$$

Where Δ^d is the d^th^ difference of $Y_{(t)}$.

SARIMA (Seasonal Autoregressive Integrated Moving Average) model

SARIMA *(p, d, q) (P, D, Q)s* model is termed as seasonal autoregressive integrated moving average model, where p is the order of auto regressive, d is the order of integration, q is the order of moving average, P is the order of seasonal auto regressive, D is the order of seasonal integration, Q is the order of seasonal moving average and s is the length of the seasonal period.

A general autoregressive integrated moving average (ARIMA) (*p, d, q*) model in terms of back shift operator B is as follows:

$(1-\varphi 1 B-\ldots-\varphi pBp)\ Wt= (1-\theta_1 B-\ldots-\theta qBq)\ At$ .... (1)

Where, $Wt = (1-B)det$ is the first difference of the original time series *Yt* and *At* is the random shock which forms a white noise process with mean zero. The details of the models are available in O'Donovan (1983) and Pankratz (1984). Similarly, the seasonal ARIMA often called SARIMA (P, D, Q)s in terms of the backward shift operator B can be expressed as

$(1-\varphi sBs-\ldots-\varphi sPBsP)\ Wt= (1-\theta sBs-\ldots-\theta sQBsQ)\ At$ ... (2)

Where, $Wt = (1-Bs)\ Dyt$, $s = 12$ monthly data and s = 4 for quarterly data. Contrary to (1), the random shocks *At* do not from a white noise process. We obtain by combining (1) and (2)

$(1-\varphi\ 1B-\ldots-\varphi pBp)\ (1-\varphi sBs-\ldots-\varphi sPBsP)\ Wt = (1-\theta 1B-\ldots\theta qBq)\ (1\text{-}\theta sBs-\ldots-\theta sQBsQ)\ At$ .... (3)

Where, $(Wt= 1-B)\ (1-Bs)Dyt$. For simplification, a constant term θ should to be added to the equation (3) in order to accommodate the possibility that the variables *Wt* may have no non-zero mean.

Finally the model can be written as follows:

$(1-\varphi\ 1B-\ldots-\varphi pBp)(1-\varphi sBs-\ldots-\varphi sPBsP)\ Wt = \theta_0 + (1\text{-}\theta_1 B-\ldots-\theta qBq)(\ 1\text{-}\theta sBs-\ldots-\theta sQBsQ)\ \ At$ .... (4)

Where, $WT = (1-B)\ d\ (1-Bs)\ Dyt$. Thus equation (4) stands as

$(1-\varphi\ 1B-\ldots-\varphi pBp)(1-\varphi_{12}B^{12}.-\ldots-\ \varphi_{12}PB^{12}P)\ Wt = \theta_0 + (1\text{-}\theta_1 B-\ldots-\theta qBq)(\ 1\text{-}\theta_{12}B^{12}-\ldots-\theta_{12Q}B^{12Q})\ \ At$ .... (5)

Where, $Wt = (1-B)\ d\ (1-B^{12})\ Dyt$. This is the multiplicative model of order (p, d, q) $(P, D, Q)_{12}$. Here the term $(1-\ \varphi 1B-\ldots-\varphi pBp)$ is known as the regular autoregressive operator of order p, the term $(1-\varphi_{12}B^{12}-\ldots-\varphi_{12}PB^{12}P)$ is known as the seasonal autoregressive operator of order P, the term $(1-\theta_{12}B^{12}-\ldots-\theta_{12Q}B^{12Q})$ is the seasonal moving average operator of order Q. All the analyses were conducted by using SPSS 20.0 software.

Results and Discussion

Growth and instability in onion production

Onion is one of the major spices crop and ranked first among all other spices in Bangladesh (BBS, 2017; Mila and Parvin, 2019). Figure 1 shows the trend of onion production from 1970 to 2022. The average onion production was almost stagnant from 1970 to 2003. After 2003, the production has rapidly increased at 2546 thousand metric tons in 2022, which was possible due to the increased per hectare productivity.

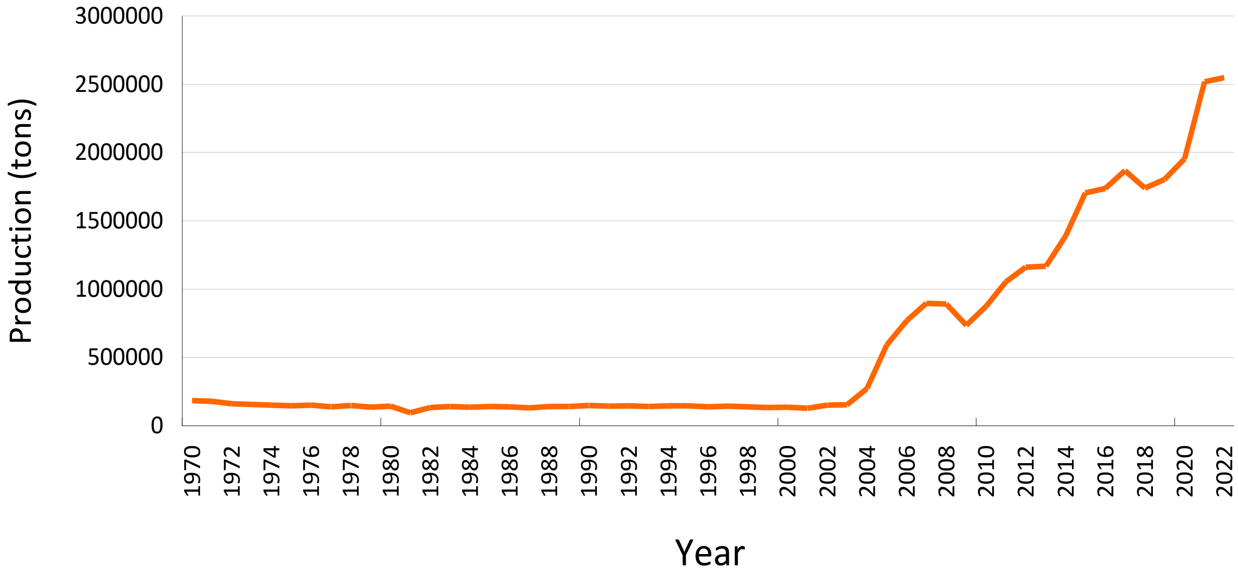


Figure 1. Onion production from 1970 to 2022

Growth rate of onion production was estimated using different deterministic growth models. Table 2 represents that the constant and coefficients of these models. The constant term and coefficients were statistically significant for all the models except inverse model.

Table 2. Parameter estimates of growth models for onion production

Model	Estimated parameter			
	Constant	Coefficients		
Linear	-405969.86***	36351.81***		
Logarithm	-708132.27***	444159.67***		
Inverse	674057.59***	-1146268.07		
Quadratic	482579.57***	-60583.79***	1795.10***	
Cubic	167693.05**	6286.04	-1271.97**	37.86***
Exponential	662219.10***	0.059***		
Compound	662219.10***	1.061***		

(**and *** indicate the significant level at 5% and 1% probability)

In addition, different model selection criteria were used to identify best fitted model. Table 3 revealed that the values of R^2(0.975) and adjusted R^2(.973) are reasonably higher for the cubic model then the linear, compound, quadratic, and exponential models. The value of RMSE (113087.83), AIC (520.74), BIC (517.65), MAE (78465.74), and MAPE (27.89) are also lower for the cubic model compared to other deterministic growth models. So the cubic growth model is the best deterministic growth model for onion production in Bangladesh. Previous studies also found (Haque, et al. 2005 for fish; Hassan et al. 2013 for coarse rice) cubic model is the best growth model in Bangladesh. In addition, Mishra et al. (2013) found cubic model was best fitted model to explain trends in area, production, and productivity of onion among different deterministic trend models in India. The average cubic growth rates of onion production were 7.85% and lies between -0.4 to 35.20%.

Table 3. Selection of model using different criteria for onion production

Model	R^2	$\overline{R^2}$	AIC	BIC	MAE	MAPE	RMSE
Linear	.653	.646	571.26	570.67	288673.44	138.00	349661.74
Logarithm	.326	.313	585.30	584.71	395690.14	173.96	480074.92
Inverse	.065	.046	592.23	591.65	468881.66	189.65	561404.43
Quadratic	.951	.949	531.05	530.17	113583.15	59.65	144783.43
Cubic	**.975**	**.973**	**520.74**	**517.65**	**78465.74**	**27.89**	**113087.83**
Exponential	.702	.696	569.49	568.90	226267.42	58.52	335969.72
Compound	.702	696	569.49	568.90	226267.42	58.52	335969.72

The coefficient of variation around the trend (CV_t) was calculated (Cuddy and Delly 1978) to analyse the instability in the production for different periods. Table 4 revealed that onion production was highly unstable (71.10%) for the period 1970-2022. From different phases, the variation for phase 2001 to 2010 was higher compared to other phases. In India, onion production and productivity also found instable for some periods (Mishra et al. 2013).

Table 4. Instability in onion production

Production period	Mean	Std. deviation	CV_t
1970-2022	575502.07	694714.58	71.10
1970-1980	153034.73	15187.41	4.75
1981-1990	133742.50	14477.72	8.38
1991-2000	139885.0	4553.67	2.03
2001-2010	545148.60	332345.66	25.13
2011-2022	1719205.58	484289.85	8.81

Forecasting of onion prices using SARIMA model

The monthly onion price (Tk. /kg) for the period 2000 January to 2021 December are shows a general seasonal pattern in the data with increasing trend (Figure 2). To test the unit root properties of the price data the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (Kwiatkowski et al. 1992) were used. Appropriate lag length was set to achieve white noise in the error term (Asche et al. 2005). The results showed that the price data were non-stationary in both test. However, after first order differentiate and the data are stationary in both tests (Table 5). This implies that the price data has a unit root problem and a non-stationary series.

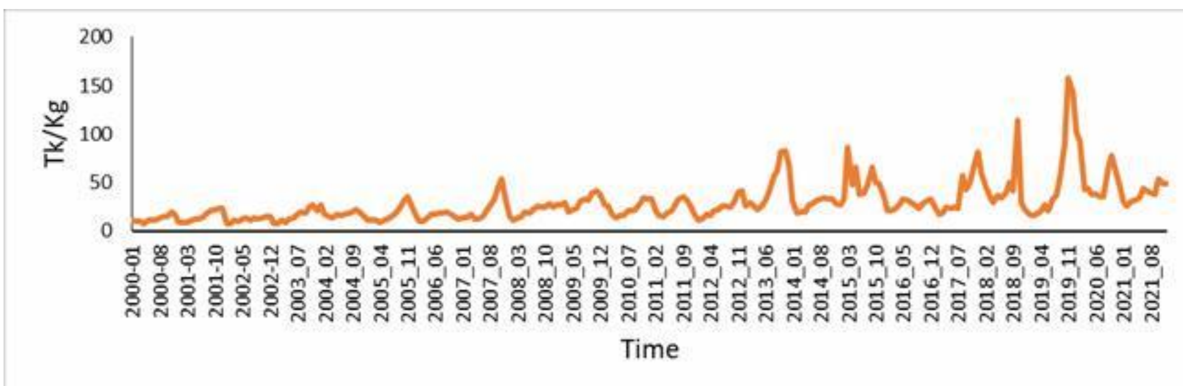


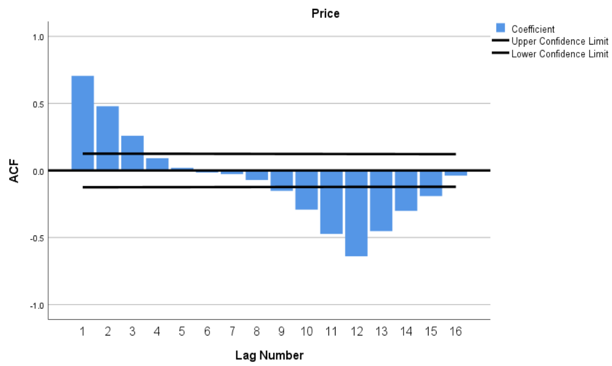
Figure 2. Wholesale price of onion (Tk. /kg) from January 2000 to December 2021

Table 5. ADF and KPSS test for unit root

Test	Level (constant)		1st difference (without trend)	
	t-statistic	Critical value at 1%	t-statistic	Critical value at 1%
ADF	-2.793	2.341	-5.239^{***}	2.341
KPSS	1.37	0.739	0.027^{***}	0.739

Diagnostic checking and estimation of the model

The monthly onion price (Tk. /kg) from January 2000 to December 2021 shows a general seasonal pattern in the data with increasing trend. This indicating that general non-seasonal ARIMA model can't fit the data properly as the Autocorrelation function (ACF) and Partial Autocorrelation Function (PACF) of the residuals are not white noise. Therefore, the study used the SARIMA model rather than the general ARIMA model. The ACF and PACF of residuals for the seasonally differenced data are shown in Figure 3. Non-stationary also appear in the data and so again the series was differenced at lag 1.



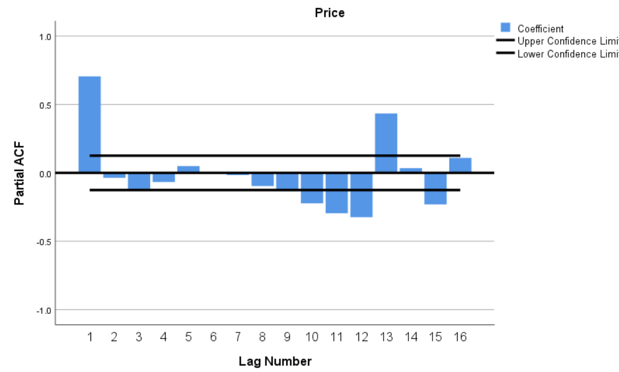


Figure 3. Residuals plot of ACF and PACF of onion price after seasonal differencing

Thus, the identified model was a SARIMA (p, 0, q) (P, 1, D)$_{12}$ where the values for non- seasonal (p, q) and seasonal, (P, Q) are yet to be determined. The exponential decay of PACF at the first lag in Figure 3 suggests a non-seasonal MA (1) model, that is q = 0 and 1. In the ACF, (Figure 3) the value of r_1 is significant reinforcing the non-seasonal MA (1) model and r_{12} is also significant which suggesting a seasonal MA (1) model, with little imagination the PACF can be used to support this seasonal MA (1) model, that is Q= 0 and 1. Exponential decay of PACF from the first lag suggests a non-seasonal autoregressive parameter of order 1 but significant spike in the first three lag suggests non-seasonal auto regression of order 3. Thus the tentative order of Q= 0, 1, 2, 3.

SARIMA model specifications and estimation of the parameters

Six possible SARIMA models with tentatively selected values of non-seasonal (p, d, q) and seasonal (P, D, Q) were specified for this study. These were SARIMA (1,0,2) (1,1,1)$_{12}$, SARIMA (2,0,2) (1,1,1)$_{12}$, SARIMA (1,0,1)(1,1,1)$_{12}$, SARIMA (1,1,1)(1,1,1)$_{12}$, SARIMA (1,1,2)(1,1,1)$_{12}$ and SARIMA (2,0,1)(1,1,1)$_{12}$.

Table 6. Model selection criterion for tentatively selected SARIMA models

Model	R^2	RMSE	MaxAPE	BIC	MAE	MAPE	Ljung-Box(Q-statistics)	P-value
SARIMA (1,0,2)(1,1,1)	**0.72**	**11.03**	**204.92**	**4.93**	**6.009**	**19.92**	**13.24**	**0.429**
SARIMA (2,0,2)(1,1,1)	0.72	11.01	210.01	4.95	6.06	20.09	14.06	0.440
SARIMA (1,0,1)(1,1,1)	0.70	11.27	218.36	4.95	6.007	19.54	24.84	0.036
SARIMA (1,1,1)(1,1,1)	0.66	12.08	246.46	5.09	6.41	20.70	25.15	0.033
SARIMA (1,1,2)(1,1,1)	0.70	11.39	228.46	4.99	6.04	19.10	26.04	0.017
SARIMA (2,0,1)(1,1,1)	0.71	11.14	224.91	4.95	6.01	20.51	23.43	0.037

Table 6 shows that the specification of SARIMA (1, 0, 2) (1, 1, 1)$_{12}$ has the lowest BIC values and higher R^2 value. Chi square value of Ljung-Box (Q-statistics) was also lowest and insignificant for SARIMA (1, 0, 2) (1, 1, 1)$_{12}$. The ACF and PACF of residuals shown in Figure 4 were white noise. Table 6 also revealed that the model SARIMA (1, 0, 2)(1, 1, 1)$_{12}$ was better than the other models in case of MAE, MAPE and among the six tentative SARIMA models only the model SARIMA ((1, 0, 2) (1, 1, 1)$_{12}$ have the parameters that are all significant. So, SARIMA (1, 0, 2)(1, 1, 1)$_{12}$ model was selected as best SARIMA model for forecasting onion price in Bangladesh. The parameters of the estimated model are presented in Table 7.

Table 7. Model parameters of SARIMA (1, 0, 2) (1, 1, 1)$_{12}$

Variable	Coefficients	Std. error	P-value
Constant	1.838	0.309	0.000
AR (lag 1)	0.536	0.101	0.000
MA (lag 2)	-0.259	0.081	0.002
AR Seasonal (lag 1)	-0.220	0.074	0.003
Seasonal difference	1		
MA Seasonal (lag 1)	0.899	0.069	0.00

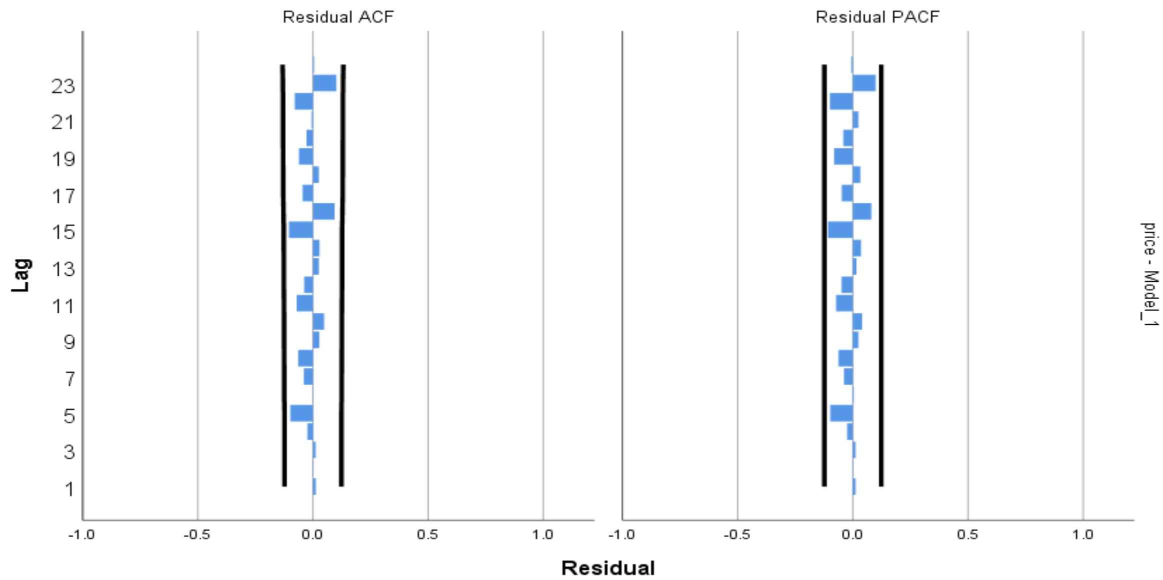


Figure 4. Residuals plot of ACF and PACF for SARIMA (1, 0, 2) $(1, 1, 1)_{12}$

In validity period (January 2000 to December 2021) prices are predicted using data set from January 2000 to December 2021 by SARIMA (1, 0, 2)$(1, 1, 1)_{12}$ model. Figure 5 represents that the predicted price of onion by the selected model. It shows that the predicted prices were consistent with the actual prices with some fluctuations.

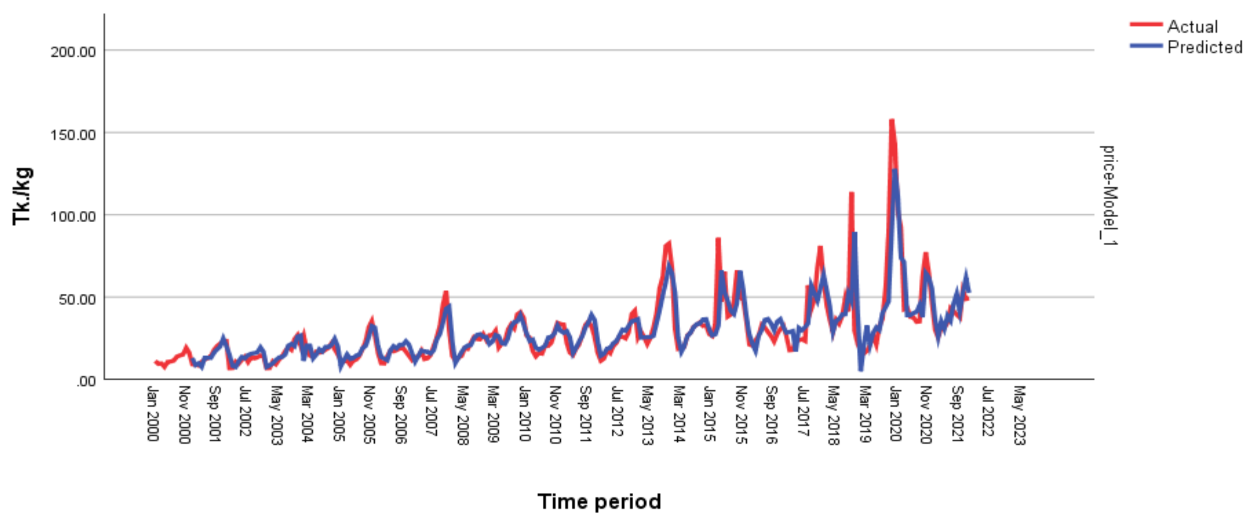


Figure 5. Plot of actual and predict price of onion (Tk. / kg)

Thus, the wholesale price of onion was forecasted for 3 years (2022 to 2024) using dataset January 2000 to December 2021 by the selected SARIMA (1, 0, 2) $(1, 1, 1)_{12}$ model and presented in Table 8. The predicted values consistently remain within the confidence interval. It was shown that the forecasted price follows a seasonal trend, and price was gradually increased from June to December and comparatively low from February to April. In Bangladesh, onion is mainly cultivated in winter season. This indicating that seasonal price variation should be consider for formulating policies such as initiative to promote cultivation of summer onion, storage facilities, reduce post-harvest losses, and market strategies to steadiness in the domestic demand and supply during the lean period.

Table 8. Ahead forecast of onion price by using SARIMA (1,0,2) $(1,1,1)_{12}$ model

Time period	Forecasted values of original series by SARIMA model	Lower limit of forecast value	Upper limit of forecast value
January-2022	39.38	17.76	61.00
February-2022	39.87	13.95	65.79
March-2022	39.92	10.80	69.04
April-2022	38.40	8.42	68.38
May-2022	43.43	13.21	73.64
June-2022	40.96	10.68	71.25
July-2022	44.72	14.41	75.02
August-2022	52.00	21.68	82.31
September-2022	57.39	27.07	87.70
October-2022	69.89	39.58	100.21
November-2022	71.39	41.07	101.70
December-2022	64.03	33.72	94.35
January-2023	50.06	19.65	80.48
February-2023	45.32	14.87	75.78
March-2023	43.63	13.13	74.13
April-2023	40.90	10.39	71.41
May-2023	44.68	14.17	75.19
June-2023	44.25	13.74	74.76
July-2023	46.54	16.02	77.05
August-2023	51.61	21.09	82.12
September-2023	55.36	24.85	85.88
October-2023	68.67	38.15	99.18
November-2023	68.69	38.18	99.20
December-2023	63.02	32.51	93.54
January-2024	52.91	22.34	83.49
February-2024	49.38	18.75	80.01
March-2024	48.08	17.40	78.76
April-2024	45.65	14.96	76.34
May-2024	49.72	19.02	80.41
June-2024	48.84	18.14	79.53
July-2024	51.45	20.75	82.14
August-2024	57.01	26.32	87.71
September-2024	61.16	30.46	91.86
October-2024	74.37	43.67	105.07
November-2024	74.70	44.00	105.40
December-2024	68.64	37.95	99.34

Conclusion

In Bangladesh, the onion production follows an upward trend with some fluctuations which are evident from the coefficient of variation and instability in different regimes. The average growth rate in onion production was 7.85%. However, every year the country needed to import onion to meet up the increased domestic demand. The imported price of onion dominates the domestic market price. The study identified SARIMA (1, 0, 2) $(1, 1, 1)_{12}$ model which was the most suitable for forecasting onion price. The results indicate that the wholesale price of onion was affected by the seasonality. The Ljung-Box Q statistic found no significant autocorrelation in model residuals, which also enhance the forecasting reliability. The forecasted price of onion was the highest in October and November, which are the lean period of onion in Bangladesh. These findings highlight the importance of Bangladesh's onion policies with estimated growth rate and forecasted price trend. Import policy throughout the year from reliable sources could be good for the stability of onion market. Additionally, it is important to take different policies and initiatives such as increasing domestic onion production and storage facilities, and reducing post-harvest losses.

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