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Instability in banana export from India

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ABSTRACT

The global demand for banana is an opportunity for India to increase its export. The data on export quantity and value of banana in India from the period of 1990-91 to 2017-18 (28 years) were considered with the aim to perform time series modeling for Indian banana export and value. The performance of Indian banana with respect to growth in quantity exhibited as positive growth rate of 22.14 per cent per annum. The quantum of banana exported exhibited less variability with coefficient of variation at 121.32 per cent while it was highest in the banana value during study period with coefficient of variation at 146.14 per cent. The instability index of banana export and value were 38.85 and 48.53 per cent respectively. Hence, it is suggested that there is a need to give more attention towards export. ARIMA (3, 1, 6) and Brown's exponential smoothing model were found best fit for banana export and its total value respectively.

Keywords: Banana; export; price; trend; instability

INTRODUCTION

Banana is the second most important fruit crop in India next to mango. Its year round availability, affordability, varietal range, taste and nutritive and medicinal value makes it the favourite fruit among all classes of people. Besides India, other major banana producing countries are China, Philippines, Ecuador, Brazil and Indonesia (Doss et al 2020). India produces a total of 23 per cent of the entire world production of banana (Bhagat et al 2022).

Because of its abundant production, it is predicted that the potential of export seems to be attractive. The total area under banana cultivation in India during the year 2021-22 was 959 thousand ha with production of 35,131 thousand MT (Meenakshi and Prasad 2022). Muchayan (2019) studied the forecasting of OAV Equitas mutual fund NAV price movements for one year data by using two different methods viz Brown's double exponential smoothing method and Holt's double exponential smoothing method and showed that Holt's method had a smaller forecasting error level as compared to Brown's method. Bhagat and Jadhav (2021) studied the forecasting and instability of grape export from India and found that Netherland was the most stable market among the major importers of Indian grape, while Bangladesh, UK and UAE were seemed to be moderately stable. The maximum gainer among importers of Indian grape was Germany. Brown's and Holt's exponential smoothing models are recommended to use for grape export and its total value in future from India. Bhagat et al (2022) studied Markov chain analysis on the export prospectus of banana in India and concluded that UAE and Maldives were found most stable markets among the major importers studied for Indian banana. However, the countries like Nepal, Oman and other countries were moderately stable.

The major banana producing states of India are Tamil Nadu, Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Assam and Madhya Pradesh (https://agritech.tnau.ac.in/banking/pdf/Banana.pdf), while, importers of Indian banana are the UAE, Saudi Arabia, Oman, Bahrain and Nepal. India being the largest producer of banana at about 28 per cent of world production, does not account as one of the banana trading nations because major production is utilized for domestic consumption (Bhagat et al 2022).

The global demand for banana is an opportunity for India to increase its export and there is huge potential in this area. Therefore, an attempt has been made in this study to perform time series modeling for Indian banana export and value.

METHODOLOGY

Source of data: The data on export quantity and value of banana in India from the period of 1990-91 to 2017-18 (28 years) were obtained from the website of Directorate General of Commerce, Industries and Statistics, Kolkata, West Bengal and Indian Horticulture Database of NHB.

Statistical analysis

Mann-Kendall test: The Mann-Kendall test is used to determine whether a time series has a monotonic upward or downward trend. Test interpretation is:

H_0: There is no trend in the series
H_1: There is a trend in the series

For the time series $x_1, .., x_n$, the MK test uses the following statistic:

$$s = \sum_{i=1}^{n-1} \sum_{j=k+1}^{n} \text{sign}\,(x_j - x_i)$$

If $S > 0$, then later observations in the time series tend to be larger than those that appear earlier in the time series, while the reverse is true if $S < 0$.

$$\text{var} = \frac{1}{18}[n(n-1)(2n+5) - \sum_t f_t\,(f_t - 1)(2f_t + 5)]$$

where t varies over the set of tied ranks and f_t is the number of times (ie frequency) that the rank t appears

The MK test uses the following test statistics:

$$z = \begin{cases} (S-1)/se, & S > 0 \\ 0, & S = 0 \\ (S+1)/se, & S < 0 \end{cases}$$

where se = Square root of *var*. If there is no monotonic trend (the null hypothesis), then for time series with more than 10 elements, z $\sim$ N (0, 1), ie z has a standard normal distribution

Export performance: Export performance of banana is examined by fitting compound growth rate as below:

$$Y = ab^t$$

where Y = Export or value quantity, a = Intercept, b = Regression coefficient, t = Time variable

Export instability: Cuddy-Della Valle index attempts to de-trend the CV by using coefficient of determination (R^2). Thus it is a better measure to capture instability in agricultural production.

$$\text{CDVI} = \text{CVX}\sqrt{(1 - R^2)}$$

where CV is the coefficient of variation in per cent, R^2 is the coefficient of determination from time trend regression adjusted by the number of degrees of freedom

ARIMA forecasting model of banana export: Autoregressive integrated moving average (ARIMA) also known as Box-Jenkins methodology (Box and Jenkins 1976) was used for the time series modeling and forecasting of banana export quantity for five leading years. It included AR and MA terms with their respective order p, d, q. Differencing eliminates trends and seasonality and stabilizes mean of the time series. The first order differencing was used to make the series stationary. The non-seasonal ARIMA (p, d, q) model for the predicted value of banana export (y) in period t based on data up to period t-1 was used as follows:

$$y_t = \mu + \varphi_1 y_{t-1} + \cdots + \varphi_p y_{t-p} - \theta_1 e_{t-1} - \cdots - \theta_q e_{t-q}$$

where μ is the constant. φ_k is the autoregressive (AR) coefficient at lag k, θ_k is the moving average (MA) coefficient at lag k and $e_{t-k} = y_{t-k} - \hat{y}_{t-k}$ is the forecast error that was made at period t-k.

The main steps of ARIMA modeling are model identification, parameter estimation, diagnostic checking and forecasting.

Forecasting of banana value by using Brown's linear (ie double) exponential smoothing: Brown's double exponential smoothing, also known as Brown's linear exponential smoothing, is one type of double exponential smoothing which uses two different smoothed series that are centered at different points in time. Let S' denote the single-smoothed series obtained by applying simple exponential smoothing to series Y and S" denote the double-smoothed series

obtained by applying simple exponential smoothing using the same constant smoothing factor α to series S':

$$St' = \alpha Yt + (1-\alpha)St-1'$$
$$St'' = \alpha St' + (1-\alpha)St-1''$$

Then the forecast for Yt + k, for any k >, is given by:

$$Ft + k = Lt + kTt$$

where Lt is the estimated level at time t and Tt is the estimated trend at time t

$$Lt = 2St' - St''$$
$$Tt = (\alpha/1-\alpha)(St' - St'')$$

RESULTS and DISCUSSION

The results of Mann-Kendall trend test are presented in Table 1. The results indicate that there was an upward positive trend of banana export from India during the study period.

Table 1. Mann-Kendall trend test of banana export (MT)

Component	Value
Kendall's tau	0.882
S	358.0
Var (S)	2,842.0
p-value (two-tailed)	0.000
Z	6.70
alpha	0.05

The performance of banana exports was examined from the period 1990-91 to 2017-18 (28 years) by using compound growth model (Table 2, Fig 1).

The performance of Indian banana with respect to growth in quantity exhibited a positive growth rate of 22.14 per cent per annum which was

Table 2. Export performance and instability of banana export quantity and value

Component	Banana export (MT)			
	Growth rate/value	CV (%)	R^2	Adj R^2
Compound	22.14**	–	0.90	0.89
Cuddy Della Valle index (export)	38.85	121.32	–	–
Cuddy Della Valle index (value)	48.53	146.14	–	–

**Significant at 1% LoS

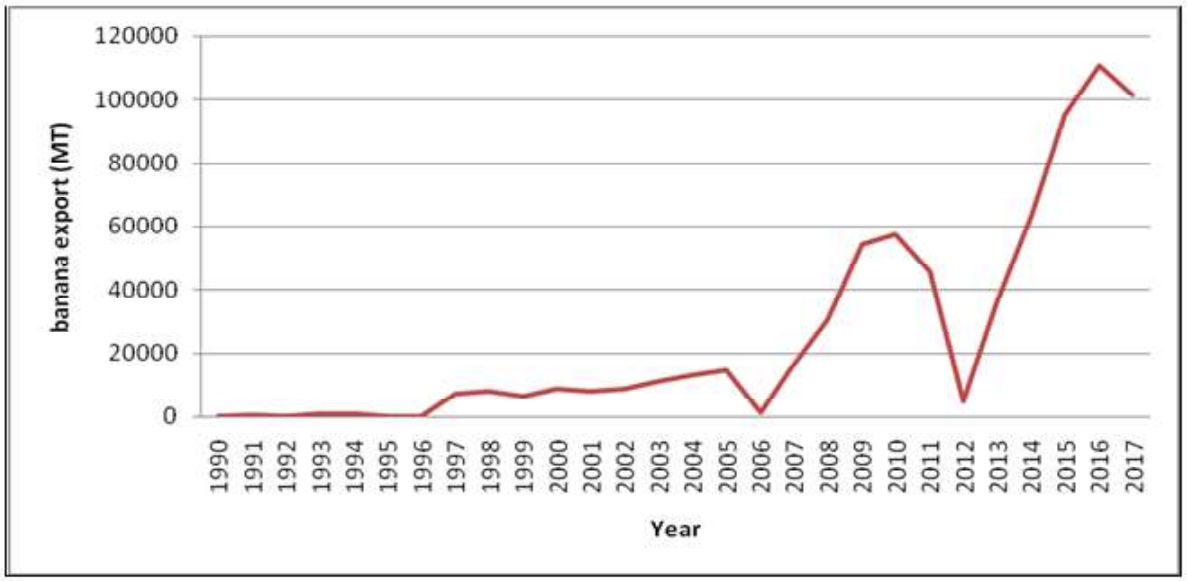

Fig 1. Annual export of banana from India during 1990-91 to 2017-18

statistically significant at 1 per cent level of significance. The similar results were reported by Bhagat and Jadhav (2021), Mokashi and Hosamani (2014) and Kiran and Sivakumar (2016).

It can be seen from Table 2 that the quantum of banana exported exhibited less variability with coefficient of variation at 121.32 per cent, while, it was highest in the banana value during study period with coefficient of variation at 146.14 per cent. The instability index of banana export and value were 38.85 and 48.53 per cent respectively. These results are in line with the findings of Anjum and Madhulika (2018) and Tiwari et al (2017).

Forecasting of banana export with ARIMA model

The time series modeling of banana export quantity from India was done with the help of ARIMA. The stationary series was necessary for application of the models and this was achieved by differencing the series by first order.

The identification of orders of p and q was done by using auto-correlation function (ACF) and partial auto-correlation function (PACF) which indicated the orders of p and q (Figs 2, 3).

The results of different model fit statistics are presented in Table 3 which reveal that the value of R^2 (0.92) was highest in the ARIMA model (3, 1, 6) and (0, 1, 6). The best fit model was decided on the basis of least normalized (BIC) value and Max AE value. It was observed that these values were found minimum by the ARIMA model (3, 1, 6).

Therefore, it is concluded that for the export of banana from India ARIMA (3, 1, 6) was best fitted model during the study period. The best fit ARIMA (3, 1, 6) model parameter estimates are presented in Table 4.

The ACF and PACF residuals of best fitted model ARIMA (3, 1, 6) and Brown's double exponential smoothing model are presented in Figs 4 and 5. It shows that all the bars lied between the two control limits. It means that these are best fitted models for banana export and its value.

Forecasting of banana value with Brown's linear (ie double) exponential smoothing model

The three different models that are Brown's, Holt's and simple exponential smoothing were tested for forecasting of banana value and subsequently best model was used for forecasting purpose (Table 5).

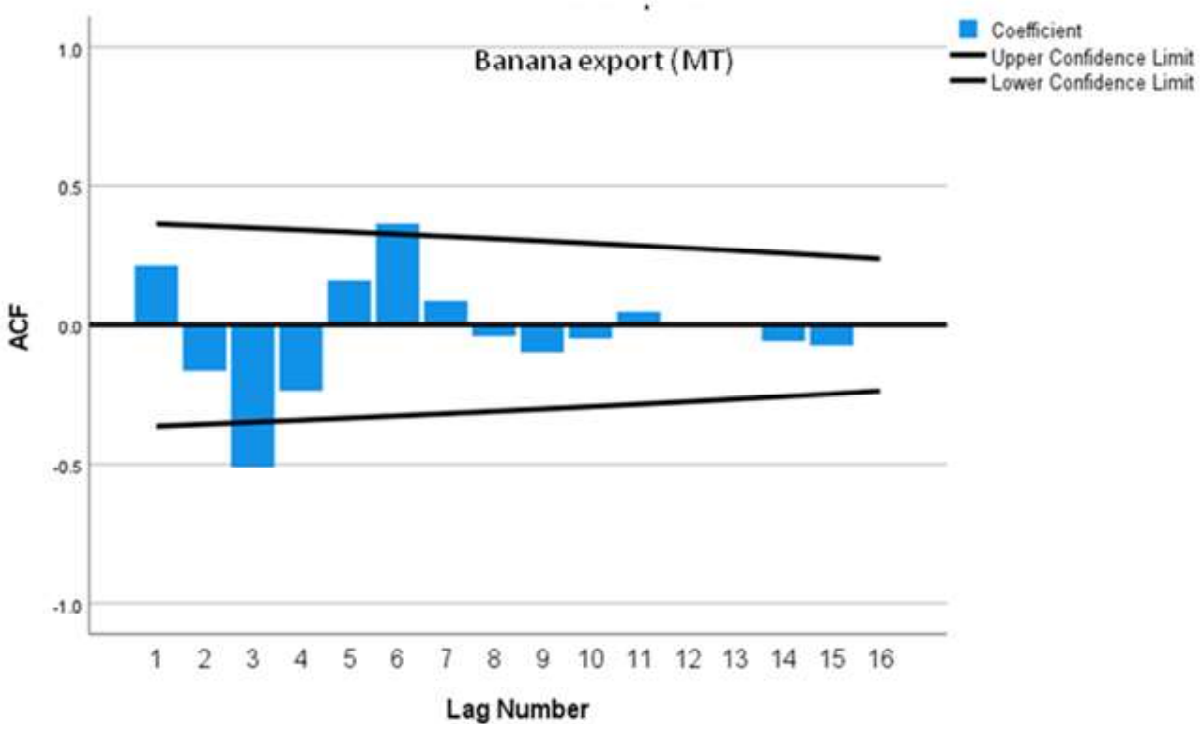

Fig 2. ACF plot for first differenced banana export from India (MT)

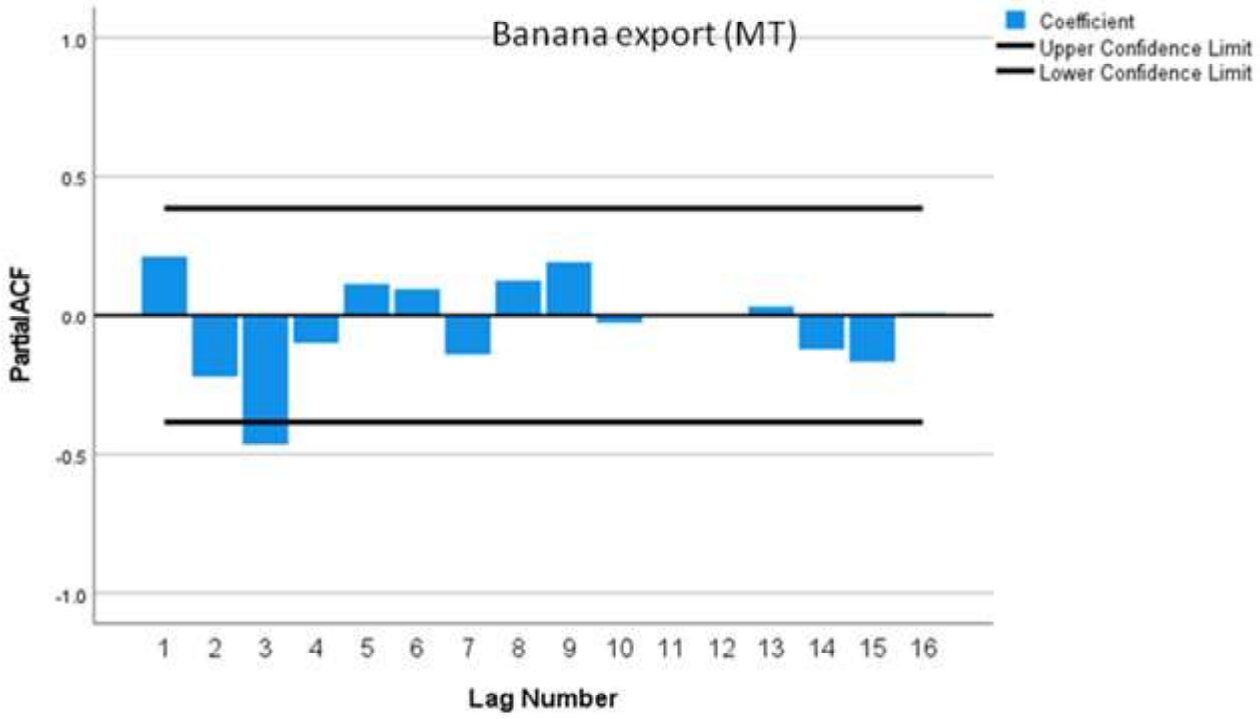

Fig 3. PACF plot for first differenced banana export from India (MT)

Table 3. Model fit statistics for four ARIMA models fitted to banana export (1990-91 to 2017-18)

Model fit statistics	(3, 1, 3)	(3, 1, 6)	(3, 1, 0)	(0, 1, 6)
Stationary R^2	0.43	0.60	0.36	0.57
R^2	0.89	0.92	0.87	0.92
RMSE	12,802.33	11,683.32	12,665.40	11,044.41
MAPE	450.05	406.91	412.81	476.80
Max APE	3,959.71	3,892.74	3,404.43	3,948.33
MAE	7,981.12	6,857.20	7,990.50	7,140.19
Max AE	30,159.99	20,349.32	33,762.16	22,714.47
Normalized (BIC)	19.77	19.25	19.38	19.47
Ljung-Box Q (18)	7.58	7.78	7.52	8.49

Table 4. Parameter estimates of the best fitted ARIMA model (3, 1, 6) banana export

Variable	Coefficient	SE	t-value	P-value
Constant	3,720.883	2,646.241	1.406	.178
AR(1)	.074	.488	.152	.881
AR(2)	–.056	.483	–.115	.910
AR(3)	–.239	.549	–.435	.669
MA(1)	1	60.079	–.001	.999
MA(2)	–.048	44.884	.002	.998
MA(3)	.105	9.922	.030	.976
MA(4)	.299	38.696	.002	.998
MA(5)	.095	63.293	–.001	.999
MA(6)	–.071	66.533	–.015	.988

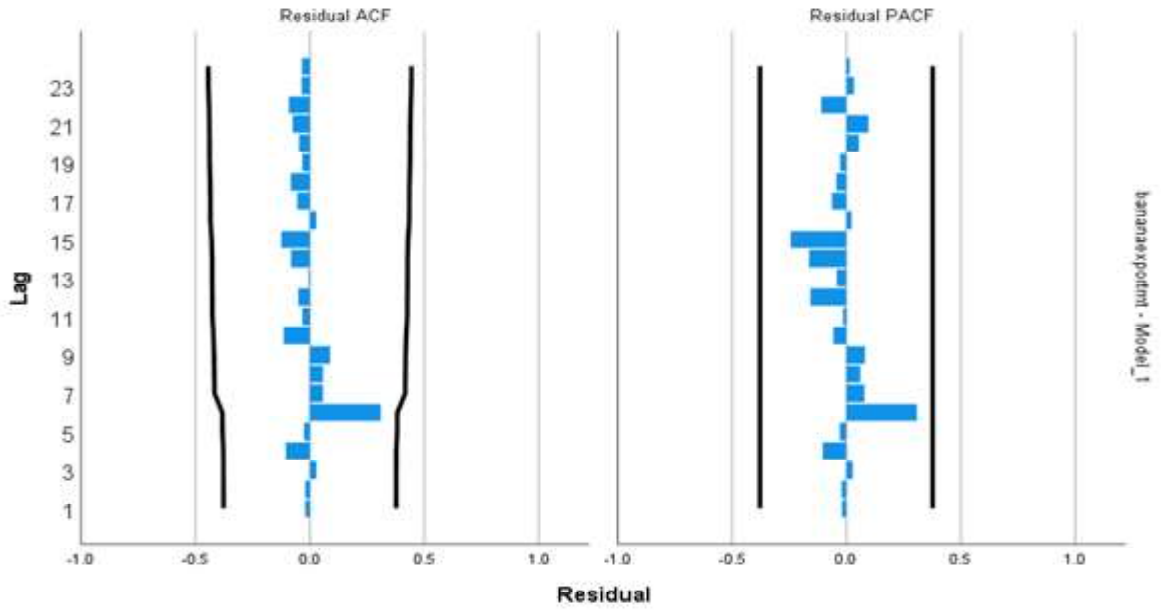

Fig 4. ACF and PACF of residuals of fitted ARIMA model for banana export

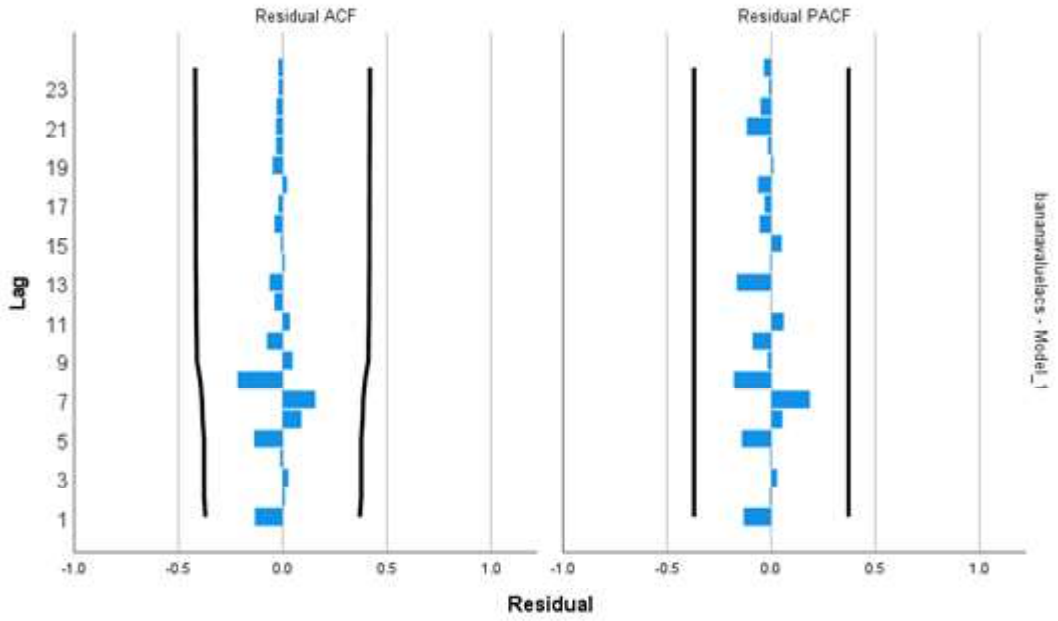

Fig 5. ACF and PACF of residuals of fitted Brown's model for banana value

The highest value of stationary R^2 and lowest value of normalized Bayesian information criteria (BIC) indicated the best model fit. The least BIC value was observed in ARIMA (3, 1, 6) that was best fit for quantity and while in case of value, Brown's exponential smoothing model was found best fit. These two best fit models were used for forecasting of banana export and value respectively. The results are in line with the findings of Bhagat and Jadhav (2021), Kumbhar et al (2019) and Meera and Sharma (2017). Brown's linear exponential smoothing model is a way to behavior of sequence of values over time. The forecasted quantity and value of export of banana are given in Figs 6 and 7.

It was observed that there will be increasing trend of annual banana export and value in next five years. The actual quantum of export of banana and its value have shown increasing trend with some minor fluctuations over the study period (Figs 6, 7).

Table 5. Model fit statistics of banana value (1990-91 to 2017-18)

Model fit statistics	Banana value (Rs in lakhs)		
	Brown's exponential smoothing	Simple exponential smoothing	Holt's exponential smoothing
Stationary R^2	0.63	0.06	0.61
R^2	0.86	0.84	0.82
RMSE	4,467.70	4,803.16	4,447.46
MAPE	367.40	313.60	391.90
Max APE	5,620.18	5,140.18	3,623.51
MAE	2,483.11	2,761.58	2,511.33
Max AE	11,280.18	12,432.58	11,699.71
Normalized (BIC)	16.93	17.07	17.04
Ljung-Box Q (18)	5.46	5.27	6.13

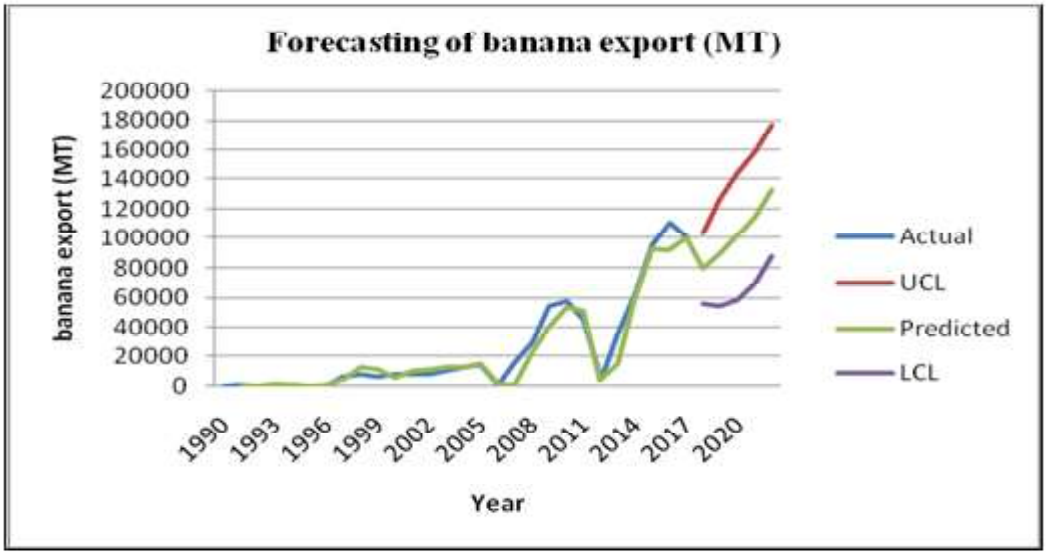

Fig 6. Forecasting of banana export quantity from India

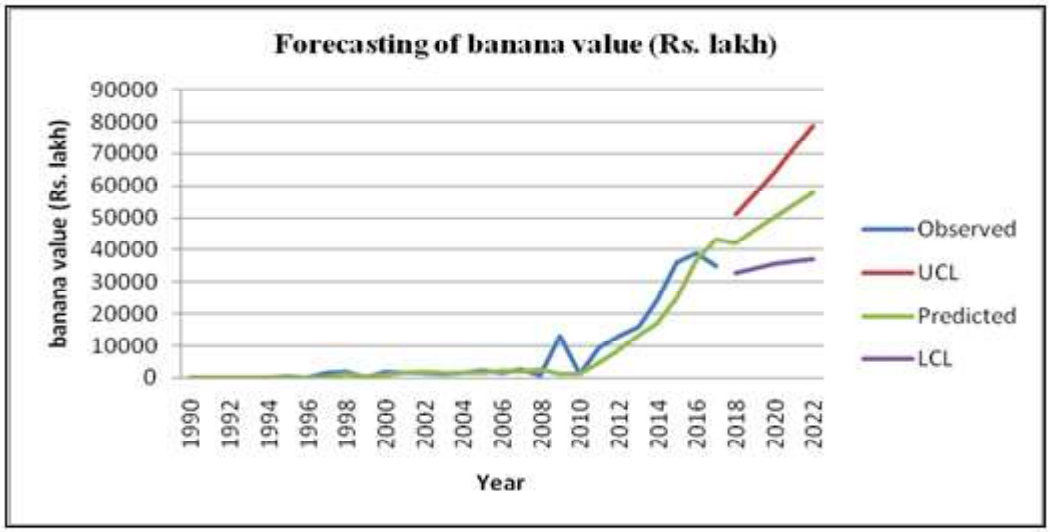

Fig 7. Forecasting of banana value (Rs in lakhs) from India

CONCLUSION

The performance of Indian banana with respect to growth in quantity exhibited a positive growth rate of 22.14 per cent per annum. The quantum of banana exported exhibited less variability with coefficient of variation at 121.32 per cent, while, it was highest in the banana value during study period with coefficient of variation at 146.14 per cent. The instability index of banana export and value was 38.85 and 48.53 per cent respectively. The forecasted quantum of banana export and its value revealed increasing trend. Hence, it is suggested that there is a need to give more attention on export. ARIMA (3, 1, 6) and Brown's exponential smoothing model were found best fit for banana export and its total value.

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