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**Vishwa Gohil**
Ph.D., Department of Agricultural Statistics, N. M. College of Agriculture, NAU, Navsari, Gujarat, India

**SM Upadhyay**
Department of Agricultural Statistics, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

**DV Patel**
Department of Agricultural Statistics, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

**Jay Delvadiya**
Ph.D., Department of Agricultural Statistics, N. M. College of Agriculture, NAU, Navsari, Gujarat, India

**Happy Patel**
Ph.D., Department of Agricultural Statistics, N. M. College of Agriculture, NAU, Navsari, Gujarat, India

**Corresponding Author:**
**Vishwa Gohil**
Ph.D., Department of Agricultural Statistics, N. M. College of Agriculture, NAU, Navsari, Gujarat, India

# Time series analysis of castor crop for price forecasting in Gujarat: A comprehensive study

**Vishwa Gohil, SM Upadhyay, DV Patel, Jay Delvadiya and Happy Patel**

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**Abstract**
The overall objective of the present paper is demonstrating the utility of price forecasting of farm prices and validating the same for castor crops in Gujarat state for the year 2022 using the time series data from 2007 to 2021. While for price data of castor was collected from AGMARKNET (www.agmarknet.gov.in). Looking to the seasonal indices, the lowest and highest seasonal indices of castor price were happened in May and August respectively for all the castor markets except Patan market. The results showed that the lower instability for price under castor was observed in Mehsana (1.045), Rajkot (0.999), Gandhinagar (1.158), Banaskantha (1.074), Patan (1.903) and Sabarkantha (1.089) districts. Majority of the districts showed the low level of instability for price. There may be chance of volatility persist in these markets yet it should be subjected to formal ARIMA effect test to confirm the presence of volatility. The seasonal component was estimated by fitting the cubic trend in Mehsana, Rajkot, Gandhinagar, Banaskantha and Sabarkantha markets. However in Patan market the trend observed in compound, growth, exponential and logistic. The results were obtained from the application of univariate ARIMA techniques to produce price forecasts for castor crop and precision of the forecasts were evaluated using the standard criteria of lower value of RMSE, MAPE, MAE MSE with higher value of Adj. $R^2$. On the basis of these criteria find out best model of ARIMA for castor price forecasted. Among the selected six markets, Mehsana ARIMA (0,1,0), Rajkot ARIMA (0,1,2), Gandhinagar ARIMA (0,1,0), Banaskantha ARIMA (0,1,0), Patan ARIMA (1,0,1) and Sabarkantha ARIMA (1,1,1) model were found to be best fitted for the forecasting the price of castor in Gujarat.

**Keywords:** Seasonality, instability index, growth, ARIMA, forecast

## Introduction
Castor (*Ricinus communis*) is probably a native to north-eastern Africa. The castor crop belongs to the family of Euphorbiaceous and is developed in tropical and semi-tropical regions. Assisting farmers in their production and marketing decisions through price forecasts will enable them to realize better prices and the price forecast can be used as an extension strategy to achieve the goal of higher income by farmers from these crops. Castor is one of the oldest cultivated crops. However, it contributes to only 0.15 per cent of the vegetable oil produced in the world. The oil produced from this crop is considered to be of importance to the global specialty chemical industry because it is the only commercial source of a hydroxylated fatty acid.

Selection of markets on the basis of maximum arrival and production of Castor in India *viz*., Banaskantha, Mahesana, Patan, Rajkot, Sabarkantha and Gandhinagar. The data was collected for monthly modal price for castor in Gujarat (Rs./quintal) from 2007-2021 Anon., (2021) [2]. For the study of price Forecasting in Gujarat market for castor monthly price data was collected. The analysis was carried out using the Eviews 11 statistical software packages.

Price forecasting is very essential for planning and development and therefore it becomes pertinent to develop methods that help the policymakers to have some idea about the prices of commodities in the future. One approach is to consider causes and their effects and the other approach ARIMA is to forecast prices without taking into consideration the causes.

Though, notably, several limitations have been imposed on this model due to its assumption of heteroscedasticity, ARIMA model combines the AR and MA process to analyze the time series data which is a renowned model for analyzing time-series data. Many agricultural price series have shown periods of stability, followed by periods of instability with high volatility (Achal *et al*. 2015) [1]. Chaudhari and Tingre (2014) [6] conducted the study on forecasting the Green Gram prices for Maharashtra. Bannor and Sharma (2015) [3] studied the modelling and forecasting wholesale groundnut prices from January 2005 to September 2015 in Bikaner district of Rajasthan. Singh and Mishra (2015) [13] studied the application of box-jenkins method for time series forecasting monthly cash prices of groundnut oil in Mumbai from April 1994 to July 2010. Rojalin *et al*. (2019) [11] studied the groundnut prices for the state of Odisha from January 2004 to December 2018 using time series model. Rathore *et al*. (2020) [10] studied the forecasting of arrivals and prices of soybean in Chhattisgarh plains. Delvadiya *et al*. (2023) [7] an application of ARIMA for forecasting rapeseed and mustard area in Gujarat.

## Materials and Methods

### Measuring seasonality

The method used has the following procedures

$$Y = TSCI$$

$$Y/MA = TSCI/TC = SI$$

Where, T= Trend, S= Seasonality variations, C= Cyclical fluctuations, I= Irregular variation, Y= original data and MA= Moving average

The sum of the seasonal indices should be 1200. If it is greater or less than1200 then adjust it using a correction factor.

$$K = \frac{1200}{S}$$

Where, K = Correction factor and S = Sum of seasonal indices

### Extent of intra year price rise

$$IPR = \left[\frac{HSPI-LSPI}{LSPI}\right] \times 100$$

$$ASPV = \left[\frac{HSPI - LSPI}{\frac{(HSPI+LSPI)}{2}}\right] \times 100$$

### Cuddy and Della instability index

As the CV (%) may overestimate the level of instability characterized by long-term trends, the CDVI (%) was used to de-trend and show the exact magnitude of instability. The specification of CDVI (%) to be used in the study

$$CDVI = CV \times (\sqrt{1 - \bar{R}^2}$$

Where, CV is the coefficient of variation; and, $\bar{R}^2$ is the coefficient of multiple determination. The instability was further categorized into 0-15 (low instability); 15-30 (Medium instability) and >30 (high instability) as per Sihmar, 2014 [12].

**Box-Jenkins Autoregressive (ARIMA) models:** Time series data can be explained using stochastic error factors and past or lag values using the ARIMA model. Typically, the ARIMA model is written as ARIMA (p d q). Where, p, d, and q, respectively, stand for moving average, integration (differencing), and auto-regression orders. Time Series (TS), as used in ARIMA, is a linear function of historical actual values and random shocks. For instance, given a TS process $\{Y_t\}$, a first order autoregressive process is denoted by ARIMA (1, 0, 0) or simply AR (1) and is given by;

$$Y_t = u + \emptyset_1 Y_{t-1} + \varepsilon_t$$

A first order moving average process is denoted by ARIMA (0, 0, 1) or simply MA (1) and is given by;

$$Y_t = u + \emptyset_1 \varepsilon_{t-1} + \varepsilon_t$$

As an alternative, the final model may combine both of these processes and higher tiers. The term "pure models" refers to models that do not include both AR and MA components. Integration (I) is the process of producing a forecast by applying differencing in reverse. ARIMA (p d q) is the acronym for an ARIMA model. The expression of an ARIMA model is as follows:

$$\emptyset(B)\ (1 - B)^d\ Yt = \theta(B)\ \varepsilon_t$$

$$Y_t = \emptyset_1 Y_{t-1} + = \emptyset_2 Y_{t-2} + \cdots + \emptyset_p Y_{t-p} + \varepsilon_t - \theta_1\, \varepsilon_{t-1} - \theta_2\, \varepsilon_{t-2} \ldots . - \theta_q\, \varepsilon_{t-q}$$

$Y_t$is the time series, $\emptyset_i$ and $e_j$ are model parameters, $\varepsilon_t$ is random error, p is number of autoregressive terms, q is number of moving terms and B is the backshift operator such that, $BY_t = Y_t - 1$ (Box *et al*., 1994; Brockwell and Davis 1996) [4, 5].

The forecasting through ARIMA model was carried by using E-Views 11.0 statistical software, *viz*., checking the stationarity using Augmented Dickey-Fuller (ADF) test, identification of tentative models based on scrutiny of the parameters of the selected models were estimated by Maximum Likelihood Estimation (MLE) method. The adequacy of the model was judge based on the value of Ljung-Box 'Q' Statistic using residual diagnostics (Garde *et al*., 2021) [8].

### The performance of developed models

The identification of the suitable forecasting models for export of total pulses was carried out using different goodness of fit techniques *viz*., Adj. $R^2$, Mean Absolute Error, Mean Absolute Percentage Error, root Mean Squared Error

### Adjusted $R^2$ ($\bar{R}^2$) (Montgomery *et al*., 2003) [9]

$$\bar{R}^2 = 1 - \frac{(n-1)(1-R^2)}{(n-k-1)}$$

Highest value of $R^2$ and adj. $R^2$ will considered as the best fitted model.

### Mean Absolute Error (MAE)

$$MAE = \left(\frac{1}{t}\right) \sum |A_t - P_t|$$

**Mean Absolute Percentage Error (MAPE)**

$$\text{MAPE} = \left(\frac{100}{t}\right)\sum |(A_t - P_t)/P_t|$$

**Root Mean Squared Error (RMSE)**

$$\text{RMSE} = \sqrt{\sum (A_t - P_t)^2 / t}$$

## Results and Discussion

### Seasonal Indices of Castor Market Price of selected District

**Table 1:** Seasonal indices

| Months | Gujarat | | | | | |
|---|---|---|---|---|---|---|
| | **Mehsana** | **Rajkot** | **Gandhinagar** | **Banaskantha** | **Patan** | **Sabarkantha** |
| January | 98.261 | 97.812 | 97.938 | 98.327 | 105.802 | 98.261 |
| February | 97.303 | 100.492 | 97.894 | 97.138 | 108.799 | 97.303 |
| March | 97.199 | 100.144 | 97.015 | 96.853 | 113.409 | 97.199 |
| April | 98.228 | 99.956 | 97.818 | 98.288 | 99.398 | 98.228 |
| May | 96.266 | 96.861 | 96.985 | 96.742 | 92.874 | 96.266 |
| June | 96.870 | 97.334 | 98.011 | 96.936 | 93.516 | 96.870 |
| July | 101.026 | 102.010 | 102.031 | 101.570 | 97.055 | 101.026 |
| August | 104.412 | 103.765 | 104.362 | 104.826 | 98.125 | 104.412 |
| September | 104.261 | 102.801 | 104.089 | 104.945 | 99.480 | 104.261 |
| October | 100.480 | 98.221 | 100.329 | 100.322 | 95.874 | 100.480 |
| November | 102.981 | 100.087 | 101.886 | 102.098 | 98.273 | 102.981 |
| December | 102.714 | 100.516 | 101.644 | 101.955 | 97.397 | 102.714 |
| Total | 1200.000 | 1200.000 | 1200.000 | 1200.000 | 1200.000 | 1200.000 |

The seasonal indices for pricing suggested that there was less price variation, with values ranging from 92.874 to 113.409 percent.

Castor price seasonal indices were highest in March (113.409) in Patan market and lowest in May (92.874) in Patan.

Among the market under study, the seasonal indices of castor price for the Mehsana market were highest in August (104.412) and lowest in May (96.266). However, for the Rajkot market, the seasonal indices of castor price were highest in August (103.765) and lowest in May (96.861). However, for the Gandhinagar market, the seasonal indices of castor price were highest in August (104.362) and lowest in May (96.985). In the Banaskantha market, however, the seasonal indices of castor price were highest in September (104.945) and lowest in May (96.742). However, for the Patan market, the seasonal indices of castor price were highest in March (113.409) and lowest in May (92.874). Whereas, the seasonal indices of castor price for Sabarkantha market was highest in month of August (104.412) and while lowest in month of May (96.266).

Looking to the seasonal indices, the lowest and highest seasonal indices of castor price were happened in May and August respectively for all the castor markets except Patan market. It might be happened due to the high price volatility or may be due to in that area there was high demand or low supply.

The higher prices of castor were observed during the months of August to September. However in Patan district highest price were found in during March. Therefore, farmers are advised to schedule the sale of castor during the above period to get the better prices for the produce.

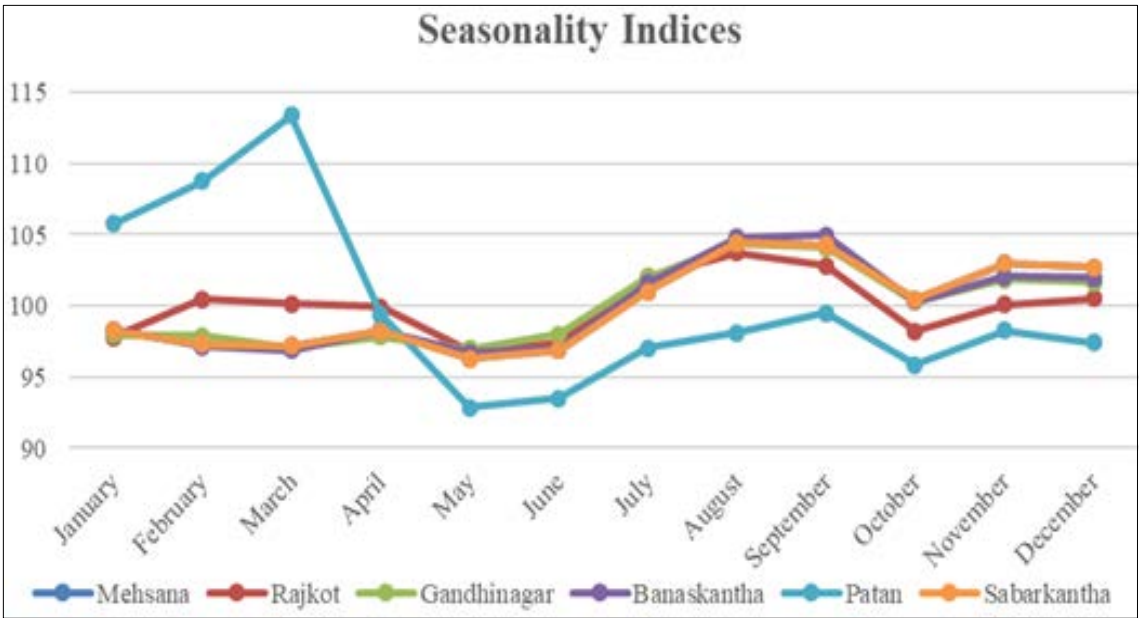



**Fig 1:** Seasonal indices of castor price of major markets of Gujarat (Jan- 2007 to Dec- 2021)

**Extents of seasonal price variation:** The extents of seasonal price variation were determined by using different measures of intra year price variations. With a view to ascertain the difference in the magnitude of the seasonal variations in the

castor, the analysis was carried out in term of IPR, ASPV and C.V. The magnitude of fluctuations in seasonal indices of castor were measured with the help of the co-efficient of average seasonal prices index variation.

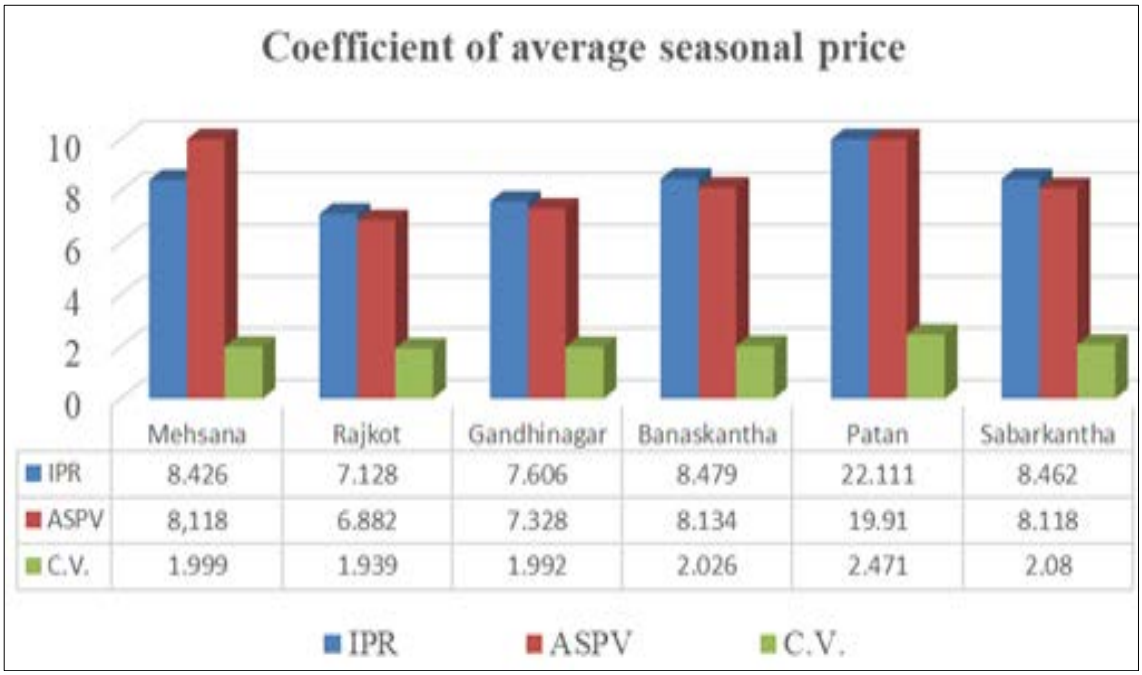



**Fig 2:** Co-efficient of average seasonal price of Castor Market

The intra year price variation (IPR) was higher (22.111) in Patan market while lowest value (7.128) of intra year price variation (IPR) was observed in Rajkot market. The average seasonal price variation (ASPV) was recorded highest (19.910) in Patan market while lowest value (6.882) of average seasonal price variation (ASPV) in case of Rajkot market. Coefficient of variation (C.V.) was recorded higher (2.471) in Patan market and lowest (1.939) in Rajkot market. As the co- efficient of variation increased, the degree of stability of prices decreased. The variability in fresh arrivals stock of the products in market and the demand affects the price to a great extent.

**Study the instability in prices in major castor growing districts of Gujarat**

The results showed that the lower instability for price under castor was observed in Mehsana (1.045), Rajkot (0.999), Gandhinagar (1.158), Banaskantha (1.074), Patan (1.903) and Sabarkantha (1.089) districts. Majority of the districts showed the low level of instability for price. There may be chance of volatility persist in these markets yet it should be subjected to formal ARIMA effect test to confirm the presence of volatility.

**Table 2:** Instability of the major castor market prices

| | Castor market Prices | | |
|---|---|---|---|
| **Districts** | **CV** | **CDVI** | **Instability** |
| Mehsana | 1.914 | 1.045 | Low |
| Rajkot | 1.876 | 0.999 | Low |
| Gandhinagar | 2.133 | 1.158 | Low |
| Banaskantha | 1.974 | 1.074 | Low |
| Patan | 2.242 | 1.903 | Low |
| Sabarkantha | 1.962 | 1.089 | Low |

**Forecasting of castor price in Gujarat:** In the current study forecasting of castor price and in value was done by ARIMA model using secondary data from the period 2007 to 2021. The forecasting of castor price was carried out by using ARIMA with adopting different steps *viz*. i) stationarity check, ii) identification of the model, iii) estimation and diagnostic check of parameters and iv) validation of model and forecasting.

**Forecasting of Castor price in Gujarat**

The ARIMA model for forecasting of export in quantity (MT) started with stationarity check of the yearly data. The Augmented Dicky Fuller (ADF) unit root test was used to check the stationarity of the castor price data. Stationarity (ADF) test at level did not prove stationarity of castor price. So, to make castor price data stationary the analysis proceeded further with 1st differencing and test result is presented in Table 2 showed that null hypothesis for test statistic was rejected which indicated castor price data had stationarity (p = 0.0001). The stationarity of the series was also checked by plotting Correlogram of the ACF and PACF (Fig. 3). The presence of peak at first values clearly indicated suitability of the choice of seasonal difference d=1, to accomplish the stationary series. Therefore, ARIMA model identification was proceeded by taking value d = 1.

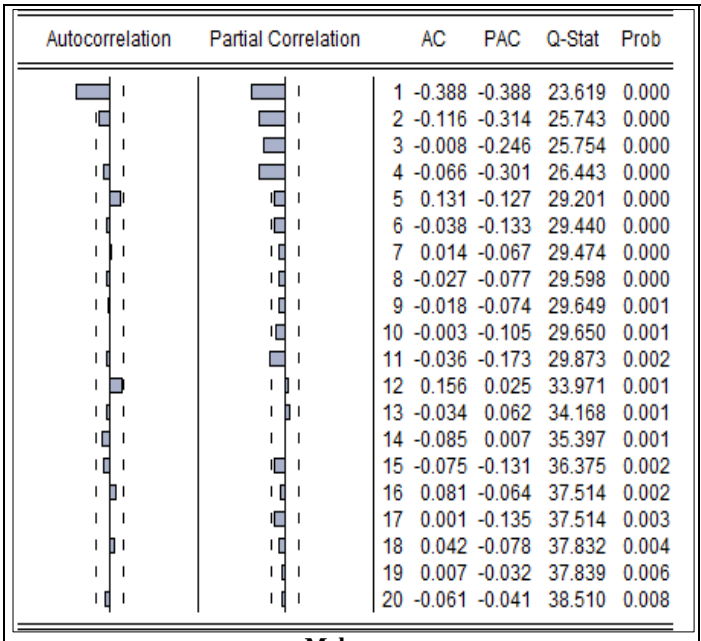
**Table 3:** Results of unit root test for castor prices markets of Gujarat

| **State** | **Castor Markets** | **Augmented Dickey fuller (ADF)** | |
|---|---|---|---|
| | | **Level** | **First difference** |
| Gujarat | Mehsana | 1.87133 $^{NS}$ (0.3923) | 81.7380 $^{**}$ (0.0000) |
| | Rajkot | 1.43804 $^{NS}$ (0.4872) | 89.2556$^{**}$ (0.0000) |
| | Gandhinagar | 3.54680 $^{NS}$ (0.1698) | 59.7793$^{**}$ (0.0000) |
| | Banaskantha | 1.98780 $^{NS}$ (0.3701) | 98.1881$^{**}$ (0.0000) |
| | Patan | 16.0542 $^{**}$ (0.0003) | 75.0597$^{**}$ (0.0000) |
| | Sabarkantha | 2.36324$^{NS}$ (0.3068) | 95.6556 $^{**}$ (0.0000) |

**Note:** $p<0.05$ indicates significance, * Significant at 5% level, ** Significant at 1% level

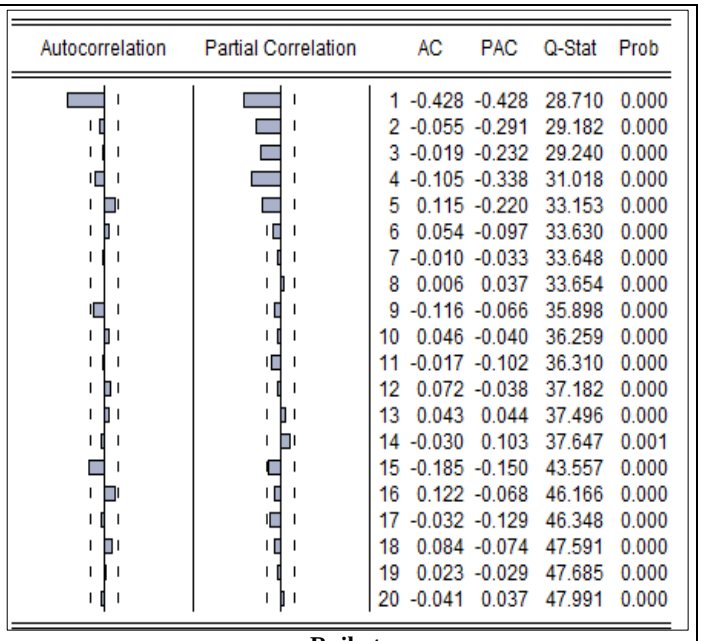
**Table 4:** ACF and PACF graph in castor prices major markets of Gujarat

**Mehsana**



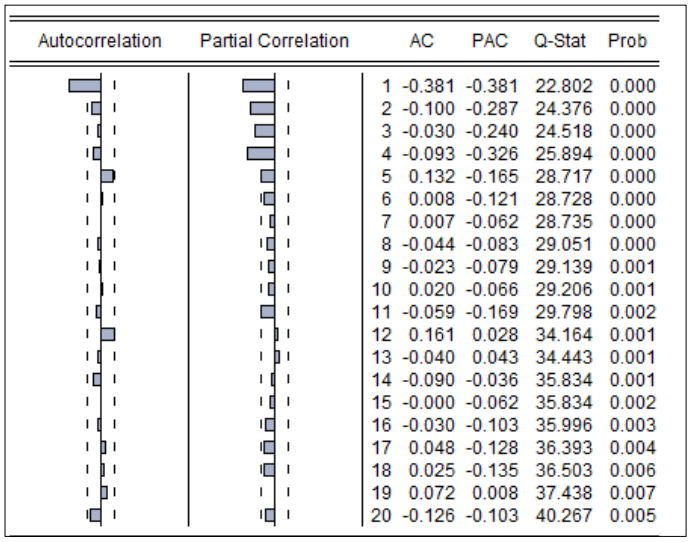
| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.388 | -0.388 | 23.619 | 0.000 |
| 2 | -0.116 | -0.314 | 25.743 | 0.000 |
| 3 | -0.008 | -0.246 | 25.754 | 0.000 |
| 4 | -0.066 | -0.301 | 26.443 | 0.000 |
| 5 | 0.131 | -0.127 | 29.201 | 0.000 |
| 6 | -0.038 | -0.133 | 29.440 | 0.000 |
| 7 | 0.014 | -0.067 | 29.474 | 0.000 |
| 8 | -0.027 | -0.077 | 29.598 | 0.000 |
| 9 | -0.018 | -0.074 | 29.649 | 0.001 |
| 10 | -0.003 | -0.105 | 29.650 | 0.001 |
| 11 | -0.036 | -0.173 | 29.873 | 0.002 |
| 12 | 0.156 | 0.025 | 33.971 | 0.001 |
| 13 | -0.034 | 0.062 | 34.168 | 0.001 |
| 14 | -0.085 | 0.007 | 35.397 | 0.001 |
| 15 | -0.075 | -0.131 | 36.375 | 0.002 |
| 16 | 0.081 | -0.064 | 37.514 | 0.002 |
| 17 | 0.001 | -0.135 | 37.514 | 0.003 |
| 18 | 0.042 | -0.078 | 37.832 | 0.004 |
| 19 | 0.007 | -0.032 | 37.839 | 0.006 |
| 20 | -0.061 | -0.041 | 38.510 | 0.008 |

**Rajkot**



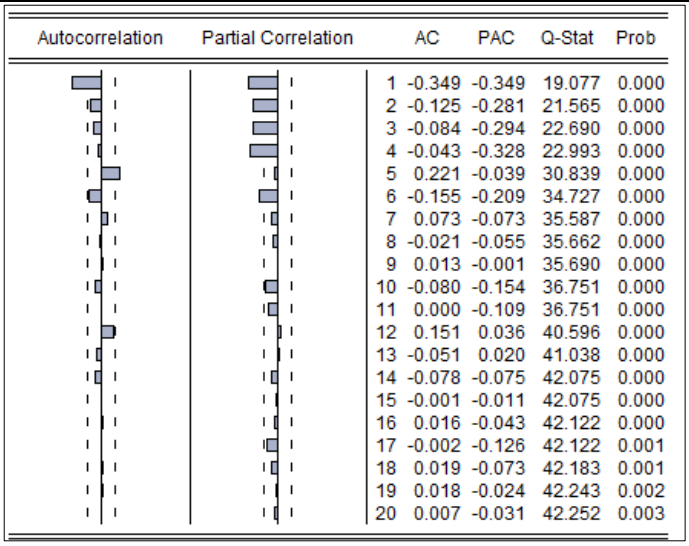
| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.428 | -0.428 | 28.710 | 0.000 |
| 2 | -0.055 | -0.291 | 29.182 | 0.000 |
| 3 | -0.019 | -0.232 | 29.240 | 0.000 |
| 4 | -0.105 | -0.338 | 31.018 | 0.000 |
| 5 | 0.115 | -0.220 | 33.153 | 0.000 |
| 6 | 0.054 | -0.097 | 33.630 | 0.000 |
| 7 | -0.010 | -0.033 | 33.648 | 0.000 |
| 8 | 0.006 | 0.037 | 33.654 | 0.000 |
| 9 | -0.116 | -0.066 | 35.898 | 0.000 |
| 10 | 0.046 | -0.040 | 36.259 | 0.000 |
| 11 | -0.017 | -0.102 | 36.310 | 0.000 |
| 12 | 0.072 | -0.038 | 37.182 | 0.000 |
| 13 | 0.043 | 0.044 | 37.496 | 0.000 |
| 14 | -0.030 | 0.103 | 37.647 | 0.001 |
| 15 | -0.185 | -0.150 | 43.557 | 0.000 |
| 16 | 0.122 | -0.068 | 46.166 | 0.000 |
| 17 | -0.032 | -0.129 | 46.348 | 0.000 |
| 18 | 0.084 | -0.074 | 47.591 | 0.000 |
| 19 | 0.023 | -0.029 | 47.685 | 0.000 |
| 20 | -0.041 | 0.037 | 47.991 | 0.000 |

**Gandhinagar**



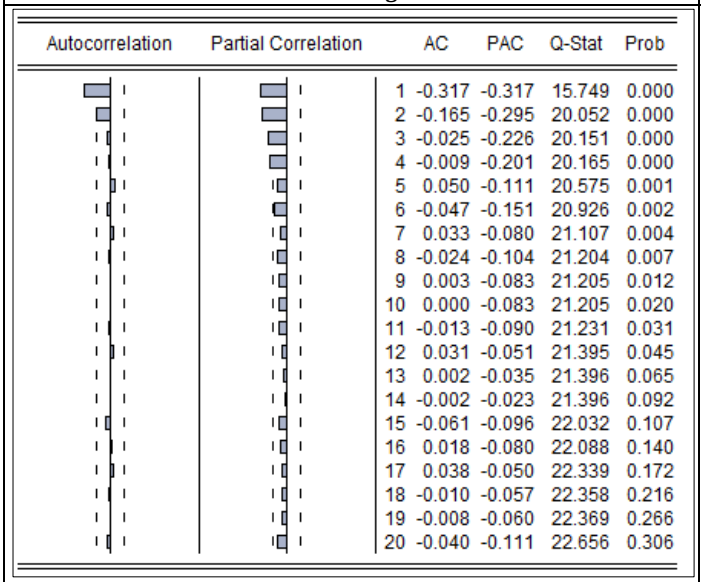
| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.381 | -0.381 | 22.802 | 0.000 |
| 2 | -0.100 | -0.287 | 24.376 | 0.000 |
| 3 | -0.030 | -0.240 | 24.518 | 0.000 |
| 4 | -0.093 | -0.326 | 25.894 | 0.000 |
| 5 | 0.132 | -0.165 | 28.717 | 0.000 |
| 6 | 0.008 | -0.121 | 28.728 | 0.000 |
| 7 | 0.007 | -0.062 | 28.735 | 0.000 |
| 8 | -0.044 | -0.083 | 29.051 | 0.000 |
| 9 | -0.023 | -0.079 | 29.139 | 0.001 |
| 10 | 0.020 | -0.066 | 29.206 | 0.001 |
| 11 | -0.059 | -0.169 | 29.798 | 0.002 |
| 12 | 0.161 | 0.028 | 34.164 | 0.001 |
| 13 | -0.040 | 0.043 | 34.443 | 0.001 |
| 14 | -0.090 | -0.036 | 35.834 | 0.001 |
| 15 | -0.000 | -0.062 | 35.834 | 0.002 |
| 16 | -0.030 | -0.103 | 35.996 | 0.003 |
| 17 | 0.048 | -0.128 | 36.393 | 0.004 |
| 18 | 0.025 | -0.135 | 36.503 | 0.006 |
| 19 | 0.072 | 0.008 | 37.438 | 0.007 |
| 20 | -0.126 | -0.103 | 40.267 | 0.005 |

**Banaskantha**



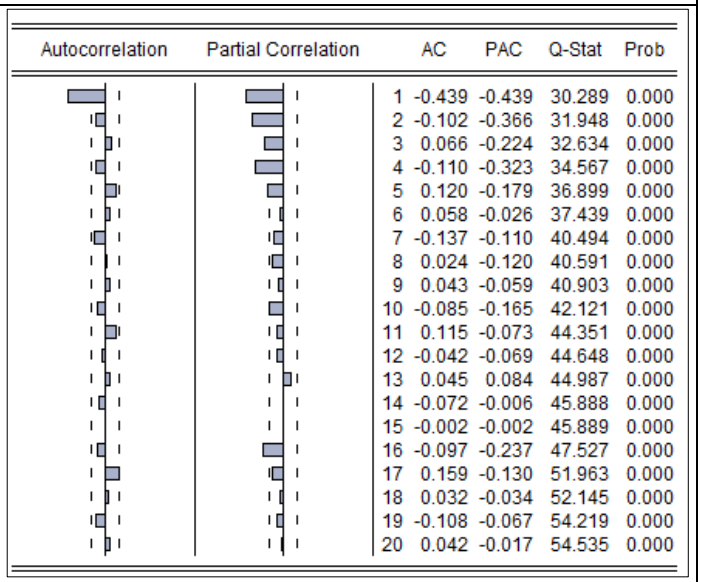
| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.349 | -0.349 | 19.077 | 0.000 |
| 2 | -0.125 | -0.281 | 21.565 | 0.000 |
| 3 | -0.084 | -0.294 | 22.690 | 0.000 |
| 4 | -0.043 | -0.328 | 22.993 | 0.000 |
| 5 | 0.221 | -0.039 | 30.839 | 0.000 |
| 6 | -0.155 | -0.209 | 34.727 | 0.000 |
| 7 | 0.073 | -0.073 | 35.587 | 0.000 |
| 8 | -0.021 | -0.055 | 35.662 | 0.000 |
| 9 | 0.013 | -0.001 | 35.690 | 0.000 |
| 10 | -0.080 | -0.154 | 36.751 | 0.000 |
| 11 | 0.000 | -0.109 | 36.751 | 0.000 |
| 12 | 0.151 | 0.036 | 40.596 | 0.000 |
| 13 | -0.051 | 0.020 | 41.038 | 0.000 |
| 14 | -0.078 | -0.075 | 42.075 | 0.000 |
| 15 | -0.001 | -0.011 | 42.075 | 0.000 |
| 16 | 0.016 | -0.043 | 42.122 | 0.000 |
| 17 | -0.002 | -0.126 | 42.122 | 0.001 |
| 18 | 0.019 | -0.073 | 42.183 | 0.001 |
| 19 | 0.018 | -0.024 | 42.243 | 0.002 |
| 20 | 0.007 | -0.031 | 42.252 | 0.003 |

**Patan**



| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.317 | -0.317 | 15.749 | 0.000 |
| 2 | -0.165 | -0.295 | 20.052 | 0.000 |
| 3 | -0.025 | -0.226 | 20.151 | 0.000 |
| 4 | -0.009 | -0.201 | 20.165 | 0.000 |
| 5 | 0.050 | -0.111 | 20.575 | 0.001 |
| 6 | -0.047 | -0.151 | 20.926 | 0.002 |
| 7 | 0.033 | -0.080 | 21.107 | 0.004 |
| 8 | -0.024 | -0.104 | 21.204 | 0.007 |
| 9 | 0.003 | -0.083 | 21.205 | 0.012 |
| 10 | 0.000 | -0.083 | 21.205 | 0.020 |
| 11 | -0.013 | -0.090 | 21.231 | 0.031 |
| 12 | 0.031 | -0.051 | 21.395 | 0.045 |
| 13 | 0.002 | -0.035 | 21.396 | 0.065 |
| 14 | -0.002 | -0.023 | 21.396 | 0.092 |
| 15 | -0.061 | -0.096 | 22.032 | 0.107 |
| 16 | 0.018 | -0.080 | 22.088 | 0.140 |
| 17 | 0.038 | -0.050 | 22.339 | 0.172 |
| 18 | -0.010 | -0.057 | 22.358 | 0.216 |
| 19 | -0.008 | -0.060 | 22.369 | 0.266 |
| 20 | -0.040 | -0.111 | 22.656 | 0.306 |

**Sabarkantha**



| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.439 | -0.439 | 30.289 | 0.000 |
| 2 | -0.102 | -0.366 | 31.948 | 0.000 |
| 3 | 0.066 | -0.224 | 32.634 | 0.000 |
| 4 | -0.110 | -0.323 | 34.567 | 0.000 |
| 5 | 0.120 | -0.179 | 36.899 | 0.000 |
| 6 | 0.058 | -0.026 | 37.439 | 0.000 |
| 7 | -0.137 | -0.110 | 40.494 | 0.000 |
| 8 | 0.024 | -0.120 | 40.591 | 0.000 |
| 9 | 0.043 | -0.059 | 40.903 | 0.000 |
| 10 | -0.085 | -0.165 | 42.121 | 0.000 |
| 11 | 0.115 | -0.073 | 44.351 | 0.000 |
| 12 | -0.042 | -0.069 | 44.648 | 0.000 |
| 13 | 0.045 | 0.084 | 44.987 | 0.000 |
| 14 | -0.072 | -0.006 | 45.888 | 0.000 |
| 15 | -0.002 | -0.002 | 45.889 | 0.000 |
| 16 | -0.097 | -0.237 | 47.527 | 0.000 |
| 17 | 0.159 | -0.130 | 51.963 | 0.000 |
| 18 | 0.032 | -0.034 | 52.145 | 0.000 |
| 19 | -0.108 | -0.067 | 54.219 | 0.000 |
| 20 | 0.042 | -0.017 | 54.535 | 0.000 |

**Fitting of time series model for castor prices in major markets of Gujarat**

ARIMA model is a parsimonious model (Explains the data more precisely with few parameter). It includes both the autoregressive and moving average components to describe the data. So compare with any other linear time series model, this model was prefer to remove the linear dependency in the data. There are three steps *viz*., identification, estimation and diagnostic checking of model to fit a given data under consideration. The results of analysis of ARIMA model were presented under following sections.

**Table 5:** ARIMA models for maximum arrival markets of Gujarat state

| Market | ARIMA Model | $R^2$ | Adj.$R^2$ | AIC | BIC | RMSE | MAPE | MAE | MSE | Ljung-Box |
|---|---|---|---|---|---|---|---|---|---|---|
| Mehsana | (0,1,0) | 0.941 | 0.940 | 739.648 | 11.050 | 235.664 | 4.060 | 147.919 | 68259.46 | $22.415^{NS}$ |
| Rajkot | (0,1,2) | 0.932 | 0.920 | 774.725 | 11.041 | 233.252 | 4.594 | 156.685 | 60770.89 | $27.290^{NS}$ |
| Gandhinagar | (0,1,0) | 0.945 | 0.936 | 736.071 | 11.032 | 226.971 | 4.110 | 147.974 | 61600.401 | $20.714^{NS}$ |
| Banaskantha | (0,1,0) | 0.915 | 0.911 | 741.337 | 11.458 | 295.045 | 4.771 | 188.027 | 99741.1 | $19.042^{NS}$ |
| Patan | (1,0,1) | 0.728 | 0.726 | 840.345 | 12.942 | 609.849 | 5.786 | 234.641 | 669373.95 | $31.963^{NS}$ |
| Sabarkantha | (1,1,1) | 0.927 | 0.919 | 748.901 | 11.296 | 267.691 | 4.614 | 166.675 | 91539.32 | $22.143^{NS}$ |

## Validation of forecasting models

**Table 6:** ARIMA model validation and forecasting of castor price of selected markets

| Month | Actual value (y) | Predicted Value ($\hat{y}$) | Forecasting Error (%) |
|---|---|---|---|
| Jan-21 | 4372.05 | 4714.35 | -7.83 |
| Feb-21 | 4350.16 | 4711.47 | -8.30 |
| Mar-21 | 4553.00 | 4691.01 | -3.03 |
| Apr-21 | 4808.09 | 4668.15 | 2.91 |
| May-21 | 4974.14 | 4652.23 | 6.47 |
| Jun-21 | 5016.08 | 4644.09 | 7.42 |
| Jul-21 | 5300.56 | 4621.98 | 12.80 |
| Aug-21 | 5586.85 | 4601.21 | 17.64 |
| Sep-21 | 6080.00 | 4572.82 | 24.78 |
| Oct-21 | 6137.33 | 4563.95 | 25.64 |
| Nov-21 | 6390.75 | 4547.34 | 28.84 |
| Dec-21 | 6044.11 | 4554.01 | 24.65 |
| Average | | | 11.00 |
| ARIMA (0,1,0) model for Mehsana market | | | |

| Month | Actual value (y) | Predicted Value ($\hat{y}$) | Forecasting Error (%) |
|---|---|---|---|
| Jan-21 | 4228.86 | 4602.64 | -8.84 |
| Feb-21 | 4233.26 | 4601.06 | -8.68 |
| Mar-21 | 4421.66 | 4578.16 | -3.54 |
| Apr-21 | 4535.00 | 4562.51 | -0.61 |
| May-21 | 4915.71 | 4527.17 | 7.90 |
| Jun-21 | 5030.00 | 4512.77 | 10.28 |
| Jul-21 | 5140.71 | 4498.69 | 12.48 |
| Aug-21 | 5317.50 | 4480.64 | 15.74 |
| Sep-21 | 5237.14 | 4478.25 | 14.49 |
| Oct-21 | 6072.50 | 4426.02 | 27.11 |
| Nov-21 | 6169.28 | 4413.83 | 28.45 |
| Dec-21 | 5880.00 | 4419.33 | 24.84 |
| Average | | | 9.96 |
| ARIMA (0,1,2 for Rajkot market | | | |

| Month | Actual value (y) | Predicted Value ($\hat{y}$) | Forecasting Error (%) |
|---|---|---|---|
| Jan-21 | 4324.87 | 4662.60 | -7.81 |
| Feb-21 | 4321.19 | 4655.50 | -7.73 |
| Mar-21 | 4538.44 | 4631.86 | -2.05 |
| Apr-21 | 4769.85 | 4608.52 | 3.38 |
| May-21 | 5022.17 | 4585.14 | 8.70 |
| Jun-21 | 5002.46 | 4577.81 | 8.48 |
| Jul-21 | 5272.78 | 4554.31 | 13.62 |
| Aug-21 | 5640.29 | 4527.47 | 19.73 |
| Sep-21 | 6047.23 | 4501.00 | 25.57 |
| Oct-21 | 6128.84 | 4488.29 | 26.76 |
| Nov-21 | 6328.16 | 4471.09 | 29.35 |
| Dec-21 | 6042.59 | 4471.79 | 25.99 |
| Average | | | 12.00 |
| ARIMA (0,1,0) model for Gandhinagar market | | | |

| Month | Actual value (y) | Predicted Value ($\hat{y}$) | Forecasting Error (%) |
|---|---|---|---|
| Jan-21 | 4366.67 | 4933.07 | -12.97 |
| Feb-21 | 4330.67 | 4932.94 | -13.90 |
| Mar-21 | 4549.50 | 4900.95 | -7.73 |
| Apr-21 | 6389.44 | 4741.82 | 25.78 |
| May-21 | 5026.67 | 4839.51 | 3.72 |
| Jun-21 | 5040.62 | 4832.45 | 4.13 |
| Jul-21 | 5269.00 | 4805.59 | 8.79 |
| Aug-21 | 5625.94 | 4770.11 | 15.21 |
| Sep-21 | 6100.56 | 4730.05 | 22.46 |
| Oct-21 | 6234.29 | 4714.82 | 24.37 |
| Nov-21 | 6381.25 | 4698.92 | 26.36 |
| Dec-21 | 6135.00 | 4707.04 | 23.27 |
| Average | | | 9.95 |
| ARIMA (0,1,0) model for Banaskantha market | | | |

| Month | Actual value (y) | Predicted Value ($\hat{y}$) | Forecasting Error (%) |
|---|---|---|---|
| Jan-21 | 4358.33 | 4367.99 | -0.22 |
| Feb-21 | 4323.26 | 4443.82 | -2.79 |
| Mar-21 | 4570.00 | 4520.85 | 1.075 |
| Apr-21 | 4839.23 | 4599.10 | 4.96 |
| May-21 | 4978.33 | 4678.56 | 6.02 |
| Jun-21 | 5034.77 | 4759.22 | 5.47 |
| Jul-21 | 5277.17 | 4841.10 | 8.26 |
| Aug-21 | 5676.96 | 4924.18 | 13.26 |
| Sep-21 | 6105.45 | 5008.47 | 17.97 |
| Oct-21 | 6139.32 | 5093.97 | 17.03 |
| Nov-21 | 6405.33 | 5180.68 | 19.12 |
| Dec-21 | 6085.96 | 5268.60 | 13.43 |
| Average | | | 8.63 |
| ARIMA (1,0,1) model for Patan market | | | |

| Month | Actual value (y) | Predicted Value ($\hat{y}$) | Forecasting Error (%) |
|---|---|---|---|
| Jan-21 | 4162.45 | 4736.95 | -13.80 |
| Feb-21 | 4134.50 | 4756.14 | -15.04 |
| Mar-21 | 4626.07 | 4676.67 | -1.09 |
| Apr-21 | 4608.33 | 4686.24 | -1.69 |
| May-21 | 4989.00 | 4631.49 | 7.16 |
| Jun-21 | 4997.00 | 4633.12 | 7.28 |
| Jul-21 | 5167.00 | 4602.81 | 10.91 |
| Aug-21 | 6000.00 | 4545.06 | 24.24 |
| Sep-21 | 6100.00 | 4525.05 | 25.81 |
| Oct-21 | 5875.00 | 4533.83 | 22.82 |
| Nov-21 | 6212.50 | 4501.53 | 27.54 |
| Dec-21 | 5597.00 | 4158.71 | 25.69 |
| Average | | | 9.98 |
| ARIMA (1,1,1) model for Sabarkantha market | | | |

**Post sample forecasting of various markets in Gujarat state**

**Table 7:** Post sample forecasted value using forecasting model (0, 1, 0) for castor price in Mehsana market

| Month | Predicted Value ($\hat{y}$) | Upper Limit | Lower Limit |
|---|---|---|---|
| Jan-22 | 4294.86 | 5989.26 | 2600.46 |
| Feb-22 | 4287.38 | 6045.75 | 2529.02 |
| Mar-22 | 4279.67 | 6099.75 | 2459.59 |
| Apr-22 | 4271.72 | 6151.49 | 2391.95 |
| May-22 | 4263.53 | 6201.16 | 2325.91 |
| Jun-22 | 4255.11 | 6248.91 | 2261.31 |
| Jul-22 | 4246.45 | 6294.88 | 2198.02 |
| Aug-22 | 4237.55 | 6339.20 | 2135.90 |
| Sep-22 | 4228.42 | 6381.97 | 2074.87 |
| Oct-22 | 4219.05 | 6423.28 | 2014.82 |
| Nov-22 | 4209.44 | 6463.21 | 1955.67 |
| Dec-22 | 4199.60 | 6501.84 | 1897.36 |

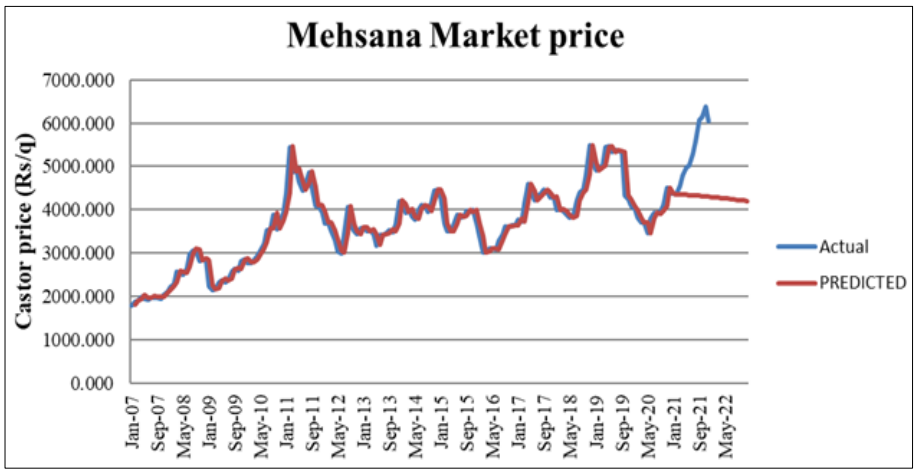



**Fig 3:** Forecasted value for castor price in Mehsana market

**Table 8:** Post sample forecasted value using forecasting model (0, 1, 2) for castor price in Rajkot market

| Month | Predicted Value ($\hat{y}$) | Upper Limit | Lower Limit |
|---|---|---|---|
| Jan-22 | 4121.74 | 5877.70 | 2365.79 |
| Feb-22 | 4113.18 | 5935.52 | 2290.85 |
| Mar-22 | 4104.37 | 5990.74 | 2218.00 |
| Apr-22 | 4095.30 | 6043.61 | 2146.99 |
| May-22 | 4085.99 | 6094.32 | 2077.65 |
| Jun-22 | 4076.41 | 6143.04 | 2009.79 |
| Jul-22 | 4066.59 | 6189.90 | 1943.28 |
| Aug-22 | 4056.52 | 6235.03 | 1878.00 |
| Sep-22 | 4046.19 | 6278.55 | 1813.82 |
| Oct-22 | 4035.61 | 6320.55 | 1750.67 |
| Nov-22 | 4024.77 | 6361.11 | 1688.44 |
| Dec-22 | 4013.69 | 6400.31 | 1627.07 |

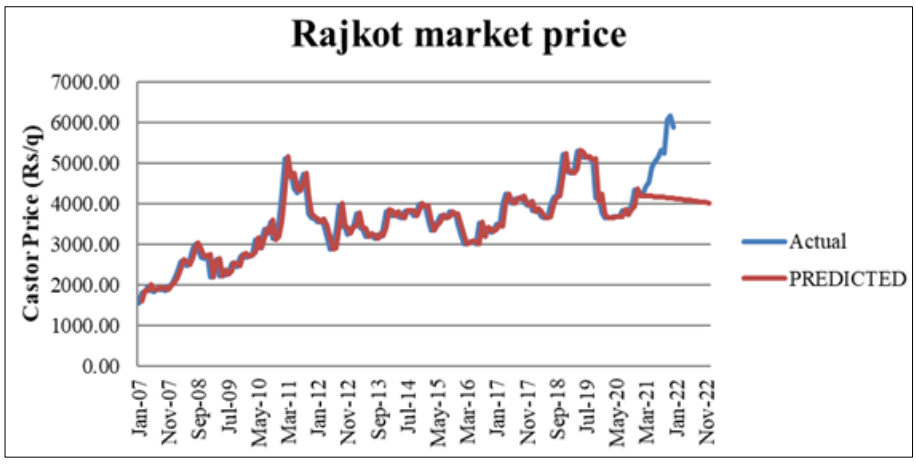



**Fig 4:** Forecasted value for castor price in Rajkot market

**Table 9:** Post sample forecast value using forecasting model (0,1,0) for castor price in Gandhinagar market

| Month | Predicted Value ($\hat{y}$) | Upper Limit | Lower Limit |
|---|---|---|---|
| Jan-22 | 4222.67 | 7013.29 | 1432.04 |
| Feb-22 | 4212.06 | 7108.03 | 1316.09 |
| Mar-22 | 4201.19 | 7198.80 | 1203.58 |
| Apr-22 | 4190.05 | 7285.97 | 1094.13 |
| May-22 | 4178.64 | 7369.84 | 987.44 |
| Jun-22 | 4166.97 | 7450.68 | 883.25 |
| Jul-22 | 4155.02 | 7528.72 | 781.32 |
| Aug-22 | 4142.81 | 7604.15 | 681.46 |
| Sep-22 | 4130.32 | 7677.15 | 583.50 |
| Oct-22 | 4117.57 | 7747.86 | 487.29 |
| Nov-22 | 4104.56 | 7816.43 | 392.68 |
| Dec-22 | 4091.27 | 7882.98 | 299.56 |

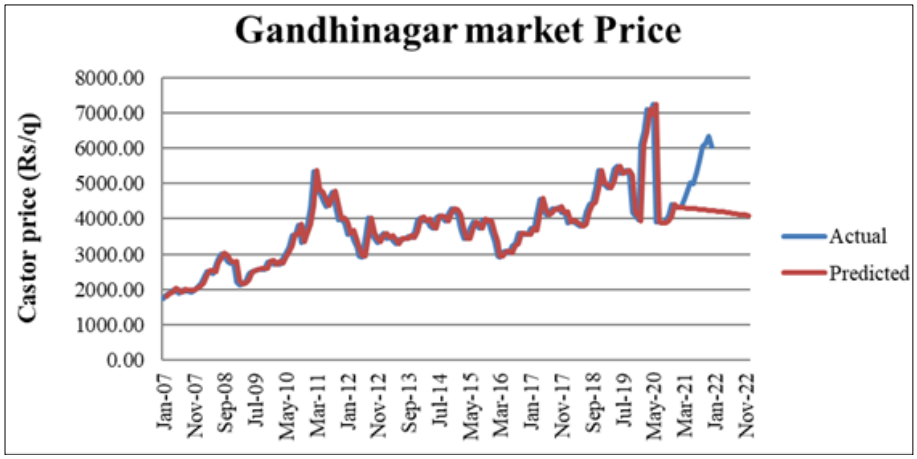



**Fig 5:** Forecasted value for castor price in Gandhinagar market

**Table 10:** Post sample forecast value using forecasting model (0, 1, 0) for castor price in Banaskantha market

| Month | Predicted Value ($\hat{y}$) | Upper Limit | Lower Limit |
|---|---|---|---|
| Jan-22 | 4303.36 | 6061.15 | 2545.57 |
| Feb-22 | 4295.71 | 6119.86 | 2471.57 |
| Mar-22 | 4287.82 | 6175.99 | 2399.65 |
| Apr-22 | 4279.69 | 6229.79 | 2329.60 |
| May-22 | 4271.32 | 6281.43 | 2261.21 |
| Jun-22 | 4262.71 | 6331.10 | 2194.33 |
| Jul-22 | 4253.86 | 6378.92 | 2128.80 |
| Aug-22 | 4244.77 | 6425.04 | 2064.5 |
| Sep-22 | 4235.43 | 6469.54 | 2001.32 |
| Oct-22 | 4225.86 | 6512.54 | 1939.17 |
| Nov-22 | 4216.04 | 6554.12 | 1877.96 |
| Dec-22 | 4205.98 | 6594.35 | 1817.61 |

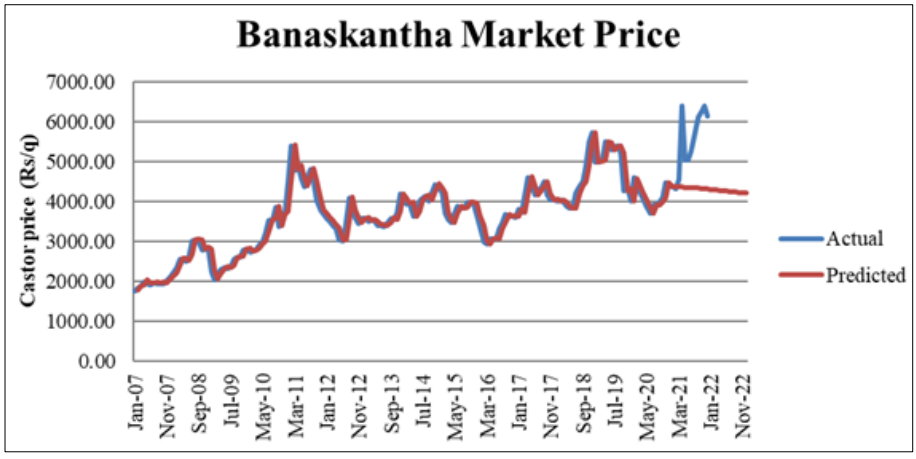



**Fig 6:** Forecasted value for castor price in Banaskantha market

**Table 11:** Post sample forecast value using forecasting model (1, 0, 1) for castor price in Patan market

| Month | Predicted Value ($\hat{y}$) | Upper Limit | Lower Limit |
|---|---|---|---|
| Jan-22 | 5357.73 | 9851.02 | 864.44 |
| Feb-22 | 5448.07 | 10115.72 | 780.42 |
| Mar-22 | 5539.62 | 10375.34 | 703.89 |
| Apr-22 | 5632.37 | 10630.53 | 634.22 |
| May-22 | 5726.34 | 10881.81 | 570.87 |
| Jun-22 | 5821.51 | 11129.63 | 513.39 |
| Jul-22 | 5917.90 | 11374.40 | 461.39 |
| Aug-22 | 6015.49 | 11616.45 | 414.53 |
| Sep-22 | 6114.29 | 11856.07 | 372.51 |
| Oct-22 | 6214.3 | 12093.53 | 335.08 |
| Nov-22 | 6315.52 | 12329.06 | 301.99 |
| Dec-22 | 6417.95 | 12562.86 | 273.04 |


**Fig 7:** Forecasted value for castor price in Patan market

**Table 12:** Post sample forecast value using forecasting model (1, 1, 1) for castor price in Sabarkantha market

| Month | Predicted Value ($\hat{y}$) | Upper Limit | Lower Limit |
|---|---|---|---|
| Jan-22 | 4146.47 | 6140.88 | 2152.05 |
| Feb-22 | 4138.57 | 6208.93 | 2068.21 |
| Mar-22 | 4126.65 | 6269.52 | 1983.78 |
| Apr-22 | 4117.56 | 6331.16 | 1903.96 |
| May-22 | 4105.69 | 6387.35 | 1824.02 |
| Jun-22 | 4095.63 | 6443.76 | 1747.50 |
| Jul-22 | 4083.62 | 6496.09 | 1671.15 |
| Aug-22 | 4072.74 | 6548.12 | 1597.36 |
| Sep-22 | 4060.47 | 6597.00 | 1523.94 |
| Oct-22 | 4048.88 | 6645.28 | 1452.47 |
| Nov-22 | 4036.26 | 6691.06 | 1381.46 |
| Dec-22 | 4024.02 | 6736.06 | 1311.98 |


**Fig 8:** Forecasted value for castor price in Sabarkantha market

## Conclusion

The highest seasonality indices observed in August month and lowest seasonality indices in May month in majority of markets except Patan market. Among six markets, the price forecast model for Mehsana, Gandhinagar and Banaskantha market, (0,1,0) was found to be the best model whereas Rajkot market (0, 1, 2), Patan market (1, 0, 1) and Sabarkantha market (1, 1, 1) was found to be the best model. In future, research needs to be conducted in these markets by using ARIMA to ascertain any asymmetrical nature and also to find the leverage effect.

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