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Price behaviour and market dynamics of onion in regulated markets of Haryana: A time series analysis

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Abstract

Onion (*Allium cepa* L.) is an essential vegetable crop in India, recognized for its extensive consumption, nutritional value and consistent year-round demand. Despite its relatively superior storability, the marketing of onions is marked by significant seasonal variations in both arrivals and prices, which results in income instability for farmers and price fluctuations for consumers. This study examines the growth, trends, seasonal patterns and price forecasting of onions in selected regulated markets of Haryana, specifically Punhana, Tauru, Jagadhari and Sadhuara, utilizing monthly arrivals and price data from 2014 to 2023 sourced from AGMARKNET. The analysis employed methods such as Compound Annual Growth Rate (CAGR), linear trend analysis, seasonal indices, the Augmented Dickey–Fuller (ADF) test and Auto Regressive Integrated Moving Average (ARIMA) models for empirical evaluation. The findings indicated significant inter-market differences in both arrivals and prices. Jagadhari demonstrated the highest growth in arrivals, whereas Punhana and Tauru exhibited moderate growth and Sadhuara showed a slight decline. Price growth was most pronounced in Tauru and Sadhuara, reflecting constraints in seasonal supply. Trend analysis revealed a limited explanatory capacity for prices across the markets, indicating the impact of external factors such as demand, inter-state trade and storage challenges. The seasonal index analysis confirmed a cyclical trend, with peak arrivals during the summer months leading to lower prices, while reduced arrivals in the autumn resulted in price increases. The ADF test established the stationarity of the price series at levels, thereby justifying the application of ARIMA models for forecasting. Among the markets, Sadhuara and Punhana demonstrated superior forecasting capabilities, while Jagadhari exhibited relatively weaker predictability. Price forecasts for the years 2024–2026 suggested a downward trend in Jagadhari, stable prices in Punhana and Tauru and significant volatility in Sadhuara. This study underscores the critical influence of infrastructure, market integration and seasonal supply fluctuations on onion price dynamics.

Keywords: Onion marketing, price volatility, seasonal variation, ARIMA forecasting, Haryana markets

Introduction

Vegetables play a crucial role in human nutrition, providing essential vitamins, minerals, dietary fiber and antioxidants that are necessary for sustaining health and preventing chronic illnesses. Among the various vegetable crops, onion (*Allium cepa* L.) holds a significant place due to its widespread consumption, consistent year-round demand and its importance in household, culinary and processing applications. Onion is classified as a cool- to moderate-season bulb crop, appreciated for its pungency, flavour and extended storage capabilities. It is grown in a variety of agro-climatic conditions and thrives best in well-drained loamy soils with moderate temperatures. To achieve optimal bulb yield and quality, the crop necessitates timely irrigation, balanced fertilization and effective management of pests and diseases.

India holds the position of the second-largest vegetable producer globally. Haryana has developed into a significant horticultural state, with onion farming being crucial for agricultural diversification and enhancing farmers' income. During the agricultural year 2022-23, the area under cultivation reached 24,158 hectares, resulting in a total output of 5,29,811 metric tons.

Onions are widely cultivated in the Nuh and Yamunanagar districts of Haryana, with significant market arrivals managed through locations such as Punhana, Taura, Jagadhari and Sadhuara. Although onions possess better storability compared to many other vegetables, they still encounter challenges stemming from insufficient storage and processing infrastructure. This inadequacy results in considerable seasonal variations in market arrivals. During peak harvest times, an excess of supply frequently leads to drastic price drops, whereas diminished availability in off-seasons triggers price surges, thereby generating instability in both farmers' earnings and consumer prices.

While the accessibility of market data via platforms like AGMARKNET has improved transparency concerning onion arrivals and pricing, issues such as post-harvest losses, inconsistent market arrivals and inadequate market integration continue to exist. Thus, it is crucial to analyze trends, growth and seasonal variations in onion arrivals and prices across the primary regulated markets in Haryana to comprehend market dynamics. In this regard, the current study aims to investigate onion arrivals to evaluate the patterns of arrivals and prices and to determine their effects on enhancing market efficiency, price stability and income

security for onion producers in Haryana. Keeping this in mind the objectives of the study are thus-

1. To analyse the growth and trend in arrivals and price of onion in selected regulated markets in Haryana
2. To estimate the seasonal price behaviour of onion in the state
3. To develop the price forecast for onion

Materials and Methodology

The research utilized a blend of descriptive, statistical and econometric techniques to examine the trends, seasonality and pricing behaviour of onion in the state. The Nuh and Yamunanagar districts were selected due to their substantial area and production within the state, with the corresponding markets chosen for their higher arrivals: Punhana (2,542.80), Tauru (3,913.33), Jagadhari (11,997.85) and Sadhuara (4,660.80). Data from AGMARKNET regarding market arrivals and prices spanning from 2014 to 2023 were collected to assess growth, trends, seasonal patterns and price forecasting, the study employed the Compound Annual Growth Rate (CAGR), linear trend analysis, seasonal indices and time-series forecasting models, including the Auto Regressive Integrated Moving Average (ARIMA), to derive the respective conclusions. The analytical tools used were explained as follows:

Estimation of Growth Rate

To examine the fluctuations in market arrivals and prices over time, the Compound Annual Growth Rate (CAGR) was calculated. CAGR quantifies the average annual growth rate of a variable across a defined timeframe and serves as a strong indicator of long-term growth patterns. The growth function was specified as:

$$Y = a + bt$$

Where,

Y = Price and arrivals of selected vegetable crops

a = Constant

b = Slope (Regression Co-efficient)

t = Time in number of years.

Then, Compound annual growth rate was calculated using following equation:

$$\text{Compound Annual Growth Rate} = [(\text{Antilog } b1) - 1] * 100$$

Linear Trend Analysis

Basic linear regression models were employed to analyze the long-term trends in market arrivals and prices, treating time as the independent variable. This methodology facilitated the quantification of both the direction and magnitude of change throughout the study period.

$$M = a + bt$$

$$P = c + dt$$

Where,

M = A monthly market arrivals of selected crop.

P = Price of selected crop in rupees.

a = Intercept

b = Regression coefficient (rate of change in monthly market arrivals for a unit change in the time)

t = Time variable in year

c = Intercept

d = Regression coefficient

Measurement of Seasonal Variations

Seasonal variations in market arrivals and prices were examined through the ratio-to-moving-average method (also known as the percentage of moving average method), which is regarded as more effective than alternative methods for calculating seasonal indices. This approach enabled the detection of both peak and lean periods. The seasonal index was calculated as:

$$\text{Seasonal Index} = \frac{\text{Monthly Average}}{\text{Grand Average}} \times 100$$

Forecasting Using ARIMA Model

To predict future prices and arrivals, the Auto Regressive Integrated Moving Average (ARIMA) model, commonly referred to as the Box-Jenkins method (Box and Jenkins, 1976), was utilized. Given that agricultural time-series data frequently display trends and non-stationarity, stationarity was assessed using autocorrelation functions (ACF). Non-stationary series were adjusted through differencing until stationarity was reached.

An ARIMA (p, d, q) model incorporates autoregressive (p), differencing (d) and moving average (q) components and is expressed as:

$$Y_t = \mu + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \dots + \phi_p Y_{t-p} + \varepsilon_t - \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q}$$

Where,

- Y_t and ε_t are the actual value and random error at time period t, respectively
- ϕ_i (i = 1, 2, ..., p), θ_j (j = 1, 2, ..., q) are model parameters.
- "p" and "q" are integers and often referred to as orders of the model.

Random errors terms ε_t are assumed to be independently and identically distributed with a mean of zero and a constant variance. The ARIMA model incorporates non-seasonal factors in a multiplicative model and is denoted as: ARIMA (p, d, q).

Where,

p = order of non- seasonal Auto Regressive (AR)

d = order of non- seasonal difference

q = order of non- seasonal

The selection of appropriate ARIMA models was based on the examination of ACF and PACF plots and automated model selection using the auto.arima() function in the forecast package of R, which applies the Hyndman-Khandakar algorithm.

Model Estimation and Diagnostic Checking

Model parameters were estimated using the least squares method. The adequacy of fitted models was evaluated through diagnostic tests, ensuring that residuals were

random and free from autocorrelation. The following criteria were used for model validation:

- Coefficient of determination (R^2)
- Root Mean Square Error (RMSE)
- Mean Absolute Percentage Error (MAPE)
- Box–Pierce Q-statistic, with p-values greater than the chosen significance level indicating model adequacy

Models with higher R^2 and lower RMSE and MAPE values were selected as optimal

Results and Discussion

Onion is a significant bulb crop that thrives in cool to moderate seasons in Haryana, cultivated during the kharif, late-kharif and rabi periods. The nursery is established in May–June, August–September and October–November, with transplanting occurring in July, October and December–January, respectively. The crop reaches maturity in 110–140 days and is harvested from October to May, thereby ensuring a continuous supply in the market throughout the year. Onions grow optimally in well-drained sandy loam soils, provided there is adequate irrigation and nutrient management

1. To analyse the growth and trend in arrivals and price of onion in selected regulated markets in Haryana

Tables 1 and 2 illustrate the Compound Annual Growth Rate (CAGR) of monthly onion arrivals and prices across four selected markets: Punhana, Tauru, Jagadhari and Sadhuara. In the Punhana market, arrivals displayed both positive and negative growth trends throughout the months. For instance, in January (3.06% arrivals, 3.32% price) and February (-0.03% arrivals, 7.32% price), respectively. Likewise, in May (-1.43% arrivals, -1.09% price) and September (1.60% arrivals, -3.13% price), both arrivals and prices moved in the same direction. In the Tauru market, significant variability was noted in the growth trends of arrivals and prices. For instance, January (-6.07% arrivals, 7.03% price) and February (-1.29% arrivals, 8.17% price) demonstrated a clear negative correlation, while July (2.71% arrivals, 1.18% price) and August (11.66% arrivals, -0.98% price), respectively exhibited partial co-movement between arrivals and prices. In the Jagadhari market, arrivals consistently recorded high growth throughout the year; however, price movements did not follow a uniform inverse trend. For example, both arrivals and prices increased in January (13.95% arrivals, 8.35% price) and February (11.41% arrivals, 8.57% price), respectively. Even during

peak arrival months such as May (23.57% arrivals, 1.57% price) and June (24.18% arrivals, -1.59% price), the growth in prices declined only slightly and not in proportion to the increase in arrivals.

In contrast, the Sadhuara market demonstrated a more significant inverse correlation between the growth in arrivals and prices as in January (-3.96% arrivals, 5.14% price) and February (-0.55% arrivals, 7.82% price), as well as in August (4.79% arrivals, -2.43% price) and September (3.62% arrivals, -1.89% price) respectively. Nevertheless, certain anomalies were noted, such as in November (-9.31% arrivals, 5.35% price) and December (-6.08% arrivals, 4.98% price), where prices rose despite a decrease in arrivals. A seasonal analysis further underscores the variations across districts and markets.

In the Nuh district, Punhana recorded modest post-harvest growth in arrivals (0.99%) alongside significant price increases (3.38%), followed by positive mid-season arrivals (4.86%) and slight price improvement (0.55%). During the lean period, arrivals remained slightly negative (-0.64%) while prices remained stable (0.61%). In contrast, Tauru reported relatively higher post-harvest arrivals (3.15%) with moderate price growth (1.46%), strong mid-season price increases (4.44%) even as arrivals declined slightly (-0.38%) and consistently negative lean-period arrivals (-2.86%) accompanied by substantial price gains (6.00%), reflecting seasonal supply constraints. In the Yamunanagar district, Jagadhari displayed robust and consistent growth in arrivals during the post-harvest (22.04%), mid-season (16.93%) and lean periods (13.43%). These trends were bolstered by positive price movements in the mid-season (1.79%) and lean months (6.60%), despite a slight decline during the post-harvest period (-1.24%). Conversely, Sadhuara experienced negative or marginal growth in arrivals across all three phases (-1.29%, -2.07% and -1.45%), while prices remained positive in most periods, recording 0.02 per cent in the post-harvest, 2.87 per cent in the mid-season and 3.92 per cent during the lean season. The overall Compound Annual Growth Rate (CAGR) reveals that total arrivals peaked in Jagadhari at 17.71 per cent, with moderate increases noted in Punhana at 1.69 per cent and Tauru at 1.00 per cent. Conversely, Sadhuara experienced a minor decrease of -2.29 per cent. In terms of pricing, there was a consistent upward trend across all markets, particularly in Tauru, which saw the most substantial growth at 4.17 per cent. These findings underscore notable spatial and seasonal fluctuations in the dynamics of the onion market throughout Haryana.

Table 1: Growth Rate of arrivals and price of kharif and rabi onion in the selected regulated markets in Haryana

District		Nuh					
Market	Punhana (Kharif Onion)			Tauru (Rabi Onion)			
Post- harvest	Months	Arrivals	Price	Post-harvest	Months	Arrivals	Price
	January	3.06	3.32		May	-2.12	2.79
	February	-0.03	7.32		June	0.33	2.83
	March	1.35	2.84		July	2.71	1.18
	April	-0.44	0.02		August	11.66	-0.98
	Average	0.99	3.38		Average	3.15	1.46
Mid-season	September	1.60	-3.13	Mid-season	September	4.54	0.20
	October	10.52	0.10		October	2.11	4.22
	November	5.32	1.51		November	-0.59	7.99

Lean- period	December	2.01	3.73	Lean period	December	-7.57	5.34
	Average	4.86	0.55		Average	-0.38	4.44
	May	-1.43	-1.09		January	-6.07	7.03
	June	0.57	2.12		February	-1.29	8.17
	July	-2.14	1.88		March	-0.34	5.81
	August	0.45	-0.46		April	-3.73	2.99
Total	Average	-0.64	0.61	Total	Average	-2.86	6.00
	CAGR (%)	1.69	1.61		CAGR (%)	1.00	4.17

Table 2: Growth Rate of arrivals and price of rabi onion in the selected regulated markets in Haryana

District		Yamunanagar (Rabi Onion)			
Market	Jagadhari			Sadhuara	
Post-harvest	Months	Arrivals	Price	Arrivals	Price
	May	23.57	1.57	-8.51	2.09
	June	24.18	-1.59	0.67	0.77
	July	18.94	-0.04	-2.12	-0.50
	August	21.47	-4.88	4.79	-2.43
	Average	22.04	-1.24	-1.29	-0.02
Mid-season	September	19.97	-3.67	3.62	-1.89
	October	19.28	0.65	3.51	3.05
	November	14.00	5.47	-9.31	5.35
	December	14.48	4.69	-6.08	4.98
	Average	16.93	1.79	-2.07	2.87
Lean period	January	13.95	8.35	-3.96	5.14
	February	11.41	8.57	-0.55	7.82
	March	11.83	6.47	-1.23	2.87
	April	16.52	3.01	-0.07	-0.15
	Average	13.43	6.60	-1.45	3.92
Total	CAGR (%)	17.71	2.31	-2.29	2.59

The coefficients for arrivals were positive across all markets-Punhana, Jagadhari and Tauru (0.0024, 0.0464 and 0.005, respectively) with the exception of Sadhuara, which exhibited a negative coefficient (-0.0024). Price coefficients were also positive in all markets, specifically Punhana (2.2486), Jagadhari (3.4215), Sadhuara (3.6741) and Tauru (6.5912), with Tauru recording the highest value. The coefficient of determination (R^2) reveals that Jagadhari demonstrated the most robust model fit for arrivals ($R^2 = 0.2822$), although the variation in price was only weakly accounted for ($R^2 = 0.0159$). Tauru displayed a low explanatory capacity for arrivals ($R^2 = 0.014$) but performed slightly better regarding prices ($R^2 = 0.0465$). Both Punhana and Sadhuara showed very low R^2 values for arrivals (0.0105 and 0.005) and prices (0.0079 and 0.0202), indicating inadequate model performance. In summary, while price coefficients were positive across all markets, the low R^2 values imply a limited explanatory capability of the models, especially concerning price behaviour.

Table 3: Trend in arrivals and price of onion in the selected regulated markets in Haryana

Districts	Markets	Arrival			Price		
		Intercept	Coefficient	R^2	Intercept	Coefficient	R^2
Nuh	Punhana	1.5906	0.0024	0.0105	1506.0	2.2486	0.0079
	Tauru	2.3475	0.0050	0.014	1515.0	6.5912	0.0465
Yamunanagar	Jagadhari	2.6074	0.0464	0.2822	1600.5	3.4215	0.0159
	Sadhuara	2.0233	-0.0024	0.005	1498.0	3.6741	0.0202

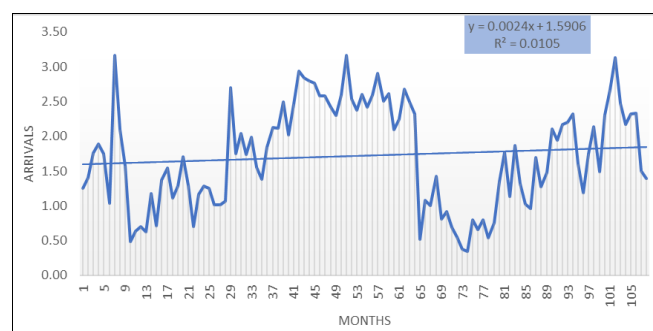


Fig 1: Trend in arrivals of onion in Punhana market

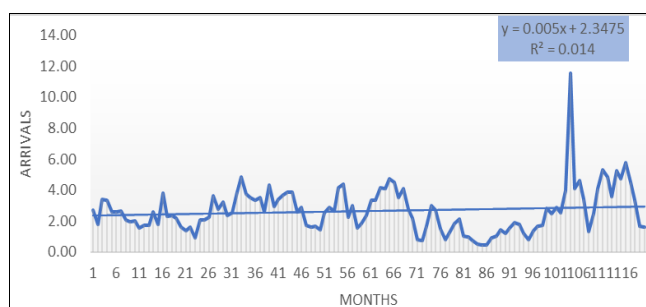


Fig 3: Trend in arrivals of onion in Tauru market

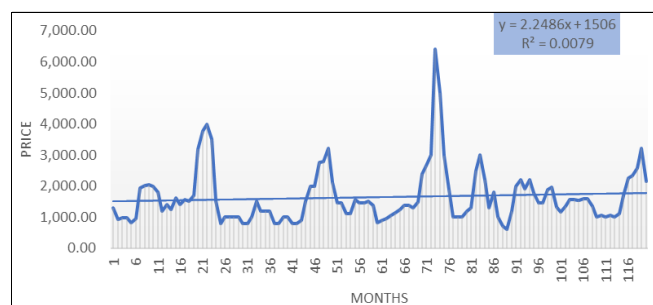


Fig 2: Trend in price of onion in Punhana market

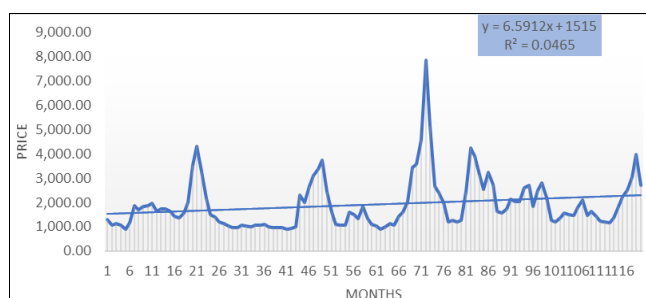


Fig 4: Trend in price of onion in Tauru market

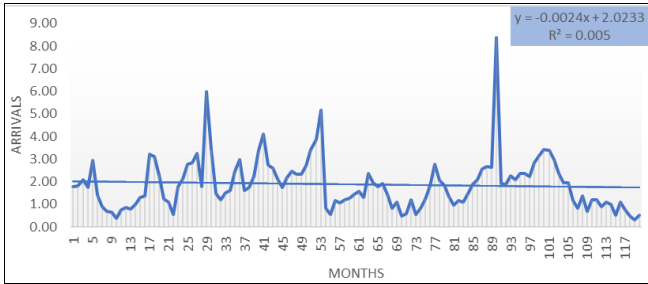


Fig 5: Trend in arrivals of onion in Sadhuara market

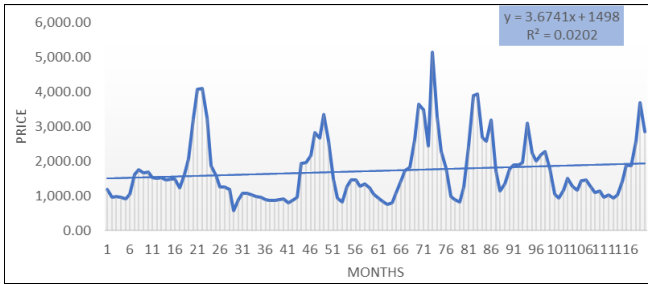


Fig 6: Trend in price of onion in Sadhuara market

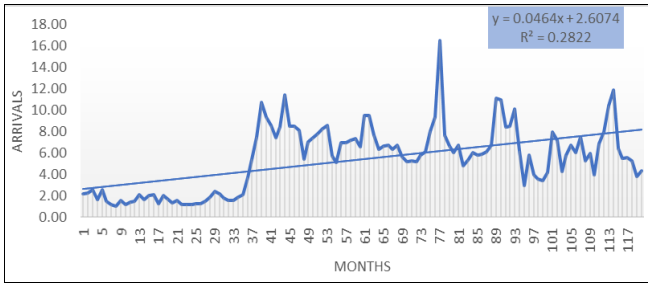


Fig 7: Trend in arrivals of onion in Jagadhari market

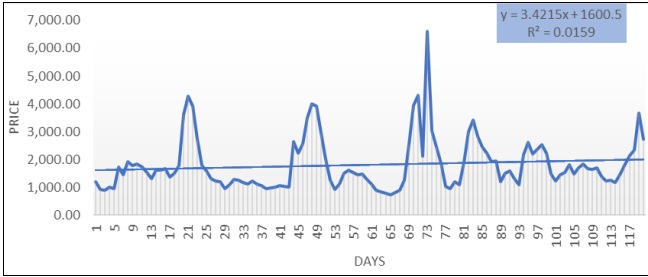


Fig 8: Trend in price of onion in Jagadhari market

1. To estimate the seasonal price behaviour of onion in the state

According to Tables 4 and 5, the seasonal indices for onion arrivals and prices across the four selected markets demonstrate distinct quarterly fluctuations. In the first quarter (January–March), arrivals showed a gradual increase in most markets, climbing from 0.81 to 1.02 in Punhana and from 0.80 to 1.19 in Tauru, while prices fell from 1.10 to 0.86 and from 1.15 to 0.84, respectively. A similar pattern was noted in Jagadhari, where arrivals rose from 0.90 to 1.05 and prices decreased from 1.29 to 0.86. In Sadhuara, a more pronounced increase in arrivals to 1.21 in March resulted in the lowest annual price index of 0.79. In the

second quarter (April–June), arrivals remained relatively stable in Punhana and Tauru, fluctuating between 1.01 and 1.12, while prices hit their lowest points, with Punhana and Tauru recording indices of 0.63 and 0.59, respectively, in May. Jagadhari achieved its highest arrivals (1.40) in May, coinciding with its lowest price (0.59), whereas Sadhuara saw a peak in arrivals (1.76) with prices dropping to 0.56 respectively. The third quarter (July–September) exhibited a reversal in trends. In Punhana, arrivals increased slightly to 1.16 in September, while prices surged from 0.88 in July to 1.18 in September. Tauru recorded its peak arrivals (1.47) in August, with prices fluctuating between 1.00 and 1.17. Jagadhari experienced moderate arrivals with a consistent rise in prices, reaching 1.11 in September. Conversely, Sadhuara faced declining arrivals (0.70), which resulted in an increase in prices to 1.17. In the fourth quarter (October–December), arrivals contracted significantly, especially in Tauru (0.62 in December) and Sadhuara (remaining below 0.90 throughout the quarter). This reduction in supply led to peak prices in November, with Punhana, Tauru and Jagadhari recording indices of 1.39, 1.41 and 1.47, respectively.

The observed seasonality illustrates the crop patterns across various markets. In Punhana, where kharif onion is the primary crop, post-harvest arrivals averaged 0.94, with prices recorded at 0.82. During the mid-season, there was a slight increase in arrivals (0.95) alongside a rise in prices (1.25). In the lean period, arrivals further increased (1.11), while prices moderated to 0.94, indicating relatively stable market conditions. Conversely, in Tauru, which is characterized by rabi production, post-harvest arrivals were higher at 1.20, but prices were lower at 0.77. Mid-season arrivals saw a decline (0.80), accompanied by an increase in prices (1.32), reflecting the pressure of demand. Throughout the lean period, arrivals remained stable at 1.00, with moderate prices at 0.91, suggesting a balanced yet constrained supply situation.

Table 4: Seasonal indices of onion arrivals and price in the selected regulated markets in Haryana

Districts		Nuh					
Markets		Punhana (kharif onion)		Tauru (rabi onion)			
Post-harvest	Months	Arrivals	Price	Post-harvest	Months	Arrivals	Price
	January	0.81	0.63		May	1.04	0.59
	February	0.92	0.68		June	1.12	0.67
	March	1.02	0.88		July	1.17	0.83
	April	1.01	1.08		August	1.47	1.00
Mid-season	Average	0.94	0.82	Mid-season	Average	1.20	0.77
	September	1.16	1.18		September	1.04	1.17
	October	0.94	1.34		October	0.91	1.36
	November	0.90	1.39		November	0.63	1.41
	December	0.81	1.08		December	0.62	1.35
Lean period	Average	0.95	1.25	Lean period	Average	0.80	1.32
	May	1.03	1.13		January	0.80	1.15
	June	1.12	1.02		February	0.87	0.96
	July	1.14	0.86		March	1.19	0.84
	August	1.16	0.73		April	1.12	0.67
	Average	1.11	0.94		Average	1.00	0.91

Table 5: Seasonal indices of onion arrivals and price in the selected regulated markets in Haryana

Districts		Yamunanagar (rabi onion)			
Markets		Jagadhari		Sadhuara	
Post-harvest	Months	Arrivals	Price	Arrivals	Price
	May	1.40	0.59	1.76	0.56
	June	1.17	0.68	1.48	0.70
	July	0.93	0.75	0.84	0.85
	August	1.01	1.01	0.72	1.03
Mid-season	Average	1.13	0.76	1.20	0.79
	September	1.02	1.11	0.70	1.17
	October	0.87	1.33	0.60	1.45
	November	0.83	1.47	0.74	1.44
	December	0.83	1.17	0.89	1.12
Lean period	Average	0.89	1.27	0.73	1.30
	January	0.90	1.29	0.86	1.19
	February	0.91	1.00	0.98	1.04
	March	1.05	0.86	1.21	0.79
	April	1.07	0.74	1.22	0.66
	Average	0.98	0.97	1.07	0.92

2. To develop the price forecast for onion

The results of the Augmented Dickey–Fuller (ADF) test demonstrate that the price series at level were stationary at the 1 percent significance level across all chosen markets. In the Punhana market, the ADF statistic for level prices was -4.7197 ($p = 0.01$), which led to the rejection of the null hypothesis concerning the presence of a unit root. Likewise, the markets of Tauru (-4.711), Jagadhari (-5.4633) and Sadhuara (-4.8092) also displayed stationarity at levels, with p -values of 0.01 . When examining first differences, the ADF statistics became increasingly negative (-7.8318 for Punhana, -8.6735 for Tauru, -7.8447 for Jagadhari and -7.919 for Sadhuara), thereby further substantiating the strong stationarity of the series. Model selection utilizing AIC, BIC, RMSE, MAPE and MAE criteria revealed discrepancies in forecasting performance among the markets. In Punhana, the ARIMA model demonstrated moderate accuracy (AIC = 1855.12, RMSE = 529.91, MAPE = 19.98). Tauru displayed relatively lower accuracy (AIC = 1888.53, RMSE = 608.61, MAPE = 20.07). Jagadhari recorded the highest error values (AIC = 1915.93, RMSE = 689.89, MAPE = 22.72), indicating a weaker predictive performance. Conversely, Sadhuara exhibited the lowest error measures (RMSE = 519.34, MAPE = 19.60), suggesting a comparatively better forecasting efficiency. The optimal ARIMA models varied across the markets. In Punhana, ARIMA (2,0,0) with a non-zero mean was identified as the most appropriate, indicating a second-order autoregressive process. Tauru was best characterized by ARIMA (1,0,1), while Jagadhari adhered to an ARIMA (1,0,0) specification. In Sadhuara, seasonal variations were significant and ARIMA (2,0,0)(2,0,0)[12] with a non-zero mean provided the best fit, underscoring the relevance of seasonal components in price behaviour.

Forecasts for the timeframe spanning January 2024 to December 2025 in Table 6 and 7 have unveiled notable market trends. In Jagadhari, prices exhibited a consistent decline from 2433.59 in January 2024 to 1812.90 by December 2025, signifying a continuous downward trajectory. Conversely, prices in Punhana remained largely stable, with minor fluctuations around the range of 1600–1640. Likewise, Tauru demonstrated significant stability,

maintaining prices close to 1865–1905 throughout the forecasting period. In stark contrast, Sadhuara experienced substantial volatility, with prices decreasing from 2494.92 in January 2024 to 1523.19 in May 2025, followed by a rebound to 2003.23 by December 2025. In summary, the forecasts indicate a downward trend in Jagadhari, stable pricing conditions in both Punhana and Tauru and considerable volatility in Sadhuara. The persistent decline in Jagadhari may be indicative of ongoing supply-demand pressures, while the stability observed in Punhana and Tauru suggests relatively balanced market dynamics. The significant price fluctuations in Sadhuara underscore the impact of seasonal influences and potential market disruptions on pricing behaviour.

Throughout the year 2026, the forecasted prices for Pehowa, Shahbad and Jagadhari remain remarkably stable, with Pehowa maintaining a level close to 1,812, Jagadhari consistently at 1,905.65 and Sadhuara remaining steady at 1,637.06. Only Shahbad exhibits significant fluctuations, decreasing to approximately 1,669 in May and subsequently increasing to about 1,835 in November, which suggests a mild seasonal variation. The forecasting outcomes indicate that Punhana (RMSE 960.95, Accuracy 76.81%) achieves the best performance, characterized by the lowest error and the highest accuracy across all markets. Tauru and Sadhuara demonstrate moderate performance with comparable accuracy levels (around 73%), whereas Jagadhari records the lowest accuracy at 68.99%.

Table 6: Short term price forecast of onion for the selected regulated markets in Haryana

District	Yamunanagar					
Market	Jagadhri			Sadhuara		
Month	2024	2025	2026	2024	2025	2026
January	2433.6	1818.71	1,812.88	2494.93	1680.73	1,905.04
February	2233.9	1816.82	1,812.86	2286.84	1663.36	1,852.77
March	2098.45	1815.53	1,812.85	1981.47	1578.23	1,768.67
April	2006.56	1814.66	1,812.84	1706.78	1556.94	1,699.90
May	1944.24	1814.07	1,812.83	1596.17	1523.19	1,669.07
June	1901.96	1813.67	1,812.83	1614.73	1545.55	1,676.32
July	1873.29	1813.4	1,812.83	1708.68	1652.61	1,712.25
August	1853.84	1813.21	1,812.83	1692.93	1763.85	1,722.30
September	1840.64	1813.09	1,812.82	1645.92	1749.8	1,709.24
October	1831.69	1813	1,812.82	1788.98	1937.23	1,767.00
November	1825.62	1812.94	1,812.82	1925.95	2224.39	1,835.70
December	1821.51	1812.9	1,812.82	1767.57	2003.24	1,770.06

Table 7: Short term price forecast of onion for the selected regulated markets in Haryana

District	Nuh					
Market	Tauru			Punhana		
Month	2024	2025	2026	2024	2025	2026
January	1865.82	1905.55	1,905.65	1601.41	1637	1,637.06
February	1881.51	1905.59	1,905.65	1422.89	1636.65	1,637.06
March	1891.03	1905.61	1,905.65	1429.26	1636.66	1,637.06
April	1896.79	1905.63	1,905.65	1498.81	1636.8	1,637.06
May	1900.28	1905.64	1,905.65	1568.14	1636.93	1,637.06
June	1902.4	1905.64	1,905.65	1614.93	1637.02	1,637.06
July	1903.68	1905.65	1,905.65	1638.61	1637.07	1,637.06
August	1904.46	1905.65	1,905.65	1646.47	1637.08	1,637.06
September	1904.93	1905.65	1,905.65	1646.19	1637.08	1,637.06
October	1905.21	1905.65	1,905.65	1643.14	1637.07	1,637.06
November	1905.38	1905.65	1,905.65	1640.09	1637.07	1,637.06
December	1905.49	1905.65	1,905.65	1638.04	1637.06	1,637.06

Conclusion

The current study aims to conduct a comprehensive analysis of onion arrivals, prices, seasonal behaviour and forecasting performance in selected markets, including Punhana, Tauru, Jagadhari and Sadhuara, located in Haryana.

From the analysis of Compound Annual Growth Rate and monthly trends, it has been identified that the classical inverse relationship between onion arrivals and prices has been observed to be prominent only in the Sadhuara market, followed to a moderate extent in Tauru. These markets are largely governed by traditional market forces of supply and demand, as lower arrivals result in higher prices and vice versa. However, markets like Punhana show irregular and moderate behaviour, indicating the impact of external sources of supply, including Faridabad and Delhi APMC. Jagadhari markets are largely divergent from conventional market behaviour, as prices tend to rise with increasing arrivals, indicating the dominance of demand factors, quality and strong regional market linkages, including Maharashtra and Rajasthan.

Further, the results of the seasonal analysis also confirmed the cyclical behaviour in the onion marketing system. The arrival and prices tended to peak in the post-harvest and summer seasons (March-August), resulting in declining prices and the shortage in the autumn season (September-November) led to an increase in prices. The temporary synchronization in the arrival and prices in August in Punhana and Tauru could be because of the demand and storage constraints in these markets. The absence of major shortages in the markets in the lean period also highlighted the role of inter-state trade and improvements in connectivity.

Further, the trend analysis, i.e., the regression models, also revealed that Jagadhari recorded the highest and most consistent growth in onion arrivals, reflecting the good infrastructure and stable supply base. Punhana and Tauru recorded marginal growth in onion arrivals, while Sadhuara recorded a decline in the trend, reflecting the irregularity in the arrival of onions in the markets. The results also indicated that the markets in Yamunanagar, i.e., Jagadhari and Sadhuara, performed better than the markets in Nuh, reflecting the better infrastructure and integration in the onion markets.

The results from the stationarity tests established that the prices of onions in all the markets were stationary at level, implying that there were no long-term trends and that the prices did not adhere to the random walk hypothesis. The results further established the applicability of the ARIMA models in forecasting the prices. Among the models, Sadhuara recorded the highest accuracy in forecasting the prices compared to the others, considering that the model took into account the seasonal components, followed by Punhana. The model for Tauru recorded moderate forecasting efficiency, while Jagadhari recorded the lowest accuracy.

Further, the results from the forecasting models from 2024 to 2025 indicated that there were different trends in the markets. Jagadhari recorded a consistent decline in the prices, implying that the demand for onions in the region was moderated, while Punhana and Tauru recorded stable prices, implying that the markets were stable. On the other hand, Sadhuara recorded fluctuations in the prices, implying that the onions arrived in the region in an unsteady manner. The accuracy of the forecasting models further supported

the results, with Punhana having the highest accuracy (76.81%) followed by Tauru and Sadhuara ranging to 73 per cent, while Jagadhari was the most difficult to predict with lowest accuracy (68.99%).

In conclusion, the study reveals that the onion price dynamics in the state of Haryana are influenced by a complex interplay of local production, inter-state trade, demand conditions, infrastructure and seasonal factors. While the Sadhuara and Tauru markets are more inclined to follow the classical supply-price relationships, the onion markets of Punhana and especially Jagadhari are more influenced by external and demand factors. The high volatility and fluctuating performance of the onion markets underscore the susceptibility of the onion markets to supply shocks.

Therefore, it is imperative that the existing storage infrastructure is strengthened, the cold chain is developed further, the market intelligence systems are improved and the inter-market coordination is strengthened to stabilize the onion prices. Moreover, efforts to promote staggered sowing, post-harvest management strategies and the integration of the onion markets with national markets can also help to reduce the extreme volatility of the onion prices.

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