

An Empirical Study on Forecasting Production and Price of Tea in India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Tea is a very indispensable beverage for Indian population as we rank the world's largest consumer of black tea. Indian tea industry had been facing many downfalls for the past few years in terms of low price, excess supply, losing flavour and all this as a whole had affected the performance of the tea industry in India. With India being the second largest producer of tea globally, the production of tea in India can be subdivided into North India and South India. The current study focuses on the comparative analysis between North India, South India and India in terms of their trends in area, production, yield, export quantity, export price, auction price and auction quantity of tea. Compounded Annual growth rate (CAGR) was the tool used to find the trends of various variables. This study also focuses on the forecasting the production and auction prices of tea in India till 2023 using Autoregressive Integrated Moving Average (ARIMA) model. The results of the present study are indicating that all the variables like area, production, yield, export quantity, export price, auction price and auction quantity of tea had shown a positive trend annually, except for that of North India's export quantity. Production and auction prices were forecasted till 2023 using different ARIMA models amongst which ARIMA (1,1,0) proved to be the best fit model for study period.

Keywords: Tea; Compounded Annual Growth Rate (CAGR); forecasting, trend; Autoregressive Integrated Moving Average (ARIMA) model.

1. INTRODUCTION

Tea (*Camellia sinensis*) is one of the most popular and low-cost beverages in the World which is consumed by a large population. Approximately more than 3 billion cups of tea are consumed Worldwide global tea report [1]. The global tea market size was valued at \$55,144 million in 2019, and is projected to reach \$68,950 million by 2027, registering a CAGR of 6.6% from 2020 to 2027. Sumesh Kumar et al. [2]. It is majorly grown in countries like China, India, Japan, Turkey, Iran, Indonesia, Vietnam, Argentina, Sri Lanka and Kenya which contributes to the 90% of the global production. Indian tea industry is one of the finest markets in the World owing to its continuous innovation, geographical indication, flavour, aroma, taste, huge investments in processing units, diversified market, export competitiveness and many other factors. There are different varieties of tea being produced in India like Black tea, white tea, Darjeeling tea, Kangra tea, green tea and many others [3]. The black tea are divided into CTC, Orthodox which has both dust and leaf grades produced in India. The black tea is fully oxidised while the white tea and green tea are not oxidised. Oxidation is a major process which takes place to convert the green leaves into made tea. During the process of oxidation, the tea leaf becomes oxidized, some cool stuff starts to happen. The Catechins (an astringent tasting

antioxidant) begin to convert into Theaflavins & thearubigins (sweet and savoury antioxidant.) The less oxidized the tea the greener it will usually be. The more oxidized the darker the tea will be.

Indian tea industry is facing crisis in terms of profitability and decreasing demand and excessive supply. The study will trace the trends in the area, production, yield, export quantity, export price, auction quantity and auction price with a comparative analysis between north India, South India and India as a whole. The study will forecast the future auction prices and production of tea in India till 2023. The Fig. 1 depicts the area of tea in India from 1980-2020. Fig. 2 depicts the production of tea in India from 1980-2020. Fig. 3 depicts the domestic consumption of tea in India from 1980-2020. Fig. 4 depicts the Percentage share of Global Tea production by various countries in 2019. From the figure we can clearly witness that the area and production of tea in India had increased steadily over the years, but the domestic consumption on the other hand had slowly increased over the years. It didn't increase steadily as the area and production may be because of the availability of other substitutes beverages. In global tea production as of 2019, China, where the origin of tea took place holds the first in production by acquiring 46% of the total global market, India ranks second with 23% market share.

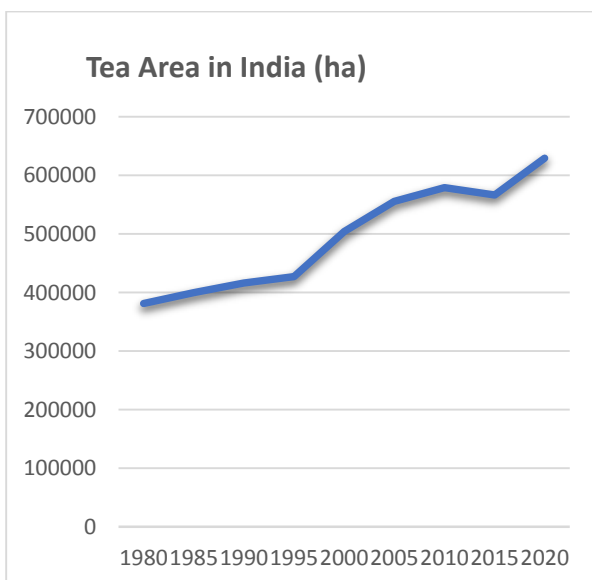


Fig. 1. Area of tea in India (1980-2020)

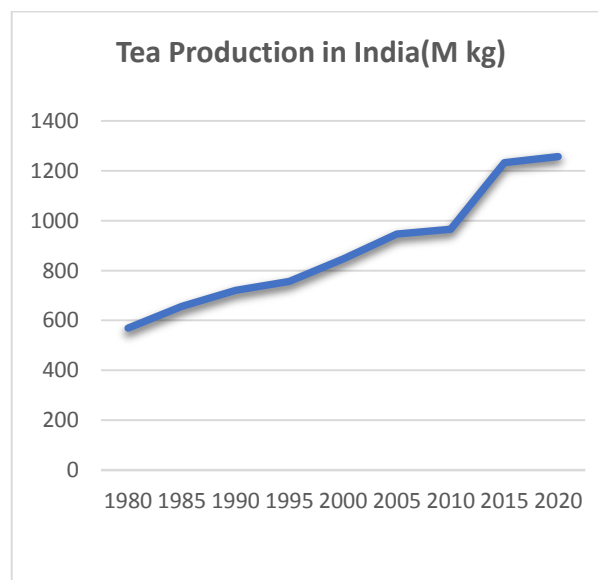


Fig. 2. Production of tea in India (1980-2020)

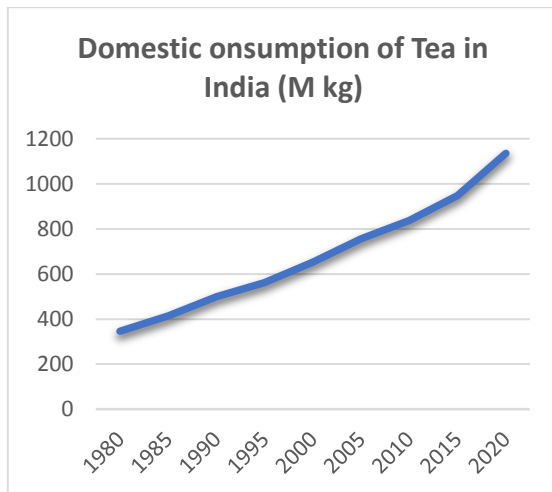


Fig. 3. Domestic Consumption of Tea in India (1980-2020)

Source: www.indiastat.com , Global Market Report : Tea (2019)
 Figures: Author's own construction

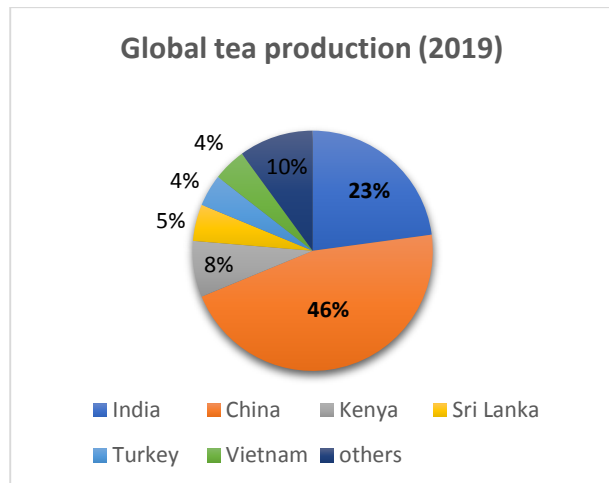


Fig. 4. Percentage contribution of Global Tea Production (2019)

1.1 Objectives

1. To study the trend in area, production, yield, export quantity, export price, auction quantity, auction price of tea in North India and South India
2. To forecast the production and auction prices of tea in India

2. REVIEW OF LITERATURE

Alastair Hicks [4] researched and found a wide range of tea products continue to be developed, through product and process development for added-value, as market shares become more sophisticated and competitive. Kakali Hazarika [5] researched and interpreted the Indian tea industry was forced to shift from production oriented approach to market creation and market matching approach to meet the growing demand. Suresh A et.al. [6] interpreted the trend in exports of agricultural commodities from India, the changes in the comparative advantage, the Indian agricultural export scenario has witnessed during the past decade and the prospects for further boosting the agricultural export. Sneha Chaudhry et.al. [7] focused on the measurement of the extent of competition in the global tea market with specific emphasis on major tea exporting countries and concluded that although India, China, Kenya and Sri Lanka are the top four tea producers in the world yet these countries have a low impact on the global competitiveness of tea; highlighting the growing competition from the other emerging tea

producing countries. Pradeep Mishra et.al. [8] forecasted the area, yield, production and export of tea in India using Auto regressive Integrated Moving Average (ARIMA) which helped in estimating relative production, price structure as well as tea market in the country. Manmath Nath Samantaray et.al. [9] studied the trend of tea industry in India, using various statistical tools like regression analysis, time series analysis and cluster analysis and concluded that the Indian export as a percentage of production had decreased over the years, and the auction prices of north India and south India did have a relationship with the production.

3. DATA AND METHODOLOGY

• Data

Secondary data on Tea area, production, export, price for a period of 40 (1980-2020) years was collected from various sources like FAOSTAT (www.fao.org/faostat), Indiastat (www.indiastat.com) , Indian Tea Association (ITA), journals and tea board

• Tools

Descriptive statistics, Compounded Annual Growth rate (CAGR) and ARIMA Model.

3.1 Descriptive Statistics

To examine the nature of each series these have been subjected to get various statistics.

Descriptive statistics are used to describe patterns and general trends in a data set. It is numerical and graphic procedure to summarize a collection of data in a clear and understandable way. Statistical tools used to describe the above series are minimum, maximum, average, standard deviation, skewness, kurtosis.

3.2 Compounded Annual Growth Rate (CAGR)

CAGR was worked out to examine the tendency of variable to increase, decrease or stagnant over a period of time. Compound annual growth rates of area, production, yield, export quantity, export price, auction quantity and auction price of tea in North India and South India from 1980-2020 were estimated by using the exponential growth function of the form: [10]

$$Y_t = a b^t U^t \quad (1)$$

Where,

- Y_t = Dependent variable for which growth rate of fruits was estimated
- a = Intercept
- b = Regression coefficient
- t = Year which takes values of (1, 2, 3, ... n)
- U_t = Disturbance term in year 't'.

The equation (1) will be transformed in to log-linear and written as:

$$\log Y_t = \log a + t \log b + \log U_t \quad (2)$$

Equation (2) will be estimated by using Ordinary Least Square (OLS) technique.

The compound growth rate (CAGR) will be then estimated by the identity given in equation (3)

$$CAGR = (b-1) \times 100 \quad (3)$$

Where,

- CAGR = Estimated compound growth rate per annum in percentage.
- b = Antilog of log b

3.3 Auto-Regressive Integrated Moving Average (ARIMA) Model

A brief description of Auto Regressive Integrated Moving Average (ARIMA) processes are given in the following sections as described by Gujarati [11] Price forecast models based on Auto Regressive Integrated Moving Average (ARIMA)

model are applied for a wide range of contexts. The popularity of ARIMA model is due to its statistical properties as well as use of well-known Box-Jenkins methodology in the model building process [12].

The ARIMA is an extrapolation method, which requires historical time series data of underlying variable. The methodology refers to the set of procedures for identifying, fitting, and checking ARIMA models with time series data [13].

In an Auto-Regressive Integrated Moving Average (ARIMA) model, time series variable is assumed to be a linear function of the previous actual values and random shocks. In general, an ARIMA model is characterized by the notation ARIMA (p, d, q), where p, d and q denote orders of Auto-Regression (AR), Integration (differencing) and Moving Average (MA), respectively [11].

3.3.1 A pth -order Auto-Regressive model: AR(p), which has the general form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \alpha_3 y_{t-3} \dots + \alpha_p y_{t-p} + \varepsilon_t \quad \text{----1}$$

- y_t = Tea Production, price at time t
- y_{t-1}, y_{t-2}, y_{t-3} ---- y_{t-p} = Tea production, price at time lags t-1, t-2, ..., t-p, respectively
- α₀, α₁, α₂, ..., α_p = coefficients to be estimated,
- ε_t = Error term at time t

3.3.2 A qth-order Moving Average model: MA(q), which has the general form:

$$y_t = \mu + \varepsilon_t - \phi_1 \varepsilon_{t-1} - \phi_2 \varepsilon_{t-2} - \dots - \phi_q \varepsilon_{t-q} \quad \text{----2}$$

- y_t = Tea Production, price at time t
- μ = constant mean
- φ₁, φ₂, ..., φ_q = Coefficients to be estimated
- ε_t = Error term at time t
- ε_{t-1}, ε_{t-2}, ..., ε_{t-q} = Errors in previous time periods that are incorporated in Y_t

3.3.3 Auto Regressive Moving Average Model: ARMA(p,q), which has general form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \alpha_3 y_{t-3} \dots + \alpha_p y_{t-p} + \varepsilon_t - \phi_1 \varepsilon_{t-1} - \phi_2 \varepsilon_{t-2} - \dots - \phi_q \varepsilon_{t-q} \quad \text{----3}$$

y_t = Tea Production, price

$\alpha_0, \alpha_1, \alpha_2, \dots, \alpha_p, \phi_1, \phi_2, \dots, \phi_q =$

Coefficients to be estimated

ε_t = Error term at time t

$\varepsilon_{t-1}, \varepsilon_{t-2}, \dots, \varepsilon_{t-q} =$ Errors in previous time periods that are incorporated in Y_t

The first step in the process of ARIMA modelling is to identify the model using Auto Correlation Functions (ACFs) and Partial Auto Correlation Functions (PACFs) to achieve stationary and tentatively identify patterns and model components. A series is regarded stationary if its statistical characteristics such as the mean and the autocorrelation structures are constant over time. Determine whether the series is stationary or not by considering the graph of ACF. If a graph of ACF of the time series values either cuts off fairly quickly or dies down fairly quickly, then the time series values should be considered stationary. If the original series is stationary, $d = 0$ and the ARIMA models reduce to the ARMA models. However, many economic time series are non-stationary, that is, they are integrated. If a time series is integrated with an order of 1, it implies that the first difference of the price is effective and it is denoted as $I(0)$. This implies that mean and covariance have attained stationarity. In general, if a time series integrated as $I(d)$, after differencing it d times we obtain a stationary $I(0)$ series. If a price series is non-stationary it is differentiated 'd' times to make it stationary using ARIMA (p, d, q) model. The stochastic trend of the series is removed by differencing, multiple ARMA models are chosen on the basis of Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF) that closely fit the data [14].

The second step involves determining the coefficients and estimation is through maximum likelihood approach such that the overall measure of errors is minimized or the likelihood function is maximized. The third step involves diagnostics checking using ACFs and PACFs of residuals to verify whether the model is valid. In this step, model must be checked for adequacy by considering the properties of the residuals whether the residuals from an ARIMA model must have the normal distribution and should be random. Otherwise repeat the steps of identification, estimation and diagnostics. The most suitable ARIMA model is selected using the smallest Akaike Information Criterion (AIC) or Schwarz-Bayesian Criterion (SBC) value and root mean square error and lowest Mean

Absolute Percentage Error (MAPE) criterion. The MAPE calculates the forecast error as a percentage of actual value. MAPE is used as relative measure to compare forecasts for the same series across different models.

The MAPE is calculated using the following formula

$$\text{MAPE} = \frac{\sum_{t=1}^n \left| \frac{y_t - \hat{y}_t}{y_t} \right|}{n} * 100$$

y_t = Actual value at time t

\hat{y}_t = Predicted value at time t

n = Number of observations

The procedure for these tests is drawn from Makridokis and Wheelright (1978). The final step is forecasting simple statistics and confidence intervals to determine the validity of the forecast and track model performance to detect out of control situation. In this study, all estimations and forecasting of ARIMA model have been done using SPSS 23.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

4.1.1 For North India

Descriptive statistics are a set of brief descriptive coefficients that summarizes a given data set, which can either be a representation of the entire population or a sample. From the Table 1 it can be interpreted that the area had increased from 306844 ha to 459613 ha for a span of 40 years. The average area is about 391346 ha which indicates a positive impact with continuous expansion. In production it had soared from 437 M kg to 1171 M kg with a consistent increase throughout the time period of study. The yield also shows a positive trend in North India. The average export quantity over the period had been about 127.79 M kg. Similarly looking at the auction prices it had been sold as low as Rs.14 per kg to as high as Rs.182 per kg. The platykurtic nature of distribution depicts there has been continuous force on enhancing in area, production, export quantity, export price and auction quantity of tea in North India.

4.1.2 For South India

The values in Table 2 helps us in interpreting that the area of plantation had increased with an

average area of 97025.17 ha in the study period. The production and auction quantity are interrelated because more than 50% of the sale of made tea in India takes place through auction centres with 3 in North India and the other 3 in south India. Looking at the auction prices in South India it is comparatively less valued than that of North India because of the plantation practices, quality of green leaves, organic tea cultivation being followed by them.

4.1.3 For India

The overall picture of Indian tea industry can be interpreted through Table 3 where it indicates a positive trend in area, production and yield of tea in India. The value of export had increased throughout the study period with the consistent increase in export quantity. There had been many irregularities in the price movements of tea in India which is clearly indicated in the table. The average auction price at which the tea had been sold through the period stands at Rs.70 /kg.

4.2 Compounded Annual Growth rate

From the Table 4 the compounded annual growth percentage of various factors in North India, South India and India can be interpreted. The annual growth percentage of area in north India, south India and India was 1.2%, 1.4% and 1.4 % annually respectively which is statistically and positively significant. Similarly the production

had grown annually in India at 2.2% which shows a positive and significant growth. The yield is interrelated with production and area which directly proves a significant positive trend. With respect to export quantity in north India it shows a negative growth rate annually at a rate of -0.58% which proves that the export quantity in North India had decreased significantly throughout the years. In terms of export price, it shows a significant and a positive trend in all parts of India. The more production the more quantity sold through auction. It is evident that the auction quantity had shown a positive and significant growth in North India, South India and India. The price of export and auction is the only factor which shows a high, positive and significant growth with the export price growing at 6.18% and the auction price growing at 5.7% in India.

4.3 ARIMA Model

The first step in building ARIMA model is the identification stage. This identification is done through plotting the autocorrelation values. Autocorrelations are numerical values that indicate how a data series is related to itself over time. These measures are most often evaluated through graphical plots called "correlograms". A correlogram plots the auto- correlation values for a given series at different lags. This is referred to as the "autocorrelation function" and is very important in the ARIMA method.

Table 1. Descriptive statistics of North India

	Area	Production	Yield	Export Quantity	Export Price	Auction Quantity	Auction Price
Mean	391346.00	695.71	1756.68	127.79	115.96	357.63	74.80
Standard deviation	57340.639	206.24	316.80	28.27	73.52	58.07	45.41
Kurtosis	-1.75	-0.35	1.00	-1.30	-1.15	-0.09	0.76
Skewness	0.06	0.84	1.38	0.25	0.37	-0.12	0.56
Minimum	306844.00	437.03	1366.00	85.42	18.74	212.42	14.00
Maximum	459613.00	1171.01	2580.00	183.82	239.69	466.94	182.45

Table 2. Descriptive statistics in South India

	Area	Production	Yield	Export Quantity	Export Price	Auction Quantity	Auction Price
Mean	97025.17	196.25	2025.37	77.31	79.42	126.80	53.74
Standard deviation	18445.016	40.47	229.346	24.21	49.95	18.81	30.08
Kurtosis	-1.71	-0.58	0.84	-1.30	0.13	0.37	-0.56
Skewness	-0.19	-0.69	-0.43	-0.24	-0.87	-0.22	0.64
Minimum	72513.00	103.14	1374.00	36.27	15.63	82.53	12.66
Maximum	119823.00	246.90	2540.00	119.92	211.91	170.37	125.53

Table 3. Descriptive statistics in India

	Area	Production	Yield	Export Quantity	Export Price	Auction Quantity	Auction Price
Mean	494813.10	892.78	1785.83	205.63	101.50	485.14	70.28
Standard deviation	82572.81	237.50	221.518	24.02	65.51	66.93	43.40
Kurtosis	-1.56	-0.74	-0.46	0.69	-0.68	0.51	-0.81
Skewness	0.13	0.54	0.66	0.18	0.64	-0.52	0.60
Minimum	381086.00	560.43	1422.00	150.69	18.11	306.96	13.06
Maximum	629199.00	1390.08	2218.00	265.60	248.55	603.54	169.45

Table 4. Compounded Annual growth Rate

Variable	CAGR **(%)		
	North India	South India	India
Area	1.22	1.4	1.38
Production	2.32	1.71	2.19
Yield	1.17	0.36	0.84
Export Quantity	-0.58	2.28	0.35
Export Price	6.5	5.58	6.18
Auction Quantity	1.08	0.72	1
Auction Price	5.72	4.8	5.7

@ 5% level of significance

Source: Author's own construction

Table 5. Forecasted Production and Auction price using various ARIMA model

Production in M kg (Check the unit)				Auction Price in Rs/kg			
Model	2021	2022	2023	Model	2021	2022	2023
100	1253.89	1250.3	1246.747	100	168.81	178.09	167.54
110	1322.966	1326.48	1349.36	110	174.05	177.08	181.92
111	1310.494	1294.396	1344.425	111	171.45	177.02	179.37
101	1253.429	1249.901	1246.409	101	173.36	172.46	171.57
011	1324.438	1343.133	1361.828	011	174.11	178.04	181.96

Table 6. Accuracy performance measures of forecast

Production		Auction price	
Model	MAPE	Model	MAPE
100	4.905	100	23.58
110	3.195	110	11.653
111	3.264	111	11.697
101	4.931	101	23.489
011	3.213	11	11.65

If a graph of ACF of the time series values either cuts off fairly quickly or dies down fairly quickly, then the time series values should be considered stationary. In our graph since the values are not dies down quickly it could be considered for non-stationarity of the series. Hence differencing could be done to make the series stationary. The model will be ARIMA [15].

4.4 Forecasted Production and Auction Price Using Various ARIMA Model

Different ARIMA models (p,d,q) values were compared in order to arrive at the best fit result. From the table it was observed that the model (1,1,0) was proved to be the best fit model with the minimum MAPE value. From the Table 5

and 6 we get to see that the ARIMA model (1,1,0) proved to be the best fit model with the lowest MAPE value of 3.195. The forecasted production for 2021,2022,2023 according to the ARIMA (1,1,0) model is 1322.966 M kg, 1326.48 M kg, 1349.36 M kg respectively. Similarly, the predicted auction prices in India for 2021,2022,2023 is Rs.174.05/kg, Rs.177.08/kg, Rs.181.92/kg respectively.

For any time series model to provide forecast, the residuals should be uncorrelated, zero mean, have constant variance and normally distributed. This was checked with the residuals of ACF and PACF graphs. From the Fig. 6 graph it can be interpreted that the selected model ARIMA (1,1,0) had the above characteristics of residuals. It could be inferred that the residuals are white noise. Since the fitted model is valid and good, the values are used for forecasting.

4.5 Forecasted Graphical Representation

From the Fig. 7, 8 we can see the forecasted and the actual trend of production and auction prices of tea in India using ARIMA (1,1,0). The above mention forecasts in production will hold good when the normal conditions prevail with no extreme weather conditions, regular rainfall and no geographical disruptions. The forecasted production of 2021,2022,2023 will be 1322.966 M kg, 1326.48 M Kg, 1349.36 M kg respectively. Similarly for the forecasted auction price it will remain the same when normal market conditions prevail. Since the prices are highly sensitive to market conditions like demand and supply, global tea market, labour availability and so on, when all these factors are remaining in the same condition the forecasted auction prices will hold true.

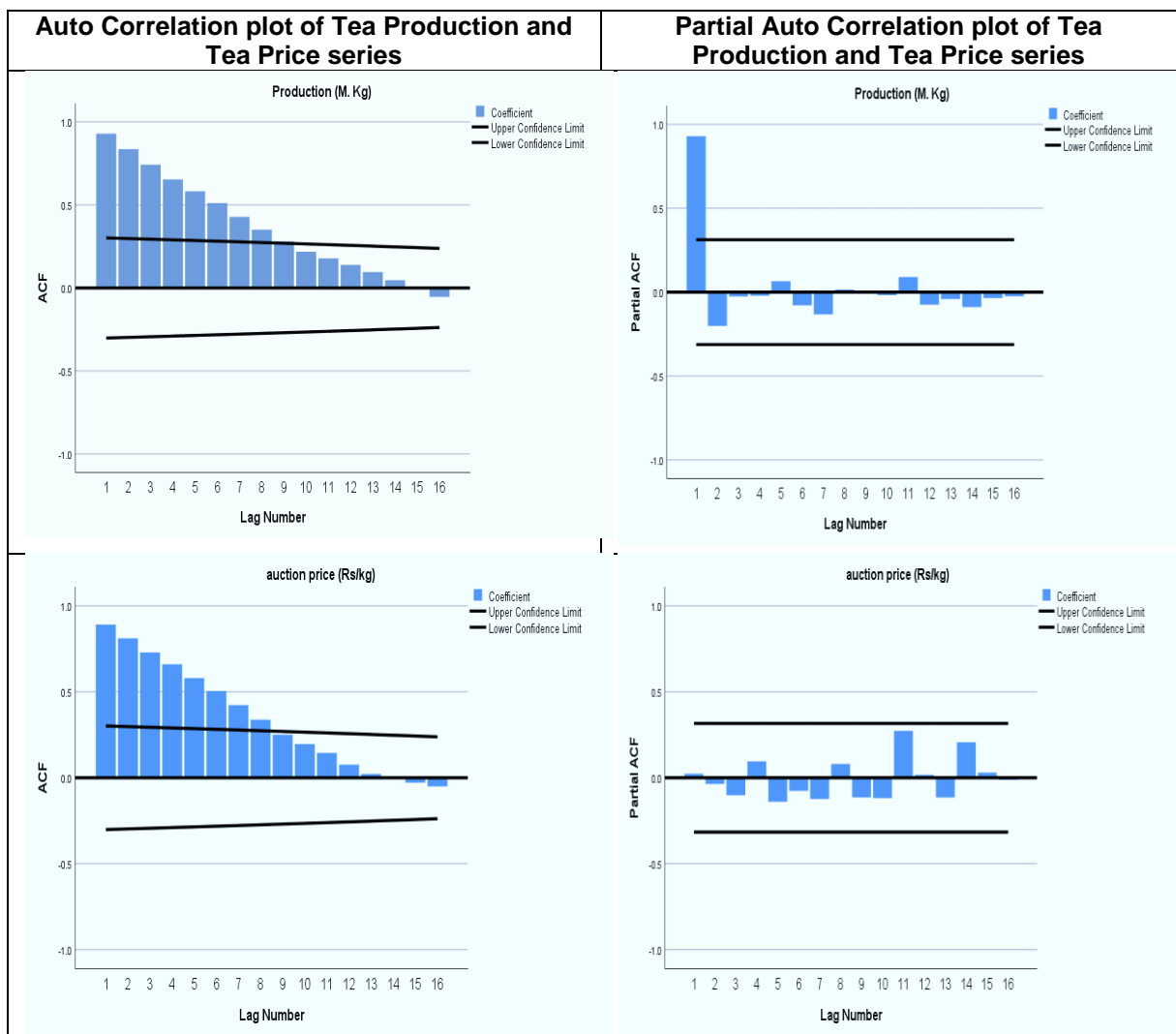
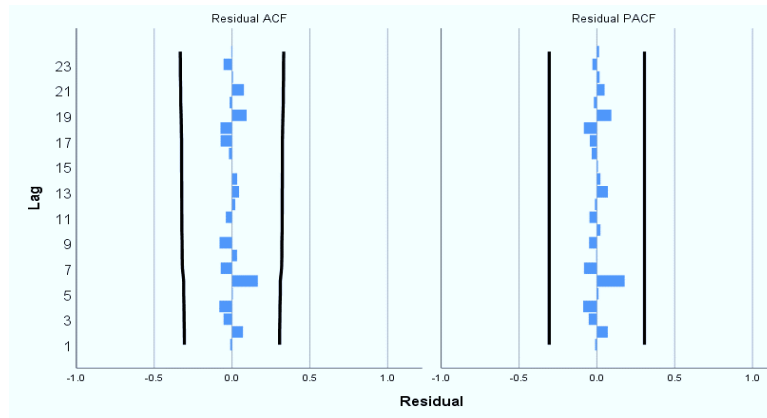


Fig. 5. Auto Correlation plot of Tea Production and Tea Price series

The ACF and PACF of the selected ARIMA (110) model is presented below in the figure for Tea Production



The ACF and PACF of the selected ARIMA (110) model is presented below in the figure for Tea Auction Prices

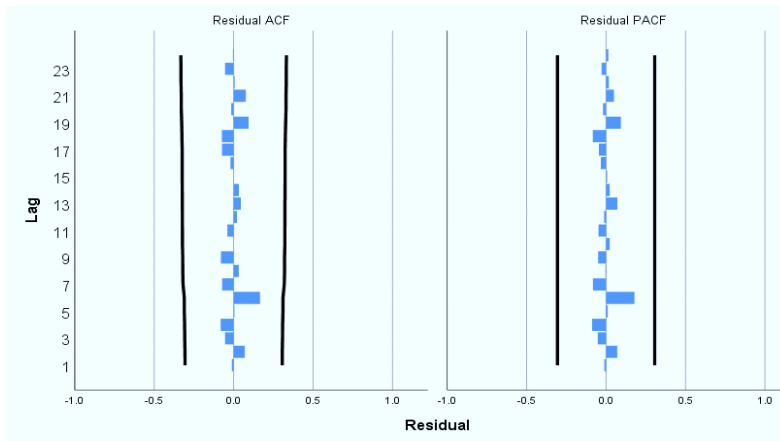


Fig. 6. Auto Correlation and Partial Auto Correlation plot of residuals of selected ARIMA (110) model

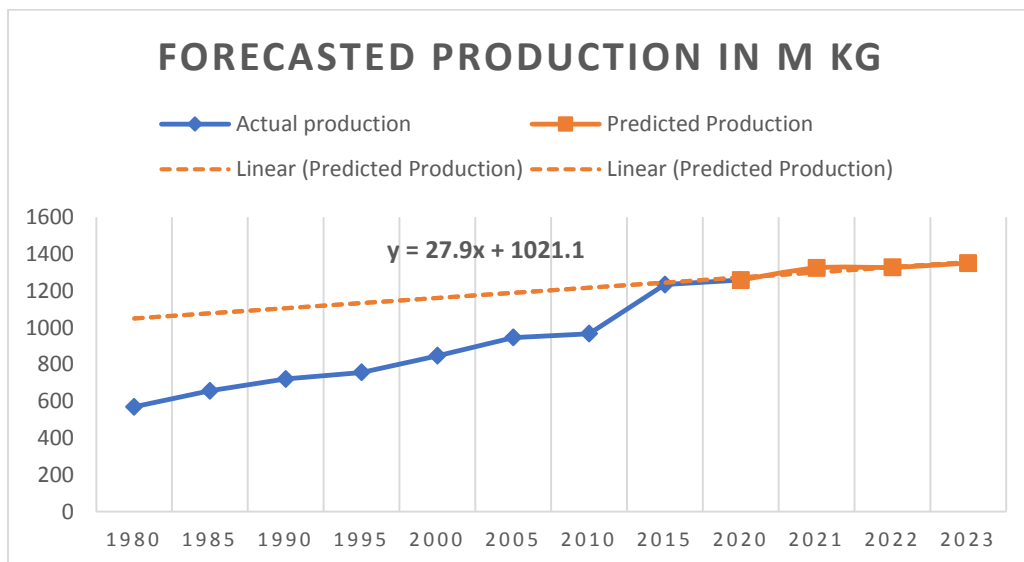


Fig. 7. Forecasted graphical representation of production in India

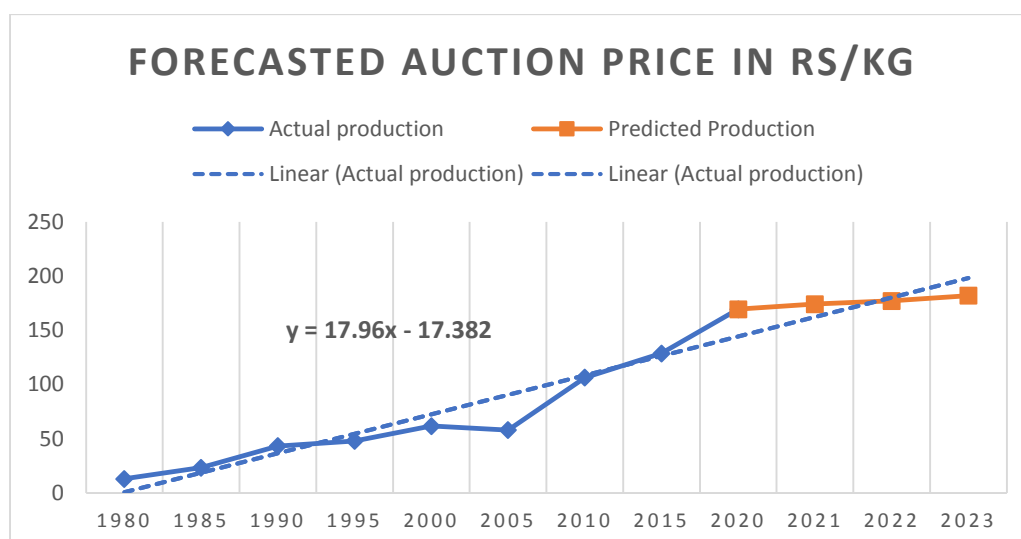


Fig. 8. Forecasted graphical representation of auction prices in India

5. CONCLUSION AND RECOMMENDATION

The supply of tea is increasing over years and the consumption of tea was not increased in pace with production. Increased costs resulted in lesser profitability of the tea firms in India. To support the industry the promotional efforts must be taken for the diversified products both in domestic and export market to make the industry profitable. To figure out the trends in area, production, yield, export quantity, export price, auction quantity and auction price of tea industry in India, this study was carried out. The study concluded the compounded annual growth rate of north India, South India and India as a whole to give a picture on how the tea plantation had upgraded over years and how the tea industry has been performing from the past decades. It was found that all the variables had a significant and positive growth rate for the past 40 years in India. Tea industry had performed better over the years and expected to be performing steadily in the upcoming years. The study also predicted the future production of tea, and future auction prices through forecasting in ARIMA (1,1,0) model and sees an increase in production and auction prices till 2023, but all these predictions are subjected to various determinants like the climatic conditions, macro-economic indicators, demand and supply, market conditions and many others factors which may affect the performance of tea industry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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