Price behaviour of Indian tea- A time series analysis

Deenamol Joy*, C. Laly John, Anil Kuruvila and K.C. Ayyoob

College of Agriculture, Kerala Agricultural University, Thrissur 680 656, Kerala, India

Received 08 June 2022; received in revised form 11 November 2022; accepted 03 December 2022

Abstract

Tea is the most important beverage crop in India. Price fluctuation is a major problem faced by tea planters in India. Price behaviour of tea in North India, South India,and All India were analysed by decomposing the monthly average auction prices of tea from January 1980 to December 2020 collected from the Tea Board of India. Time series components *viz.,* trend, seasonal variation, cyclic variation, and irregular variation were estimated for all the prices. Overall increasing trends and prominent seasonal variations were observed for North India and South India tea prices. No visible cyclic variation was observed in South India and North India tea prices. Seasonal indices were computed to study the within year price pattern and it was observed that, for North India, highest price is in June and lowest in March. For South India, the highest price is observed in February and the lowest price is in July. All India tea price was found to be the simple average of North India and South India tea prices and thus could not provide much information.

Keywords: Cyclic variation, Irregular variation, Seasonal variation, Tea, Trend.

Introduction

Tea, the "Queen of beverages" is one of the most popular and widely consumed hot beverage worldwide. It is produced in more than forty-five countries around the world. China, India, Kenya, and Sri Lanka are the world's biggest tea producers. Among them, India is the largest consumer and second largest tea producer in the world, with a production of around 1390.08 million kg in the year 2020. In India, tea growing is confined to two widely separated regions – North India and South India. Production in North India was around 1171.09 million kg in the year 2020 with 535629.04 ha in area under tea. South India had a production of 218.99 million kg and an area of 100928.03 ha. Tea is grown in sixteen Indian states, of which Assam, West Bengal, Kerala, and Tamil Nadu account for about 96 per cent of total tea production (Tea Board of India, 2020). In North India, Assam accounts for about 63 per cent of the total area, while, in South India, Tamil Nadu constitutes 62 per cent of the total area under tea, followed by Kerala (36%).

Price fluctuation is a major problem for tea planters in India and impacts the nation's economy. Wide fluctuation in tea price has been reported by Saravanakumar (2012), while analysing the tea prices in North India and South India. Anoopkumar (2014) observed high price instability for tea. Reports on analysis of the price behaviour of tea are scanty in the literature. Many researchers have made studies on price behaviour of other crops. Jyothi (2011) and Reeja (2011) studied the price behaviour of turmeric and natural rubber in India, respectively. Indraji (2016) analysed the seasonality in prices of coconut, coconut oil, and copra in three major markets of Kerala. Shana (2018) and Preethi (2019) conducted studies on the price behaviour of Nendran banana and coconut, respectively in Kerala.

Information on price behaviour of tea is very important for tea planters and also the Government

*Author for Correspondences: Phone: 9633258634, Email: deenajoy999@gmail.com

for making proper price policies. Time series analysis of tea price for quite long period is required to reveal its price behaviour. Hence a study was conducted out to analyse the price behaviour of tea in North India, South India and All India, by decomposing tea price data for 492 months into four components, trend, seasonal variation, cyclic variation and irregular variation.

Materials and Methods

The monthly auction price of tea for North India, South India, and All India collected from Tea Board of India from January 1980 to December 2020 were used to study the price behaviour of tea. A time series is a sequence of observations ordered in time (Anderson, 1971). Various forces at work affecting the values of a variable in a time series can be broadly classified into four categories known as components of time series. The four components are trend, seasonal variation, cyclic variation, and irregular variation (Croxton et al., 1979). The time series of tea prices in North India, South India, and All India were decomposed into four components, as per Croxton et al. (1979) and Spiegel (1992), assuming a multiplicative model.

Decomposition model for tea prices
Let X_t be the price of tea at time t. Then the multiplicative model is given by,

$X_t = T_t * S_t * C_t * I_t$
T_t, S_t, C_t and I_t are the components of time series, where,
T_t: Trend at time t
S_t: Seasonal variation at time t
C_t: Cyclic variation at time t
I_t: Irregular variation at time t
t: January 1980 to December 2020 (492 months)

Trend of tea price
Trend is the general tendency of the price data to increase or decrease during the period under report. The increase or decrease doesn't need to be in the same direction throughout the given period. Different tendencies of increase or decrease or stability can be observed in different sections of time. But overall tendency may be upward, downward or stable. Trend values were calculated using 12 point moving average method.

Moving Average (MA) : For a time series, the moving average of order k is defined as the mean of k consecutive observations.

MA of order k = $\frac{\Sigma_{t=1}^{k} x_t}{k}$, when k=12, we get MA of order 12.

Seasonal variation in tea price
Seasonal variations are due to the rhythmic forces which operate in a regular and periodic manner over a period of less than one year. For monthly tea price data, the months from January to December represented the 12 seasons. The price data were analysed to check whether the seasonal pattern repeats from 1980 to 2020.

Estimation of seasonal indices
Seasonal indices were worked out for 12 months from January to December from the monthly price data of tea in North India and South India from January, 1980 to December, 2020, to understand the seasonal behaviour of tea prices and make a comparison among the two regions.
Assuming multiplicative model,
$X_t = T_t * S_t * C_t * I_t$ ….(1)
The ratio to moving average method was used for the estimation of Seasonal Indices (SI).

The steps involved in the ratio to moving average method are given below:
Calculate the centred 12 month moving average (CMA) of time series of price, X_t. The centred 12 month moving average (CMA) of time series data, X_t is given by,
$CMA = T_t * C_t$…. (2)
Price data, X_t expressed as the percentage of the CMA values will give the seasonal (S_t) and irregular (I_t) components as given below:

$$\left(\frac{X_t}{CMA}\right) * 100 = S_t * I_t \ldots. (3)$$

By averaging the above percentages over years, the irregular component, I_t will get eliminated. The resultant values will be preliminary seasonal indices (S) of tea prices for the 12 months from January to December. Sum of the preliminary seasonal indices may not be equal to 1200. Hence preliminary seasonal indices were adjusted by multiplying throughout by the factor $\frac{100}{S}$. The resultant values will be the seasonal indices of tea prices for 12 months from January to December.

Seasonal indices of prices of tea in North India and South India were plotted against corresponding months. The resultant graph is called a seasonal plot.

Cyclic variation

Cyclic variations are the oscillatory movements in a time series with period of oscillation of more than one year. Cyclic fluctuation though more or less regular are not uniformly periodic. A cycle may be in the range of 2-11 years. North India and South India tea prices were analysed for the presence of cycles during the study period.

Estimation of cyclical variation

The estimation of cyclic variations in the prices of tea in North India and South India was done in three steps.

1. Removal of trend component
2. Removal of seasonal effect
3. Removal of irregular component

Removal of trend component

The effect of the trend component was removed from the time series data of tea price by dividing the original values, (X_t) by the corresponding trend (T_t) and expressing the same in per cent. That is,

$$\left(\frac{X_t}{T_t}\right) * 100 = S_t * C_t * I_t \ldots.(4)$$

Removal of seasonal effect

The trend eliminated data for each month computed in (4) was divided by the corresponding seasonal effect and the result was multiplied by 100.

$$\left(\frac{S_t * C_t * I_t}{S_t}\right) * 100 = C_t * I_t \ldots.(5)$$

Removal of irregular component

Removal of irregular variation is very difficult because it is highly entangled with cyclical movements. Values computed in (5) was divided by irregular component (I_t) to estimate the cyclic variation.

Irregular variation

Irregular variations are random or irregular fluctuations in a time series which are not accounted for by trend, seasonal variation, and cyclic variation. These fluctuations are purely random, erratic, unpredictable and are due to non-recurring and irregular circumstances which are beyond the control of human hands such as flood, war, earthquakes etc. The plot of irregular variation was made for the different tea prices.

R package was used to decompose the time series of tea prices in North India, South India and All India and the results are presented graphically.

Results and Discussion

Time series data on monthly prices of tea in North India, South India, and All India were decomposed, and the results are depicted in Figures 1,2 and 3, respectively. In all figures, four panels are shown. In the first panel, the observed price is plotted, second panel is the plot of trend, third and fourth panels give the plots of seasonal and irregular variations.

For both North India and South India, an overall increasing trend and a prominent seasonal variation could be observed. Irregular variations in the prices of tea occurred owing to numerous non-recurring and irregular circumstances which were beyond

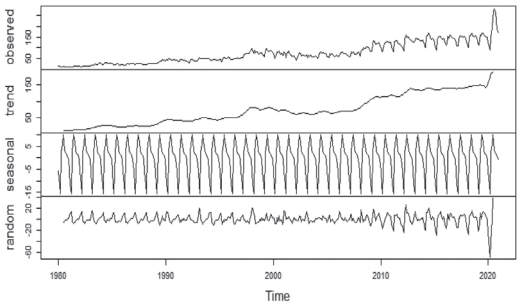

Figure 1. Time series decomposition of North Indian tea price

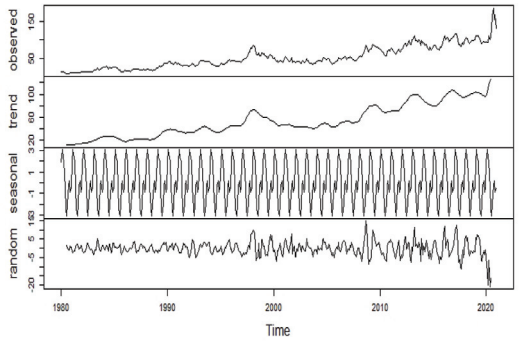

Figure 2. Time series decomposition of South Indian tea price

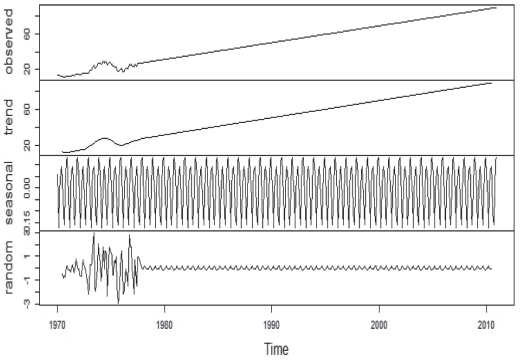

Figure 3. Time series decomposition of All India tea price

human control. It was observed that irregular variations in tea prices were highly unpredictable and did not follow any uniform pattern over the period in both North India and South India.

All India price is the simple average of tea prices in North India and South India, and hence no valid conclusions could be made from the results (Figure 3). Seasonality observed for All India tea price is the combined seasonality of both North India and South India. Hence, this result could not be interpreted and is not of much significance. Further analysis were made for North India and South India tea prices only.

Seasonal indices of tea price

To get a clear picture of the price pattern in the 12 months from January to December, seasonal indices were computed for tea prices for North India and South India and are provided in Table 1 and seasonal plots are shown in Figure 4.

Table 1. Seasonal indices of tea prices in North India and South India

Month	Seasonal Indices	
	North India	South India
January	94.3	103.4
February	88.1	105.9
March	82.6	105.1
April	102	103.8
May	106.8	99.7
June	111.6	95.7
July	108.9	94.2
August	102.9	95.5
September	101	98.7
October	101.6	100.0
November	100.8	98.8
December	99.3	99.2

From the Table 1 and Figure 4, it could be observed that, for North India, April to November are the high price months with highest price in June (seasonal indices = 111.6) followed by July (108.9), whereas, December to March are the low-price months with the lowest price in March (seasonal indices = 82.6). A hike can be observed from March to June. This is because, in North India, the first flush starts in late

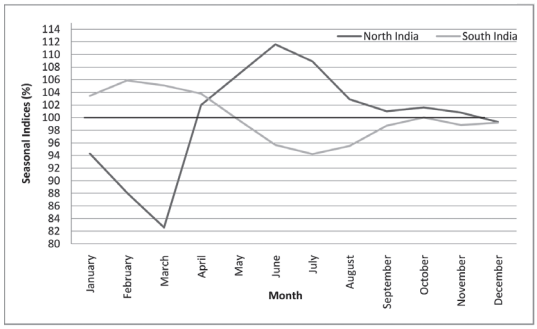

Figure 4. Seasonal plots of tea prices for North India and South India

March, and the second flush occurs from end of May to June. This season produces the best quality tea leaves and has the highest price. Third or autumn flush occurs from October to November, which is of low quality compared to the first and second flush. This product commands the least market price compared to the first two. Hence a decline in the price could be observed during these months due to deterioration in quality of autumn flush (Anonymous, 2019).

For South India, high price could be observed from January to April, with the highest price in February (seasonal indices = 105.9) followed by March (seasonal indices = 105.1). Compared to North India, South India doesn't show much seasonal variation. This is because, in South India, tea growers harvest the plants throughout the year. Hence the quality of tea leaves will be same throughout the year. Low price months are from June to September, which coincides with the southwest monsoon season, and lowest price is observed in July (seasonal indices = 94.2).

Cyclic variation

The cyclic indices of tea for North India and South India are given in Figure 4 and Figure 5. From the plot, it could be observed that, in the long run, no visible cycles are observed for both North India and South India.

North India and South India tea price data were decomposed in to time series components like trend, seasonal variation, cyclic variation, and irregular variation. It was observed that tea prices in both

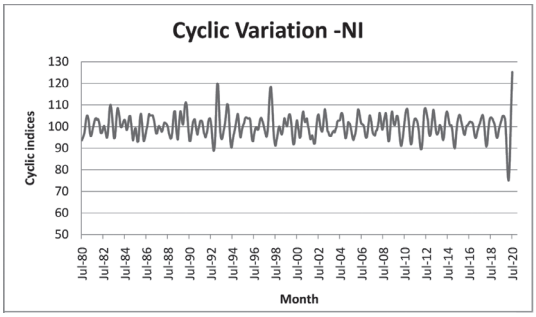

Figure 5. Cyclic variation of tea price in North India

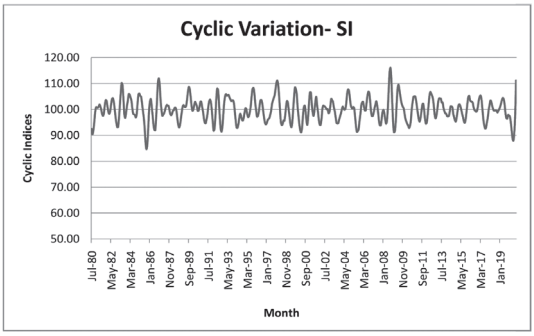

Figure 6. Cyclic variation of tea price for South India

North India and South India showed an overall increasing trend and prominent seasonal variation. For North India, April to November are the high price months, with the highest price in June whereas December to March are the low-price months, with the lowest price in March. For South India, the high price could be observed from January to April, with the highest price in February, and low-price months are from June to September, with the lowest price in July. All India tea price was found to be the simple average of North India and South India tea prices, and hence the seasonality observed in All India tea price was the combined seasonality of both North India and South India tea prices. No visible cyclic variation was observed for both North India and South India. This information is beneficial for the tea planters, and the Government for making proper price policies.

Acknowledgment

Financial help in the form of KAU fellowship is gratefully acknowledged.

References

Anderson, T.W. 1971. The Statistical Analysis of Time Series. John Wiley & Sons, New York, 704 p.

Anoopkumar, M. 2014. Intra-year price instability of commercial crops in India: Exploring the underlying dynamism. Intl. J. Food and Agric. Econ. 2(1): 145-156.

Anonymous. 2019. Tea planting variety and harvesting season [on-line]. Available: http://

www.myassamtea.com/tea-plantation/tea-harvesting. [04 Aug. 2021].

Croxton, F. E., Cowden D. J., Klein, S. Applied general statistics. Prentice Hall of India, New Delhi, India, 1979, 754p.

Indraji, K. N. 2016. Price forecast models for coconut and coconut oil. M.Sc. (Ag. Stat.) thesis, Kerala Agricultural University, Thrissur, 123p.

Jyothi, T. 2011. Price behaviour of Turmeric in India. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur. 152p.

Preethi, V. P., Thomas, J. K., Kuruvila, A., John, L. C. and Phuge, S. C. 2019. Price behaviour of coconut in major markets of Kerala: A time series analysis. Int. J. Chem. Studies., 7(1):148-154.

Reeja, V. 2011. Price behaviour of natural rubber in India. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 109p.

Saravanakumar, M. 2012. An analysis of the tea price fluctuations in South India and North India.Int. J. Social Sci. Tommorrow.1(7): 1-7.

Shana, K. K. 2018. Price behaviour of Nendran banana in Kerala: An economic analysis. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 96p.

Spiegel, R. M. (1992). Theory and problems of statistics (2nd Ed.). Mc Graw-Hill International, Singapore. 504p.

Tea Board of India. 2021. [on-line]. Available: http://www. teaboard. gov.in. [04 June 2021].