Forecasting Monthly Export Price of Sugarcane in India Using Sarima Modelling

Ali J. Ramadhan[1*], *S R* Krishna Priya[2], *Noor* Razzaq Abbas[3], *N* Kausalya[4], *Shikha* Yadav[5], *Pradeep* Mishra[6], *Mostafa* Abotaleb[7] and *Hussein* Alkattan[7]

[1]University of Alkafeel, Najaf, Iraq
[2]PSG College of Arts and Science, Tamil Nadu, India
[3]Al-Furat Al-Awsat Technical University, Najaf, Iraq
[4]PSG College of Arts& Science, Coimbatore, India
[5]JNKVV College of Agriculture, Rewa, India
[6]University of Delhi, New Delhi, India
[7]South Ural State University, Chelyabinsk, Russia

Abstract. Sugarcane is the primary agricultural industry that sustains and promotes economic growth in India. In 2018, the majority of India's sugarcane production, specifically 79.9%, was allocated for the manufacturing of white sugar. A smaller portion, 11.29%, was used to produce jaggery, while 8.80% was utilized as seed and feed components. A total of 840.16 million metric tonnes of cane sugar was shipped in the year 2019. The primary objective of this research is to determine the most suitable forecasting model for predicting the monthly export price of sugarcane in India. The input consists of a time series with 240 monthly observations of the export price of sugarcane in India, spanning from January 1993 to December 2013. The SARIMA approach was employed to predict the monthly export price of sugarcane and it is concluded that the SARIMA (0, 1, 1), $(0, 0, 0)^{12}$ model is the best-fitted one by the expert modeler method. As a result, the fitted model appears to be adequate. The RMSE and MAPE statistics are used to analyze the precision of the model.

1 Introduction

An important part of India's agricultural and economic activity is the export of sugarcane. India is a major global producer of sugarcane, and the sector is vital to the agro-economy of the nation. Although sugar is the main commodity made from sugarcane, other by-products like ethanol and molasses also have a significant economic impact in India [1,2].

With extensive agricultural regions spanning several states, including Maharashtra, Uttar Pradesh, Karnataka, Tamil Nadu, and others, India is a leading global producer of sugarcane [3,4]. Sugarcane production is essential to the sugar industry, which in turn provides jobs for many farmers and associated industries. Sugarcane is cultivated well in many places of India due to its tropical climate. One of the world's top producers of sugarcane is India [5,6]. It's important to remember, nevertheless, that specifics about sugarcane exports might alter over time as a result of adjustments to production levels, legislation, and the dynamics of the

* Corresponding author: ali.j.r@alkafeel.edu.iq

worldwide market [7,8]. The main purpose of India's sugarcane industry is to produce sugar. Sugar is produced by processing juice extracted from sugarcane, which is crushed in sugar mills. In addition to being used domestically, this sugar is a valuable export good. India sells sugar to a number of nations worldwide [9,10]. Depending on trade agreements, market conditions, and worldwide demand, the export destinations could change. Common export destinations include countries in the Middle East, Africa, and Asia, as well as adjacent countries [11,12]. The regulation of the sugarcane sector is a critical function of the Indian government. The price, export incentives, and sugar production policies have an impact on sugarcane export dynamics. Tariffs, trade agreements, and export regulations can all affect how competitive Indian sugar is on the international stage [13,14].

India's export portfolio includes sugarcane by-products like ethanol and molasses in addition to sugar. The usage of ethanol in particular as a biofuel has made it more significant. The sugarcane business must contend with a range of factors, including volatile sugar prices worldwide, weather-related crop production reductions, and competition from other countries that produce sugar [15]. Nevertheless, value addition, research and development, and diversification into other uses for sugarcane present growth prospects. A growing emphasis on sustainable methods in agriculture is a result of the increased global awareness of sustainability. In order to comply with global regulations and win over environmentally conscious customers, the sugarcane sector in India is likewise making adjustments to more ecologically friendly methods [16].

In summary, India uses its sugarcane to create sugar and other by-products mostly for domestic use. Sugar exports from the nation have been documented to a number of foreign markets. The exports of sugarcane from India are impacted by various factors, including trade agreements, global sugar prices, government regulations, and production levels.

This study focuses on analysing the time series of monthly export prices of sugarcane in India using the SARIMA model.

2 Materials and methods

2.1 Study area and data

The nature of the data is secondary. Different regions of India see different amounts of rainfall at different times of the year. Additionally, temperatures vary from place to place. Different regions of the country have distinct cropping patterns and soil textures. The total sugarcane exports from India, broken down by month, were gathered from *www.indiastat.com* between January 1993 and December 2013.

2.2 Model

Model SARIMA model were developed for modelling and also the forecasting process was done for the data set.

2.3 Auto-Regressive Integrated Moving Average (ARIMA)

ARIMA is a standard non-stationary time series analysis method. Unlike regression models, the ARIMA model contains previous or lagged r_t and stochastic error variables, also called "Mixed Models". While this may complicate forecasting, the structure may be able to duplicate the series and produce a more accurate forecast. Pure models have either AR or MA parameters, not both. This methodology produces ARIMA models, which use Autoregressive (AR), Integration (I)—the inverse process of differencing for forecasting—and Moving Average (MA) processes. An ARIMA model is usually ARIMA(p,d,q).

2.4 Forecasting

Final model predicts future values and calculates errors for produced model values. The following are good ARIMA model properties, according to Box and Jenkins. Finally, expected model accuracy is assessed by Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE).

2.5 Analysis and Interpretation

This time series of India's monthly sugarcane exports price, comprising 240 monthly observations, has been analyzed. This study's significance stemmed from the use of the Box and Jenkins (Seasonal ARIMA Models) approach to analyze monthly series data using the SPSS software. Through analysis of the times series, the seasonal ARIMA model that best fits this data is determined, and the model parameters are computed. The residuals for variance, autocorrelation, and normality assumptions are then obtained by means of the diagnostic procedures. In order to enable decision makers to rely on it when making future plans, the suitable seasonal ARIMA model for forecasting is finally employed.

2.6 Preliminary investigation of the data

The time series plots show observations on the y-axis against equally spaced time intervals on the x-axis. They assess data patterns, trends, and behaviours throughout time. Figure 1 shows India's monthly sugarcane exports throughout time.

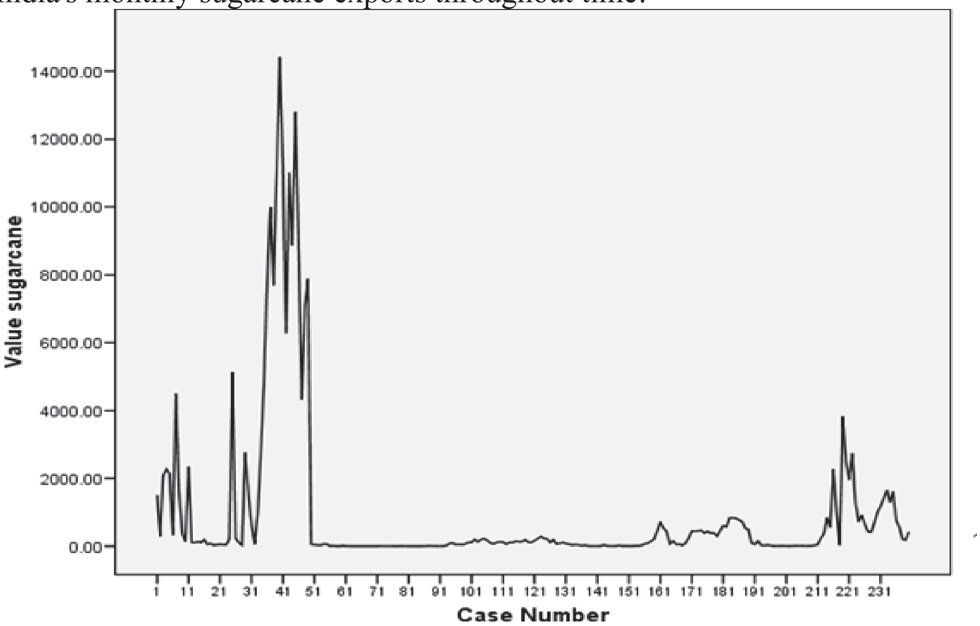

Fig. 1. Time series plot of monthly export price of sugarcane in India.

Figure1 shows that the time series is not stationary. The graphic reveals consistent short-term data variations, indicating seasonal swings. This series fluctuates unpredictably and seasonally.

Autocorrelation and partial autocorrelation functions are examined in Figure2. All results and charts show that the original time series data needs treatment to become stationary.

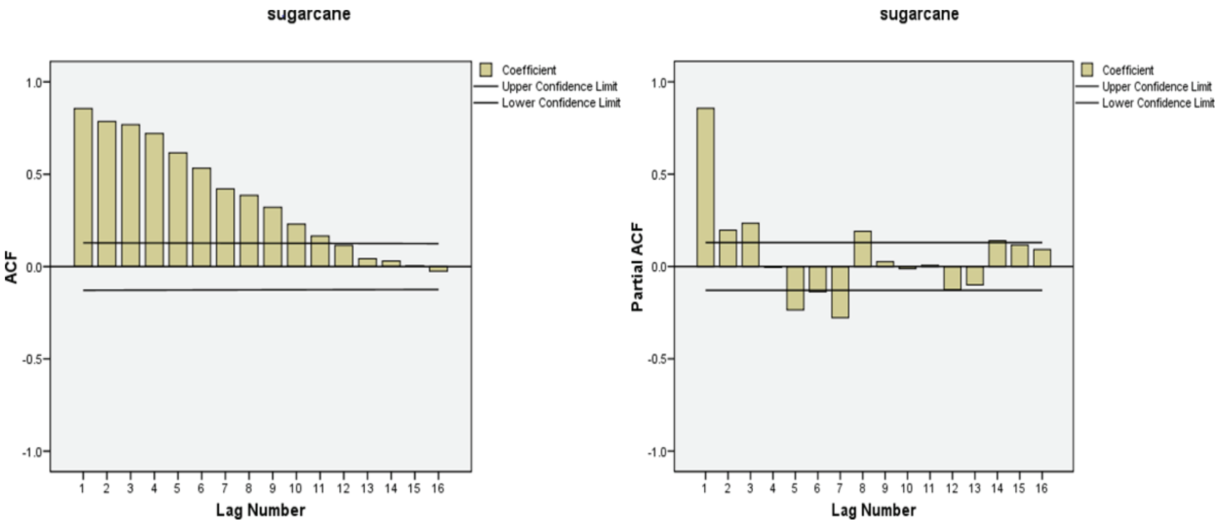

Fig. 2. Autocorrelation Function and Partial Autocorrelation Function for the monthly export price of sugarcane in India.

Consequently, many transformations are employed, and it is determined that differencing the series is the best appropriate transformation. To achieve stability of the series, the original series is detrended by taking its first differences. The time series for the first differenced series in Figure 3 clearly demonstrates the existence of seasonal trends. Upon analysing the autocorrelation function and partial autocorrelation function of the first differenced series depicted in Figure 4, it is evident that the coefficients exhibit significant values at lag 12. This suggests the presence of a seasonal component with a duration of 12 units, as illustrated in Figure 5

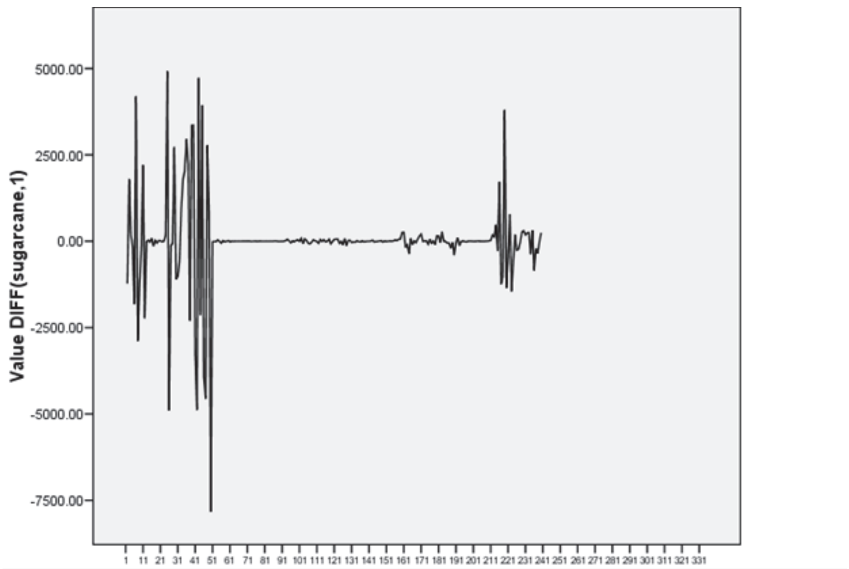

Fig. 3. Time series plot of the first differences of monthly export Price of sugarcane in India.

To remove the effect of seasonal component to achieve a stationary series, the differences of the first differenced series at lag 12 are taken as follows: where $z_t = x_t - x_{t-1}$ is the first differenced series.

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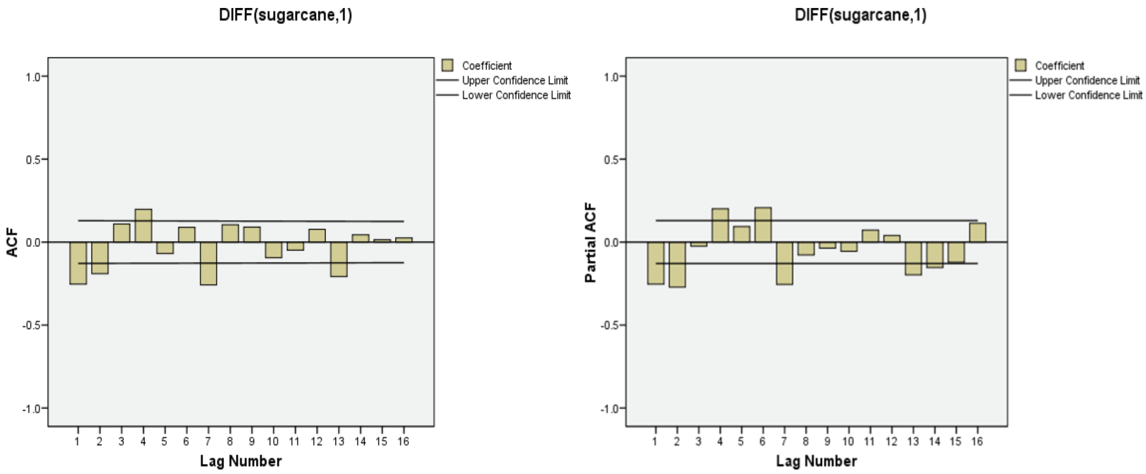

Fig. 4. Autocorrelation Function and Partial Autocorrelation Function of the first differenced monthly export Price of Sugarcane in India

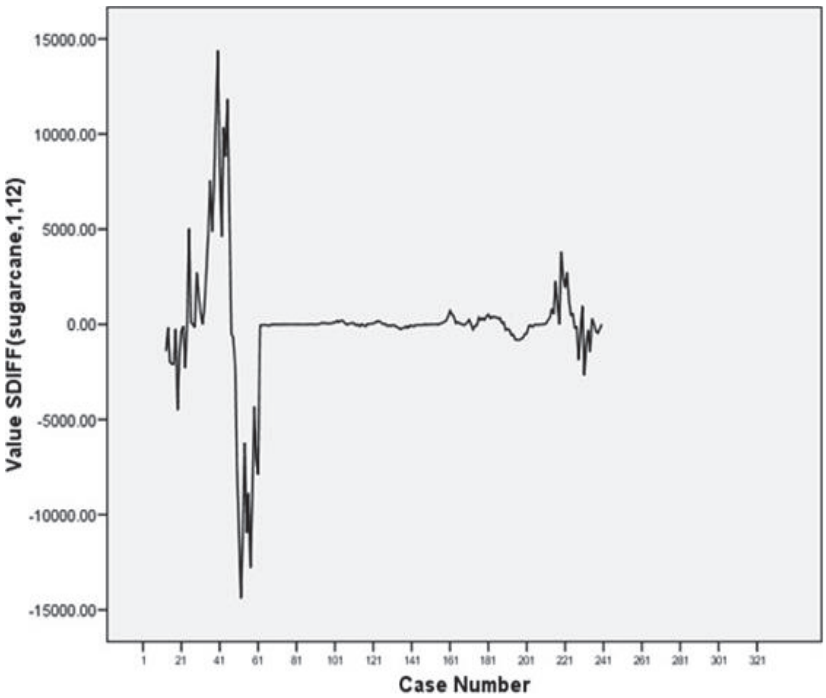

Fig. 5. Time series plot for the first differenced series at lag 12

Subsequently, the ACF and PACF analysis are done to check the time series data is stationary or non-stationary. The Figure 6 clearly shows that the time series data is after differencing the series at lag 12 specifies non-stationary because most of the lines are not in under control.

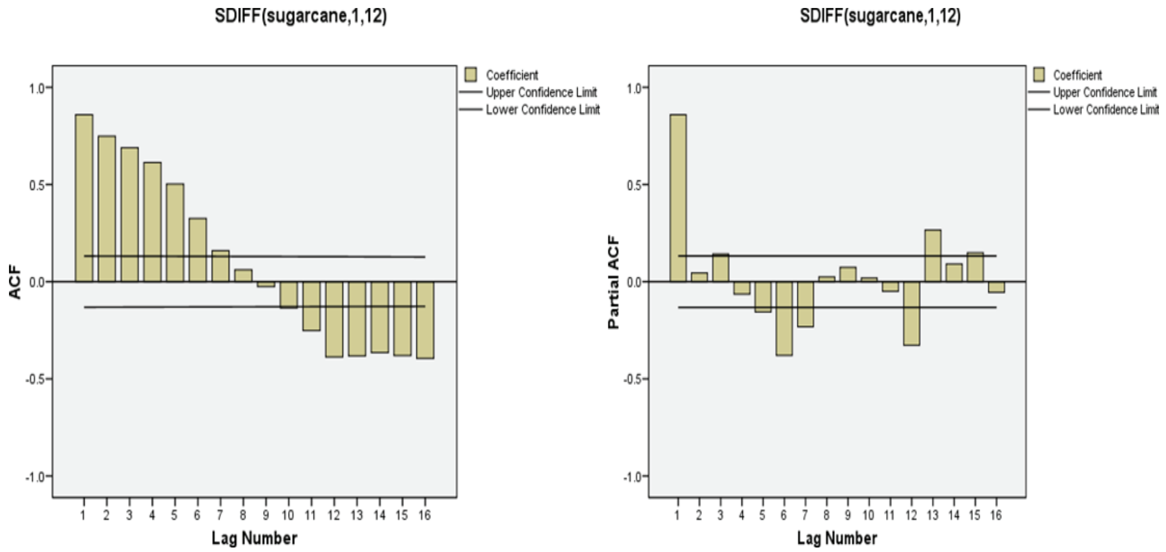

Fig. 6. The autocorrelation function partial autocorrelation function for the first differenced series at lag 12.

2.7 Model Identification

This section outlines the methodology for determining the order of the seasonal ARIMA model and identifying the specifications of the model. The ACF and PACF are included, along with the BIC, RMSE, MAPE and MAE (Mean Absolute Error) criterion. When selecting and estimating the model, it is essential to take into account the seasonal fluctuations based on the autocorrelation coefficients and the partial autocorrelation coefficients of the series. The most suitable model by expert modeller method (SPSS Program) for the monthly exports of sugarcane in India is SARIMA (0, 1, 1), (0, 0, 0)^{12} model.

2.8 Parameters estimation

Since it is concluded previously, that the SARIMA (0, 1, 1), (0, 0, 0)^{12} model is the best model, the parameters had been estimated using the method of maximum likelihood estimation is the best and most appropriate method of estimation. The results of the parameters estimation of the model are shown in the Table 1.

Table 1. Parameter estimates of SARIMA (0, 1, 1), (0, 0, 0)12 model estimates & model coefficients

Stationary $\boldsymbol{R^2}$	$\boldsymbol{R^2}$	RMSE	MAPE	Max APE	MAE	Max AE	Normalized BIC
0.0899	0.125	2158.22	320.55	23356.196	765.072	1133.165	15.377

Coefficients	Estimate	SE	t-value	Sig.
MA lag 1	0.332	0.061	5.432	0.000

It is shows that the p-value for the parameter MA 1 coefficients are less than α=0.05. This indicates that the coefficients are significantly different from zero. Therefore, in addition it reveals that this model is appropriate. Thus, the final model is SARIMA (0, 1, 1), (0, 0, 0)^{12} can be expressed as, $(1-B^{12})$, $(1-B)r_t$= (1-0.332B)ε_t.

2.9 Diagnostic tests

Prior to accepting a fitted model and interpreting its findings, it is crucial to verify if the model is accurately described, meaning that the model assumptions are corroborated by the data. If certain fundamental assumptions appear to be disregarded, it is necessary to define, apply, and reevaluate a new model repeatedly until a model that adequately corresponds to the data is identified. Here, the quality of the model is assessed. The model diagnostics for the resulted SARIMA (0, 1, 1), (0, 0, 0)^{12} indicated above also been checked.

3 Analysis of residuals

Figure 7 shows the estimated autocorrelation function and partial autocorrelation function for the residuals of the model SARIMA (0, 1, 1), (0, 0, 0)^{12}. The autocorrelation function and partial autocorrelation function parameters consistently fall within the confidence bounds for all time delays. Furthermore, the ACF and PACF parameters exhibit values near 0 for all time lags, indicating the stability of the time series.

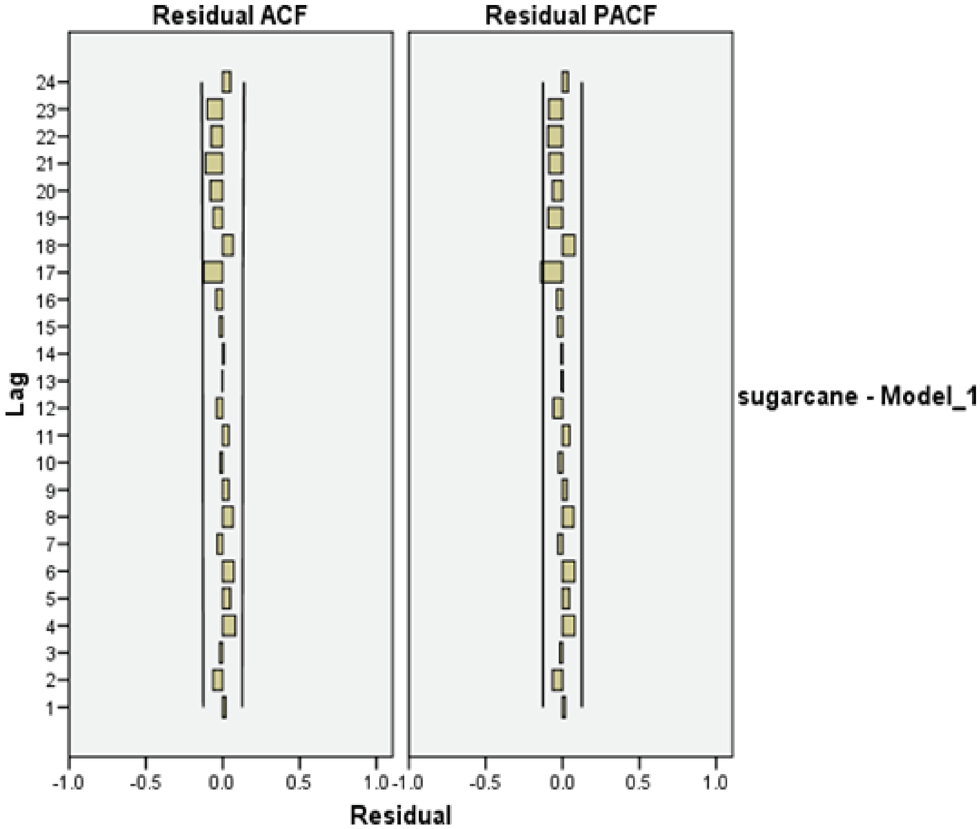

Fig. 7. ACF and PACF of residuals for monthly export price of sugarcane in India.

After finding the final model SARIMA (0, 1, 1), (0, 0, 0)^{12} of the data of the monthly export price of sugarcane in India that has been discussed above which can be expressed in equation (1), the researcher used it for predicting future export price of sugarcane in India. The forecasting of time series for monthly export price of sugarcane in India have been plotted in Figure 8.

The Figure 8, shows that the resulted series of forecasted values for the years 2014 to 2017 follows the same behaviour of the original series of monthly export price of sugarcane in India. The results of the forecasted values in Table 2 for the years 2018-2020 are all between the upper and lower boundaries of the 95% confidence internals. This authorizes that the forecasting is very efficient.

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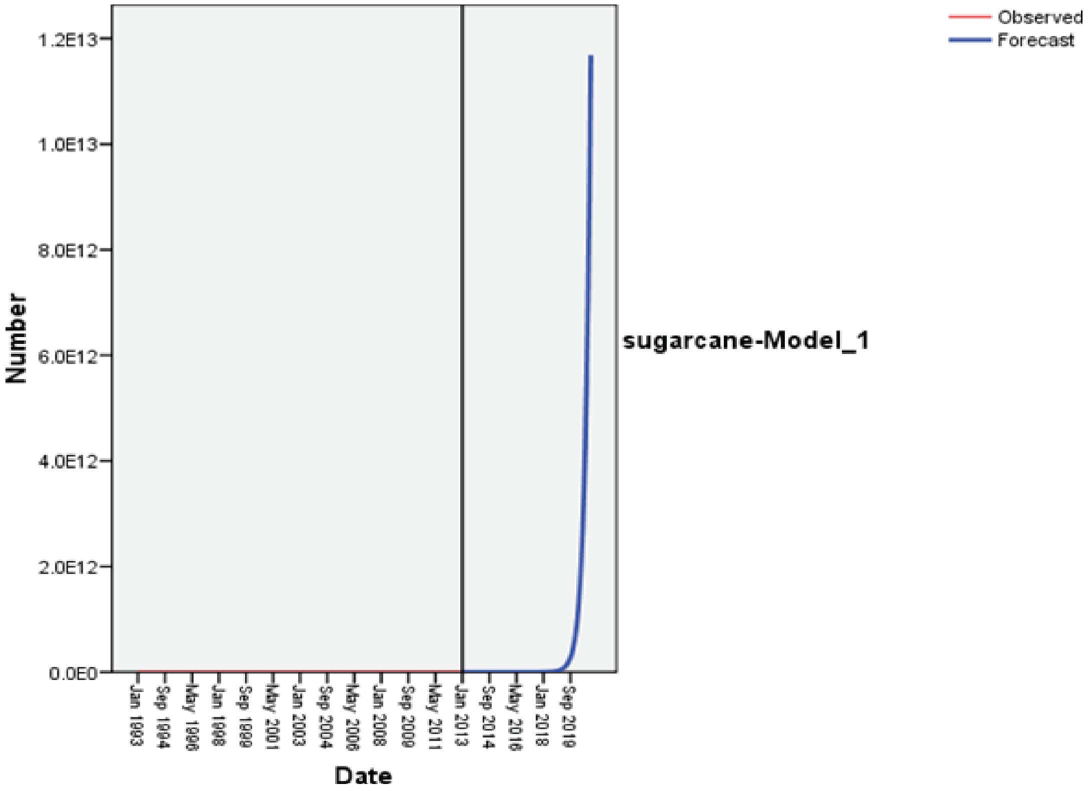

Fig. 8. The representation of the forecasted data.

Table 2. Forecast future value with the lower and upper 95% confidence interval

YEAR 2018	Month	1	2	3	4	5	6
	Forecast (in Crores)	1.86E9	2.39E9	3.07E9	3.94E9	5.07E9	6.50E9
YEAR 2018	Month	7	8	9	10	11	12
	Forecast (in Crores)	8.35E9	1.07E10	1.37E10	1.76E10	2.26E10	2.91E10
YEAR 2019	Month	1	2	3	4	5	6
	Forecast (in Crores)	3.73E10	4.80E10	6.16E10	7.91E10	1.01E11	1.30E11
YEAR 2019	Month	7	8	9	10	11	12
	Forecast(in Crores)	1.67E11	2.14E11	2.75E11	3.53E11	4.54E11	5.83E11
YEAR 2020	Month	1	2	3	4	5	6
	Forecast (in Crores)	7.48E11	9.61E11	1.23E12	1.58E12	2.03E12	2.61E12
YEAR 2020	Month	7	8	9	10	11	12
	Forecast (in Crores)	3.35E12	4.30E12	5.52E12	7.08E12	9.10E12	1.16E13

*E9: 109 and so on.

In summary, there is an uptrend in the Export price of sugarcane in India for the years 2018 -2020.

4 Conclusion

In this paper, the SARIMA technique is used to examine & forecast sugarcane export prices in India. To achieve stability in the series, the first-order differencing is used to remove the general trend, and differences of lag 12 are used to remove the seasonal changes. The SARIMA (0,1,1) $(0,0,0)^{12}$ is found to be the best model by the expert modeler method and additionally confirmed by the parameter estimation. The monthly export price of sugarcane in India from 2018 to 2020 falls within the 95% confidence interval, making it valuable for agriculturists and decision-makers in making informed decisions and assessing trends.

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