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RESEARCH PAPER

Spatio-temporal analysis of maize market arrivals and price behavior in Maharashtra

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Abstracts: Maize (*Zea mays* L.) is a crucial cereal crop with significant contributions to global food security, livestock feed, and industrial applications. In India, it ranks third among cereals and is cultivated across diverse agro-climatic regions, with Maharashtra being a major producing state. Despite its production potential, maize marketing faces challenges including price volatility, seasonal gluts, and inadequate storage infrastructure. This study analyzed monthly time-series data on maize market arrivals and wholesale prices from 2012 to 2021 across nine key markets in Maharashtra, representing Western Maharashtra, Marathwada, and Vidarbha regions. Correlation and regression analyses were employed to examine the relationship between arrivals and prices. Results indicated that in most markets, arrivals were inversely correlated with prices, reflecting typical supply–demand dynamics, particularly during peak harvest months. Intra- and inter-year analyses revealed significant spatial and temporal variations, with some markets exhibiting positive correlations due to off-season supply or higher local demand. Regression results showed that previous month prices positively and significantly influenced current prices, while arrivals generally exerted a negative but mostly non-significant effect. Findings underscore the importance of strategic storage, improved market intelligence, and policy interventions to stabilize prices and enhance farmer income. Region-specific marketing strategies and infrastructure development are essential to mitigate price fluctuations and strengthen the maize value chain in Maharashtra.

Keywords: Correlation • Price function • Arrivals and prices • Intra and Inter year

Introduction

Maize (*Zea mays* L.) is one of the most important and versatile cereal crops in the world, valued for its wide adaptability and multiple end uses. The crop is grown across diverse agro-ecological regions, ranging from semi-arid tropics to humid and sub-humid environments. Globally, maize is cultivated on nearly 150 million hectares across more than 160 countries, contributing about 36 per cent of total global grain production, which highlights its significance in global food and feed systems (FAO, 2023). Owing to its high yield potential and diverse industrial applications, maize has emerged as a strategic crop for ensuring food security, supporting livestock and poultry industries, and promoting agro-based industrial growth. The United States of America is the world's largest producer of maize, contributing close to 35 per cent of total global production. The country records the highest productivity levels, exceeding 11 t ha^{-1}, which is almost twice the global average yield of around 5.9 t ha^{-1}. Advanced production technologies, widespread adoption of high-yielding hybrids, mechanization, and efficient market systems have positioned maize as a major driver of the U.S. agricultural economy. In contrast, maize productivity in India remains comparatively low at about

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3.24 t ha^{-1}, indicating considerable scope for improvement through technological interventions, improved agronomic practices, and better post-harvest management (FAO, 2023; Government of India, 2022).

In the Indian agricultural scenario, maize ranks third among cereal crops after rice and wheat. It is cultivated under a wide range of climatic conditions, extending from rainfed semi-arid regions to high-rainfall humid zones. Nearly 82 per cent of the maize area in the country is sown during the *kharif* season, reflecting its dependence on monsoon rainfall. Maize contributes approximately 10 per cent to India's total food grain production and plays a vital role in meeting the rising demand from poultry feed, livestock feed, starch, ethanol, and other industrial uses. The Indian maize sector offers substantial opportunities across its value chain, including seed production, non-seed inputs, farm mechanization, processing industries, storage, and market-linked infrastructure (NITI Aayog, 2023).

Maharashtra is one of the leading maize-producing states in India, ranking third in area and second in production during 2020–21. The crop is grown across almost all districts of the state under diverse production environments, supported by both rainfed and irrigated systems. Despite its production potential, maize marketing in Maharashtra faces challenges related to price volatility, seasonal glut, and inadequate storage and market intelligence systems (DoES, Maharashtra, 2021).

A sound agricultural and marketing policy requires a detailed understanding of price behaviour, market arrivals, and temporal price movements. Variations in market arrivals, especially during peak harvest periods, are a major cause of price instability in agricultural commodities. When large quantities of maize enter the market simultaneously, prices tend to decline sharply, leading to distress sales and reduced farm income. Conversely, off-season arrivals often fetch higher prices, benefiting farmers with adequate storage capacity. Therefore, analysing price trends over time and across markets is essential for designing effective strategies to stabilize prices, improve market efficiency, and enhance farmers' decision-making. Strengthening market information systems, improving storage infrastructure, and facilitating access to credit through warehouse receipt systems can significantly help farmers plan the disposal of produce and improve income stability (Chaudhary *et al.*, 2019; Kunnal *et al.*, 2016).

Materials and methods

For the present study monthly time-series data on average market arrivals and wholesale prices of maize covering the period from 2012 to 2021 were obtained from the Maharashtra State Agricultural Marketing Board (MSAMB), Pune. The selection of markets was based on the volume of maize arrivals to ensure adequate representation of major trading centres. A total of nine important maize markets were chosen, i.e., three from each region were selected *viz*., Western Maharashtra, Marathwada and Vidarbha. Accordingly, Nasik, Dhule and Nandurbar from Western Maharashtra, Aurangabad, Kannad and Jalana from Marathwada and Malkapur, Khamgaon and Savner APMCs from Vidarbha region were selected for the study. These markets collectively represent the principal maize-producing and trading zones of Maharashtra and provide a reliable basis for analyzing temporal variations in arrivals and prices.

Analytical tools

The Karl Pearsons correlation coefficient

The Karl Pearsons correlation coefficient was computed to estimate the degree of relationship between market arrivals and prices.

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x2 - (\sum x)2][n\sum y2 - (\sum y)2]}}$$

Where,
r = Correlation coefficient
x = Prices of maize in selected market
y = Arrivals of maize in selected market
n = Number of observations or time in number of years

Simple linear regression

$Yi = a + b_1X_1 + b_2X_2 + e_t$
Where,
Y_i = Price of maize for the i^{th} observation
X_1 = Market arrivals of maize
X_2 = Previous month price of maize
a = Intercept
bi' s = Regression coefficient
e_t = error term for the i^{th} observation

Results and discussion

The relationship between monthly maize arrivals and wholesale maize prices in selected market of Maharashtra

For the past 10 years (2012 to 2021), the correlation coefficient between arrivals and prices of maize was calculated and shown in Table 1.

Table 1. Correlation between arrivals and prices of maize in selected markets of Maharashtra (2012-2021)

Market	Correlation Coefficient
Western Maharashtra	
Lasalgaon	-0.26
Dhule	-0.59*
Nandurbar	-0.17
Marathwada	
Aurangabad	-0.45
Kannad	0.04
Jalana	-0.68**
Vidarbha	
Malkapur	0.62**
Khamgaon	-0.46
Savner	0.28

*, ** and ***, indicates significant at 10, 5 and 1 per cent, respectively

Table 1 depicts the correlation between monthly market arrivals and wholesale prices of maize in selected markets of Maharashtra for the period 2012–2021. The results indicate notable spatial variation in the relationship between arrivals and prices across regions and markets. In most of the selected markets, the correlation coefficient was negative, implying an inverse relationship where an increase in maize arrivals was generally associated with a decline in prices. This trend reflects the typical supply–price interaction observed in agricultural markets, particularly during peak harvest periods (Acharya and Agarwal, 2016).

In Western Maharashtra, all three markets exhibited negative correlations between arrivals and prices. The relationship was statistically significant in Dhule (–0.59), suggesting that price movements in this market were strongly influenced by variations in arrivals. Lasalgaon (–0.26) and Nandurbar (–0.17) also showed negative correlations, though these were not statistically significant, indicating a comparatively weaker influence of arrivals on prices in these markets.

In the Marathwada region, Jalana market recorded a strong and significant negative correlation (–0.68), highlighting the pronounced impact of arrivals on price fluctuations. Aurangabad showed a moderate negative relationship (–0.45), while Kannad exhibited a negligible positive correlation (0.04), suggesting limited or inconsistent association between arrivals and prices.

Contrasting results were observed in the Vidarbha region. Malkapur market registered a positive and statistically significant correlation (0.62), indicating that higher arrivals coincided with higher prices, possibly due to off-season supplies or stronger demand from feed and industrial users. Khamgaon recorded a moderate negative correlation (–0.46), whereas Savner showed a positive but non-significant relationship (0.28). (Badal and Jain, 2016).

Overall, the findings suggest that maize prices in Maharashtra are largely influenced by market arrivals, although the strength and direction of this relationship vary across markets due to regional demand conditions, market structure, and seasonal factors (Kunnal *et al.*, 2016; Chaudhary *et al.*, 2019).

Table 2 presents the intra-year correlation between monthly maize arrivals and wholesale prices in selected markets of Maharashtra from 2012 to 2021. The results indicate that the relationship between arrivals and prices varies across months and regions. In Western Maharashtra and Marathwada, most months exhibit negative correlations, suggesting that higher arrivals generally led to lower prices during the peak harvesting season. For instance, Dhule consistently shows strong negative correlations in several months (e.g., –0.71 in June), reflecting a pronounced inverse relationship between arrivals and prices. In contrast, some markets in Vidarbha, such as Malkapur, displayed positive correlations in several months (e.g., 0.69 in January and 0.83 in December), indicating that prices sometimes increased despite higher arrivals, possibly due to off-season supplies or higher local demand. (Tingre and Bhopale, 2021). Other markets like Khamgaon and Savner show mixed correlations, reflecting market-specific demand-supply dynamics. Overall, the intra-year analysis highlights that maize price movements are seasonally influenced and differ across regions, emphasizing the need for region-specific marketing strategies and effective storage and price information systems (Kunnal *et al.*, 2016).

Table 2. Intra-year correlation in arrivals and prices of maize in selected markets of Maharashtra (2012-2021)

Month	Western Maharashtra			Marathwada			Vidarbha		
	Lasalgaon	Dhule	Nandurbar	Aurangabad	Kannad	Jalana	Malkapur	Khamgaon	Savner
January	-0.38	-0.38	-0.11	-0.09	-0.11	-0.28	0.69	0.12	0.14
February	-0.53	-0.38	-0.18	-0.36	-0.08	-0.38	0.03	-0.29	0.19
March	-0.48	-0.56	-0.04	-0.45	-0.09	-0.42	0.03	-0.15	-0.34
April	-0.55	-0.4	-0.07	-0.39	-0.24	-0.54	0.11	-0.38	0.01
May	-0.45	-0.47	-0.46	-0.35	-0.1	-0.52	-0.13	-0.43	0.44
June	-0.3	-0.71	-0.02	-0.6	-0.08	-0.54	0.1	-0.48	0.47
July	-0.5	-0.46	-0.27	-0.53	-0.49	-0.43	-0.02	-0.35	0.00
August	-0.56	-0.46	-0.27	-0.54	-0.75	-0.39	-0.23	-0.38	-0.42
September	-0.45	-0.6	-0.44	-0.64	-0.58	-0.55	-0.3	-0.38	-0.75
October	-0.21	-0.53	-0.18	-0.06	-0.18	-0.12	-0.15	0.42	0.33
November	0.12	-0.48	-0.34	-0.18	-0.01	-0.26	0.72	0.18	0.54
December	0.45	-0.33	0.25	-0.06	-0.21	-0.43	0.83	0.02	0.33

Note: *, ** and *** Significant at 10, 5 and 1 per cent level, respectively

Table 3. Inter-year correlation in arrivals and prices of maize in selected markets of Maharashtra (2012-2021)

Month	Western Maharashtra			Marathwada			Vidarbha		
	Lasalgaon	Dhule	Nandurbar	Aurangabad	Kannad	Jalana	Malkapur	Khamgaon	Savner
2012	0.01	-0.48	0.28	-0.06	0.44	-0.23	-0.26	-0.35	-0.21
2013	-0.6**	-0.81***	-0.39	-0.07	0.04	-0.76***	-0.5*	-0.4	-0.01
2014	-0.46	-0.46	0.24	-0.81***	-0.57*	-0.57*	-0.64**	-0.34	-0.77***
2015	-0.35	-0.42	-0.13	-0.41	-0.13	0.02	0.1	-0.45	0.86***
2016	-0.68**	-0.6**	-0.44	-0.37	-0.41	-0.78***	-0.67**	-0.45	-0.56*
2017	-0.78***	-0.25	-0.27	-0.6**	-0.64**	-0.37	-0.54*	0.35	-0.56*
2018	-0.07	0.31	0.51*	-0.01	0.6**	0.27	0.58**	-0.12	0.43
2019	-0.72***	-0.62**	-0.28	-0.66**	-0.43	-0.73***	-0.43	-0.47	-0.38
2020	0.39	0.2	0.14	0.46	-0.38	0.4	0.33	-0.29	0.17
2021	-0.47	-0.57*	0.31	-0.34	-0.45	-0.37	-0.69**	-0.85***	0.26

Note: *, ** and *** Significant at 10, 5 and 1 per cent level, respectively

Table 3 presents the inter-year correlation between maize arrivals and wholesale prices in selected markets of Maharashtra from 2012 to 2021. The results reveal that in many markets, particularly in Western Maharashtra and Marathwada, a strong negative correlation exists for several years (e.g., Dhule: –0.81*** in 2013; Jalana: –0.78*** in 2016), indicating that higher annual arrivals typically lead to lower prices. This highlights the sensitivity of maize prices to yearly supply fluctuations. However, certain markets show positive correlations in specific years, such as Savner (0.86*** in 2015) and Malkapur (0.58** in 2018), suggesting that local demand, off-season production, or effective storage practices may stabilize or even increase prices despite higher arrivals (Kunnal *et al.*, 2016). The variability across years and markets underscores that price formation is influenced not only by arrivals but also by regional market structures, storage capacity, and demand patterns.

Overall, the inter-year analysis emphasizes the need for improved market intelligence, strategic storage facilities, and price stabilization policies to mitigate price volatility and enhance farmer income (Chaudhary *et al.*, 2019).

Price function of maize

The Table 4 revealed that, the two explanatory variables explained 45 (Kannad) to 84 (Lasalgaon) per cent of the variation in maize prices across the selected markets

Table 4. Price function result of selected markets of maize in Maharashtra

Market	Price Function	R^2
Western Maharashtra		
Lasalgaon	$Y=148.40-0.0003X_1+0.9051X_2$***	0.84***
Dhule	$Y=270.28-0.0003X_1+0.8188X_2$***	0.73**
Nandurbar	$Y=221.74+0.0015X_1+0.8315X_2$***	0.67**
Marathwada		
Aurangabad	$Y=193.43+0.0008X_1+0.8499X_2$***	0.71**
Kannad	$Y=467.3-0.0017X_1+0.6562X_2$**	0.45
Jalana	$Y=257.55-0.0002X_1+0.814X_2$***	0.68**
Vidarbha		
Malkapur	$Y=181.48+0.0016X_1+0.8507X_2$***	0.74***
Khamgaon	$Y=222.9-0.0036X_1+0.8298X_2$***	0.74***
Savner	$Y=132.73+0.006X_1+0.893X_2$***	0.81***

Note: *, ** and *** Significant at 10, 5 and 1 per cent level, respectively

under study. The regression coefficient of arrivals was negative but non-significant in Lasalgaon, Dhule, Kannad, Jalana and Khamgaon markets. It was made abundantly clear that the increased arrivals of maize in any market, prices decline. In all markets under study, the lagged month price of maize was positive and significant. It means that the current month's prices of maize were positively impacted by the lagged month prices. The positive magnitude of the lagged month price regression coefficients showed that, if the lagged month prices increased by one rupee per quintal, the current month's price increased by a minimum of Rs. 0.6562/q in Kannad and a maximum of Rs. 0.9051/q in Lasalgaon market. Reduced variation in maize arrivals and prices would be achieved due to dramatic increase of maize demand for human consumption as well as animal and poultry feed, developing storage facilities at primary markets and offering credit to farmers against warehouse receipt (Chaudhary *et al.,* 2019).

Conclusion

The study has concluded that the negative relationship between market arrivals and prices over the years in all the nine selected markets. However, across different months, there have been several instances of a positive relationship between arrivals and prices in a few markets. These positive and significant correlation coefficients could be attributed to the off-season supplies of maize which fetch higher prices. It is clear that arrivals at any market had an impact on prices, though sometimes prices at a market were unaffected by arrivals. Maize prices increased with an increase in the lagged month prices of maize in the market and not much more effect on maize prices with an increase in the arrivals of maize in the majority of the markets of Maharashtra state. The flexible maize supply, the demand for maize, domestic production, maize export and import could all be contributing factors to this situation. The flow of market information must be speed up, as the market information plays an important role in linking the distance markets. It will help in improving the marketing efficiency. There must be strengthening of good information network system for the flow of price information. There must be improvement in the storage facilities through improvement in warehouse structure, storage chambers in order to improve the retention capacity of the farmers. It will also help to reduce the post-harvest losses.

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