FOREACASTING OF COTTON PRICES IN MAJOR PRODUCING STATES USING ARIMA

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ABSTRACT

Cotton is a very important commercial crop in Indian economy. India is one of the largest producer, consumer and exporter of cotton in the world. There is cotton price fluctuation from time to time due to which forecasting of cotton prices is an inevitable need which shall help the policy makers in addressing all concerns relating to its production and acreage under cultivation. Hence, the main objective of the research paper is to forecast cotton prices using secondary data pertaining to a period of 10 years from 2010-2020. The analysis of the data and thereon the prediction of cotton prices for the harvest months of 2021 (October'21 – January'22) has been done using Auto Regressive Integrated Moving Average (ARIMA) technique. The sample time series data pertains to four major cotton producing states of India, i.e. Gujarat, Maharashtra, Karnataka and Madhya Pradesh. The monthly price data relating to the states has been collected from the AGMARKNET website under the Ministry of Agriculture; Government of India. The estimation of model parameters has been done using the EViews software. The performance of the model was gauged by analysing and comparing various measures like Akaike Information Criteria (AIC), Adj R2,, volatility and significant coefficients. The results predict that the market prices of cotton in India would be ruling in the range of Rs 4869 – Rs 5973 per quintal in the kharif harvesting season, 2021-2022.

Key Words: ARIMA, Cotton, forecasting, time series, production, AIC, kharif

INTRODUCTION

Cotton is a creamy white soft fibre, which plays a dominant role in the agricultural and industrial economy. It is commonly used in the production and manufacturing of textiles and garments throughout the world. Apart from this, even the by-products of cotton have a number of ends uses. Cotton is a tropical as well as a labour-intensive cash crop. It is an appealing crop for the arid regions because of its quality of being drought tolerant. It is the Asian countries who dominate the cotton production and are also considered to be one of the biggest consumers of cotton. According to the latest US department of agriculture (USDA) report, global cotton consumption is expected to grow by 4.1 % in the year 2021-2022. The major cotton producing countries are India, Brazil, Pakistan, China, Turkey, Turkmenistan, Australia and Uzbekistan. Amongst the countries, India is the second largest producer of cotton which has the maximal area under cotton cultivation as compared to the world economy. The states which specialize in cotton production are western states like Maharashtra, Gujarat; southern states like Andhra Pradesh, Karnataka, Tamil Nadu; and northern states like Rajasthan, Madhya Pradesh and Punjab. Indian productivity is around 300 kg per hectare which is very low as compared to the world productivity of 500 kg per hectare. India is also a major exporter of cotton apart from being the major producer and consumer. Cotton is a cash crop, but the fluctuating prices of cotton largely dependent upon the quantum of production often pose a significant risk to all the stakeholders who are involved in the cotton production and marketing chain. Thus, forecasting of cotton prices becomes essentially important.

This paper has applied univariate time series models known as the ARIMA (Auto Regressive Integrated Moving Average) models, to forecast the prices of cotton. ARIMA models are considered powerful as they help in predicting future outcomes on the basis of observed data and that too with maximum accuracy and minimal

forecasting error. These models do have certain limitations in terms of its applicability in agriculture due to data constraints and their inability to incorporate dynamic factors like rainfall etc. in affecting agricultural crops.

LITERATURE REVIEW

In this context, it is worth mentioning some studies and research papers which have made use of ARIMA modeling for forecasting prices of agricultural commodities. Using ARIMA models , Hossain et al.(2006) forecasted prices of three varieties of pulses namely mash, moong and motor using time series data of twelve years; Darekar et al(2016) forecasted onion prices in Western Maharashtra; Jishnu et al(2017) forecasted prices of cotton in Kesinga market of Odisha, India; Darekar and Reddy (2017) forecasted cotton prices in major producing states in India & also forecasted maize and groundnut prices in major producing states in another study; Kumar et al(2019) forecasted jute prices in Murshidabad market of West Bengal ; Areef et al(2020)forecasted onion prices in Kurnool market of Andhra Pradesh ;Kumar and Baishya (2020) forecasted potato prices in India using time series data of eighteen years relating to six states in India. The survey of literature is suggestive of the fact that there have been very few or minimal studies on forecasting cotton prices in India using ARIMA model. Hence, the research paper intends to plug the gap in existing literature by conducting research on forecasting cotton prices (specifically in the harvest months) in major cotton growing states.

DATA & METHODOLOGY

Data:

The study is carried out based on daily price of cotton per quintal in four major states in India i.e., Gujarat, Maharashtra, Karnataka, Madhya Pradesh from 2010-2020. The secondary data was collected from the website of Agricultural Market Network (AGMARKNET) under Ministry of Agriculture, Government of India. The time series data was modelled using Box-Jenkins's method, through Autoregressive Integrated Moving Average (ARIMA) model.

Methodology:

ARIMA method is used for forecasting variables by using the information obtained from the variable itself to forecast the trend. The variable is regressed upon its past values. Two underlying assumptions of ARMA model are stationarity for AR model and invertibility for MA model. As most of the finance series are non-stationary, it has to go through a differencing process to become stationary known as integration. ARMA model applied on an integrated series known as ARIMA model. An ARIMA model is represented by ARIMA*(p,d,q)* where order of auto regression, integration and moving average is represented by *p, d, q* respectively. An ARMA *(p,q)* process can be represented by the following equation;

$$Y_t = a + \sum_{i=1}^{p} b_i y_{t-i} + d_0 u_t + \sum_{j=1}^{q} d_j u_{t-j} \qquad \text{(i)}$$

Where Y_t = Price of Cotton at time't'; a = constant term; U = white noise error term; p = lags of dependent variable; q = lags of error term.

An ARIMA model involves four steps; identification, estimation, diagnostic checking and forecasting. In the identification stage, order of autoregression, integration and moving average p,d,q are determined and based on that ARIMA models are developed. Estimation stage involves estimating various models developed at the identification stage and choosing the most appropriate model based on various criterions like significance of coefficients, volatility, adj R^2 and AIC values. After identifying the appropriate model, diagnostic checking has

to be done for fitness of the model and if need arises, the model has to be re-estimated by including more criteria. The effort will be to have a parsimonious model instead of an over parameterised model. Then at the last step, forecasting is done by using the most appropriate model and forecasting done is validated. Price forecasts of kharif season of 2021 was done for four major cotton producing states and it was averaged to forecast expected minimum, maximum and modal prices of cotton for India. The Kharif season has been taken as the duration from October 2021-January 2022.

EMPIRICAL RESULTS AND DISCUSSION

1. Model Identification

Correlograms of average monthly maximum, minimum and modal price series data of cotton from 2010-2020 were plotted at level and first difference to observe values of *p* and *q*. Based on the spikes observed in ACF and PACF, different possible ARIMA models are identified and estimated. Details of the ARIMA models identified to forecast minimum, maximum and modal prices for the state of Gujarat, Maharashtra, Madhya Pradesh and Karnataka respectively are provided in Table 1.

2. Model Estimation

Different ARIMA models identified in step 1 by observing correlograms are estimated. The appropriate ARIMA models were selected based on model having highest number of significant coefficients, higher adjusted R^2, lowest volatility and lowest AIC. Following aforesaid criteria ARIMA (1,0,13), ARIMA (12,1,4), ARIMA (12,1,4) models are selected for forecasting minimum, maximum and modal prices for state of Gujarat. Similarly, ARIMA (1,0,1), ARIMA (2,0,1) and ARIMA (1,0,1) have been opted for forecasting minimum, maximum and modal prices for state of Maharashtra. For forecasting prices for Madhya Pradesh ARIMA (4,1,4), ARIMA (11,1,1) and ARIMA (4,1,11) are selected. Lastly ARIMA (1,1,2), ARIMA (1,1,2) and ARIMA (4,1,1) have been chosen for forecasting prices of Karnataka. Detailed model estimation is provided in Table 1.

Table 1: Identification of ARIMA Models

	Significant coefficients	Adj. R2	Sigma^2 (Volatility)	AIC
		Gujarat: Min Price		
ARIMA (1,0,1)	0	0.14	0.0005	14.99
ARIMA (1,0,13)	**1**	**0.24**	**0.0003**	**14.92**
		Gujarat : Max Price		
ARIMA (12,1,4)	**1**	**0.17**	**0**	**14.72**
ARIMA (12,1,12)	0	0.28	0.1393	14.75
		Gujarat : Modal Price		
ARIMA (12,1,4)	**1**	**0.29**	**0**	**14.73**
ARIMA (12,1,12)	2	-0.08	0	15.06
ARIMA (13,1,4)	0	0.09	0	14.92
ARIMA (13,1,12)	0	0.54	0.97	14.65
		Maharashtra Min Price		
ARIMA (1,0,1)	**1**	**0.54**	**0.01**	**15.01**
ARIMA (2,0,2)	0	-0.15	0.99	15.91
		Maharashtra Max Price		
ARIMA (1,0,1)	1	0.72	0.02	14.64

ARIMA (2,0,1)	**2**	**0.72**	**0.01**	**14.64**
		Maharashtra Modal Price		
ARIMA (1,0,1)	**1**	**0.64**	**0.02**	**14.8**
ARIMA (2,0,2)	0	-0.16	0.99	15.95
		Madhya Pradesh Min Price		
ARIMA (4,1,4)	**1**	**0.17**	**0.0007**	**14.76**
ARIMA (11,1,4)	0	0.035	0.999	15.13
		Madhya Pradesh Max Price		
ARIMA (1,1,1)	1	0.2	0.98	15.08
ARIMA (11,1,1)	**1**	**0.31**	**0**	**14.95**
ARIMA (1,1,11)	1	0.54	0.99	14.89
ARIMA (11,1,11)	0	0.52	0.99	15
		Madhya Pradesh Modal Price		
ARIMA (4,1,4)	1	0.12	0.0002	14.95
ARIMA (4,1,11)	**1**	**0.24**	**0.0054**	**14.86**
ARIMA (11,1,4)	1	0.21	0.0003	14.88
ARIMA (11,1,11)	0	0.18	0	14.94
		Karnataka Min Price		
ARIMA (1,1,1)	1	0.45	0.0022	15.73
ARIMA (1,1,2)	**1**	**0.43**	**0.0011**	**15.79**
		Karnataka Max Price		
ARIMA (1,1,1)	0	0.55	0.98	16.37
ARIMA (1,1,2)	**1**	**0.54**	**0.0049**	**16.41**
		Karnataka Modal Price		
ARIMA (1,1,1)	1	0.42	0.0003	15.69
ARIMA (1,1,2)	2	0.41	0.0004	15.72
ARIMA (4,1,1)	**2**	**0.47**	**0.0005**	**15.63**
ARIMA (4,1,2)	1	0.15	0.0012	16.09

Source: Author's own calculation using Eviews

3. *Diagnostic Checking*

In order to ensure that no information is left uncaptured in the model correlogram ,Q statistics of residuals are plotted. The ideal correlogram of the residuals shall be flat which means they should lay within 95% confidence interval. Figures are provided in the appendix table 1,2,3 & 4. It can be observed that correlogram of residuals for all the selected ARIMA models are flat indicating selection of appropriate model.

4. *Forecasting*

Minimum, Maximum and Modal Prices for the 2020-21 Kharif season i.e from October'21 to January'22 for the state of Gujarat, Maharashtra, Madhya Pradesh and Karnataka are forecasted by using the selected ARIMA Models. Details of the forecasting is placed at Table 2. Based on the forecasted prices for the four states, it is estimated that average minimum price for India during kharif season will be Rs 4869 per quintal, average maximum price will be Rs 5973 per quintal and Modal price of the cotton will be around Rs 5556 per quintal. To know the accuracy of the forecast, the forecast graphs are checked to see whether it falls within ± 2 standard error or 95% C.I. Graphs are displayed in appendix table 5 to 8, which clearly proves the relative accuracy of the forecasts.

Table 2: Forecasting Cotton Prices for Kharif Season - 2021

	Gujarat			Maharashtra		
	Min. Price	Max. Price	Modal Price	Min. Price	Max. Price	Modal Price
Oct'21	4790	5846	5528	4845	5353	5111
Nov'21	4633	6171	6030	4774	5315	5052
Dec'21	4272	6044	5785	4724	5245	5001
Jan'22	4283	6033	5721	4690	5215	4957
Avg	4494	6024	5766	4758	5282	5031

	Madhya Pradesh			Karnataka		
Oct'21	5260	5937	5718	5026	6336	5381
Nov'21	5225	6079	5930	5060	6331	5587
Dec'21	5126	6332	5954	5105	6455	5545
Jan'22	4955	6421	5995	5140	6450	5597
Avg	5142	6192	5899	5083	6393	5528

Indian Average	**4869**	**5973**	**5556**

Source: Author's own calculation using Eviews

CONCLUSION

Indian economy in the neoliberal era today is characterized by a free market economy wherein determination of commodity prices is dependent upon the market forces. To add to this, both domestic and global demand-supply conditions influence the pricing mechanism of commodities. This certainly has added an element of uncertainty in the agricultural sector. More so over, the volatility in prices of a no of agricultural commercial crops is certainly and has always been a cause of concern for all the farmers and stakeholders who are involved in the production and supply chain process. Under this circumstance, the decision of a farmer pertaining to area and quantity of cultivation of a crop can be taken in the right direction if there is proper information dissemination to the farmers' prior hand. One such method is by forecasting future prices (harvest month prices) which shall enable the farmers in making right choice of crops.

This research paper makes an attempt in this regard and has used the historical monthly prices of cotton in four major cotton producing states to forecast future prices for the harvest months (October – Jan) by using Box-Jenkins ARIMA modelling. Even though this method has its own limitations in making perfect forecasts yet the model has been used by many researchers to forecast future crop prices. The ARIMA model makes use of historical time series data to make necessary extrapolations and it is mostly suggestive of the fact that actual market price may not be the same as the forecasted price.

In the present paper, the forecasts are indicative of narrow variations in between the actual and forecasted values of prices of cotton in the selected states. The forecasts of the model shows that the market prices of cotton would be ruling in the range of Rs 4869 – Rs 5973 per quintal in the kharif harvesting season,2021-2022. The prices(modal) of cotton in the market during the harvesting period would be high in Madhya Pradesh (Rs. 5899) and Gujarat (Rs.5766). The modal prices would be comparatively lower in Karnataka (Rs. 5528 and Maharashtra (Rs. 5031)respectively. The modal price for cotton in India would be Rs.5556 as per the

estimations of ARIMA model. The Government has announced the cotton minimum support price as Rs.5515 per quintal (medium staple cotton) for 2020-2021.Thus the forecasted price of cotton can be used by the farmers and the policy makers in taking timely decisions accordingly. In real scenario, the possibility of deviation of actual prices from the predicted prices cannot be ruled out in light of the changes in many determinants in the global economy. Given that the model is making estimations on past values of variables, the accuracy of information might vary in real.

SUGGESTIONS

The farmers in Indian economy are unable to take informed decisions on acreage under commercial crops like cotton because of high price instability. Hence, the acreage decision pertaining to a crop can be suitably taken through the help of price forecasting tools which can enable the famers in taking decisions before the sowing of the crop.

However, the government can ensure changes in procurement policy in a need-based manner so that the farmers can avail assured price for their produce. There should also be more expansion of facilities in the regulated market yards and the provisioning of agricultural credit should be strengthened in the village areas. Appropriate extension programs should be conducted to spread awareness amongst the cotton farmers. Along with government support, forecasting of cotton prices will be definitely helpful not only to the producers and consumers but also to the other stakeholders in cotton trading especially in the prime cotton growing areas of the country.

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Appendix Tables : Model Validations by Correlogram of Residuals of ARIMA models selected for prices

Table 1 : Correlogram of Residuals of ARIMA models selected for prices - Gujarat

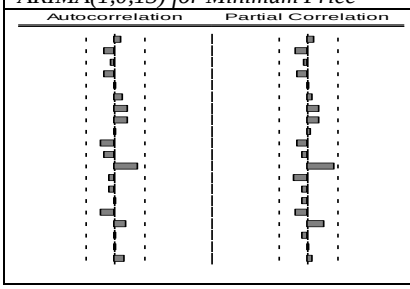
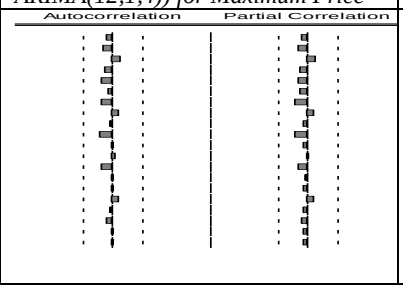
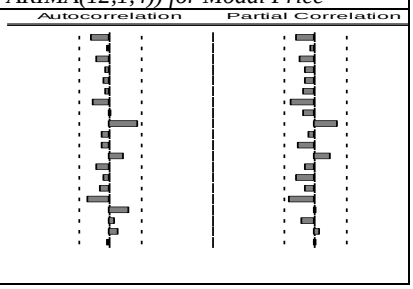
Correlogram Q stat of residuals of ARIMA(1,0,13) for Minimum Price	*Correlogram Q stat of residuals of ARIMA(12,1,4)) for Maximum Price*	*Correlogram Q stat of residuals of ARIMA(12,1,4)) for Modal Price*
		

Table 2 : Correlogram of Residuals of ARIMA models selected for prices - Maharashtra

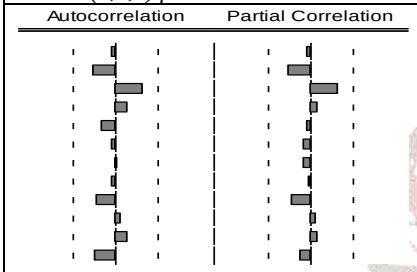
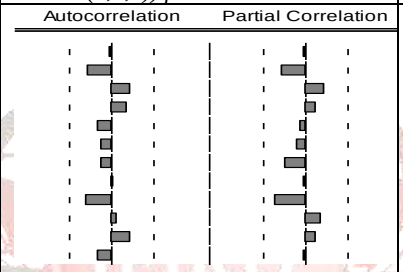
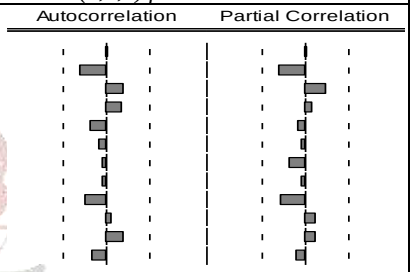
Correlogram Q stat of residuals of ARIMA(1,0,1) for Minimum Price	*Correlogram Q stat of residuals of ARIMA(2,0,1)) for Maximum Price*	*Correlogram Q stat of residuals of ARIMA(1,0,1) for Modal Price*
		

Table 3 : Correlogram of Residuals of ARIMA models selected for prices – Madhya Pradesh

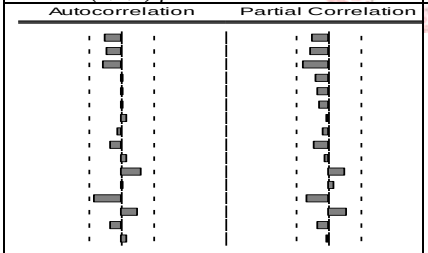
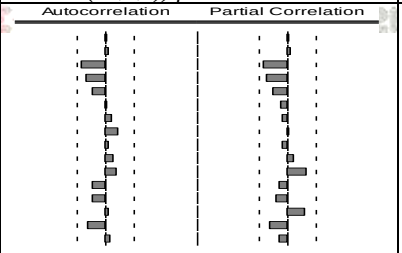
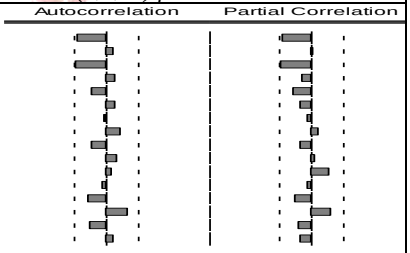
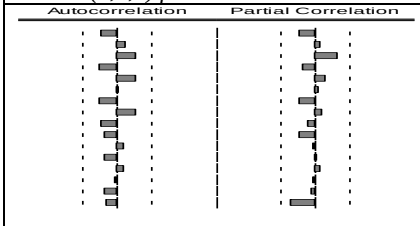
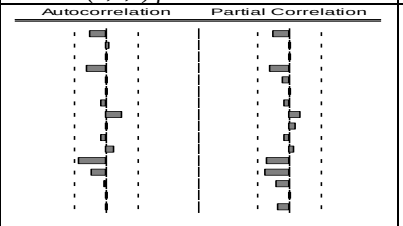
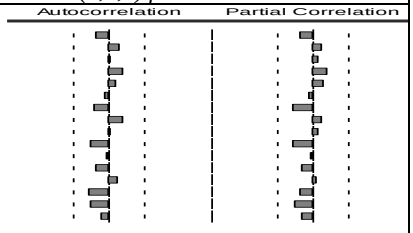
Correlogram Q stat of residuals of ARIMA(4,1,4) for Minimum Price	*Correlogram Q stat of residuals of ARIMA(11,1,1)) for Maximum Price*	*Correlogram Q stat of residuals of ARIMA(4,1,11) for Modal Price*
		

Table 4 : Correlogram of Residuals of ARIMA models selected for prices – Karnataka

Correlogram Q stat of residuals of ARIMA(1,1,2) for Minimum Price	*Correlogram Q stat of residuals of ARIMA(1,1,2) for Maximum Price*	*Correlogram Q stat of residuals of ARIMA(4,1,1) for Modal Price*
		

Source: Author's Calculation Using Eviews software

Appendix Tables : Forecast Validation Graph

Table 5: Forecast Validation Graph - Gujarat

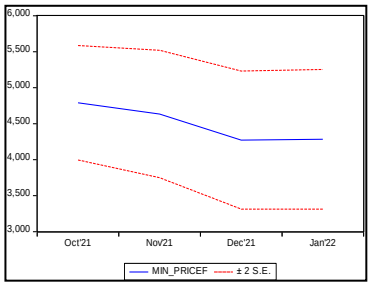
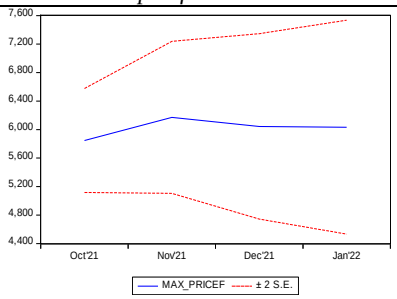
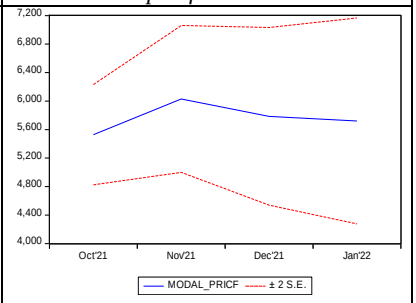
Forecast Graph of Minimum Price	*Forecast Graph of Maximum Price*	*Forecast Graph of Modal Price*
		

Table 6 : Forecast Validation Graph - Maharashtra

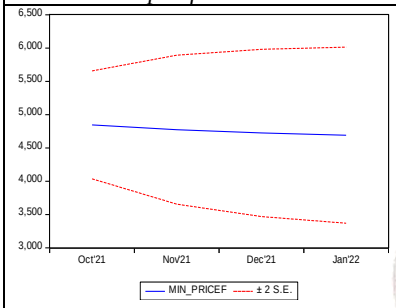
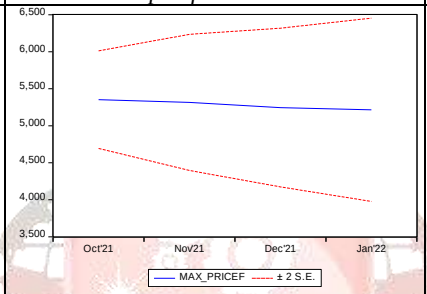
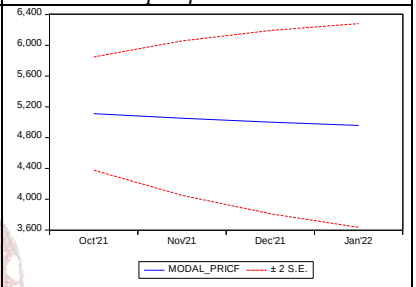
Forecast Graph of Minimum Price	*Forecast Graph of Maximum Price*	*Forecast Graph of Modal Price*
		

Table 7: Forecast Validation Graph – Madhya Pradesh

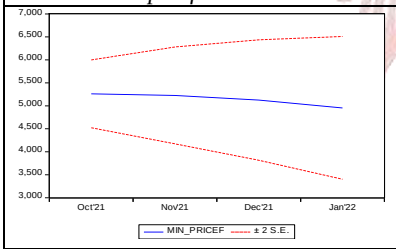
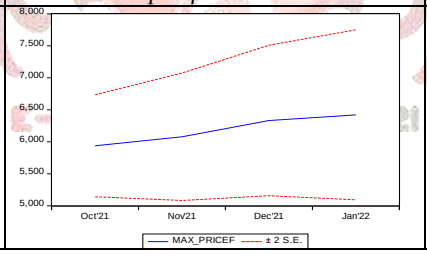
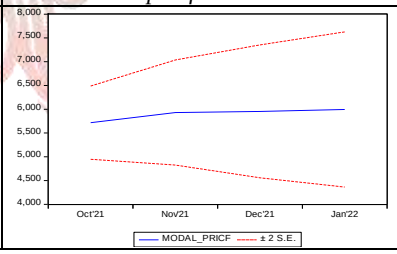
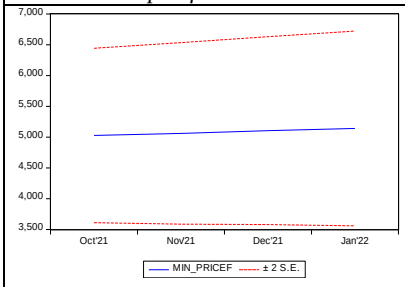
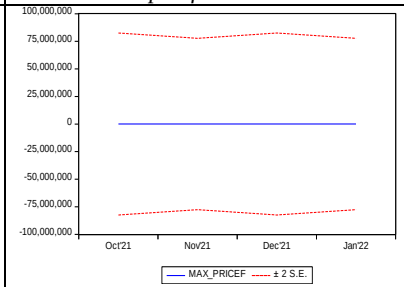
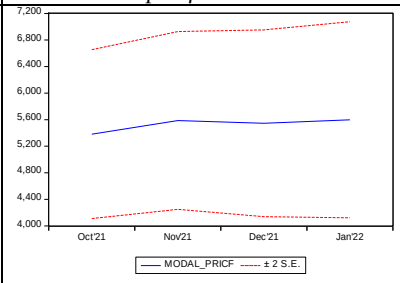
Forecast Graph of Minimum Price	*Forecast Graph of Maximum Price*	*Forecast Graph of Modal Price*
		

Table 8 : Forecast Validation Graph – Karnataka

Forecast Graph of Minimum Price	*Forecast Graph of Maximum Price*	*Forecast Graph of Modal Price*
		

Source: Author's Calculation Using Eviews software