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Article

Economic Analysis of the Behavior of Prices and Market Arrivals of Tomatoes—A Case Study of West Bengal, India

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Abstract: The oscillations in prices and arrivals of agricultural goods are primarily influenced by the seasonal character of the agricultural production system. Here, we investigate the trends and seasonal price dynamics concerning market arrivals of tomatoes in West Bengal, India. Monthly data on arrivals and prices of tomatoes were collected for the period between 2013–14 and 2019–20. Both the ordinary least square and the twelve-month moving average techniques were employed to identify the long-term trends and seasonal variations in price and arrival patterns. The market arrivals exhibit negative trends in three markets, except for *Barasat* and *Bardhaman*, where the observed values are not statistically significant. However, the lone market in *Diamond Harbour* shows a positive and significant trend in arrivals. Regarding current prices, all markets, except for *Chakdah* and *Siliguri*, exhibit positive and significant trends. Seasonality is more prominent in market arrivals than the price for all the markets. Results suggest the variability in arrivals is proportional to the amount of arrivals in the market, in turn, larger arrivals lead to higher variability. Price variations are substantial and exhibit relative stability both within and across markets, unlike arrivals which show more fluctuation. Price fluctuations are significant not only within a given year but also between different years. Additionally, an inverse relationship between current prices and market arrivals suggests as arrivals increase, prices tend to decrease and vice versa. The study provides new insights into the trends in market arrivals and seasonal price dynamics of tomatoes in West Bengal, eastern India.

Keywords: market arrival and trends; tomato prices; ordinary least square; twelve-month moving average; seasonal indices; price dynamics

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1. Introduction

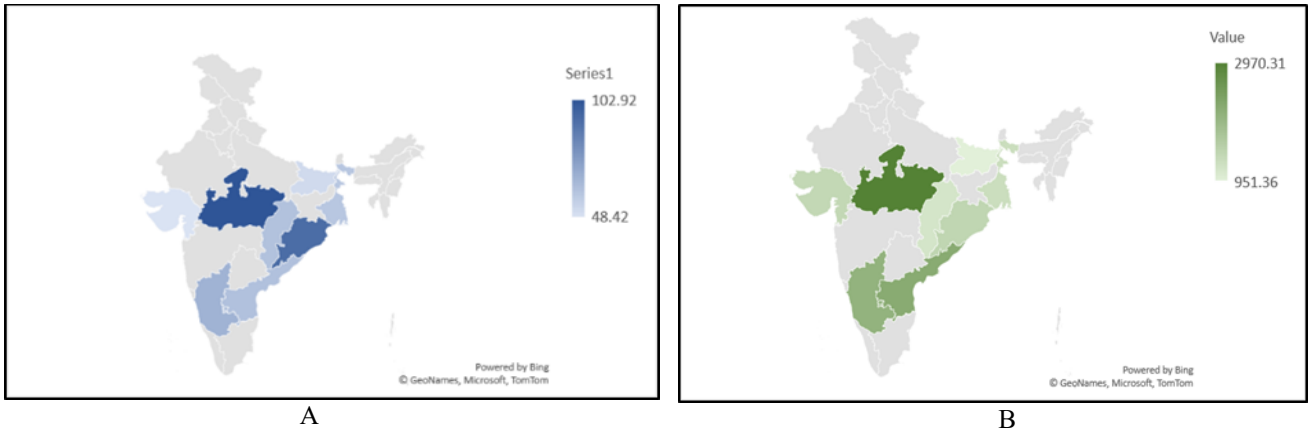
The attention of the public has recently been drawn to price changes and projections on the global goods marketplace. The seasonal and perishable nature of agricultural output results in price variations that are significantly greater than those of manufactured products (Paul et al., 2022a; Singh et al., 1993; Tomek & Kaiser, 2014). For the pricing dynamics in the agriculture industry, two historical interpretations have been put up. First, the argument that best fits the framework of rational expectations is that actual shocks including climatic and macroeconomic shocks are what drive prices and second one is that the fluctuations in prices are the result of forecasting errors (Gouel, 2012). Though the explanation of these two theories may lead to the opposite conclusion, are not mutually exclusive. If real shocks affect supply, price adjustment is a natural correction process. Policymakers could want to mitigate their adverse effects on fragile populations, but they should not alter the overall dynamics. If price volatility is caused by a failure to forecast next period market conditions, future scarcity is not driving resource allocation and the state of the economy could be improved through public intervention (Gouel, 2012).

Price volatility in agricultural commodities is caused by several factors, including annual variation in output, low demand price flexibility, and the periodicity of agricultural results (Kahlon & Tyagi, 1983). All variables that produce price changes, whether directly or indirectly, impact the

demand and supply of the commodity. This variation in agricultural product prices has a detrimental impact on farmers' earnings, adding to farm investment instability and, as a result, crop yield (S. A. Patel & J. M. Patel, 2013) the consumer side, this unpredictability in agricultural commodity prices also impacts millions of non-farming people in the nation, particularly the unorganized sectors (Bera, 2017). Because of this, it is difficult for producers and consumers to cope with excessive price swings, especially for small and marginal farmers in developing countries like India who have limited access to effective saving techniques and a low propensity for saving (Sarkar & Bera, 2022).

The Indian economy depends heavily on the agricultural sector, which employs more than 60% of the workforce and generates about 18.50% of the country's GDP (Arjun, 2013; Mondal et al., 2023). Being a state of India, West Bengal is also not an exception in this regard. About 70 percent of the rural population of the state depends on agriculture for their livelihood. There are 71.23 lakh agricultural households in the state, with 96% being small or marginal farmers. The average landholding is about 0.77 hectares in size (Department of Agriculture, Cooperation & Farmers Welfare, Agriculture Census Division, & Ministry of Agriculture & Farmers Welfare, 2015). As they have very low retention capacity and bargaining strength, they dispose of their produce just after harvesting or during post harvesting period leading to a distress sale (Bhat et al., 2014; Kanungo, 2015). As a result, seasonal indices of prices are high during the lean season when the supply or arrival of the products in the market is low (Asmitaben & Narendra, 2020) i.e., market arrival of a commodity influences the market price of that commodity inversely when other parameters like seasonal demand pattern, competitor presence in the market remain same.

For a long time, a need to have a better understanding of the relationship between price and market arrivals of crops has been urged by many scholars (Naidu, 2014; Sharma & Singh, 2014; Sudhakarrao & Katkade, 2016). This will help to provide insights into the differences in price across regions since it indicates that not only do consumers pay different prices in different areas for the same products (unless subsidized by programs like PDS), but those producers also receive varied prices depending on their geographical location (Chatterjee & Kapur, 2016; Paul et al., 2022a). Access to price and arrival data also enhances farmers' bargaining power and fosters increased competition among traders by enabling informed decisions, allowing farmers to strategically navigate alternative nearby markets and secure favorable prices for their produce (Paul et al., 2022b). To formulate a good agricultural pricing strategy for price stabilization, a thorough understanding of the interrelationship between market arrivals and farm product prices is required. The market arrival refers to the items available for purchase at a specific location at a specific moment (Prakash, 1995). It can be computed on a year, month, or fortnight basis. To determine the efficacy of a commodity at the local and international level, as well as to draw implications for future pricing and design long-term trade strategies, the most crucial variables are the data about price level, trend, and fluctuations (Chand, 2022). Being originated in the Peru-Ecuador-bolivia area of the Andes, Tomato, a rich source of minerals, vitamins, and healthy organic acids (Thamburaj & Singh, 2001) is one of the major vegetables consumed and produced in India sharing an area of 7.89 percent with a production of 10.68 percent the of total area and production of vegetables grown in India (Department of Agriculture & Farmers Welfare, Directorate of Economics and Statistics, & Ministry of Agriculture & Farmers Welfare, 2021). It acts as a good appetizer and its soup is a useful remedy for patients having constipation (Thamburaj & Singh, 2001). As per the 3rd advance estimate of 2020−21, West Bengal ranked 7th in both area and production of tomatoes among the 10 major tomato cultivating states (Figure 1) of India with a productivity of 21.7 kg/ha (Department of Agriculture & Farmers Welfare et al., 2021).



A B

Figure 1. (A) Area (in '000 ha) and (B) production (in'000 tonnes) of the top10 tomato cultivating states in India

The vast geographic extent and diverse range of agroclimatic conditions inside the nation significantly impact the availability of the majority of agricultural commodities, particularly vegetable crops, which have shorter growth seasons and a wider ecological range (Kumar et. al., 2005). The fluctuation in the output of vegetable crops leads to a wide variation in market price exposing the growers to risk (Sharma, 2011; Singh et al., 2017). Non-availability of institutional support, disease and insect infestation, high cost of seeds, high cost of pesticides, and high cost of labor during peak season are some of the primary limitations found in tomato growing regions (Agarwal & Banerjee, 2019). As a result, output and market arrival fluctuate depending on good and/or bad harvests leading to a wide variation in price. Hence, it is important to understand the volatility and/or variations of market prices across different areas. However, this type of research is very scanty in the study region though it's one of the major tomato-growing and consuming states of India.

In light of the recent extreme price volatility that has affected both producers and consumers and compelled the state government to regulate prices, the goal of this paper is to look into trends in market arrivals and prices as well as to investigate the seasonal price movement concerning market arrivals of tomatoes in West Bengal markets. Overall, this study aims to provide new insights into the trends in market arrivals and seasonal price dynamics of tomatoes in West Bengal in eastern India.

2. Materials and Methods

2.1. Site Selection and Data Sources

Monthly data on arrivals and prices were collected from a published data source, AGMARKNET by Govt. of India during the period of 2013−14 to 2019−20. The distribution of markets is done purposively from the different agro-climatic zones of West Bengal. Five different markets viz. *Bardhaman* (Bardhaman District; Vindhyan Alluvial Zone), *Siliguri* (Darjeeling District; Hill Zone), *Chakdah* and *Barasat* (Nadia District; and North 24 Parganas District, respectively; Gangetic Alluvial Zone), and *Diamond Harbour* (South 24 Parganas; Coastal Saline Zone) markets have been selected across the study area (Figure 2).

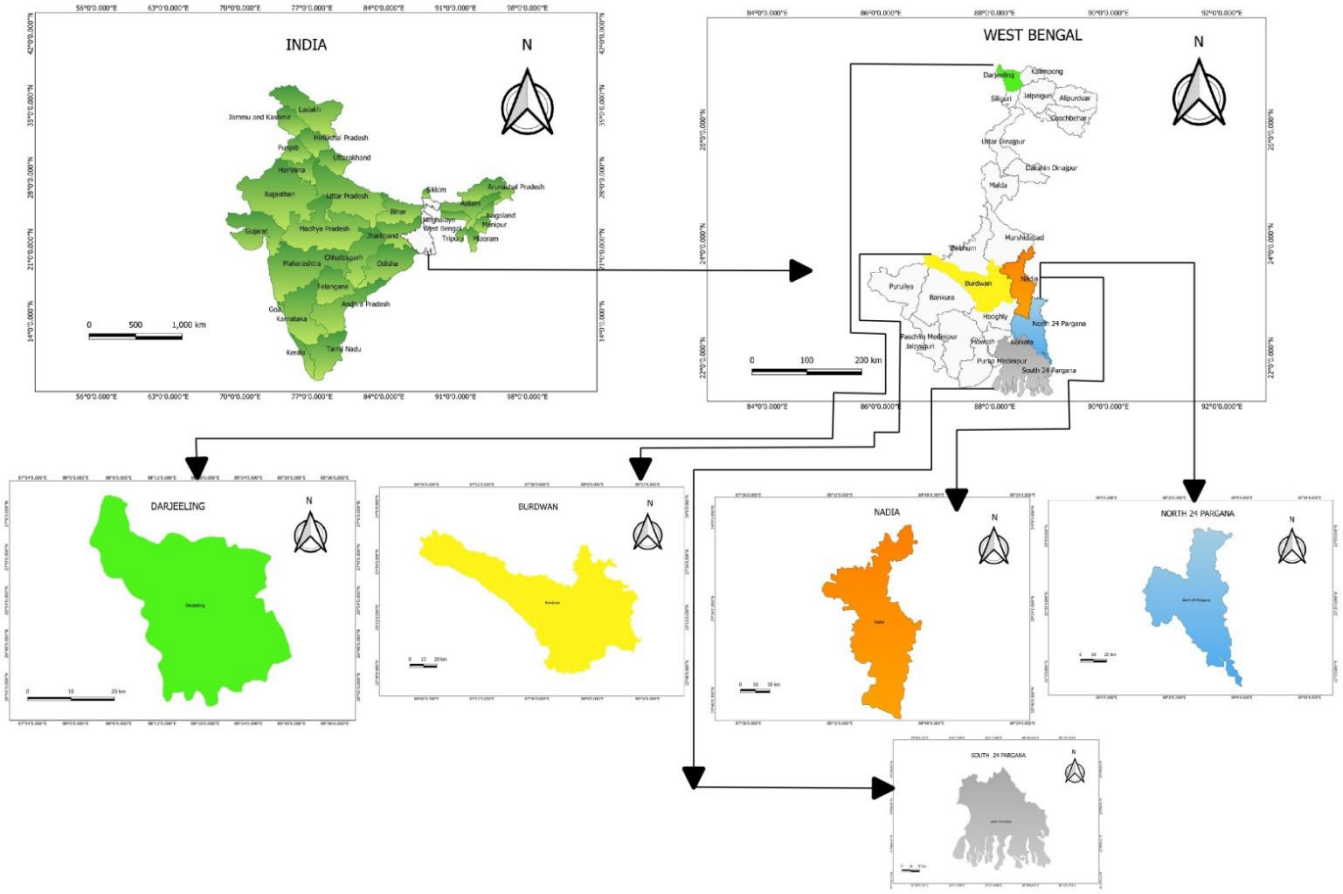


Figure 2. Location map of the study area.

2.2. Determining the Trend of Monthly Arrivals and Prices

To estimate the trend of monthly arrivals and prices of Tomatoes in five different markets of West Bengal, the time series data of monthly arrivals and prices are de-seasonalized for adjustment of the seasonal variation by applying of empirical equation (Eq. 1) as proposed by Acharya (2004). De-seasonalized price for the month

$$(SI) = \frac{Y}{T \times C} = \frac{T \times S \times C \times I}{T \times C}, \quad (1)$$

After de-seasonalization, the linear trend is estimated by applying the Ordinary Least Square method of the following form (Eq. 2) (Gujarati, 2021).

$$MA\ (12) = \frac{1}{12} \times \sum PI, \quad (2)$$

Y_t = Monthly time series data on market arrivals/prices, a = intercept, b = coefficient, and t = time period in month and U_t = disturbance terms

2.3. Statistical Analysis to Estimate Seasonality and Variations of Prices and Arrivals

The twelve-month centered moving average (TMMA) decomposition approach, which provides us with periodic changes without seasonality, is used to calculate seasonal variation (Sarkar & Bera, 2022). To get the seasonal fluctuations, the actual values are divided by the TMMA computed values (Eq. 3).

$$\text{Seasonal Indices (SI)} = \frac{Y}{T \times C} = \frac{T \times S \times C \times I}{T \times C}, \quad (3)$$

Where the letters Y, T, S, C, and I represent the time series data on arrivals and prices, trend components, seasonal variations, cyclical movements, and irregular fluctuations exist in the time series data of arrivals and prices respectively.

Further, to estimate the twelve-month moving average of market arrivals and price indices, we have used the following function (Eq. 4).

$$\text{MA (12)} = \frac{1}{12} \times \sum \text{PI}, \tag{4}$$

Further, all data related to market arrivals and prices are converted to an index form i,e, multiplied by 100 as given below (Eq. 5).

$$\text{SI} = \frac{\sum \text{PI}}{\text{MA}} \times 100, \tag{5}$$

Where MA (12) = twelve-month moving average which represents T×C, PI = market arrivals/price indices, and SI = seasonal indices for market arrivals/prices.

An extra 2-month moving average is computed to center the 12-month moving average (Eq. 6–7). As a result, irregular and seasonal impacts are represented by the ratio to the moving average. The most random influences will generally be minimized if the ratios for each worked over years are then averaged (Acharya, 2004).

$$\text{Adjusted seasonal indices (ASI)} = \text{Seasonal indices} \times \text{correction factor}, \tag{6}$$

$$\text{Correction factor} = 1200 \div \text{sum of seasonal indices}, \tag{7}$$

Further, seasonal monthly arrivals or price index was estimated by applying the function presented as follows (Eq. 8).

$$\text{Si} = [(I_h - I_l) / I_l] \times 100, \tag{8}$$

Where I_h = highest value of the seasonal index and l_l= lowest value of the seasonal index.

Descriptive statistics followed by an estimation of mean and coefficient of variation (CV) was used to compare month-wise variability in market arrivals and prices of Tomato in the selected markets. By averaging monthly data across years, the impacts of irregular components from monthly time series have been removed and the results are deflated by a correction factor to generate seasonal monthly indices of market arrivals/prices. The amount of intra-year price volatility was estimated using the following techniques (Eq. 9–10), which were further combined with the CV (Eq. 11) (Sarkar et al., 2021).

$$\text{Intra-year price rise (IPR)} = \frac{\text{HSPI} - \text{LSPI}}{\text{LSPI}} \times 100, \tag{9}$$

Where the highest and lowest seasonal price indexes are denoted by HSPI and LSPI, respectively.

$$\text{Coefficient of average price variation (ASPV)} = \frac{\text{HSPI} - \text{LSPI}}{\frac{\text{HSPI} + \text{LSPI}}{2}} \times 100, \tag{10}$$

$$\text{Coefficient of variation} = \frac{\text{STANDARD DEVIATION}}{\text{MEAN}} \times 100, \tag{11}$$

An estimate of Pearson's correlation coefficient (r) is required in order to determine the link between market arrivals (x) and pricing (y) (Eq. 12). The strength of the correlation was compared against a test for significance at 1% (p<0.01) and 5% (p<0.05), respectively.

$$r = \frac{\text{cov}(x,y)}{\sigma_x . \sigma_y}, \tag{12}$$

Where COV(x, y)= covariances of x and y, = standard deviation of x, and = standard deviation of y.

3. Results and Discussion

The term "trend" refers to determining the overall direction of a commodity's market arrivals or pricing over several years (Sreepriya & Sidhu, 2015). Table 1 shows the estimated parameters for arrivals and pricing of tomato harvests for *Barasat*, *Burdwan*, *Chakdah*, *Siliguri*, and *Diamond Harbour*. It exhibits that the trend of market arrivals in the first three markets, namely, *Barasat*, *Burdwan*, and *Chakdah* is negative, but significant at the first two markets such as *Barasat* and *Burdwan*, i.e., shows a declining trend., show a declining trend.

Table 1. Trend equations for market arrivals and prices of Tomatoes.

Sl. No.	Market	Arrivals (Y=a+bT)	Price (Y=a+bT)
1.	Barasat	Y = 15325.54 –280.36*t	Y=1.899 +1.899**t
2.	Burdwan	Y = 1254.93 – 12.561*t	Y= 82.78 + 0.241**t
3.	Chakdah	Y = 106.91 – 228^{NS}t	Y= 82.78 + 0.288^{NS} t
4.	Siliguri	Y = 102.79 + 0.013^{NS} t	Y = 90.94 + 0.302^{NS}t
5.	Diamond Harbour	Y= 334.03 + 6.812* t	Y = 2158.95 + 17.627**t

Note: * and ** indicate significance at 1% and 5% levels, respectively and NS refers to statistically non-significant.

The remaining two markets, namely, *Siliguri* and *Diamond Harbour* have experienced increasing trends at the rate of 0.013% and 6.812%, respectively but a positive significant trend was observed only in the *Diamond Harbour* market (Table 1). The positive price trend is recorded in all five markets with varying magnitudes but the results are significant only in *Barasat*, Burdwan, and *Diamond Harbour* markets. So, only in one market, i.e., *Diamond Habour*, the trends are positive in both the market arrivals and price of tomatoes to the tune of 6.81 and 17.63%, respectively (Selvi et al., 2020). Earlier, there was no specific trend concerning arrivals but prices have shown an increasing trend over the years (Keerthi & Naidu, 2013).

The average monthly arrivals are depicted in Table 2. The *Barasat* market is found to be the highest in January (13100 t), followed by February (11810 t) and later by March (9215 t). It shows a downward trend from March to July, and then gradually moves upward and hits the highest point in January month. The average market arrival in January is associated with the highest degree of fluctuation calculated in terms of coefficient of variation (89.26%). Market arrival is highly inflicted with fluctuation ranging from 76.45% in April to 89.26% in January. The *Bardhaman* market has experienced a maximum arrival in March accounting for 1419 t, followed by February (1324 t) and January (1236 t). The market experienced the highest fluctuation rate of 43.96% in January and the lowest fluctuation in April with 33.73%.

Table 2. Month-wise variability in market arrivals of Tomato in the selected markets.

Months	Barasat		Bardhaman		Chakdah		Siliguri		Diamond Harbour	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
January	13100	89.26	1236	43.96	3961	129.39	3399	108.5	522	101.73
February	11810	87.00	1324	41.90	4414	143.79	3004	103.6	676	132.07
March	9215	79.51	1419	38.51	4791	149.17	3128	115.9	711	120.27
April	6138	76.45	1035	34.50	4179	127.63	3768	146.7	570	96.06
May	5698	77.46	763	33.73	3549	100.23	3232	126.7	571	91.36
June	4815	76.84	683	35.16	2454	73.71	2709	70.60	490	88.54
July	4206	77.39	596	36.76	2509	68.74	2018	64.87	487	86.15
August	4614	79.50	621	38.44	2665	83.97	4105	134.3	485	81.13
September	5186	80.67	565	39.74	3226	71.44	3550	107.1	408	88.29
October	4392	82.03	576	40.47	3353	72.11	3385	100.5	370	66.07
November	4370	84.46	689	40.77	3497	81.75	3283	89.89	427	70.58
December	5355	86.58	889	41.04	4053	109.88	2363	79.50	738	158.09

In the *Chakdah* market of Nadia district, the maximum arrival of 4791 t was recorded in March and gradually declined to the lowest level of 2454 t in June and again started rising for the rest of the periods with small variations across the months. The market has witnessed a major month-wise variation in arrivals ranging from 149.17% to 68.74%, the highest fluctuation of 149.17% is associated with March, and the lowest variability was observed in July (68.74%). Interestingly, the fluctuation in arrivals was positively related to market arrivals, i.e. higher the market arrivals, the higher the variability. The highest amount of average market arrival of 4105 t was recorded in August in the *Siliguri* market of the Darjeeling district with a variability of 134.30%. A gradual deceleration in successive months hit the lowest point of 2018 t in July, though the movement was not smooth across the months. Monthly arrival fluctuation ranges from as low as 64.87% in July to 146.7% in April. The average monthly arrival in the *Diamond Harbor* market was observed to be the highest in December, measuring 738 t with the highest variability of 158.09%, and showed a sudden dip in January and from the next two exhibited an upward movement. From April, it experienced a steady deceleration with slight month-wise variation before it hit the lowest point of 370 t in the lean month of October with the lowest variability of 66.07% and then started rising to reach the maximum level of 711 t in March. The average monthly arrivals in the selected five markets showed broad month-wise variability across the markets, even with the same markets and the peak month of arrival being different for different markets, no definite pattern across all markets over the months was observed.

The average price with associated variability is depicted in Table 3. It reveals that the average prices for tomatoes are the highest in July at Rs. 3196.40/q and changed marginally in each successive month to record the lowest value in March at Rs.1003/q in the *Barasat* market. After hitting the minimum level in March, a growing trend was observed, indicating a definite pattern in the fluctuation of the price of tomatoes in the *Barasat* market i.e., first, a growing pattern from March to July and then a downward movement from July to March. The related monthly volatility varies from 51.28% in September to 54.28% in November. Average prices for tomatoes in the *Bardhaman* market showed up and down movement over the months. In this market, the highest average price level was registered in July accounting for Rs. 4339.29/q to the lowest level in February of Rs. 829.00/q. The variability was recorded as the lowest in September (63.21%) and highest in February (67.25%), which was eventually associated with the lowest average prices. In this context, it should be noted that though their coefficient of variation, measuring monthly variability was very high, but consistent across the months ranging from 63.21 to 67.25%. The monthly average price in the *Chakdah* market was recorded to be the highest in July amounting to Rs. 3995.40/q and showed a declining trend up to September and there was an upward trend for the next two months till November. From November onwards, there was a gradual deceleration in prices to attain the lowest level in March accounting for Rs. 940.20/q, and again showed an increasing pattern to reach the peak in July. Price in the *Chakdah* market showed wide fluctuation across the months ranging from 39.17% in March to 166.01% in August and there is a positive relationship between price and the associated coefficient of variation across the months. In the *Siliguri* market, the average tomato price was the highest in August with a magnitude of Rs. 3318.60/q, and the corresponding volatility was found to be 179.42% accounting for Rs. 3995.40/q and showed a declining trend up to September. There was an upward trend for the next two months till November. From November

onwards, there was a gradual deceleration in prices to attain the lowest level in March accounting for Rs. 940.20/q, and again showed an increasing pattern to reach the peak in July. Price in the *Chakdah* market showed wide fluctuation across the months ranging from 39.17% in March to 166.01% in August and there is a positive relationship between price and the associated coefficient of variation across the months. In the *Siliguri* market, the average tomato price was the highest in August with a magnitude of Rs. 3318.60/q, and the corresponding volatility was found to be 179.42%. The price dropped to the lowest point (Rs. 1137.20/q) in March and the corresponding volatility was calculated to be 52.51%. The average price of tomato in the *Diamond Harbor* market of South 24 Parganas has dropped to Rs. 684.30/q in February after reaching the highest price point in July at Rs. 4467.93/q. The behavioral pattern of average prices is similar to that of the *Chakdah* market with a marginal variation across the months. Maximum price variation was observed in July when consumers in that market witnessed a maximum price and it ranged from as low as 23.48% in February to as high as 164.98% in July. Briefly, the price trend in all five markets is more or less the same across the seasons, from the highest point in the lean season of July or August when arrival is lower and it drops slowly to the lowest level in February or March just after harvest season and then rises upward again to hit the maximum with some minor variation in demand. Month-wise price volatility is wide across the markets, but it is more stable in *Barasat* and *Bardhaman* across the months compared to the remaining three markets, namely, *Chakdah*, *Siliguri*, and *Diamond Harbour* which have experienced large month-to-month fluctuations in the prices of tomatoes. The reason for this greater fluctuation may be due to the seasonality of the agricultural production system and regional specialization arising out of resource endowments including fluctuations in weather conditions.

Table 3. Month-wise variability in the price of tomatoes in the selected markets. (Price in Rs. /q)

Months	Barasat		Bardhaman		Chakdah		Siliguri		Diamond Harbour	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%/)	Mean	CV (%)
January	1079.30	52.63	1273.40	67.09	1487.20	60.40	1652.50	76.11	1398.60	52.53
February	1059.80	52.46	829.00	67.25	977.80	39.09	1146.40	56.03	684.30	23.48
March	1003.40	51.89	2620.00	66.28	940.20	39.17	1137.20	52.51	866.40	32.98
April	1148.00	51.32	1282.60	65.37	1203.80	49.88	1258.40	58.36	1570.20	62.70
May	2222.80	51.53	2477.97	63.95	2474.80	97.77	1515.20	70.74	2485.60	97.72
June	2718.20	51.45	3476.03	63.35	3270.40	135.23	2150.80	100.76	3712.15	147.69
July	3196.40	51.78	4339.29	63.28	3995.40	161.61	3170.40	147.10	4467.93	164.98
August	3074.00	51.86	3533.26	63.28	3482.20	166.01	3318.60	179.42	3879.63	145.37
September	2430.40	51.28	2946.89	63.21	2740.80	113.10	2621.60	120.13	2812.32	109.44
October	2202.20	53.31	3586.30	63.25	3279.80	129.96	2770.40	117.98	3633.20	140.79
November	2466.00	54.28	3350.29	63.26	3446.80	137.42	3000.60	138.51	4024.08	145.66
December	1944.60	53.51	1828.00	63.76	2218.20	83.80	2354.60	103.17	2537.80	85.99

Table 4 details the seasonal market arrival and tomato price indices for these selected markets. This shows that the highest index of market arrivals was found in the *Barasat* market in January (218.33%) and the lowest value was recorded in June (52.26%), and it slowly increased in December (95.37%). A peak arrival index value of 158.48% was recorded in *Bardhaman* in March, followed by February (142.47%), January (130.68%), and December (113.43%). In October, it was the lowest with a value of 69.35%. The *Chakdah* market has witnessed more than 100 indices in the five successive months from December (108.81%) to April (126.39%) and the following seven months have achieved less than 100 indices confirming the lowest in July (68.07%). The peak arrival period was noted in December with a magnitude of 109.84% in terms of the maximum ranking of indices. In the *Siliguri* market, there are six months; January (104.34%), March (111.42%), April (141.04%), May (121.85%), August (129.15%), and September (102.97%) when seasonal indices have exceeded 100%. April has witnessed a maximum seasonal index while July had the lowest (62.35%). Four months in tandem starting from December to March, the *Diamond Harbor* market has maintained more than 100 index values while the highest was observed in December with an index value of 160.72%. In general, for three consecutive months from January to March, all the markets observed more than 100 indices values, except the *Siliguri* sector, which registered less than 100 values in February that could be because the tomato harvesting period in West Bengal starts from this month. In addition to these three months, in three out of five markets, namely, *Bardhaman*, *Chakdah*, and *Siliguri*, the market arrival index value of more than 100% has been extended to other months depending on the farmer's anticipation of higher prices in the future.

Table 4. Seasonal indices of market arrivals and prices of Tomato in the selected markets.

Months	Barasat		Bardhaman		Chakdah		Siliguri		Diamond Harbour	
	Arrival	Price	Arrival	Price	Arrival	Price	Arrival	Price	Arrival	Price
January	218.33	55.15	130.68	48.87	128.13	59.73	104.34	74.82	103.43	52.12
February	171.01	54.71	142.74	31.00	142.38	38.66	99.58	55.07	134.27	23.29
March	128.59	46.30	158.48	99.56	147.72	38.74	111.42	51.62	122.27	32.73
April	95.51	53.91	110.42	47.66	126.39	49.33	141.04	57.37	97.66	62.22
May	63.48	114.10	84.34	93.90	99.25	96.68	121.85	69.53	92.88	96.96
June	52.26	134.46	79.71	130.60	72.99	133.73	67.86	99.04	90.02	146.55
July	58.83	153.94	70.96	162.16	68.07	159.82	62.35	144.59	87.58	163.70
August	66.03	147.27	84.94	159.74	83.15	164.17	129.15	176.36	82.48	144.25
September	89.46	122.61	71.59	113.37	70.74	111.85	102.97	118.08	89.76	108.60
October	80.89	130.20	69.35	127.47	71.41	128.52	96.66	115.96	67.17	139.70
November	80.23	96.31	83.37	121.88	80.95	135.90	86.39	136.14	71.76	144.54
December	95.37	91.06	113.43	63.80	108.81	82.87	76.41	101.41	160.72	85.33

The lowest price index value was observed to be 46.30% in March, from which it follows an increasing pattern to reach the value of 100% in May, with small fluctuations in the *Barasat* market. The monthly seasonal index of prices was found to be the strongest in July (153.94%). The seasonal tomato price index of the *Bardhaman* market was the lowest in February (31.00%). Then it increased sharply and reached the maximum of 162.16% in July. The *Chakdah* market's peak seasonal price index was recorded as 164.17% in August and the lowest in February (38.66%). The lowest seasonal price index in the *Siliguri* market was recorded as 51.62% in March and slowly rose upwards in successive months to cross the 100 percentage value in July. Not only that, but held the same for the next five months consistently, while the highest value was noted in August (176.36%). It implies that due to the seasonal and perishable nature of the crops (Tomatoes), wholesale prices were relatively lower during the post-harvest period and very expensive during the lean period (Mishra & Kumar, 2012). The seasonal price index for the *Diamond Harbor* market was the highest in May (163.70 %) and gradually fell to the lowest in February (23.29%).

Further, the magnitude of the intra-year price variance was calculated in terms of the intra-year price rise (IPR), the average seasonal price variability (ASPV), and the coefficient of variation in Table 5. Results indicate that the highest intra-year price was witnessed by the *Diamond Harbour* sector (602.76%) followed by *Bardhaman* (423.04%) and *Chakdah* (324.64%). The lowest intra-year price increase was estimated to be 241.67 and 232.49%, respectively in the *Siliguri* and *Barasat* sectors. On the other hand, the highest and lowest ASPV was estimated in the *Diamond Harbour* and *Barasat* sectors at 37.54 and 26.88%, respectively. The coefficient of variation in prices was maximum in *Diamond Harbour* (46.70%) and minimum in *Barasat* (37.77%).

Table 5. Intra-year price rise, average seasonal price variation, and coefficient of variation in the selected markets.

Markets	IPR	ASPV	CV (%)
Barasat	232.49	26.88	37.77
Bardhaman	423.04	33.95	42.07
Chakdah	324.64	30.94	43.86
Siliguri	241.67	27.36	38.13
Diamond Harbour	602.76	37.50	46.70

Theoretically, market arrival is expected to raise the price function while the market price is expected to decrease the market arrival function (Sharma, 2011). The lagged price of tomatoes gave a high response and explained high variation indicating that the lagged price of tomatoes is an important factor in determining the current prices (Mahalle et al., 2014) (Table 6). In the present context, the price of tomatoes is negatively related to the market arrivals in all five markets whereas one year lagged price was positively correlated with the market arrivals in two markets i.e., *Barasat* and *Chakdah* (Table 6).

Table 6. Correlation coefficient (r) values between the current prices and market arrivals as well as one-year lagged prices of Tomatoes.

Markets	Correlation Coefficients	
	Current Prices	Lagged Prices
Barasat	−0.10	0.59
Bardhaman	−0.41	−0.67
Chakdah	−0.22	0.74
Siliguri	−0.06	−0.61
Diamond Harbour	−0.073	−0.24

4. Conclusions and Recommendations

To gain perceptions of the trends and seasonal variations of tomato prices in West Bengal, the present study aims to investigate the trends in market arrivals and prices to further determine the seasonal price movement concerning market arrivals of tomatoes in West Bengal. The market arrivals exhibit negative trends in three markets, except for *Barasat* and *Bardhaman*, where the observed values are not statistically significant. However, the lone market in *Diamond Harbour* shows a positive and significant trend in arrivals. Regarding current prices, all markets, except for *Chakdah* and *Siliguri*, exhibit positive and significant trend values. Seasonality is more prominent in market arrivals than the price for all the markets. The variability of arrival is proportional to the amount of arrivals in the market, i.e., the larger the arrival, the higher the variability. Price variations are substantial, although they are more or less steady throughout and within the market as opposed to arrival. In the harvesting or post-harvesting season (February–March), seasonal indices are high for arrival and low for the price, and the reverse is true in the lean season as also reported by Kundu et al. (2019). Price fluctuation is considerable in both within and between years, and the current prices are inversely associated with arrivals. Additionally, the study highlights an inverse relationship between current prices and market arrivals, implying that as arrivals increase, prices tend to decrease and vice versa. The very perishable nature of these veggies, a lack of adequate post-harvest facilities, a lack of scientific storage facilities, or farmers' poor retention capacity for selling their goods in the off-season might be contributing factors to this. Therefore, it is recommended that initiatives be taken to establish a storage structure, the dissemination of market information, a loan facility based on the crop received, and a constant watch on market arrivals and prices to reduce the extent of variability in market arrivals and prices, which is necessary to protect both producers and consumers' interests.

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