Journal of Research Administration
Society of Research Administrators International

FORECASTING OF APPLE PRODUCTION IN INDIA USING ARIMA MODEL

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Abstract

Apples are the most regularly cultivated temperate fruit in India, and fifth most often cultivated worldwide after bananas, oranges, and grapes. Only in the “northwestern Himalayan states of Jammu & Kashmir, Himachal Pradesh, and Uttarakhand” is the apple grown commercially in India. In these states, horticulture is the primary source of income. Year-wise good apples with high yield are not only profitable for the farmers but also for the government in farm planning and making strategic decisions regarding marketing and storage. Therefore, prediction beforehand is crucial. The purpose of the study is to forecast apple production in India using the ARIMA (p,d,q) model. For this purpose, the time series data (2001-2002 to 2021-2022) on apple production from National Horticulture Board, Government of India was taken into account. According to the data, the Arima (2,1.0) model is the most accurate tool for predicting India’s apple output. The best fitting model is validated by a visual comparison of actual and predicted apple output.

Keywords: *Forecasting; Apple production; ARIMA Model; National Horticulture Board*

1. Introduction

India is known as the "fruit and vegetable basket of the world," and apples are a popular crop there. Its production numbers are unparalleled among countries due to the extraordinary diversity of fruits and vegetables and apple holds a unique position in production figures among all the countries (Ahmad 2019). India ranks fifth in global apple production, with the vast majority of apples coming from only three hilly states: Jammu and Kashmir, Uttarakhand, and Himachal Pradesh (Bhat, 2019).

As one of India's most important agricultural products, apple production is a major industry in the country. India is a major producer of apples and other fruits that are shipped all over the world. Apple exports from India are up 82 percent since 2014, according to statistics from the country's commerce ministry, while fruit imports are up 3.8 percent (The Economic Times, 2022). The increased exports are assisting the farmers of Kashmir and Himachal Pradesh in expanding their global sales. The statistics revealed that by 2020-2021, exports were worth US Dollars 14.45 million, up from US Dollars 8.6 million in 2014-2015. The USD 12.25 million in apple exports from April through November of the current fiscal year is a sign of robust expansion (The Economic Times, 2022). In dollar terms, exports rose to USD 12.25 million, a number that is indicative of sustained growth. In contrast, imports increased by 3.8 percent, from USD 230.8 m in 2014-2015 to USD 240 million in 2020-2021. Among the world's 6,500 apple varieties, 20 are grown in India (PBNS 2023). The government is making concerted attempts to increase global demand for apples. It is worth noting that the market places a disproportionate amount of value on Indian apples due to their relatively cheap price, high freshness, and good quality. For example, the valley's weather and other agroecological variables are perfect for developing different apple varieties and other temperate fruits. Apple agriculture employs approximately 0.5 to 0.6 million households, totaling approximately 3 million persons, and generates yearly revenue of USD 80 billion for the state (PBNS 2023).

Imports, on the other hand, rose by 3.8 percent in 2020-21, from USD 230.8 million the previous year. "Chile, New Zealand, Turkey, Italy, Brazil, and the United States" account for around 82 percent of India's apple imports. Chile accounted for one-fourth of Indian imports. It was succeeded by "New Zealand (16.45 percent), Turkey (12.43 percent), and Italy (10.8 percent)." Between April and November of 2021 and 2022, Iran would provide 7.73 percent, the UAE would supply 3.29 percent, and Afghanistan would supply 0.43 percent of India's apple needs (The Economic Times, 2022).

The purpose of the study is to forecast apple production in India using the ARIMA (p,d,q) model. Several studies have been conducted by researchers using various kinds of forecasting techniques in order to predict apple production in India.

A significant investigation on apple production in Jammu and Kashmir's Kulgam District, based on secondary data gathered from the Directorate of Horticulture Department, Jammu and Kashmir was proposed by **Mir and Shampth (2022)**. The research spans the years 2010–11–2018–19. Descriptive statistics have been used in the analysis of the data. According to the study's findings, Kashmir Valley's apple output scaled from 1139180 million tons in 2014–15 to 1851723 million tons.

Comparably, the Kulgam district's output of Apple has grown from 57518 million tons in 2014–15 to 213653 million tons.

Tosmu (2022) studied the pattern of productivity and apple output in Arunachal Pradesh and across India. In India, the hilly states of Himachal Pradesh, Uttarakhand, Arunachal Pradesh, and Nagaland are the places where apples are cultivated. Arunachal Pradesh has a varied economy growing a wide range of horticulture products, including cardamom, ginger, oranges, apples, and pineapples. Apple is a significant fruit crop farmed in Arunachal Pradesh. Although the fruit is now also cultivated in Tawang, Lower Subansiri, and Anjaw district, apple farming is mostly focused in the West Kameng district. A recent study was proposed by **Kumari et.al (2022)** to develop both Autoregressive Integrated Moving Average (ARIMA) and Exponential Smoothing (ES) models that may be used to predict the area, productivity, and output of all fruit crops in Gujarat. Based on the model fit statistics, they found exponential smoothing model was the best-fitted model for the area and productivity of fruit crops while ARIMA was best fitted model for the productivity of fruit crops.

An additional investigation was carried out by **Kumar (2020)** to ascertain the patterns in the acres, yield, and efficiency of apple crops in Jammu & Kashmir and Himachal Pradesh**.** This comparative study showed that area, production of apple crops was higher in Jammu and Kashmir as compared to Himachal Pradesh. A study on the marketing of apple fruit, requirement of apple fruit cultivation, and an analysis of the area and production of apple fruit in Himachal Pradesh was conducted by **Wani and Songara (2017)** based on the results obtained, was found that the area of apple crop cultivation was gradually increasing in Himachal Pradesh every year**. Islam and Shrivastava (2015)** have conducted studies on the patterns, yield, and productivity of apples in Jammu and Kashmir's horticultural industry during 2006–2007 and 2015–2017 and analyzed the annual compound growth rate of area, efficiency, and output of apple in Jammu & Kashmir. The area, production, and productivity of apples have increased in the state of Jammu and Kashmir.

An analysis of the economics of apple growing with an emphasis on south Kashmir was proposed by **Ahmad and Choure (2014)** they estimated the one-year cost and return from matured apple orchards and also examined the apple production and its input-output in the study region. This study showed that in the past decade, the production of apples in south Kashmir has increased, but productivity per hectare shows a decreasing trend, which is a serious problem mainly in the districts of Anantnag and Kulgam from 2009 to 2010. **Sharma et.al (2020)** carried out a practical investigation to forecast the area and production of apple crop apple in Himachal Pradesh. For the 2022–2023 forecasting of area and output, they used the ARIMA model. From this investigation, it was found that the area of the apple crop was expected to increase for the coming year 2018-19 to 2022-23.

Bhat (2014) analysed the trends and expansion in the region, production, and productivity of apples in Kashmir valley. Apple industry is the main source of economy in Kashmir valley which contributes to 98% of the total fruit production. 60% of the population depends on its livelihood on this industry but unfortunately during the last ten years there is no significant increase in the production of apples due to several reasons. The study done by **Malik (2013)** depicted that though horticulture is important component of agriculture of India, yet it faces lots of problems regarding its growth. The research is an attempt to assess them and also throws light on the dimensions of supply chain management of apple production in the valley.

2. Methods and Measures

2.1 Data Collection

Secondary information was employed in this investigation. From 2001-2002 to 2021-2022, data was gathered from the "National Horticulture Board (NHB) of J&K, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Nagaland, Sikkim, Tamil Nadu" apple-producing states in India. These are real, reliable resources, and the time series data they provide is often static.

2.2 Method

There are various tools and techniques that can be used to perform the forecasting of Apple production in the upcoming year. But to better predict the forecasting, the study utilizes two tools, namely SPSS and R tool. Both of these tools have numerous techniques to choose from, from which two models, namely ARIMA and HOLT, were utilized to understand the difference in the forecasting in both tools.

ARIMA

The Box – Jenkins (B.J.) technique is well-known. Several research employed ARIMA Models. If time series are varied, they obey both Moving-average (M.A.) and Autoregressive (A.R.) models, giving rise to the term "autoregressive integrated moving average. p signifies the number of autoregressive terms (A.R.), d the number of times the series is to be subtracted before it becomes stationary (I), and q the number of moving average terms in an ARIMA (p, d, q) time series (M.A.)."

"Auto-Regressive Process of order (p)" is,

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \varepsilon_t$$

"Moving Average Process of order (q)" is,

$$y_t = c + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q}$$

And the general form of the "ARIMA model of order (p, d, q)" is,

$$y'_t = c + \phi_1 y'_{t-1} + \cdots + \phi_p y'_{t-p} + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t$$

Here, y_t is apple production, ε_t are independently and normally distributed with zero mean and constant variance for t = 1, 2,….., n; and $\emptyset_p$ and θ_q are also projected.

ARIMA model includes the following steps:

- **Model Identification: "**The autocorrelation function (ACF) and partial autocorrelation function (PACF)" are used to examine the data for stationarity. Finding the initial values for the ordering of non-seasonal variables is the next stage in the recognition process p and q by examining the PACF and ACF charts for robust correlations.
- **Estimation:** This computation is usually done using basic least squares. However, nonlinear (in-parameter) estimate techniques are often required. The software programs SPSS and Stata were utilized for the investigation since they are simple and straightforward to use.

- **Diagnostic Checking:** The results from the fitted model are reviewed for model adequacy, and alternative models are explored if required. Additional ARIMA models are explored until a sufficient model match to the data found in the initially discovered model proves to be unsatisfactory. For diverse permutations of A.R. and M.A. separately and jointly, several models are produced, with the optimal model being determined by the least value of the "Bayesian Information Criterion (BIC) and Second-order Akaike Information Criterion (AICc)" provided by

$$BIC = (RSS + \log(n)\, d\hat{\sigma}^2)/n$$

d = Variables used for forecasting
n = Sum of all measurements
$\hat{\sigma}$ = Variance of error in response measurements estimated using a regression model
$RSS = Residual\ sum\ of\ squares\ of\ the\ regression\ model$
$TSS = Total\ sum\ of\ squares\ of\ the\ regression\ model$

$$AICc = AIC + \frac{2k^2 + 2k}{n - k - 1}$$

Where n is the total number of observations and k is the total number of free parameters. The number of parameters is therefore penalized, making AICc effectively the same as AIC. As $n \to \infty$, As the supplementary penalty term tends toward zero, the AICc metric approaches the AIC metric.
The effectiveness of several techniques was assessed using the "Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE)," which are computed using the:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

$M = mean\ absolute\ percentage\ error$
$n = number\ of\ times\ the\ summation\ iteration\ happens$
$A_t = actual\ value$
$F_t = forecast\ value$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \hat{x}_i)^2}{N}}$$

$RMSE = root\ mean\ square\ error$
$N = number\ of\ non\ missing\ data\ points$
$x_i = actual\ observations\ time\ series$
$\hat{x}_i = estimated\ time\ series$

If A_t represents the actual apple yield in multiple years, F_t Represents the anticipated Apple output in the same years, and the aggregate number of years used as the forecasting time frame is indicated by the letter n. The Bayesian Criteria of Schwartz is also utilized for assessment.

- **Forecasting:** Forecasting mistakes rise significantly while going too far into the future. Therefore, the author does a 5-year projection from 2022 to 2027.

3.Result and Discussion

ACF and PACF are used to test data stationarity. Figure 1 shows that the data is stationary since the ACF and PACF values are both zero, or between -0.5 and 0.5. The accuracy of the fit of ARIMA models was assessed in SPSS by using the minimal MAPE and Normalized BIC values. Table 1 displays the MAPE and Normalized BIC for ARIMA models. When evaluating ARIMA (2, 1, 0), the study uses the MAPE (10.555) and BIC (11.855) values. Table 2 also displays the additional diagnostic metrics, which show that the model is an excellent fit and may be used for forecasting (R square = 0.603 and RMSE = 299.650). Table 3 and Figure 2 provide the forecast for the years 2022-2026.

Table 1: Diagnostic Checking

MODEL	R		SPSS	
	BIC	**AICc**	**Normalized BIC**	**MAPE**
ARIMA (1,1,0)	298.6764	297.1892	12.042	12.191
ARIMA (2,1,0)	**294.2387**	**292.9224**	**11.855**	10.555
ARIMA (2,1,1)	296.4723	295.7794	12.024	10.556
ARIMA (1,1,1)	295.4712	294.1549	11.919	11.026

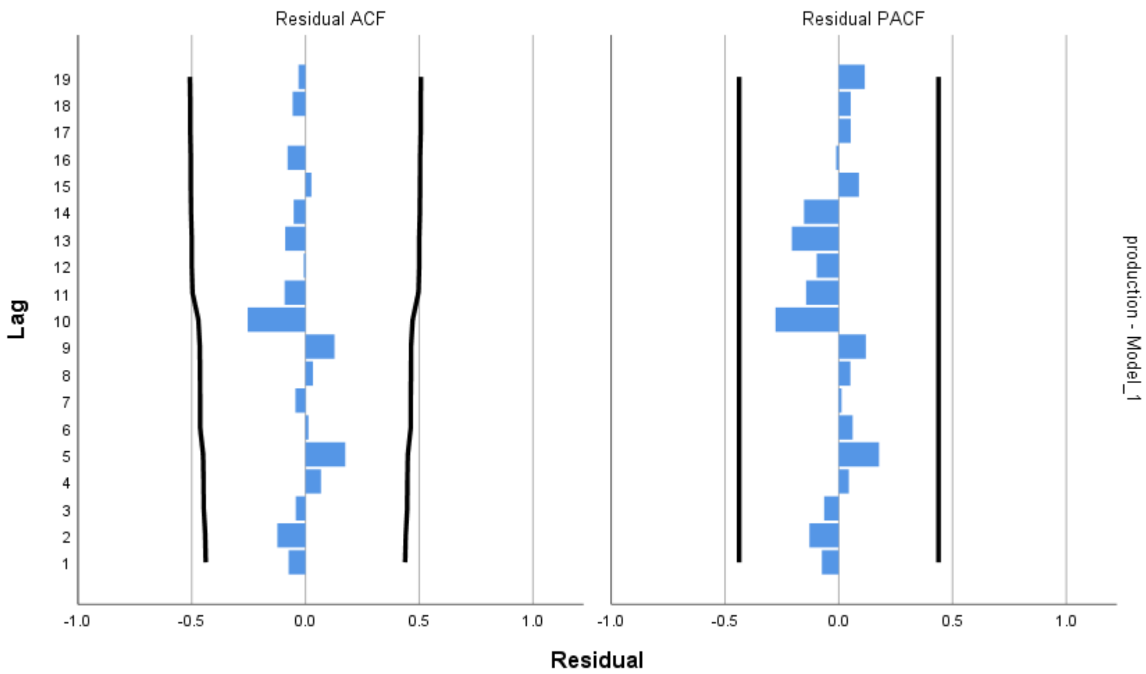

Figure 1: ACF and PACF values

Table 2: Model Fit

Fit Statistics	Model Fit		
	Mean	**Fit Statistics**	**Mean**

Stationary R-squared	0.543	MaxAPE	26.651
R-squared	0.503	MAE	227.630
RMSE	299.650	MaxAE	770.359
MAPE	10.555	Normalized BIC	11.855

Using the SPSS program, the study used the Holt technique. R squared = 0.503, RMSE = 299.650, and MAPE = 10.555 were the final numbers. This suggests that the model is suitable for further investigation. Table 5 displays the Holt method's prediction of annual apple output between 2022 and 2026.

4.Findings and Conclusion

Different forecasting programs provide widely contrasting outcomes. ARIMA (2,1,0) is the optimal model for SPSS apple production forecasts. The ARIMA (2,1,0) model provides the best fit regardless of whether R is utilized.

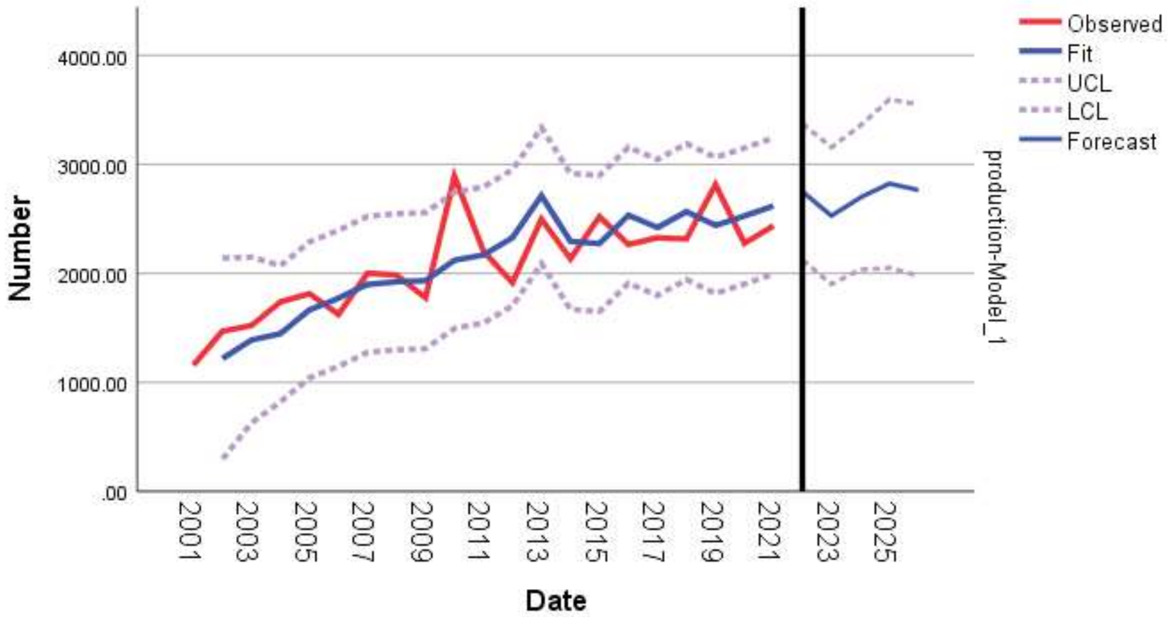

Figure 2: Forecast by ARIMA with SPSS

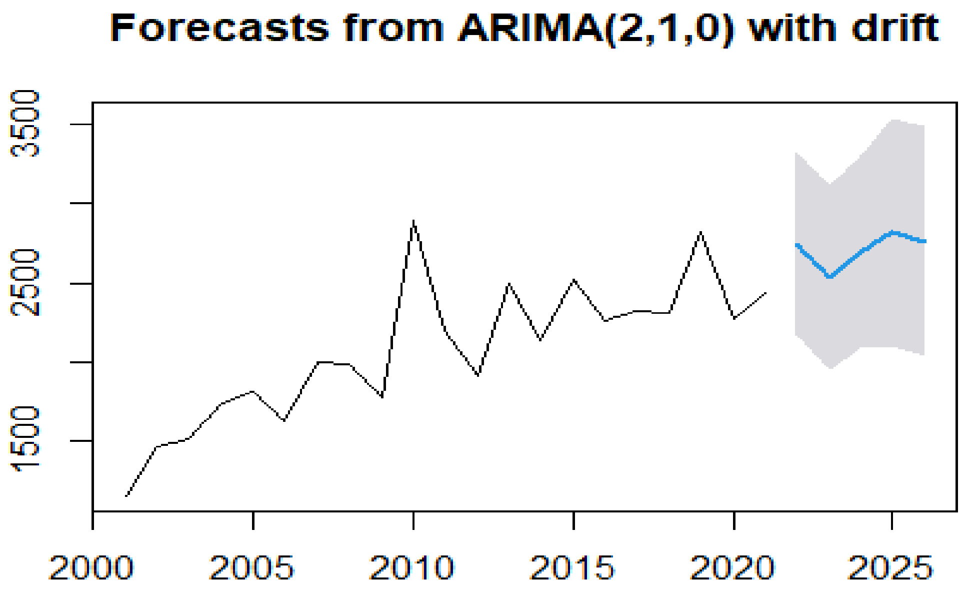

Figure 3: Forecast ARIMA with R

Table 3: Forecasting with R

Obs.	Prediction (metric tons)	95% interval
2022	2763.19	(2132.505, 3393.867)
2023	2608.52	(1977.211, 3239.831)
2024	2689.88	(2047.015, 3332.739)
2025	2827.02	(2113.777, 3540.267)
2026	2827.19	(2103.068, 3551.302)

Table 4: Forecasting with SPSS

Years	Production of Apple (metric tons)	Prediction of Production	Lower class limit of Production	Upper class limit of Production	Production of N residual
2001	1158.3	1332.27	729.7	1934.84	-173.97
2002	1470.1	1461.58	859.01	2064.15	8.52
2003	1521.6	1610	1007.43	2212.57	-88.4
2004	1738.9	1739.88	1137.31	2342.45	-0.98
2005	1814.01	1878.4	1275.83	2480.98	-64.39
2006	1623.72	2004.15	1401.57	2606.72	-380.43
2007	2001.45	2060.22	1457.65	2662.79	-58.77
2008	1985.13	2142.59	1540.02	2745.16	-157.46
2009	1777.23	2199.34	1596.77	2801.91	-422.11
2010	2890.59	2187.39	1584.82	2789.96	703.2
2011	2203.37	2358.35	1755.78	2960.92	-154.98
2012	1915.38	2427.96	1825.39	3030.53	-512.58
2013	2497.68	2410.53	1807.95	3013.1	87.15
2014	2133.84	2461.8	1859.23	3064.37	-327.96

2015	2521.1	2438.75	1836.18	3041.32	82.35
2016	2265.24	2464.98	1862.4	3067.55	-199.74
2017	2326.91	2443.01	1840.44	3045.58	-116.1
2018	2315.8	2417.79	1815.22	3020.36	-101.99
2019	2814.31	2383.78	1781.21	2986.35	430.53
2020	2275.84	2446.11	1843.54	3048.68	-170.27
2021	2437.37	2431.31	1828.73	3033.88	6.06
2022	-	2434.75	1832.18	3037.32	-
2023	-	2437.58	1823.07	3052.09	-
2024	-	2440.42	1799.85	3080.98	-
2025	-	2443.25	1758.82	3127.69	-
2026	-	2446.09	1698.24	3193.94	-

SPSS software seems to provide a more reliable prediction when compared to R software. Apple production estimates from the previous year.

Using ARIMA (2,1,0) and SPSS, the study anticipates a total of 2446 metric tons apple harvest in 2026. Using ARIMA (2,1,0), study anticipates a yield of 2827 metric tons with R.

The CAGR (Compound Annual Growth Rate) (in percentage terms) for apple output is 8.61 percent (calculated based on results). As a result, a strategy to speed up apple production in India is urgently required. However, the government of India is implementing various programs like the Promotion of Low Chilling Apple Plantation in NER of India. Similarly, helping farmers and promoters to increase the production capacity of apples is required.

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