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Forecasting the arrivals and prices of soybean in Chhattisgarh plains

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Abstract
Under agricultural sector in India Oilseed crops have diverse area. In the State of Chhattisgarh, the oilseed crops, namely, groundnut, sunflower, niger, sesame, Soybean, linseed, mustard-rapeseed are grown in its different parts. Soybean occupies first position both in area and production among oilseeds in Chhattisgarh. It is grown mainly in Chhattisgarh Plains. For the development of agriculture it is quite necessary that farmers get good prices of their products in the agricultural markets. If there could be some forecast of arrivals and prices, the farmer would be benefitted in terms of selling its products. With the help of forecasting of arrivals and prices, farmers of this State could find the forecast for the specific month in which they get high and remunerative price of their produce. To get a good idea of the arrivals and prices of oilseeds varying over the time, it is necessary to study the time series patterns of arrivals and prices of Soybean over the years in Chhattisgarh Plains. Using the data collected in this study, different linear, non-linear and time series models are fitted for both variables in Chhattisgarh Plains, and best model based forecasts were made to fulfil the requirements of planners and farmers.

Keywords: Arrivals, prices, soybean, Chhattisgarh plains

Introduction
Oilseed crops play a very important role in the agricultural economy of India which has the distinction of large area under oilseed crops. The diverse agroecological conditions in the country are favourable for growing nine types of oilseeds. Out of these the seven edible oilseeds include the crops groundnut, rapeseed-mustard, Soybean, sunflower, sesame, safflower and niger seed while two non-edible oilseeds include the crops castor and linseed. Oilseeds occupy about 13% of gross cropped area and account for nearly 3% of gross national product (GNP) and 10% of the value of all agricultural commodities. In the State of Chhattisgarh, the seven oilseed crops, both edible and non-edible, namely, groundnut, sunflower, niger, sesame, Soybean, linseed, mustard-rapeseed are grown in its different parts. Soybean occupies first position both in area and production among all oilseeds in Chhattisgarh. The Soybean is one of the most important vegetable protein providing crops for millions of people across the world and is also ingredients for hundreds of chemical products.
For the development of agriculture it is quite necessary that farmers get good prices of their products in the agricultural markets. Therefore, the trends in market arrivals of commodities are useful in forecasting the arrivals and prices of the commodities for the betterment of farmers, governments, and agribusiness industries.
With the help of forecasting of arrivals and prices of Soybean, farmers of this State would find the forecast for the specific month in which they get high and remunerative price of his/her produce. This study aims at collecting the data of arrivals and prices of agricultural markets of Chhattisgarh Plains for Soybean, where data could be obtained. Using these data, different linear, non-linear and time series models have been fitted for Arrivals and Prices of Soybean in Chhattisgarh Plains, and best model based forecast has been attempted to fulfil the requirements of planners and farmers.

Materials and Methods
The time series data on the monthly arrivals and prices of Soybean have been collected from the records of the Agricultural Products Market Committees and the website of Chhattisgarh State Agricultural Marketing (*Mandi*) Board, http://agriportal.cg.nic.in/agrimandi/ or

http://cg.nic.in/agrimandi/. The data have been collected for the study period, i.e. 2010 to 2019 (10-years). For the study of arrivals and prices of Chhattisgarh Plains, the data for monthly arrivals and prices of Soybean have been obtained by summing up the monthly arrivals and averaging the monthly prices over different constituent markets for the period from 2010-2019. In the present study, Statistical analyses have been carried out using the powerful software "R: The Project for Statistical Computing".

Various time series forecasting models have been fitted to the arrivals and prices of the Soybean crop for the Chhattisgarh Plains, namely, polynomial models of suitable degree in time variable. Additionally, some non-linear models emanating from such transformation as Compound function, Inverse function, Logarithmic function, Power function, Exponential function, growth function, S-curve function, Exponential smoothing, apart from Holt-Winters, Autoregressive Integrated Moving Average (ARIMA) models have also been fitted. All the above-cited models were fitted using various functions available in the R software packages, like *lm()* function in the 'base' package, *HoltWinters()* in the 'stats' package, *arima()* in 'stats' package and 'forecast' package.

An autoregressive integrated moving average (ARIMA) is a generalization of an autoregressive moving average (ARMA). The autoregressive (AR) part of the ARIMA model indicates a type of random process representing certain time-varying processes in nature, economics, etc., while the moving average (MA) part is the average attained over a particular period of cycle.

This AR(p), an autoregressive model of order p, can be defined as,

$$Y_t = \mu + \sum_{i=1}^{p} \Phi_i Y_{t-i} + \varepsilon_t \text{ ----------(3.2)}$$

where $\Phi_1, \ldots \Phi_p$ are the parameters of the model, μ is a constant, and ε_t is white noise

The general MA process of order q can be defined as,

$$Y_t = \mu + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} \text{ ----------(3.3)}$$

where μ is the mean of series, the $\theta_1 \ldots \theta_q$ are the parameters of the model and the $\varepsilon_t, \varepsilon_{t-1}, \ldots, \varepsilon_{t-q}$ are the noise error terms.

Now, combining the AR process with the MA process and integrating, with differencing step, to remove non-stationarity from the non-seasonal time series, the ARIMA is generally denoted by ARIMA(p,d,q), where parameters p, d, and q are non-negative integers, where p is the order of the autoregressive model, d is the degree of differencing, and q is the order of the moving-average model. Thus, the ARIMA(p,d,q) model can be represented by the following general forecasting equation:

$$Y_t = \mu + \sum_{i=1}^{p} \Phi_i Y_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon_t$$

For Arrivals and Prices of Soybean in Chhattisgarh Plains the best model will be that which have maximum R^2, minimum Mean Absolute Percentage Error (MAPE), minimum Mean Absolute Error (MAE), and minimum Root Mean Square Error (RMSE) criterion.

Results and Discussion

By fitting different linear and non-linear time series models, we got following results for arrivals of Soybean in Chhattisgarh Plains presented in the Table 1.

From the Table 1, although many linearized models have significant R^2 values, the ARIMA(1,0,1)(1,0,1)[12] model has been found to be the best from various model-goodness-criteria points of views. It has significant Ljung-Box statistic (P-value <0.000) and lowest AIC value (2953.5), as indicated above, among various models fitted apart from lowest error measures like RMSE (47227.7), MAE (32699.7) and MAPE (60.9). Thus, ARIMA model is chosen as best model for forecasting of Soybean arrivals in Chhattisgarh Plains.

Similarly, by fitting different linear and non-linear time series models as indicated above in Table 1, following results for prices of Soybean in Chhattisgarh Plains were obtained as presented in the Table 2.

From the Table 2, although many linearized models have significant R^2 values, the ARIMA(0,1,2)(1,0,1)[12] model has been found to be the best from various model-goodness-criteria points of views. It has significant Ljung-Box statistic (P-value <0.000) and lowest AIC value (1739.8), as indicated above, among various models fitted apart from lowest error measures like RMSE (344.6), MAE (249.1) and MAPE (10.5). Thus, ARIMA model is chosen as best model for forecasting of Soybean prices in Chhattisgarh Plains.

Table 1: Parameters of Fitted Model of Arrivals of Soybean in Chhattisgarh Plains

S.N.	Models	A	β_1	β_2	β_3	R^2 / Test-Statistics	P-Value / AIC	RMSE	MAE	MAPE
1.	Linearized Polynomial 1st order	-8172493$^{\$}$	4100.9$^{\$}$	-	-	R^2=0.02$^{\$}$	P=0.076	72121.6	57913.5	239.6
	2nd order	-1.3x10^{10} **	1.1x10^{7} **	-2799.1**	-	R^2=0.10**	P=0.001	69438.4	54413.2	246.1
	3rd order	56353.1**	-6547.2^{NS}	7696.3^{NS}	-777.4*	R^2=0.14***	*P*<0.000	68338.3	50570.3	232.0
2.	Linearized Compound	-156.3*	0.08*	-	-	R^2=0.05*	P=0.011	78054.6	58399.3	155.8
3.	Linearized Inverse	1.2x10^{-68} $^{\$}$	-1.6x10^{10} $^{\$}$	-	-	R^2=0.02$^{\$}$	P=0.075	72117.4	57907.6	239.5
4.	Linearized Logarithmic	-6.2x10^{7} $^{\$}$	8.2x10^{6} $^{\$}$	-	-	R^2=0.02$^{\$}$	P=0.075	72119.5	57910.5	239.6
5.	Linearized Power	-	167.4*	-	-	R^2=0.05*	P=0.011	78051.8	58395.5	155.8
6.	Linearized Exponential	1.2x10^{-68} *	0.08*	-	-	R^2=0.05*	P=0.011	78054.6	58399.3	155.8
7.	Linearized Growth	-156.3*	0.08*	-	-	R^2=0.05*	P=0.011	78054.6	58399.3	155.8
8.	Linearized	178.4**	-3.3x10^{-5}	-	-	R^2=0.05*	P=0.011	78049.0	58391.6	155.8

	S-curve									
9.	Exponential Smoothing	0.54	-	-	-	χ^2=1.92	*P*<0.000	66044.0	45987.0	75.4
10.	ARIMA (1,0,1)(2,0,0)[12]	-	-	-	-	χ^2=0.01	*P*<0.000 AIC=2953.5	47227.7	32699.7	60.9
Note: - Polynomial models upto 3rd order are significant.										
Notations:-										
*	Significant at 5% level of Significance									
**	Significant at 1% level of Significance									
***	Significant at 0.1% level of Significance									
$	Significant at 10% level of Significance									

Table 2: Parameters of Fitted Model of Prices of Soybean in Chhattisgarh Plains

S.N.	Models	α	β_1	β_2	β_3	R^2 /Test-Statistics	P-Value / AIC	RMSE	MAE	MAPE
1.	Linearized Polynomial 1st order	-192789.3***	96.83***	-	-	R^2=0.20***	*P*<0.000	546.3	433.0	21.5
	2nd order	-9.0x10^7 ***	89626.3***	-22.2***	-	R^2=0.27***	*P*<0.000	523.6	431.5	20.3
	3rd order	1066.81***	1240.9***	-298.7***	20.4***	R^2=0.62***	*P*<0.000	377.6	277.6	12.0
2.	Linearized Compound	2.6x10^{-45} ***	1.05***	-	-	R^2=0.27***	*P*<0.000	561.6	445.9	20.7
3.	Linearized Inverse	197502***	-3.9x10^8 ***	-	-	R^2=0.20***	*P*<0.000	546.1	433.0	21.5
4.	Linearized Logarithmic	-1.4x10^6 ***	1.9x10^5 ***	-	-	R^2=0.20***	*P*<0.000	546.2	433.0	21.5
5.	Linearized Power	-	110.3***	-	-	R^2=0.27***	*P*<0.000	561.5	445.9	20.7
6.	Linearized Exponential	2.6x10^{-45} ***	0.05***	-	-	R^2=0.27***	*P*<0.000	561.6	445.9	20.7
7.	Linearized Growth	-102.6***	0.05***	-	-	R^2=0.27***	*P*<0.000	561.6	445.9	20.7
8.	Linearized S-curve	118.1***	-2.2x10^5 ***	-	-	R^2=0.27***	*P*<0.000	561.5	445.9	20.7
9.	Exponential Smoothing	0.55	-	-	-	χ^2=0.90	*P*<0.000	358.3	262.2	11.0
10.	ARIMA (0,1,2)(1,0,1)[12]	-	-	-	-	χ^2=0.007	*P*<0.000 AIC=1739.8	344.6	249.1	10.5
Note: - Polynomial models upto 3rd order are significant.										
Notations:-										
*	Significant at 5% level of Significance									
**	Significant at 1% level of Significance									
***	Significant at 0.1% level of Significance									
$	Significant at 10% level of Significance									

After identification of the model, forecasting of arrivals and prices of Soybean has been done. The best ARIMA model has been used to forecast the arrivals and prices of Soybean in Chhattisgarh Plains for the period of Jan 2020 to Dec 2021 and the results so obtained are presented in the Table 3 and also depitcted in graph in Fig. 1 and Fig. 2.

Table 3: Forecasted values of arrivals and prices of Soybean in Kawardha market

Months	Predicted Arrivals (quintals)		Predicted Prices (Rs./quintal)	
	2020	2021	2020	2021
January	81529.35	87655.07	3294.98	3191.81
February	80507.95	85439.18	3162.55	3184.89
March	85209.04	89144.56	3060.53	3144.61
April	68336.20	71608.58	3047.17	3139.33
May	66702.03	69363.13	3167.61	3186.89
June	67038.09	69197.42	3124.53	3169.88
July	57578.90	59399.58	3110.11	3164.19
August	48027.20	49588.86	3109.17	3163.81
September	38240.76	39608.40	3080.52	3152.50
October	136175.62	136688.17	3130.72	3172.32
November	190583.12	190569.23	3136.59	3174.64
December	101487.87	101928.90	3216.29	3206.11

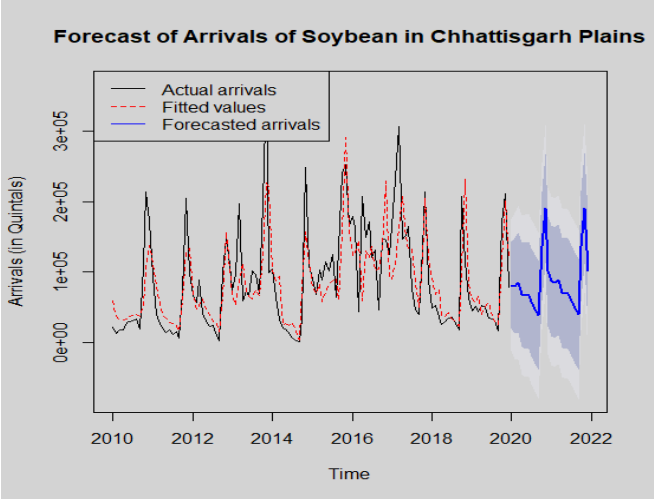

Fig 1: Forecasts of Arrivals of Soybean in Chhattisgarh Plains

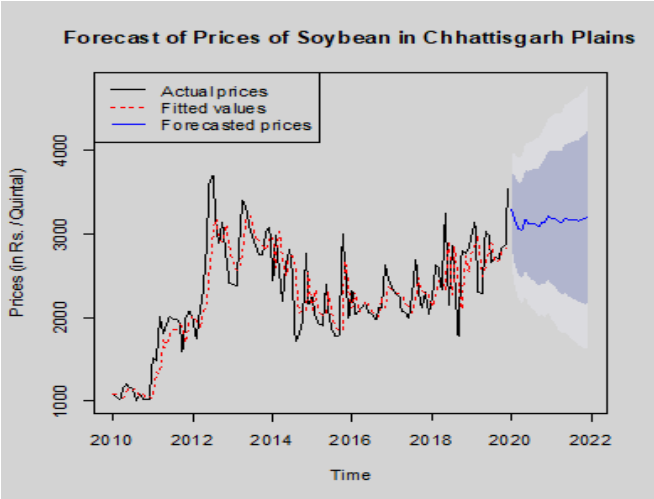

Fig 2: Forecasts of Prices of Soybean in Chhattisgarh Plains

From the Table 3, the highest forecasted arrivals of Soybean for Chhattisgarh Plains are expected to be 190583.12 quintals and 190569.23 quintals respectively in the months of November, 2020 and November, 2021 with respective for casted prices to be Rs. 3136.59/quintal and Rs. 3174.64/quintal. However, the maximum prices were found to be Rs.3294.98/quintal in the month of January, 2020 and Rs. 3206.11/quintal in the month of December, 2021.

Conclusion

Among the different models fitted, the model ARIMA(1,0,1)(1,0,1)[12] for arrivals and the model ARIMA(0,1,2)(1,0,1)[12] for prices have been found to be the best to forecasting the arrivals and prices of Soybean in Chhattisgarh Plains from various model-goodness-criteria points of views. Both variables have significant Ljung-Box statistic (P-value <0.000 for both arrivals and prices) and lowest AIC values (2993.5 for arrivals and 1739.5 for prices), among various models fitted, apart from lowest error measures like RMSE, MAE and MAPE, the values not being given here for brevity. In the study period, it was observed that the forecasted prices corresponding to highest arrival are very close to maximum prices within a close variation of months. Such a case is very beneficial to the farmers.

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