

Time series modelling for forecasting of maize prices in Nandurbar market of Maharashtra

A. S. Gadakh · R. B. Hile · S. B. Sapkal

Abstract Maize is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. In Maharashtra, it is grown throughout the year for various purposes including consumption, food & feeds to industrial products. In light of this, the feasibility and probability of adopting maize as a key crop have been determined by analysing time series modelling for forecasting of maize prices in Nandurbar market of Maharashtra. The time series data on monthly prices of maize were collected from MSAMB, Pune for Nandurbar market. ARIMA stochastic modelling was used to anticipate maize prices in Nandurbar market, with the goal of identifying the best effective model for forecasting prices up to September 2024. The forecasted results indicated that there might be increase in the maize prices in the Nandurbar market. This requires the government to take appropriate measures to ensure farmers and end user get benefited.

Keywords: ACF · ARIMA · Forecast · PACF · Prices

Introduction

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. It cultivated on around 150 m ha of land across over 160 nations with diverse soil, temperature, biodiversity, and management approaches, it makes up 36 per cent (782 mt) of the world's grain production. The United States of

America is the world's greatest producer of maize, accounting for about 35 per cent of global production, and maize is the primary driver of the US economy. The USA has highest productivity ($> 11.13 \text{ t ha}^{-1}$) which is double than the global average (5.92 t ha^{-1}). Whereas, the average productivity in India is 3.24 t ha^{-1} . Maize is India's third most significant cereal crop after rice & wheat and it is grown in a variety of climate, ranging from extreme semi-arid to sub-humid and humid regions, accounting for 82 per cent of the land under cultivation during the *kharif* season. It accounts for approximately 10 per cent of total food grain production in the country. The Indian maize sector has numerous potential in all of its sub-sectors, including seed, non-seed inputs, agricultural mechanization, processed foods, industrial products, market-related infrastructure, storage and processing.

Maharashtra ranked 3rd in area under and 2nd in maize production among different maize producing states in the year 2020-21. Maize is grown in almost all the districts of all the region of Maharashtra. However, Marathwada and Western Maharashtra are the two main producing regions of Maharashtra for maize. Nashik has highest area under maize followed by Aurangabad, Dhule, Ahmednagar and Jalgaon and in production, Nashik is at the top followed by Dhule, Aurangabad, Ahmednagar, Jalgaon and Jalna.

In the agricultural production system, price fluctuations are the second biggest source of risk after weather variations. Farmers' decision-making processes are directly impacted by these price fluctuations in both production and marketing (Darekar and Reddy, 2017). Price forecasting is required to ensure that farmers receive fair prices for their produce in the agricultural markets, which is essential for the greater economic development of agriculture. The farmer may gain from delivering the produce during the higher rates in terms of selling for better financial fulfillment

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Received: 25 April 2024/ Accepted: 04 July 2024

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if there could be some forecasting of arrivals and prices in the agricultural marketplaces.

Materials and methods

Time series data on monthly maize prices were collected from MSAMB in Pune for the Nandurbar market. Data on monthly modal prices (Rs/qt) were collected from October 2012 to September 2022 (11 years) and were used for model fitting.

Auto-regressive integrated moving average (ARIMA) model

In the ARIMA model (Box and Jenkins, 1970) assumes that the estimated value of a variable is a linear combination of past values and errors. In general, a time series can be described as a combination of past values and errors, designated as ARIMA (p,d,q), which is expressed in the following form

$$Y_t = \theta_0 + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_p Y_{t-p} + \epsilon_t - \theta_1 \epsilon_{t-1} - \theta_2 \epsilon_{t-2} - \dots - \theta_q \epsilon_{t-q} \dots (1)$$

where, Y_t and ϵ_t are the actual values and random error at time t , respectively, Φ_i ($i = 1, 2, \dots, p$) and θ_j ($j = 1, 2, \dots, q$) are model parameters, p and q are integers and often referred to as orders of autoregressive and moving average polynomials, respectively.

It is assumed that random errors have a mean of zero and constant variance and that they are independently and identically distributed. Similarly, a seasonal model is represented by the ARIMA (p, d, q) x (P, D, Q) model, where P = number of seasonal autoregressive (SAR) terms, D = number of seasonal differences, Q = number of seasonal moving average (SMA) terms. The main stages in setting up a forecasting ARIMA model are: (i) Model identification, (ii) Parameters estimation, (iii) Diagnostic checking and (iv) Forecasting. The ARIMA model is a data- oriented approach that is adopted from the structure of the data itself.

Results and discussion

Forecasting of prices of maize in Nandurbar market

a. Identification of the model

A seasonal, non-seasonal, or both orders of differencing calculation were used to convert the research variables

into stationary series before the ARIMA model was estimated. Stationary series can be achieved by computing autocorrelation (ACF) and partial auto-correlation functions (PACF), which are shown in Table 1.

Table 1. ACF and PACF of maize prices in Nandurbar market

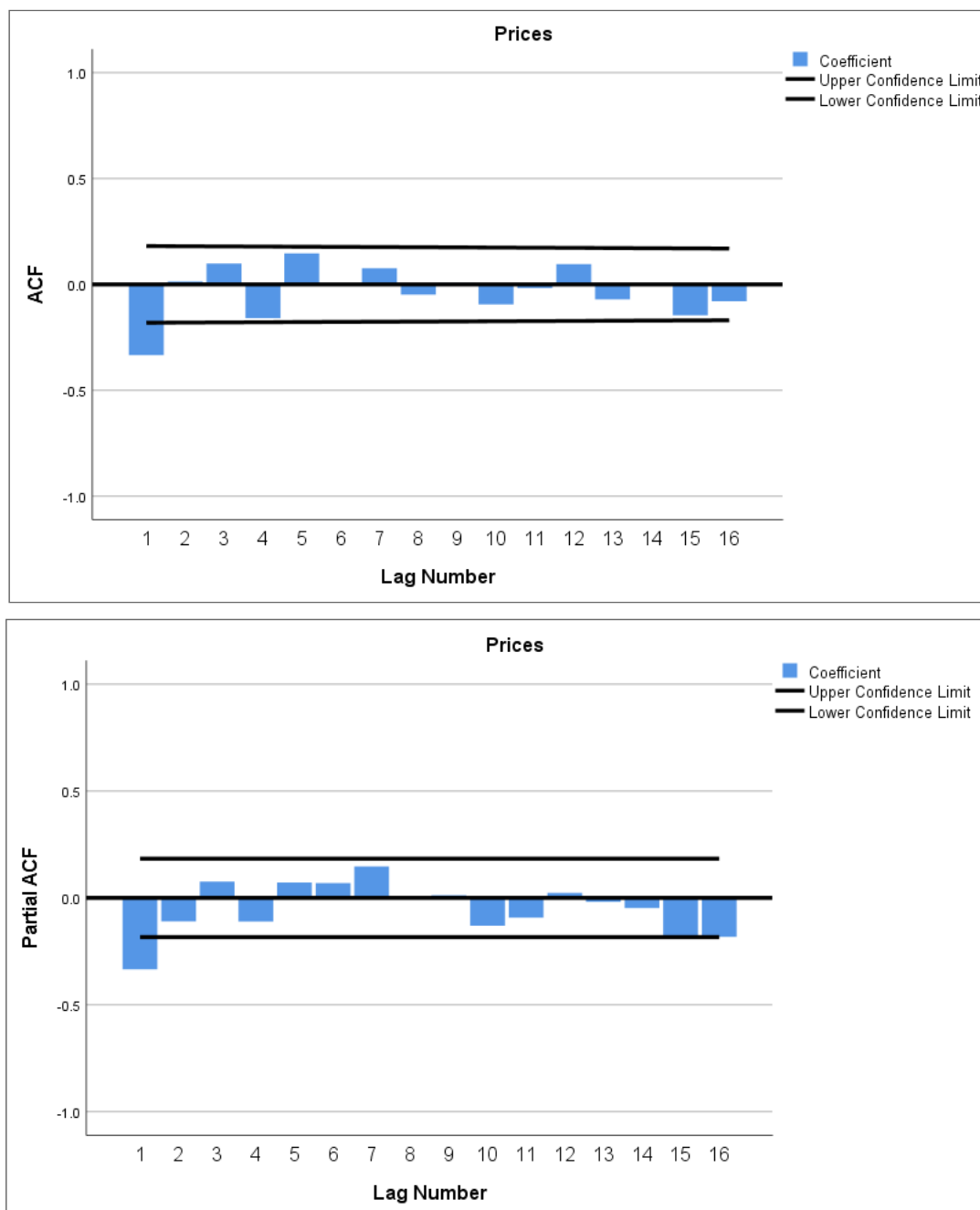
Lags	Prices	
	ACF	PACF
1	-0.334	-0.334
2	0.014	-0.110
3	0.099	0.076
4	-0.159	-0.111
5	0.147	0.072
6	0.002	0.069
7	0.076	0.147
8	-0.048	0.005
9	0.006	0.013
10	-0.095	-0.130
11	-0.017	-0.092
12	0.096	0.023
13	-0.071	-0.018
14	0.004	-0.048
15	-0.146	-0.180
16	-0.080	-

The presence of seasonality in the data was identified by carefully examining ACF and PACF up to 16 lags in Table 1. However, the coefficient went to zero after the second lag, indicating that the series was stationary. The significance of each coefficient of the ACF and PACF was examined using the “t” test. Further, the lack of a peak at the first values demonstrated that the non-seasonal difference with $d=1$ was a suitable choice for achieving a stationary series. Hence, based on ACF and PACF many models were tested. Finally, model (4,1,3) was ultimately determined to be the best model for predicting maize prices in the Nandurbar market (Kapngaihlian *et al.*, 2017).

b. Model estimation

The model parameter were calculated and shown in Table 2 by using SPSS software. In the model estimation stage, we conduct a fixed-order analysis for p and q . We set p and q as 4, 1, 3, by checking different orders of ARIMA models combinations which are obtained in total. The minimum information criteria used to decide the order

Figure 1. ACF and PACF of maize prices in Nandurbar market



of the ARIMA model trade-off are AIC (Akaike information criterion), SBC (Schwarz criterion), HQ (Hannan-Quinn criterion) and maximum R^2 . In this paper, SBC, MAPE, and R^2 were utilized as criteria for selecting the ARIMA model in order to acquire the best trade-off impact and so construct a superior ARIMA model.

Diagnostic checking

The residual diagnostics (Correlogram-Q-statistics) was carried out on ARIMA (4,1,3) in Figure 1 and estimated the coefficient for a good forecast. We obtained ACF and

Table 2. Estimates of the ARIMA model fitted for maize prices in Nandurbar market

Parameter	Estimates	SE $\pm$	t value	Sig.
Constant	-525.355	1306.917	-0.402	0.688
MAPE	7.095			
Df	11			
R^2	0.782			
BIC Value	10.212			

PACF of residual terms up to certain lags of the estimated ARIMA model and then checked whether the coefficients were statistically significant or not through the Correlogram-Q-statistics and Ljung-Box statistics (Darekar and Reddy,

Figure 2. Residual fit ACF and PACF of maize prices in Nandurbar market

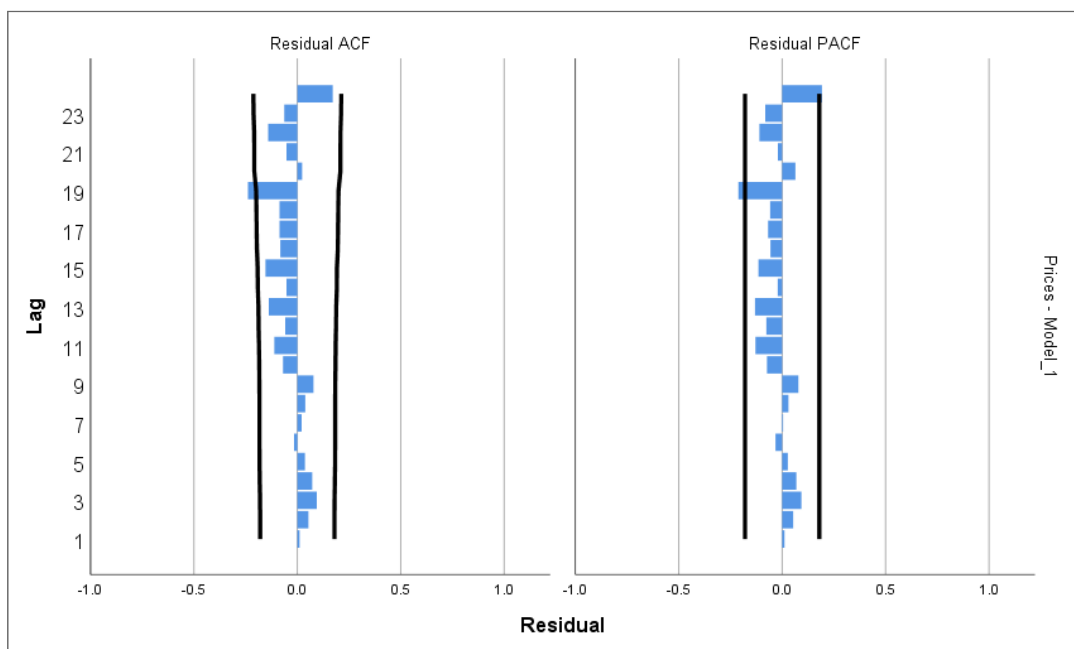
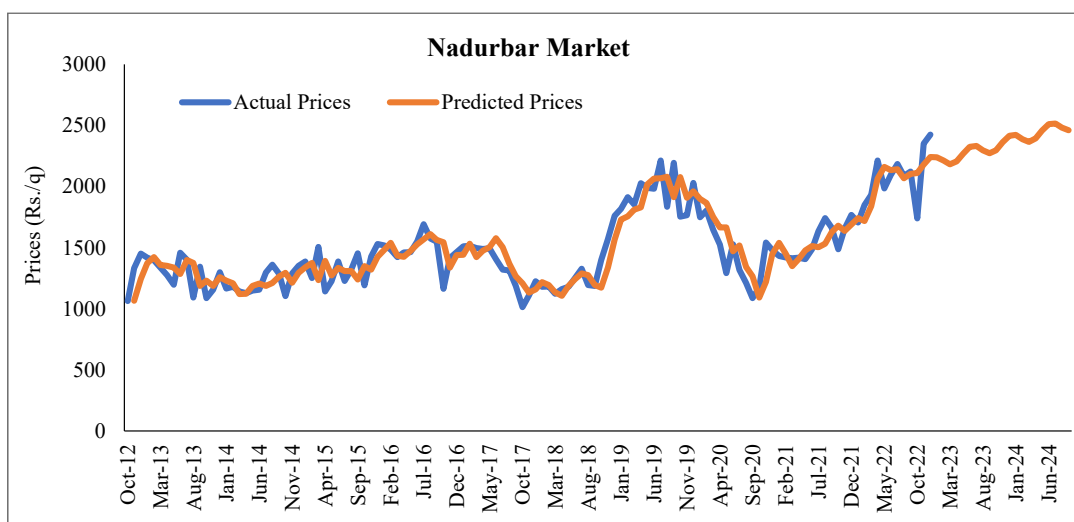


Figure 3. Ex-ante and Ex-post forecast of monthly prices of maize in Nandurbar market



2017). According to the results of maize autocorrelation and partial autocorrelation, there is no autocorrelation in the residual sequence, which means white noise, so it indicating that it is an adequate model, and the model fitting figure is displayed in Figure 1. Hence, the fitted ARIMA model for the maize price data in Nandurbar market was $Y_t = -525.35 - 0.413Y_{t-1} - 0.633e_{t-1}$.

Forecasting of prices

These joint statistics proved that, all the tentatively identified and estimated models were appropriate for forecasting the maize prices of the selected market. The values of these statistics are shown in Table 2.

Subsequently, the best-fitted model (4,1,3) is being used for forecasted up to the year September, 2024.

Table 3 revealed that, the small differences between the actual and anticipated prices of maize in the Nandurbar market and the forecasted values of prices showed an increasing trend in the Nandurbar market. The predicted prices for maize on the market during 2023 will be high *i.e.*, Rs. 2472 per q, during September and low *i.e.*, Rs. 2182 per q during March, respectively. In 2024, the prices will be high in August *i.e.*, Rs. 2481 per q and low *i.e.*, Rs. 2365 per q during March (Panasa *et al.*, 2017). The above results were revealed that the general forecasts were recorded highest in the month of low maize supply and lowest in the month of highest maize supply.

Table 3. Ex-ante and Ex-post forecast of monthly prices of maize in Nandurbar market

Year	Prices (Rs/qt)		
	Actual	Predicted	Difference (%)
Oct-12	1062	-	-
Nov-12	1331	1064	25.09
Dec-12	1451	1243	16.73
Jan-13	1416	1372	3.21
Feb-13	1396	1422	-1.83
Mar-13	1337	1357	-1.47
Apr-13	1274	1350	-5.63
May-13	1195	1335	-10.49
Jun-13	1457	1283	13.56
Jul-13	1400	1397	0.21
Aug-13	1090	1374	-20.67
Sep-13	1343	1187	13.14
Oct-13	1085	1230	-11.79
Nov-13	1154	1187	-2.78
Dec-13	1297	1258	3.1
Jan-14	1164	1228	-5.21
Feb-14	1179	1208	-2.4
Mar-14	1140	1119	1.88
Apr-14	1127	1122	0.45
May-14	1149	1185	-3.04
Jun-14	1155	1206	-4.23
Jul-14	1295	1187	9.1
Aug-14	1361	1209	12.57
Sep-14	1285	1263	1.74
Oct-14	1103	1293	-14.69
Nov-14	1288	1212	6.27
Dec-14	1351	1293	4.49
Jan-15	1385	1339	3.44
Feb-15	1251	1375	-9.02
Mar-15	1505	1234	21.96
Apr-15	1142	1392	-17.96
May-15	1225	1271	-3.62
Jun-15	1385	1334	3.82
Jul-15	1226	1308	-6.27
Aug-15	1322	1307	1.15
Sep-15	1453	1239	17.27
Oct-15	1192	1348	-11.57
Nov-15	1426	1319	8.11
Dec-15	1528	1425	7.23
Jan-16	1516	1481	2.36
Feb-16	1484	1538	-3.51

Table 3. contd..

Year	Prices (Rs/qt)		
	Actual	Predicted	Difference (%)
Mar-16	1422	1434	-0.84
Apr-16	1461	1425	2.53
May-16	1463	1472	-0.61
Jun-16	1550	1527	1.51
Jul-16	1691	1568	7.84
Aug-16	1574	1610	-2.24
Sep-16	1547	1562	-0.96
Oct-16	1162	1544	-24.74
Nov-16	1415	1337	5.83
Dec-16	1462	1439	1.6
Jan-17	1510	1440	4.86
Feb-17	1514	1531	-1.11
Mar-17	1495	1423	5.06
Apr-17	1489	1475	0.95
May-17	1494	1503	-0.6
Jun-17	1404	1577	-10.97
Jul-17	1320	1502	-12.12
Aug-17	1313	1368	-4.02
Sep-17	1187	1265	-6.17
Oct-17	1013	1207	-16.07
Nov-17	1108	1132	-2.12
Dec-17	1224	1157	5.79
Jan-18	1179	1218	-3.2
Feb-18	1182	1194	-1.01
Mar-18	1122	1133	-0.97
Apr-18	1160	1104	5.07
May-18	1179	1186	-0.59
Jun-18	1251	1240	0.89
Jul-18	1326	1288	2.95
Aug-18	1194	1275	-6.35
Sep-18	1185	1193	-0.67
Oct-18	1398	1171	19.39
Nov-18	1569	1335	17.53
Dec-18	1759	1565	12.4
Jan-19	1818	1730	5.09
Feb-19	1912	1756	8.88
Mar-19	1853	1811	2.32
Apr-19	2026	1830	10.71
May-19	1989	2017	-1.39
Jun-19	1982	2064	-3.97
Jul-19	2212	2068	6.96
Aug-19	1833	2078	-11.79

Table 3. contd..

Year	Prices (Rs/qt)		
	Actual	Predicted	Difference (%)
Sep-19	2193	1913	14.64
Oct-19	1754	2077	-15.55
Nov-19	1764	1907	-7.5
Dec-19	2030	1961	3.52
Jan-20	1748	1897	-7.85
Feb-20	1802	1866	-3.43
Mar-20	1646	1751	-6
Apr-20	1524	1664	-8.41
May-20	1292	1665	-22.4
Jun-20	1527	1470	3.88
Jul-20	1316	1518	-13.31
Aug-20	1209	1341	-9.84
Sep-20	1086	1264	-14.08
Oct-20	1171	1091	7.33
Nov-20	1542	1219	26.5
Dec-20	1480	1448	2.21
Jan-21	1432	1538	-6.89
Feb-21	1419	1454	-2.41
Mar-21	1412	1347	4.83
Apr-21	1418	1405	0.93
May-21	1404	1477	-4.94
Jun-21	1487	1513	-1.72
Jul-21	1634	1504	8.64
Aug-21	1741	1532	13.64
Sep-21	1664	1625	2.4
Oct-21	1486	1679	-11.49
Nov-21	1656	1637	1.16
Dec-21	1768	1689	4.68
Jan-22	1706	1742	-2.07
Feb-22	1847	1718	7.51
Mar-22	1931	1838	5.06
Apr-22	2213	2064	7.22
May-22	1984	2161	-8.19
Jun-22	2094	2134	-1.87
Jul-22	2183	2141	1.96
Aug-22	2087	2068	0.92
Sep-22	2121	2104	-0.8
Oct-22	1838	2110	14.8
Nov-22	2351	2179	-7.32
Dec-22	2425	2240	-7.63
Jan-23	2266	2239	-1.19
Feb-23	2018	2212	9.61

Table 3. contd..

Year	Prices (Rs/qt)		
	Actual	Predicted	Difference (%)
Mar-23	1927	2182	13.23
Apr-23	2143	2206	2.94
May-23	2038	2269	11.33
Jun-23	2079	2324	-10.54
Jul-23	2109	2331	-9.53
Aug-23	2065	2296	-10.06
Sep-23	2194	2472	-11.24
Oct-23	2239	2297	-2.52
Nov-23	2242	2362	-5.08
Dec-23	2360	2416	-2.31
Jan-24	2370	2421	-2.10
Feb-24	-	2387	-
Mar-24	-	2365	-
Apr-24	-	2393	-
May-24	-	2458	-
Jun-24	-	2511	-
Jul-24	-	2515	-
Aug-24	-	2481	-
Sep-24	-	2461	-

Conclusion and policy implication

The results concluded that, the ARIMA 4 1 3 model was the most adequate and efficient model. The results of autocorrelation and partial autocorrelation of maize show that there is no autocorrelation in the residual sequence. From the selected model in all two years of monthly maize prices were forecasted out of which for 9 months actual prices were compared. The forecasted results indicated that there might be increase in the maize prices in the Nandurbar market. The anticipated prices of chosen commodities were almost identical to the actual prices, with excellent confirmation.

A greater understanding of maize price status and future pricing would help farmers and end users make informed judgments about buying and selling patterns, thus the government should implement appropriate policies. With the projected increase in maize prices, farmers are encouraged to grow due to higher yields and a higher farm income. Additionally, it will employ efficient market information distribution, such as price forecasts, to stakeholders, who may be very helpful in determining farm business decisions and monitoring price volatility. Its

limitation includes its requirements for long time series (large sample size). Like any other method, this technique also does not guarantee perfect forecasts.

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