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Analysing Price Variation and Transmission among Major Potato Markets of Punjab

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Abstract

This study investigated wholesale potato price trends in Punjab, with a specific focus on market integration. The study analysed potato markets in Punjab, covering Amritsar Mewa, Ludhiana, Jalandhar, Hoshiarpur, Ferozpur, and Bathinda. The weekly wholesale potato prices from 2010-11 to 2021-22 were taken from the Punjab statistical abstract and AGMARKNET, and examined year-round price fluctuations. Data confirmed absence of unit root problems; all markets had test statistics below the critical one percent level (3.44%). Johansen co-integration test indicated higher trace statistic values and probabilities below 0.05 percent, confirming the existence of co-integrated series. As far as market integration is concerned, the results revealed that the various wholesale potato markets in Punjab display good integration with a better price connection. This signifies that these markets function in a competitive and effective manner at the wholesale level. The findings from this investigation will guide the policy makers to suggest the pertinent role of the Government in price stabilization. Further the study suggested to strengthen the market intelligence and reducing the distortion in markets will improve the existing overall performance.

Keywords: Market Integration, Potato, Stationarity, Price Transmission, Seasonality

JEL Classification: M31, C19, Q13, D40

Introduction

Punjab which is well known as 'Granary of India' cultivates two major cereals namely wheat and rice. Of the state's total geographical area of 50 lakh ha, 41 lakh ha is under cultivation out of which about 35 lakh ha under wheat and about 30 lakh ha under rice (PAU, 2023). The specialisation of cereal crops causes degradation of soil, lowering down of water level, stagnation of yield and environment related problems (Srinivasarao *et al* 2021). It is emphasized that diversification of cropping pattern can reduce these tribulations up to some extent. In diversification plan of Punjab agriculture, it was suggested that more area under fruits and vegetables should be covered (Kumar *et al* 2013). In Asia, potato production constitutes 50 per cent of the world's total output, with China and India collectively contributing to almost 38 per cent of this global production (Scott and Rosegrant 2020). The potato crop in India, especially in Punjab, witnessed its peak in terms of both area under cultivation and production. From 1990-91 to 2005-06, the growth in vegetable production in Punjab was primarily driven by an expansion in cultivated land. However, in the period from 2005-06 to 2010-11, the increase in productivity played a more significant role in boosting vegetable production (Kumar and Kumar 2012).

Potatoes have emerged as a reliable staple food crop, offering significant potential to enhance potato consumption. This is especially important in light of the increasing demand for food resources to sustain current consumption levels due to ongoing population growth. Therefore, it's essential to recognize the influence of seasonal surpluses on the prices and earnings of producers, even as we acknowledge this reality (Pandey 2007, Pandey *et al* 2009). Analysing potato production in Punjab revealed substantial growth over time. There has been a remarkable increase in production. In 2004-05, the production amounted to 14.70 lakh tons, and it experienced a significant surge, reaching 28.70 lakh tons by the year 2019-20 (PAU, 2023). Consequently, among all the vegetables, potato stands out as a promising crop in the Punjab. The primary potato cultivation areas in Punjab are concentrated in specific districts, namely Hoshiarpur, Jalandhar, Kapurthala, Amritsar, Ludhiana, Moga, Patiala, and Bhatinda. Notably, the early-season potato crops, planted in September, are exposed to higher temperatures during the

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initial sprouting and growth stages (Brar *et al* 2019). Potatoes typically reach their peak arrival in Punjab's major markets from December to April, while the period between May and September is considered the lean season. Additionally, Punjab also exports seed potatoes to states like Maharashtra, Bihar, and West Bengal etc.

In developing economies like India, several obstacles hinder the efficient operation of markets (Beag and Singla 2014). Agricultural marketing involves several intermediaries, contributing significantly to marketing costs, which in turn lead to price escalations. To address various market-related challenges effectively, it's crucial to have access to comprehensive market information, including insights into potential markets, quantity supplied, as well as current and projected prices across different regions and months of the year (Reddy *et al* 2012). To assess market performance and address the challenges related to price fluctuations, one approach is to focus on market integration, as highlighted by the study conducted by Mukhtar and Javed in 2007. Efficient and well-functioning commodity markets play a crucial role in conveying price signals effectively across different geographical locations and over various time periods. This importance lies in their ability to facilitate the distribution of resources within the market and encourage investment, ultimately contributing to overall market success (Sendhil *et al* 2023).

Market integration is a term used to describe a scenario where the prices of a particular commodity, found in various markets located in different geographical areas, consistently follow a similar trend over an extended period. When a set of prices demonstrate a proportional movement across different markets, it signifies that these markets are integrated (Ahmed and Singla, 2017). Integrated markets are characterized by the fact that prices of differentiated products within them do not act in isolation or independently of each other (Monke and petzel 1984). So the assessments of potato price mechanism in Punjab wholesale markets are essential. In this direction, the present study has designed to know the price variation and transmission among major potato markets of Punjab.

Data Sources and Methodology

The study sourced its data from secondary resources, specifically obtaining time series data on weekly wholesale potato prices from selected markets in Punjab. The monthly data on potato arrival and prices collected for the period of last 10 years spanning from 2011-12 to 2021-22. The major markets covering 80 per cent of arrivals in Punjab were selected. The data related to arrival and prices of potato from each market is generated from the data portals of AGMARKNET and various issues of Statistical Abstract of Punjab.

Seasonal indices

To measure the seasonal variations in prices, seasonal indices were calculated employing twelve months ratio to moving average method.

$$Y_t = T_t \times S_t \times C_t \times I_t$$

Where,

Y_t = Observed value at time t

T_t = Trend component at time t

S_t = Seasonal component at time t

C_t = Cyclical component at time t

I_t = Irregular component at time t

The seasonal indices were calculated by adopting the following steps :

Augmented Dickey-Fuller (ADF) Test

In order to test for co-integration, which indicates the existence of long-term equilibrium, it is crucial to ensure that the time series data are stationary. Stationarity is important to avoid spurious and meaningless relationships (Reddy, 2012). In this study, the Augmented Dickey-Fuller (ADF) test, was employed to assess the stationarity of the price series. The ADF test examines the presence of a unit root, which indicates non-stationarity in the data. By performing the ADF test using these regression equations, it is possible to determine the presence or absence of a unit root, which indicates the stationarity of the price series.

$$\Delta P = \alpha_0 + \delta_1 t + \beta_1 t + P_{t-1} + \sum_{j=0}^{q} \beta_t \Delta P_{t-1} t + \in_t$$

Where,

Δ refers to difference parameter, P is the price in each market, refers to constant or drift and $_t$ is the Pure white noise error term

Johansen Co-Integration Test

The Johansen co-integration test, developed by Johansen and Juselius (1990), is employed to examine the long-run price relationship between markets. This test utilizes two test statistics based on the maximum likelihood ratio: the trace test statistic and the maximum eigenvalue test statistic. The presence of a co-integrating relationship among the price series was assessed through the utilization of a trace test. This test involved examining the estimates of characteristic roots and determining the number of characteristic roots that did not significantly deviate from unity, using specific statistical measures.

$$\lambda_{trace} = -T \sum_{i=r+1}^{N} \ln(1 - \lambda_{i1})$$

$$\lambda_{max} = -T \ln (1 - \lambda_{r+1})$$

Where, 'r' is the number of co-integrated vector, 'λ_1' represents the estimated Eigen values and 'T' is the number of observations. The eigenvalues indicate the degree of correlation between the first difference and error correction in the dataset.

Granger Causality Test

The Granger causality test is a method used to assess whether one variable, denoted as X, is influenced by another variable, denoted as Y. This test examines whether the values of Y can be used to predict the values of X and vice versa. To explore the causal connection between two price series, the study utilizes pairs of ordinary least squares (OLS) regression equations within the bivariate vector auto-regression (VAR) framework, as illustrated below:

$$\ln X_t = \sum_{i=1}^{m} \alpha_i \ln X_{t-i} + \sum_{j=1}^{m} \beta_j \ln Y_{t-j} + \varepsilon_{1t}$$

$$\ln Y_t = \sum_{i=1}^{m} \alpha_i \ln Y_{t-i} + \sum_{j=1}^{m} \beta_j \ln X_{t-j} + \varepsilon_{2t}$$

Where, 'X and Y' are two different market prices series, 'In' stands for price series in logarithmic form and 't' is the time trend variable

Vector Error Correction Model

Once co-integration among the price series has been confirmed, the study applies the Error Correction Model (ECM) to examine short-term causal relationships between the variables. Error correction model will often provide additional theoretical tractability since there is no longer any reason to lump short and long-term dynamics together. By VECM the work can be formulated efficiently and test theories that are better able to discriminate between two processes that have short versus long-run behaviour (Keele and Boef 2000). To start, let's take a subsystem approach where we focus on a group of random variables. These variables are integrated at a certain level, and we treat them as structurally exogenous. This means that any connections they have with cointegrating vectors won't show up in the subsystem's vector error correction model (VECM). Additionally, the errors in this subsystem aren't connected or influenced by errors in the rest of the system (Pesaran *et al* 2000). This model helps in understanding the pace at which these variables make adjustments from short-term imbalances to reach a long-term equilibrium. In this study, a generalized formulation of the error correction model is used to analyze both short-term and long-term price actions by solving the autoregressive distributed lag equation (Gujarati, 2010). The error correction model is derived by assuming that both X and Y are integrated and demonstrates that it captures the causal movements of equilibrium between these co-integrated systems.

$$\Delta y_i = a + \mu(y_{t-1} - \beta x_{t-1}) + \sum_{i=0}^{i-i} \delta_i \Delta x_{t-i} + \sum_{i=1}^{i-t} \gamma_i \Delta y_{t-1}$$

The model encompasses lagged differences in both variables, x and y, which exert a more immediate influence on the value of Dy_t. The coefficient of the error-correction term reflects the pace at which the series readjusts towards equilibrium. When this coefficient is negative, it suggests that the series are converging towards a long-term equilibrium. Conversely, if it is positive or zero, it implies that the series are moving away from equilibrium.

Results and Discussion

Production Scenario of Potato

Potato accounts for about 35 per cent of the total vegetable production in Punjab. Area under potato has increased from 83.6 thousand ha in 2010-11 to 108 thousand ha in 2021-22 (Table 1). The pea production has also more than doubled from 2088 thousand tonnesto 2989 thousand tonnes during this period. As a result, among the various vegetables cultivated in Punjab, potatoes emerge as a particularly promising and significant crop. Growers opt to harvest potatoes before maximum bulking has occurred to capture higher farm-gate prices, to avoid the crash in producer prices at the peak of the harvesting period, and to achieve early planting for the subsequent crop (Pande *et al* 2008). At the peak of harvest in the major potato-producing states in the Indo-Gangetic plain, potatoes can become a "seasonal staple" for the very poor and/ or migrant labourers as a flood of supplies appear when other staples are less readily available (Scott 2002). Although only five per cent of India's total potato production, which amounts to nearly 50 million tonnes, Punjab has effectively fulfilled the nation's need for seed potatoes (Rana *et al* 2012). In this scenario, market intelligence are crucial to farmers as it enables to make informed decisions about marketing of potato. There are many hindrances found in the efficient functionality of the markets in a developing economy like India (Beag and Singla 2014). Farmers often encounter numerous challenges, such as inadequate technical assistance, subpar product quality and issues pertaining to price fluctuations. Additionally, they grapple with the absence of crop insurance (Mishra and Singh, 2010). One method to concentrate on the problems of price volatility for the examination of market performance is through market integration (Mukhtar and Javed 2007).

Trends in Wholesale Prices of Potato

The trend component was computed to determine the long-run movement of potato prices in the selected markets within Punjab namely Mewa, Ludhiana, Ferozpur, Bathinda, Tanda Urmur and Jalandhar city. Table 1 illustrate the trend component of wholesale potato prices in the selected markets of Punjab. The wholesale price data from the chosen markets, Mewa, Bathinda, Tanda Urmur, Ferozpur, Ludhiana, and Jalandhar city markets, displayed a significant, trend at one per cent threshold. Moreover, analyzing the coefficients associated with the wholesale prices of potatoes across these selected markets revealed a consistent pattern, all coefficients were found to be positive. This positive sign signifies a consistent upward trend in the wholesale prices of potato over the observed period. In other words, it suggests a gradual increase in potato prices over time within these markets.

It was observed that among the selected markets, the highest annual increment in wholesale price of potato was occurred in Tanda Urmur market at Rs 12.7 per qtl per annum

Table 1. Trends in wholesale prices of potato at selected markets of Punjab, 2010-11 to 2021-22

Markets	Intercept	Co efficient	R^2	t-value
Mewa	384.4	9.4	0.09	8.3*
Bathinda	554.5	8.2	0.06	6.7*
Tanda Urmur	589.7	12.7	0.12	9.8*
Ferozpur	464.4	10.8	0.09	8.3*
Ludhiana	446.6	7.4	0.08	7.4*
Jalandhar city	428.6	4.5	0.03	5.1*

** Significant at 1 per cent level of significance*

and with time as an independent variable explaining 12 per cent of the price changes across the years. Following closely, the Ferozpur market displayed the second highest annual increase in potato price, accounting to Rs 10.8 per quintal per annum, with time explaining a per cent of the price shifts in the market over time. In contrast, the Jalandhar city market exhibited the smallest annual increase in potato`s wholesale price, recording Rs 4.5 per qtl annually and the time variable accounted for three per cent of the price fluctuations in the market over the years.

Moving forward, the annual increase in wholesale prices of potato in Mewa, Bathinda and Ludhiana markets are Rs 9.4, Rs 8.2 and Rs 7.4 per qtl per annum respectively and 9, 6 and 8 per cent of the changes in wholesale prices in Mewa, Bathinda and Ludhiana markets respectively were governed by the time variable. In the year of 2016-17 there are several challenges leading to price fluctuations, including absence of government procurement at Minimum Support Price (MSP), limited contract farming options, insufficient market data, especially during the rainy season, unhygienic conditions, and inadequate market infrastructure, including timely access to cold storage and railway transportation. In the period of 2020-21, COVID pandemic occured where potato gained its importance in the market as a result price surge was witnessed.

Seasonal Indices of Wholesale Potato Prices

In this direction, the study has started to know the seasonal pattern. as all horticultural production activities experience certain degree of seasonality. In the case of prices, they tend to follow a consistent pattern each year, with lower prices observed during the post-harvest months and higher prices during the off-season months predicting the subsequent harvest (Kaur *et al* 2022). The seasonal Index of weekly prices of potato in selected markets were worked out by the twelve-month moving average method for the period of 11 years i.e., from 2010-11 to 2021-22 (Table 2). The examination of seasonal indices revealed the existence of significant seasonal variations in wholesale prices of potato across all the selected markets of Punjab. These indices play a vital role in identifying to obtain the optimum time for the sale of produce in the market.

An evident trend has been observed across all chosen markets, where in prices start to rise after reaching their lowest during the 6th to 8th week. This upward trend continuous, maintaining higher levels during the 38th to 48th weeks, after which prices gradually decline in subsequent weeks. The prices of potato increased significantly in all the selected markets of Punjab. The seasonal indices of prices of potato in most of the selected markets are showing similar pattern indicating the presence of price integration among the markets.

Table 2. Seasonal indices of wholesale prices of potato in selected markets of Punjab (Weeks)

Markets	Highest Index (weeks)	Lowest Index (weeks)
Mewa	**43th**,46th,41st	7th,**6th**,8th
Ludhiana	**48th**,**47th**,46th	**7th**,6th,8th
Ferozpur	**46th**,47th,48th	**6th**,8th,7th
Bathinda	37th,**45th**,29th	9th,**10th**,7th
Hoshiarpur	**45th**,**48th**,46th	7th,**6th**,5th
Jalandhar City	**43rd**,**45nd**,42nd	**6th**,**7th**,5th

Note: Bold letters indicate extreme values

Stationarity of the Series

Stationarity is important because many useful analytical tools and statistical tests and models rely on it (Palachy 2019). However, non-stationarity is the inherent property of real-world time series and also good guidance for discovering temporal dependencies for forecasting (Liu *et al* 2022). The results of the ADF test revealed that all the markets under examination produced ADF values that exceeded the critical thresholds (table 3). This signifies that the wholesale price series in these markets are not influenced by the presence of a unit root and can be regarded as stationary. The ADF test, conducted with the null hypothesis that assumes the absence of a unit root, led to the rejection of this null hypothesis for all the chosen wholesale markets. The results revealed that all the selected markets were stationary at level. As a result, it can be inferred that there is no unit root issue in the wholesale price series, and they can be considered dependable without

Table 3. Results of ADF test in selected markets of Punjab

Markets	At level		Critical value at 1% level
	Test Statistic	Stationarity	
Mewa	-4.8928*	Stationary	-3.440
Ludhiana	-3.6967*	Stationary	
Bathinda	-4.3312*	Stationary	
Ferozpur	-4.4211*	Stationary	
Jalandhar city	-3.7204*	Stationary	
Hoshiarpur	-6.2582*	Stationary	

**Reject null hypothesis at 1 per cent level.*

being affected by spurious relationships.

Long-term Price Relationship among Selected Markets

In this study, the Johansen and Juselius (1990) cointegration test was employed to examine the long-term relationship among the price series. Near-integrated and integrated time series have implications for estimation and inference that are similar in many respects. For instance, spurious regressions are a problem when variables are near-integrated as well as integrated, and therefore, it is also relevant to discuss cointegration of near-integrated variables (Perron and Campbell 1993). Johansen's technique is said to be more efficient and more powerful in that it not only allows for a feedback effect among the variables that enter into cointegrating space, but it is also based on the maximum likelihood procedure for estimating the long-run cointegrating vectors (Bahmani and Brooks 2003). This test utilized maximum likelihood ratio statistics to determine the number of co-integrating vectors. The analysis of Eigen values was carried out to gauge the strength of correlation between the first difference and the error correction term.

The outcomes of the test revealed that the values of the trace statistic surpassed the critical thresholds at a significance level of 0.05 (Table 4). Furthermore, the p-values were found to be less than 0.05. Consequently, the null hypothesis, which suggested no co-integration among the series, was rejected. This indicates the presence of co-integrated series, implying that the wholesale markets are well-connected, and a long-term relationship exists among their price series.

Price Transmission among Markets

Applying the Granger-causality test can get three different results reject the null in one of the tests (i.e. find a one-directional causal relation), reject the null hypothesis of the two tests (i.e. get a bi-directional Granger-causality) or do not reject the null hypothesis (Maziarz 2015). Drawing causal conclusions from non-experimental data through standard regression analysis can be a complex undertaking (Freedman, 2007). The study on market reliability must rely on theory to establish potential causal pathways (Heckman, 2008), ascertain the true exogeneity of variables, and should be free from the presence of combined unnecessary variables. Granger causality tests showed bidirectional causal relationships in the price transmission between Ludhiana, Ferozpur, Bathinda, and Hoshiarpur markets, and Mewa, Bathinda, Ferozpur, Hoshiarpur, Jalandhar city, and Ludhiana markets as showed in Fig 1. It implies that all these markets swiftly reacts with others reaction. Among the selected wholesale potato markets in Punjab, it was observed that

Table 4. Results of Johansen Co-integration test in selected markets

Hypothesized No. of CE(s)	Eigen value	Trace statistic	Critical Value at 0.05 level	Prob.**
None *	0.112898	248.9483	95.75366	0.0000
At most 1 *	0.083676	173.3573	69.81889	0.0000
At most 2 *	0.070560	118.2173	47.85613	0.0000
At most 3 *	0.053702	72.04490	29.79707	0.0000
At most 4 *	0.035053	37.21533	15.49471	0.0000
At most 5 *	0.023027	14.70017	3.841465	0.0001

Trace test indicates 6 cointegration eqn(s) at the 5 per cent level
** denotes rejection of the hypothesis at the 5 per cent level*

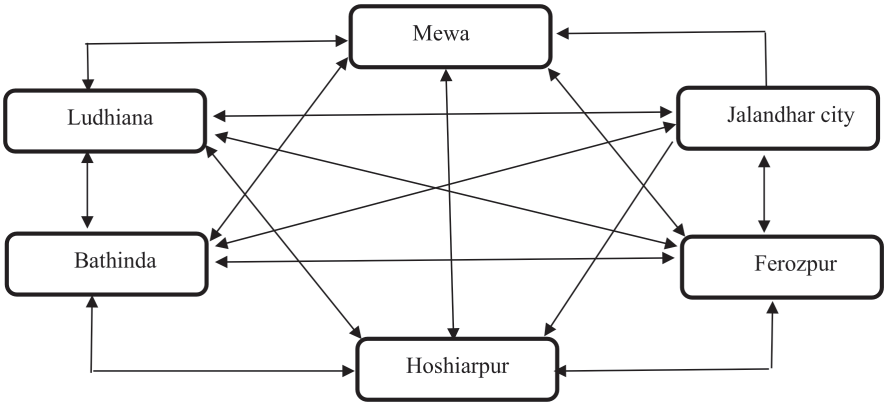

Fig 1: Granger Causality direction between the selected market pairs

the wholesale prices in the Mewa and Hoshiarpur markets do not impact the wholesale prices in Jalandhar city.

Equations of Vector error correction model (VECM) for the selected markets

However, the wholesale prices in Jalandhar city exert a one-way influence on the wholesale prices in the Mewa and Hoshiarpur markets. These findings indicate varying levels of interdependence and price transmission among different wholesale potato markets in Punjab, with some markets influencing each other bidirectionally, while others exhibit a unidirectional influence.

The results obtained from utilizing the Vector Error Correction Method revealed the existence of a long-term relationship among the prices in all the selected markets, which include Ferozpur, Hoshiarpur, Bathinda, Ludhiana, Jalandhar city, and Mewa. This suggests that these markets are interconnected and undergo price adjustments over time. The short-term price fluctuations eventually lead to a convergence towards a stable long-term equilibrium. The findings indicated the presence of a lasting relationship among the prices in all markets, encompassing Ferozpur, Hoshiarpur, Bathinda, Ludhiana, Jalandhar city, and Mewa.

$$\Delta InBAT_t = -0.00908ECT_{t-1} - 0.4980\Delta InBAT_{t-1} - 0.2388\Delta InBAT_{t-2} + 0.5458\Delta InJAL_{t-2} + 0.2876\Delta InLUD_{t-1}$$

$$\Delta InJAL_t = -0.000ECT_{t-1} - 0.3628\Delta InJAL_{t-1} - 0.1580\Delta InJAL_{t-2} + 0.1179\Delta InLUD_{t-1} + 0.1412\Delta InLUD_{t-2}$$

$$\Delta InFER_t = -0.2544ECT_{t-1} - 0.345\Delta InFER_{t-1} - 0.0911\Delta InFER_{t-2} + 0.1334\Delta InMEWA_{t-1} - 0.0679\Delta InMEWA_{t-2}$$

$$\Delta InLUD_t = -0.0001ECT_{t-1} + 0.0662\Delta InFER_{t-1} + 0.0719\Delta InFER_{t-2} - 0.2865\Delta InLUD_{t-2}$$

$$\Delta InMEWA_t = -0.3703ECT_{t-1} + 0.1088\Delta InBAT_{t-1} + 0.1055\Delta InBAT_{t-2} + 0.2328\Delta InFER_{t-1} - 0.3919\Delta InMEWA_{t-1} - 0.1826\Delta InMEW_{t-2} + 0.2089\Delta InLUD_{t-1}$$

$$\Delta InHOS_t = 0.00021ECT_{t-1} - 0.3589\Delta InHOS_{t-1} + 0.2453\Delta InLUD_{t-1}$$

(Price series: LUD-Ludhiana FER-Ferozpur HOS-Hoshiarpur JAL-Jalandhar city BAT- Bathinda)

Conclusion and Policy Implications

Potatoes have emerged as a significant food crop, not only in India but also on a global scale. Punjab, in particular, has experienced a huge surge in potato production over the last 30 years. This increase can be attributed to the increase of cultivated land dedicated to potatoes and enhancements in yield. However, the prices of potatoes exhibit substantial volatility, with significant fluctuations occurring both from one year to another and within the same year. This instability is primarily influenced by two key factors: the levels of potato production and the seasonal patterns of production. In the context of price patterns, the potato markets in different regions of Punjab exhibited distinct seasonal price fluctuations. Prices generally peaked from the 39th to the 47th week and were the lowest in the 6th and 7th weeks. This pattern was influenced by the timing of primary crop planting in October, with higher prices from September to November and lower prices in February and March. Coming to price cycles in Punjab markets from 2010-11 to 2021-22, It was found that cyclical price variations followed a consistent pattern. Prices increased from 2012 to 2013, decreased until 2016, rose again from 2017 to peak in 2019, and then declined until 2021. Two distinct price cycles were identified: one marked by a decreasing trend from 2013 to 2019 and another beginning with a price increase.

As far as market integration is concerned, the results revealed that the various wholesale potato markets in Punjab display good integration with a better price connection. This signifies that these markets function in a competitive and effective manner at the wholesale level. The findings from this investigation will guide the policy makers to suggest the pertinent role of the Government in price stabilization. Given the increasing significance of potatoes as a staple food, it becomes essential to implement measures for price

stabilization to meet the increasing demand and guarantee food security. Further the study suggested to strengthen the market intelligence and reducing the distortion in markets will improve the existing overall performance.

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