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Forecasting Tomato Price and Arrival Patterns in Krishi Upaj Mandis, Rajnandgaon, Chhattisgarh using ARIMA Models

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Seasonal indices are a statistical method using for explore of seasonal pattern of time series data. Twelve months ratio to moving average method is good for know about pattern of arrival and price around the year. The study was revealed that the peak arrivals season of tomato was found in month August (3084) to October (1767) and Peak price of tomato observed in the month Jun to August months of the year. In this study, for the use of farmers, traders and policy makers, we have made forecasts by most ARIMA Model (Box-Jenkins method) with the help of statistical package R (v 4.1) for a few years in which it was found that the highest arrivals and price in July-August

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months of the year. It is noticed that the positively relationship between price and arrivals of tomato in Krishi Upaj Mandi, Rajnandgaon, Chhattisgarh. Price of tomato was ranging from the minimum Rs.225/ qtl. to Rs. 9000/qtl. during the last eight years [year 2016-17 to Oct. 2023 (session 2023-24)]. The findings suggest that financial support for off-season protected cultivation and strategic planning in annual budgets can help mitigate price fluctuations.

Keywords: Seasonal analysis; ARIMA model; price fluctuations & predication; tomato.

JEL Code: C10, C53, D78

1. INTRODUCTION

"Tomato is a quickly perishable commodity. At present it is being seen that the price of tomato is very fluctuating a lot due to which the household budget of the common people is getting deteriorated. There is a demand for tomato throughout the year, without it the taste of home-made jaika gets spoiled. Tomato (*Solanum lycopersicum L*.) are produced and processed during two seasons across much of India: August to October (rainy season) and December to April (winter season). Where conditions suit, tomatoes are grown during the off season (summer season: May to July), including under protected cultivation, though given the low volumes of production, prices are often the highest during this period. Due to high fluctuations between seasons, growers do not always capitalize on the best price for the crop" (Reddy, A. A., 2018). In our state, it is grown in both kharif and rabi seasons, but it is mostly grown in rabi. But the demand for tomato remains throughout the year. The area of tomato in Chhattisgarh is 61.63 thousands ha. and production is 10.70 lakh MT. While the total area of tomato in Rajnandgaon district is 2.35 thousands ha. (3.83 per cent) and the production in 0.32 lakh MT (3.06 per cent). In the state, there are 9thranks in term of area and production (Directorate of Horticulture and Farm Forestry, Raipur, Chhattisgarh, 2022-23.).

Rajnandgaon Krishi Upaj Mandi is a well-known "A" grade mandi of the state. The total arrival of tomato in this mandi in the financial year 2022-23was 66.09 thousand MT (Department of mandi board Raipur, Chhattisgarh, 2022-23). In the off seasons, the tomato is cultivated in a protected structure by the few no. of farmers and the supply is done from outside the state which is not available as per the quantity demanded due to which the price becomes higher. Recently it was observed that there has been a lot of percentage fluctuation in both the arrivals and price of tomato throughout the year. Tomato is a crop that affects everyone from the public, traders, governments and international traders. The price of tomato can shake any household's budget or economy. "Due to the perishable nature of tomato (*Solanum lycopersicum L*.), price fluctuates based on supply and demand. It is necessary to forecast harvest period tomato prices, so growers, traders and policy makers can make informed production decisions" [1]. Henceforth, such arrivals and price of tomatoes were considered for the study. This manuscript is significant as it addresses the volatile nature of tomato prices in Rajnandgaon, Chhattisgarh, an issue affecting both consumers and farmers. The study's use of ARIMA modeling for price forecasting provides a robust tool for policymakers and stakeholders to predict and manage price fluctuations effectively. This research contributes positively into agricultural economics, particularly in regions with similar climatic and market conditions. I appreciate the manuscript's focus on a real-world problem and the application of advanced statistical methods to propose solutions.

2. METHODOLOGY

2.1 Selection of Krishi Upaj Mandi

Rajnandagaon Krishi Upaj Mandi was purposely randomly selected on the basis of its maximum arrivals of tomato in central western part of Chhattisgarh state.

2.2 Data Collection

The time-series data on arrivals (in quintals) and price (in Rs./quintal) of tomato in Chhattisgarh for a period of 08 years from 2016-17 to 2023-24 was obtained from the Chhattisagrh Rajya Krishi Vipdan (Mandi) Board(*https://agriportal.cg.nic.in>RptDate...*) for conducting the present study.

2.3 Analytical Tools

2.3.1 Estimation of seasonal indices of monthly data

The seasonal indices were calculated by adopting the following steps:

1. Firstly generate a series of twelve months moving totals
2. Generate a series of twelve months moving averages: A series of twelve months moving averages was generated by dividing twelve months moving totals by twelve.
3. Generate a series of centered twelve months moving averages. This step involves taking averages of pairs of two subsequent twelve months moving averages and entering between each pair. There are no corresponding moving averages for the first six and last six months.
4. Express each original value as a percentage of corresponding centered moving average. The percentage of moving average represents indices of seasonal and irregular components combined.
5. Arrange the percentages of moving averages in the form of monthly arrays.
6. Next, the average index for each month has been calculated.

In this study, we used statistical package in R (v 4.1) for studies.

2.4 Forecasting Analysis

The Box-Jenkins method is one of the most useful methodologies for the analysis of time-series data [2]. It is a mixture of Autoregressive, Integrated and Moving Average models. In ARIMA model, firstly identify stationary or non-stationary of data series. It is referring only a stationary time series for predict the future value accurately [3]. The manuscript appears to be scientifically robust and technically sound. The use of the ARIMA model is well-justified for time-series forecasting, and the steps followed are in line with standard practices in econometric analysis. The application of statistical tests like the Augmented Dickey-Fuller test to ensure data stationary adds to the scientific rigor. Also, the study's findings are backed by thorough data analysis and are relevant to real-world applications. In practice, most time series: Purely Random Process, Random Walk, Moving Average Processes, Autoregressive Process and Autoregressive Moving Average processes are non- stationary. In ARIMA model, a non- stationary series to stationary series can be easily converted by successive differencing. A statistical test for stationary is the most widely used Dickey Fuller test [4]. Augmented Dickey-Fuller (ADF) is a unit root test for stationary [2]. The basic step in the [5] methodology are: 1) Differencing the series so as to achieve stationary, 2) Identification of tentative model, 3) Estimation of the model, 4) Diagnostic checking (if the model is found inadequate, we go back to step 2), 5) using the model for forecasting and control, and 6) Evaluating forecast accuracy by Akaike's Information Criterion (AIC) , lowest Root Mean Squared Error (RMSE), Mean Absolute Square Error (MASE) value and Least Mean Absolute Percentage Error (MAPE). Schematically, we describe the steps as in Fig. 1 [2]. Have used lowest Root Mean Squared Error (RMSE) criterion is better for model selection. In this study, we used statistical package in R (v 4.1) for studies.

3. RESULTS AND DISCUSSION

3.1 Seasonal Analysis

The patterns of variations in arrivals within a year as revealed by the seasonal indices were computed for each month. The final estimates were stabilized monthly seasonal indices *i:e;* shown in Table 1 and Figs. 7 & 8. It indicates that there were three peak arrivals was found in month August (3084), July (2277) and October(1767) while the lowest arrivals were observed that during the month of April (-6590), March (- 3536) and February (-1674). However, seasonal indices of price of tomato.

It indicates that there were three peak prices that is during the month July (1164), August (593) and Jun (585), while the lowest prices indices were observed that during the month of March (-1066), February (-977) and January (-824).

Seasonal movements of tomato on arrivals indicate that season start from June and peak arrival was observed during the month of August due to more demanded by customer and shortage supply in local market by farmers. In this month only progressive farmers increase their supply to get good prices in there gulated market. The lowest arrival was seen in the month of April because very harmful impact on tomato production due to rise of temperature in summer season. While the highest arrivals and price in July-August months.

Table 1. Actual price and arrivals of Tomato in Krishi Upaj Mandi, Rajnandgaon, Chhattisgarh (Year 2016-17 to 2023-24)

Months /years	2016-17		2017-18		2018-19		2019-20	
	Price/ qtl.	Arrivals (qtl.)	Price/ qtl.	Arrivals (qtl.)	Price/ qtl.	Arrivals (qtl.)	Price/ qtl.	Arrivals (qtl.)
April	850	7125	600	12250	500	14015	1950	15900
May	1750	15075	1000	15525	950	17875	2500	22540
June	2900	18775	1950	15450	1750	23150	2250	26700
July	2300	22000	5150	13550	2100	21925	3000	28800
August	1150	33800	3350	18300	1300	23950	2250	30100
September	1150	36150	1300	19975	1000	23000	2000	30200
October	1050	25625	2700	17175	1100	22725	2000	29550
November	750	23350	2950	17875	1150	20100	2100	27700
December	350	23625	1750	20400	650	20800	1300	29500
January	**225***	21250	650	17000	750	23800	850	34225
February	275	19375	450	14750	400	21500	600	28300
March	350	15235	350	15000	950	17900	650	22200

Months /years	2020-21		2021-22		2022-23		2023-24	
	Price/ qtl.	Arrivals (qtl.)	Price/ qtl.	Arrivals (qtl.)	Price/ qtl.	Arrivals (qtl.)	Price/ qtl.	Arrivals (qtl.)
April	700	25700	750	16000	1700	36700	750	59400
May	1400	31900	900	34800	4100	34900	1400	72400
June	2500	31100	1050	40000	3400	41300	4000	77600
July	3250	33900	1400	42000	1500	50700	9000**	54300
August	2750	32400	1600	41800	1750	52900	6950	38400
September	3000	21200	1350	40600	2400	51100	1200	37500
October	2500	33500	2700	41000	2350	53400	1450	36492
November	1850	30500	3250	33600	1050	65600		
December	1400	32100	2750	40810	600	71800		
January	900	33300	1100	44600	600	67000		
February	750	30500	1450	36000	600	63200		
March	500	32100	750	36600	600	61800		

*Note: * indicated the minimum price and ** indicated the maximum price during the year (2016-17 to 2023-24)*

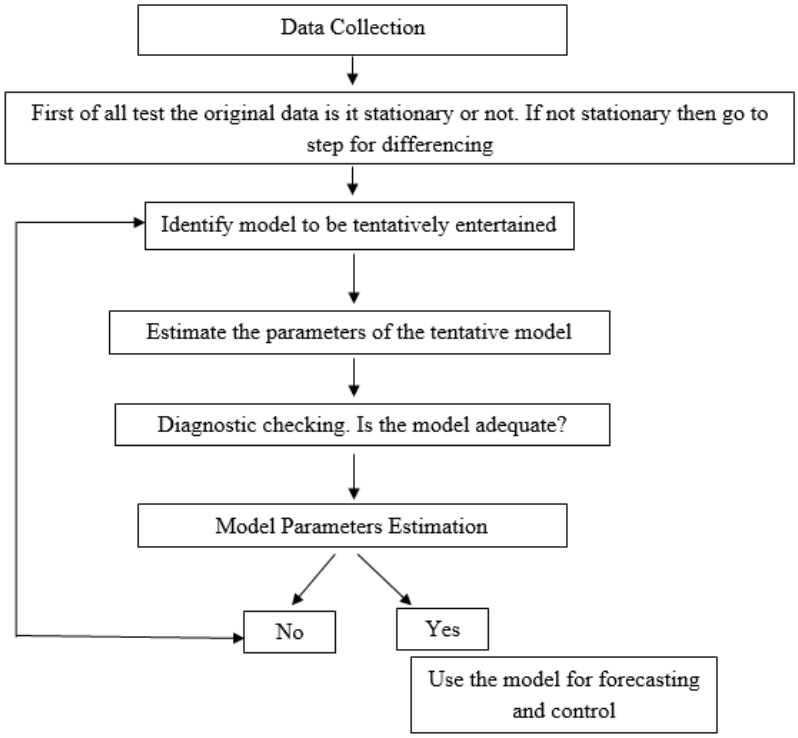

Fig. 1. Complete methodology of the forecasting approach

Table 2. Seasonal indices of arrivals and prices of tomato in Krishi Upaj Mandi, Rajnandgaon (2016-17 to 2023-24)

Month	Arrival	Price	Month	Arrival	Price
Jan	2481	-824	**July**	**2277**	1164
Fab	-1674	-977	**Aug**	**3084**	593
Mar	- 3536	-1066	Sep	227	264
Apr	-6590	-668	Oct	1767	555
May	-1997	247	Nov	507	372
Jun	**734**	585	Dec	2717	-246

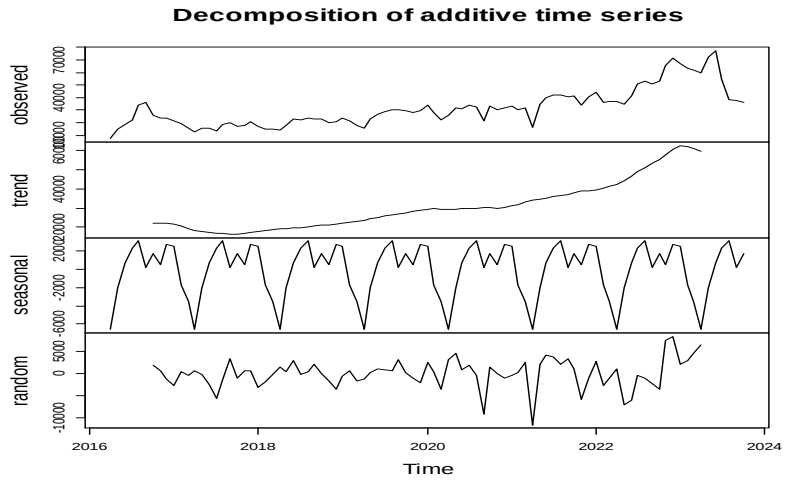

Fig. 2. Pattern of tomato arrivals in Krishi Upaj Mandi, Rajnandgaon (C.G.)

The study was revealed that the positively relation has been observed in between arrivals and prices of tomato in Krishi Upaj Mandi, Rajnandgaon. During the peak production season of tomato was consumed by local people and producer not supply of tomato due to low price earned from Krishi Upaj Mandi. The study has supported to the decision making of farmers and marketing intermediaries.

3.2 Forecasting Analysis

Auto Regressive Integrated Moving Average (ARIMA) model was applied for forecasting of arrival and price of tomato in Krishi Upaj Mandi, Rajnandgaon, Chhattisgarh. This model also called Box-Jenkins model. The Auto-Regressive Integrated Moving Average (ARIMA) methodology using for forecasting of fish production in Assam (1980-81 to 2014-15) (13). The most common method is to check stationary by examining the graph or time plot of the data. Non-stationary means connected through appropriate differencing. If there is trend, apply difference to the data and then reevaluate the trend. If a trend remains, then take first or second or third differences were presented in Fig. 4 for tomato arrival data and Fig. 5 for tomato price data. The time plot was show that obtained stationary data series and ADF test was significant after second differences in both arrivals & price data.

Forecasting of arrivals and price of tomato in Krishi Upaj Mandi, Rajandagon, Chhattisgarh in required three steps: The first step includes the identification of model through coding under which p, d, q (Non-seasonal) and P,D,Q (Seasonal). The step III made diagnostic checking with respect to reliability of model and the last step III made forecasting of arrival and price which is presented on follows:

Identification of the Model: Transforming the arrival and price data into stationary series was made for estimation in ARIMA model. The Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) values are graphically presented in Fig. 6. An *ARIMA* (*p; d; q P, D, Q)* 12 model was identified by finding significant spikes in auto correlation and partial auto correlation functions with all lags.

At the identification stage, one or more models were chosen which seem to provide statistically adequate representations of the available data. Identified best suitable model for the state's fish production was ARIMA (1,1,0) based on values of the model selection criterion [6]. An excellent discussion of model selection and different phases of time series approach for forecasting was made [5]. The Akaike information criterion and Bayesian information criterion were best performed for ARIMA model selection [7]. The seasonal ARIMA (2,0,2) (1,0,1) with 12 lags model was found suitable to produce price forecasts for tomato commodity for subsequent years 2002 to 2010 [8].

Finally, the ARIMA (5,1,3) (1,1,2) and ARIMA (2,1,2) (2,1,1) were selected as the most suitable models for forecasting compared to various models of arrivals as well as price of tomato based on Akaike Information Criterion (Akaike 1972), Least Mean Absolute Percentage Error (MAPE), Mean Absolute Square Error (MASE) value and Lowest Root Mean Squared Error (RMSE) value (Table 3).

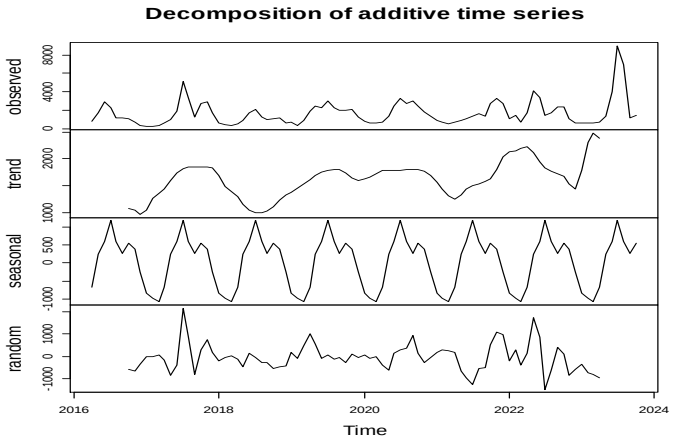

Fig. 3. Pattern of tomato price in Krishi Upaj Mandi, Rajnandgaon (C.G.)

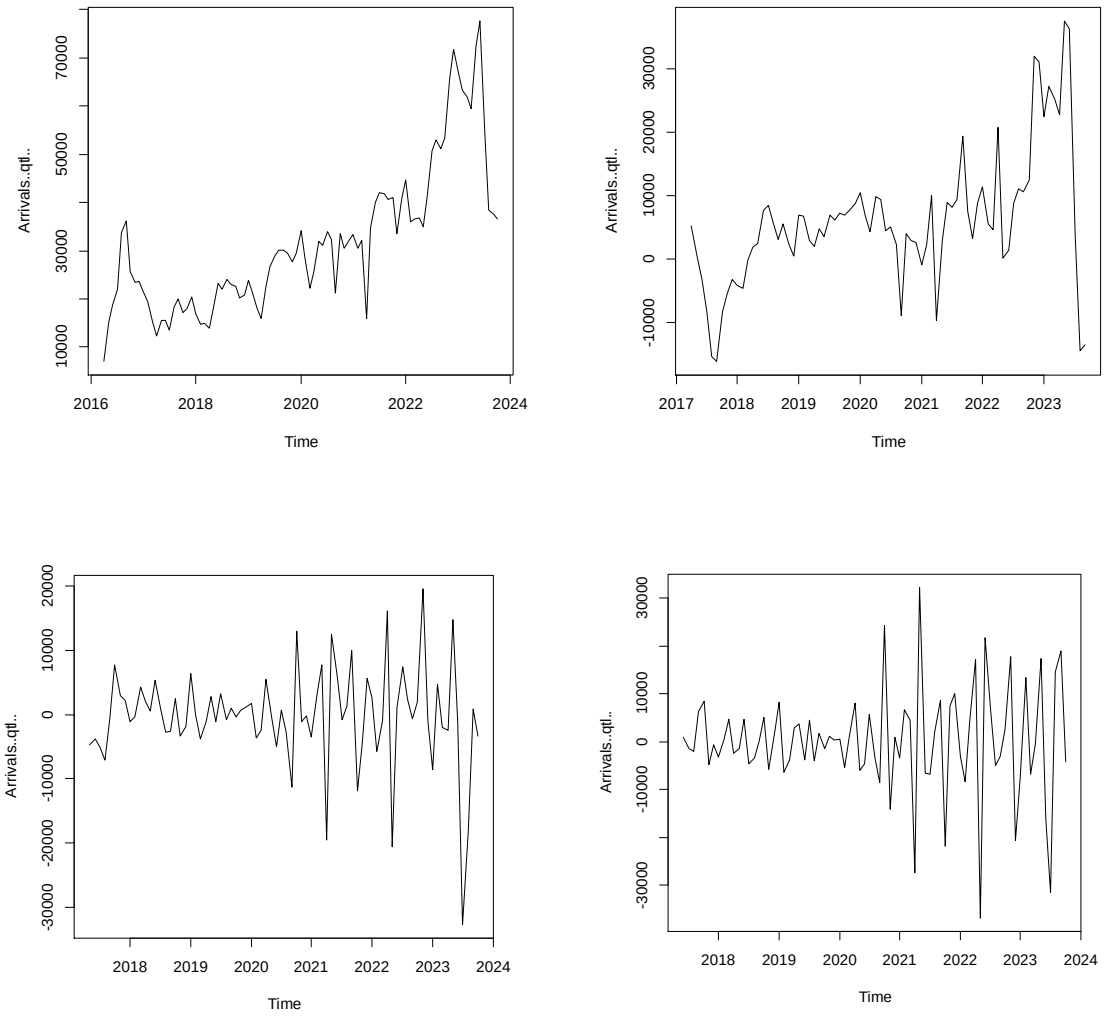

Fig. 4. a) Tomato arrivals original data b) Tomato arrivals seasonal datac) Tomato arrivals with first difference d =1 d) Tomato arrivals with first difference d =2 d)

Table 3. Models and selection parameters

Particulars	Model (p,d,p) (P,D,Q)	RMSE	MAPE	MASE	AIC
Tomato Arrivals	**(5,1,3) (1,1,2)**	4824.35	10.76	0.76	1595.78
	(6,2,5) (2,2,2)	5356.32	10.44	0.83	1384.00
	(4,0,2) (0,0,1)	5580.15	14.68	0.96	1848.98
	(3,2,3) (3,2,2)	5625.45	14.91	0.97	1844.38
	(4,2,2) (0,2,1)	6623.75	11.71	0.93	1393.80
Tomato Price	**(2,1,2) (2,1,1)**	701.69	30.82	0.62	1307.07
	(2,1,2) (1,1,1)	702.01	30.83	0.63	1307.07
	(2,0,2) (2,0,1)	755.53	42.89	0.70	1500.31
	(3,2,3) (3,2,2)	862.99	40.56	0.76	1156.07
	(1,0,1) (1,0,0)	907.81	50.42	0.84	1509.17

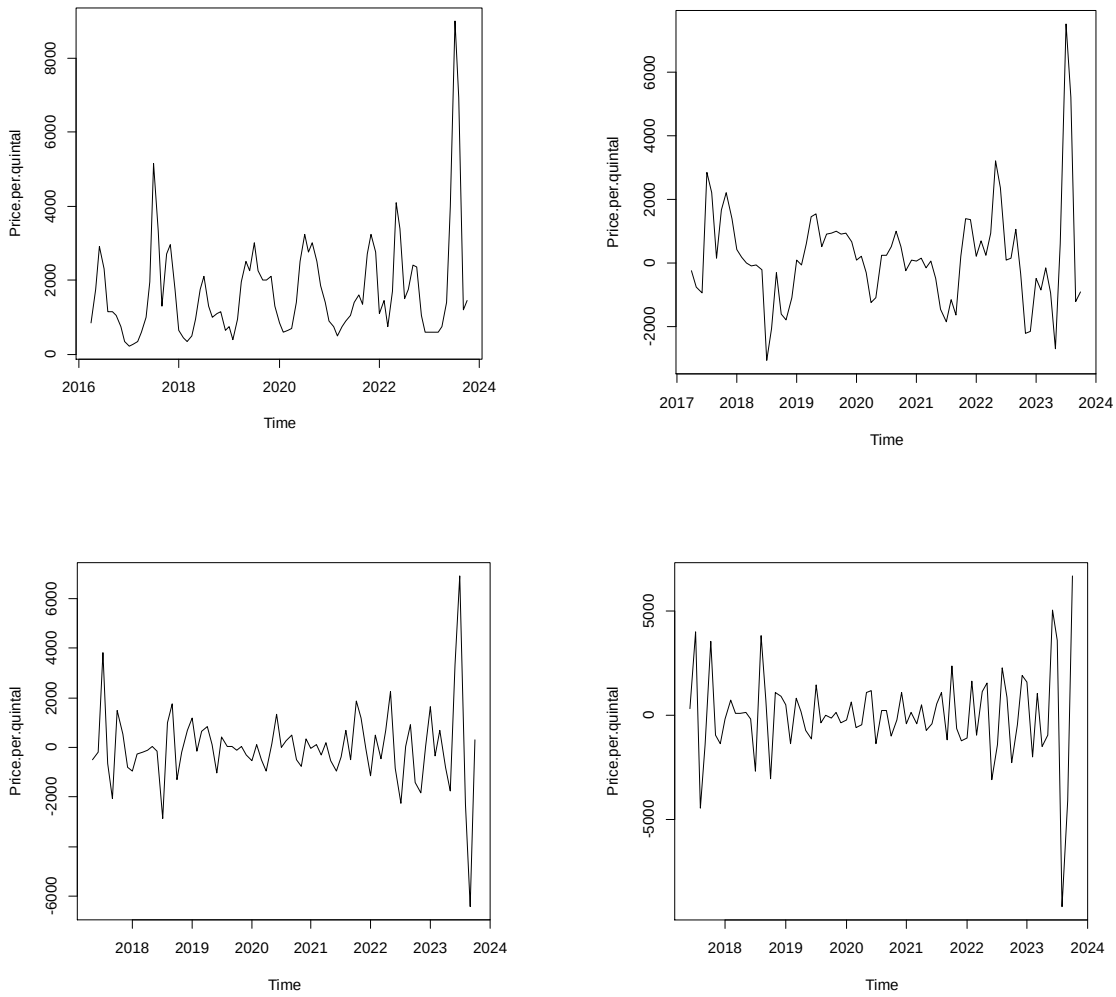

Fig. 5. a) Tomato arrivals original data b)Tomato arrivals seasonal data c) Tomato arrivals with first difference d =1 d) Tomato arrivals with first difference d =2 d)

Diagnostic Checking: Diagnostic checking is second phase of forecasting of time series data. It is an important phase that lead to accurate forecasted value. Diagnostic checking for arrival and price are graphically presented in the Figs. 7 and 8. The study revealed that plot of standardized residuals was not a trend in the residuals and in general, no changing variance found across the time (Figs. 7 and 8). The residuals plot of ACF was non-significant auto correlations that is a good result. The tested p-values for the Ljung-Box statistics is represented above the dashed blue line for each lag. That was a good result. The p-values for the Ljung-Box runs above to significant line, indicating non-zero auto correlation in the forecasting error for lags [9].

Forecasting of arrival and price of tomato in Krishi Upaj Mandi in Rajnandgaon, Chhattisgarh: After identification of the model and its adequate checking then model used to forecast the arrival and price of tomato in the coming periods. Hence, we used the identified ARIMA model to forecast the arrival and price of tomato in Krishi Upaj Mandi in Rajnandgaon, Chhattisgarh the Chhattisgarh for the period of 2023-24 to 2025-26 and the results are presented in Table 4. The forecasted market price of tomato would be in the range of Rs. 930 to 3220 per quintal during August to September, 2017. The tomato price very

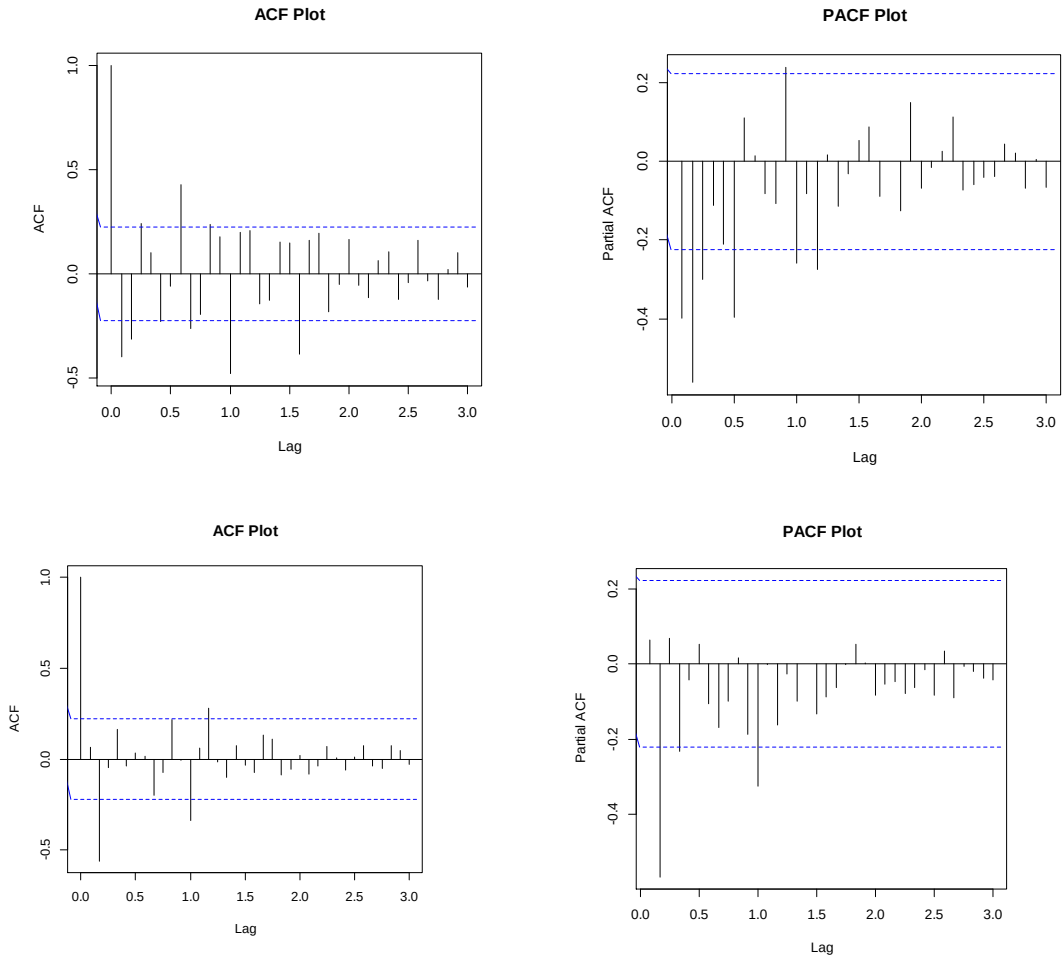

Fig. 6. a) Expressed Auto -Correlation Function (ACF) of tomato arrivals b) Partial Auto - Correlation Function (PACF) of tomato arrivals c) Auto -Correlation Function (ACF) of tomato price d) Partial Auto -Correlation Function (PACF) of tomato price

differences around the year in across regions due to the lack of refrigerated transport facilities with localize market rather than emergence of national market. The study was indicated that the prices fluctuated with in a wide range during the harvest period indicating low forecasting power of the econometric models for tomato [2].

The collected data over the period of 1971 to 2013 for forecasting study of tomato in Bangladesh. Bangladesh was Around 100350.24 tonnes per annum with maximum production 255430 tonnes occurred in the year 2012 and the minimum production was 52545 tonnes in the year 1974 in Bangladesh [10].

The predicated arrivals of lathyrus in the selected market was ranging from the minimum 832.55 tonnes in September, 2018 to the maximum 4299.91 tonnes in March, 2021. It was noticed that the line of actual and forecasted arrivals of lathyrus was similar trend. The forecasted arrivals of chickpea in Chhattisgarh plains would be ranging from the minimum 1054.85 tonnes in October, 2018 to the maximum 5459.60 tonnes in March, 2021 and in case of price of chickpea would be ranging from Rs./qtl 2859.08/- to Rs./qtl 3878.50/- for the months from October 2018 to April 2020. The study was reported that the maximum price is near to minimum arrivals month. It is noticed that the inversely relationship between price and arrivals of chickpea in selected market of Chhattisgarh plains [11].

The estimated milk production would be reached 219.73 MMT and 1.599 MMT by 2022-23 in India and Chhattisgarh respectively [12].

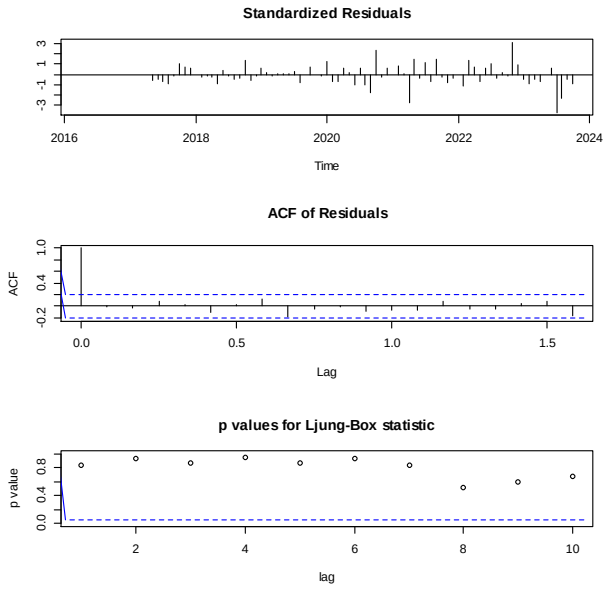

Fig. 7. Diagnostics checking for tomato arrivals data.

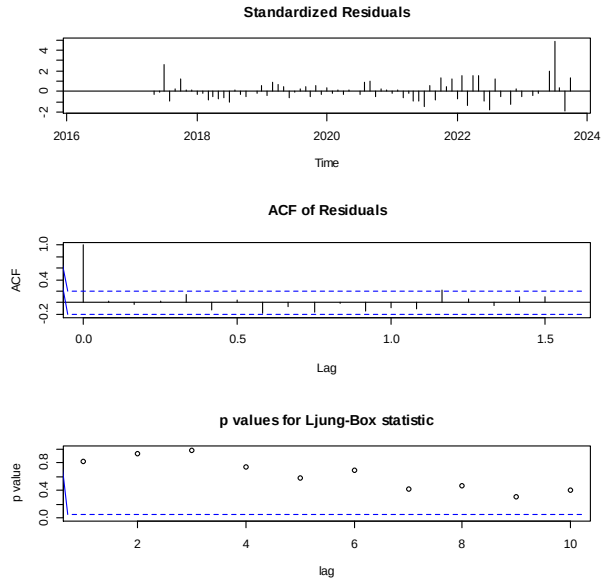

Fig. 8. Diagnostics checking for tomato price data

The forecasted fish production would be from 336.97 to 358.21 thousand metric tonnes for during years 2019-20 to 2022-23in Assam state. The study noticed that actual and forecast values were closer [6].

The study was found that forecasts the fish production would be ranging from the minimum 628417.90 metric tonnes in2021-22 to the maximum 857323.80 metric tonnes in 2025-26. The predicated fish seed production would be reached 44053.01lakhs in 2025-26. The actual and forecasted fish & fish seed production was more or less closer. The study reported that the both forecasted fish & fish seed production were increasing trend. It is noticed that the increasing positively relationship between fish & fish seed production but a low income of farmers and more share in total fish & fish seed production by limited farmers in Chhattisgarh.

The study was found that forecasts the arrivals of tomato would be ranging from the minimum 12763 qtl. In March, 2023 to the maximum

Table 4. Predicated arrivals and prices of tomato in Krishi Upaj Mandi, Rajnandgaon, Chhattisgarh (2023-24 to 2025-26)

Month/Year	2023-2024		2024-25		2025-26	
	Arrival (qtl)	Price (Rs/qtl)	Arrival (qtl)	Price (Rs/qtl)	Arrival (qtl)	Price (Rs/qtl)
April	-	-	13848	1790	24157	1738
May	-	-	24476	2601	33941	2506
June	-	-	30940	2841	40748	3267
July	-	-	32374	2872	35618	4387
August	-	-	28618	2360	29794	3540
September	-	-	23401	2565	26436	2441
October	-	-	26127	2899	26023	2756
November	35493	3124	31664	2551	26657	2849
December	33899	2548	39072	1921	29745	2231
January	26745	1514	38829	1417	27887	1612
February	15474	1270	32028	1364	21139	1518
March	12763	1273	28386	1342	19059	1501

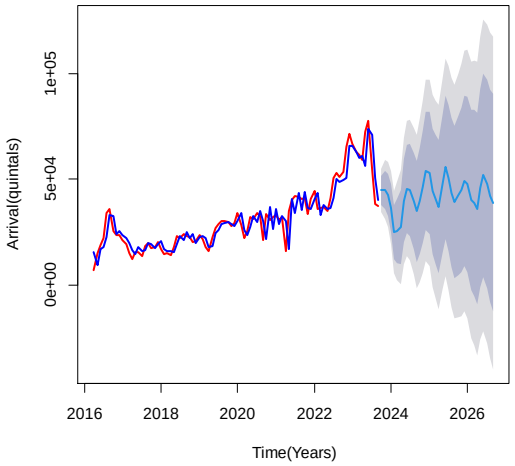

Fig. 9. Predicated and actual graph of arrival data

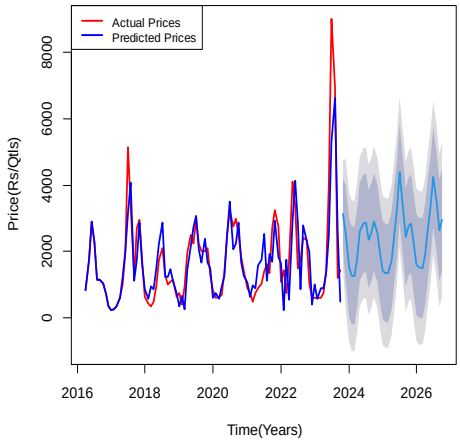

Fig. 10. Predicated and actual graph of price data

40748qtl. in June 2025. The predicated price would be reached Rs. 4387/qtl. in July 2025. The Figs. 9 and 10 was show that the actual and forecasted arrival and price of tomato was more or less closer. It is noticed that the positively relationship between price and arrivals of tomato in Krishi Upaj Mandi, Rajnandgaon, Chhattisgarh [13, 14].

4. CONCLUSION

It is noticed that the positively relationship between price and arrivals (Means if, increase of price was increases arrivals in same season) of tomato in Krishi Upaj Mandi, Rajnandgaon, Chhattisgarh. In view of findings of this study, it may be suggested that there is need to tomato processing unit and low cost refrigeration unit should be open in near to the village. Provide the financial support of tomato grower for rise area of tomato under protected cultivation in off season. There is also a need of skill oriented training/demonstrations for farming and tomato processing technologies at farmer's farms for least cost production technologies and minimum losses inputs & farm products. Provided bonus in peak production time for farmers and provided subsidy for consumer at time of high price of tomato. The government should include in annual budget to fight price fluctuation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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