**Market Integration and Price Transmission in India's Major Paddy Markets: An Econometric Introspection**

**ABSTRACT**

This study investigates the integration dynamics of five major wholesale paddy markets in India, each representing distinct zonal councils: Kota (Rajasthan), Attabira (Odisha), Sindhanur (Karnataka), Dahod (Gujarat), and Bhatapara (Chhattisgarh). Unlike prior research, which primarily focuses on localized short-term market integration, this study addresses a critical gap by employing long-term market integration analysis using structural break techniques. By utilizing a 15-year dataset (2009–2023), we systematically examine price linkages, structural shifts, and the speed of price adjustments across markets. A robust econometric framework was applied to assess market efficiency, incorporating the Augmented Dickey-Fuller test, Johansen's Co-integration Test, Structural Break Analysis, and the Vector Error Correction Model (VECM). The findings confirm long-term price integration, with the structural break analysis identifying critical market disruptions. The VECM results indicate that price adjustments occur at varying speeds—Kota (32.5%), Sindhanur (35.4%), and Dahod (19.56%)—highlighting asymmetries in market efficiency. In the short-run, adjustments are significant between Attabira and both Dahod and Sindhanur markets, suggesting localized transmission effects. Furthermore, Granger causality tests reveal unidirectional price leadership in select market pairs. These insights underscore the need for targeted policy interventions to enhance market efficiency. Improved market oversight, digital price dissemination, and enhanced storage and transport infrastructure can facilitate smoother price transmission and minimize volatility. Additionally, strengthening farmer awareness programs on price trends and inter-market linkages can help optimize market participation and price realization.

**Keywords**: Market Integration, Co-Integration, Granger Causality, Paddy Markets

**Introduction:**

India's agricultural sector plays a pivotal role in its economy, employing nearly 46.07% of the population and contributing approximately 16% to the country's Gross Domestic Product (GDP) (PLFS, 2023-24; Economic Survey, 2024-25). Over the past decade, this sector has maintained an average annual growth rate of 5%, highlighting its resilience and economic importance. Among the various agricultural commodities, paddy is a particularly significant staple food crop and a key contributor to rural livelihoods and export revenues. India is the second-largest rice producer globally, with a total production of 137.83 million tonnes in the fiscal year 2023-24, accounting for 41.47% of the country's total food grain output (Agricultural Statistics at a Glance, 2023). Major paddy-producing states, including Uttar Pradesh, Telangana, West Bengal, Punjab, Chhattisgarh, Odisha, Andhra Pradesh, Tamil Nadu, Bihar, and Madhya Pradesh, collectively contribute over 80% of national production, underscoring the widespread cultivation and economic relevance of this crop.

Despite its production dominance, inefficiencies in paddy markets remain a pressing concern. Fragmentation, price volatility, and asymmetries in price transmission across regions pose significant challenges to farmers and consumers. Efficient market integration ensures fair price discovery, optimizing resource allocation, and stabilises farm incomes. However, empirical evidence suggests that India's paddy markets exhibit considerable inefficiencies, primarily due to infrastructural disparities, the involvement of multiple intermediaries, speculative trading, and government interventions that distort natural price signals (Andrle & Blagrave, 2020; Pumihic, 2023). These inefficiencies manifest in price asymmetry, wherein farmers in surplus-producing regions fail to receive remunerative prices, while consumers in deficit regions face disproportionately high costs. This situation calls for a rigorous assessment of the degree and direction of price linkages among major paddy markets in India (Hamulczuk, 2020; Pokharkar & Yadav, 2021).

Existing literature has explored the integration of agricultural markets in India, particularly in the cereal sector. However, several critical gaps limit the applicability of these studies in designing effective policy interventions. First, most studies adopt a highly localized approach, focusing on individual states or districts rather than providing a broader, national-level perspective on market integration (Akbari & Ng, 2020; Paul & Karak, 2022; Udhayan et al., 2023). Second, the majority of studies rely on relatively short timeframes, typically spanning 7 to 10 years, which may not adequately capture long-term structural changes, policy shifts, or macroeconomic shocks affecting market behavior (Zalkuwi & Joshua, 2024). Third, prior research often employs basic econometric techniques, such as simple correlation analysis or bivariate co-integration models, which do not provide a comprehensive understanding of both short-run and long-run integration dynamics. Moreover, many studies fail to account for structural breaks in price series, which can arise due to policy interventions, trade liberalization, or macroeconomic disruptions, thereby limiting the robustness of their findings.

Addressing these gaps, the present study seeks to offer a comprehensive and methodologically rigorous analysis of market integration in India’s paddy sector. This research investigates the long-term integration dynamics of five major wholesale paddy markets—Kota (Rajasthan), Attabira (Odisha), Sindhanur (Karnataka), Dahod (Gujarat), and Bhatapara (Chhattisgarh)—which represent distinct geographical zones of the country. By utilizing an extensive 15-year dataset covering the period from 2009 to 2023, this study moves beyond short-term analyses to capture broader market trends, policy impacts, and structural shifts in price behavior. Unlike previous research, this study systematically examines structural breaks, market efficiency, price linkages, and the short-run versus long-run price relationships among these markets using advanced econometric methodologies, including Johansen’s Co-integration Test, the Augmented Dickey-Fuller (ADF) Unit Root Test, the Granger Causality Test, and the Vector Error Correction Model (VECM).

Through this investigation, the study aims to assess the extent of price co-integration among major paddy markets and determine whether they function as a unified national market. It further seeks to identify structural breaks in paddy price trends and analyze their impact on market dynamics, examine both short-term and long-term price transmission mechanisms to evaluate the efficiency of inter-market price adjustments, and derive policy insights that can help enhance market efficiency, stabilize prices, and secure higher returns for farmers. By addressing these objectives, this study contributes valuable empirical insights that can inform policy interventions aimed at improving the efficiency of India’s paddy markets. The findings will serve as a crucial resource for policymakers, market regulators, and agricultural stakeholders, helping to develop strategies for market integration, price stabilization, and farmer welfare, ultimately ensuring a more equitable distribution of market benefits across regions.

**Methodology:**

This study employs a robust econometric framework to analyze the integration of five major wholesale paddy markets in India. The selected markets—Kota (Rajasthan), Attabira (Odisha), Sindhanur (Karnataka), Dahod (Gujarat), and Bhatapara (Chhattisgarh)—represent different **geographical zones of the country** and were chosen based on multiple considerations. The **primary criterion for market selection** was **representativeness**, ensuring that each market reflects price trends in its respective region. Secondly, **high trade volume and data availability** were essential, ensuring consistent and uninterrupted long-term price and arrival records, making them suitable for time-series econometric analysis. The **selected markets are among the largest contributors to paddy arrivals in their respective states**, playing a significant role in regional price discovery. Furthermore, these markets exhibit **distinct variations in supply chain structures, market linkages, and price transmission patterns**, making them an ideal sample for evaluating the dynamics of market integration at the national level.

The study utilizes **secondary data** on monthly wholesale prices and arrivals of paddy from **Agmarknet** and other relevant governmental publications, such as the **Agricultural Statistics at a Glance (2023), Economic Survey (2024-25), and reports from the Ministry of Agriculture and Farmers Welfare**. The dataset spans a **15-year period (2009-10 to 2023-24),** enabling a **longitudinal analysis** of market integration dynamics. Given the **potential issues of data inconsistencies**, rigorous **data cleaning and preprocessing** procedures were undertaken. Missing values were addressed through **linear interpolation**, a widely accepted method in time-series analysis that maintains the integrity of the dataset while minimizing bias. Outliers were detected using **Tukey’s Fences method**, which identifies extreme price fluctuations that could distort model estimates. Furthermore, the **Augmented Dickey-Fuller (ADF) test** was conducted at the preliminary stage to confirm the stationarity of price series, ensuring that subsequent econometric analysis adhered to fundamental time-series assumptions.

To systematically assess the degree of market integration, a combination of **advanced econometric models** was employed. First, the **Bai-Perron structural break test** was applied to identify **significant changes in the price series over time**. Structural breaks in agricultural price series often arise due to **policy interventions, macroeconomic shocks, or climate-related events**, and failing to account for these breaks can lead to **misleading inferences about market integration** (Bai & Perron, 2003). This test was preferred over traditional **Chow tests**, as it allows for the detection of **multiple unknown breakpoints**, making it more flexible for analyzing structural shifts in price data.

To examine long-run price relationships, **Johansen’s Co-integration Test** was employed, which is more robust than the **Engle-Granger two-step method** in the presence of multiple cointegration relationships (Johansen, 1988). Given that agricultural markets exhibit **complex interdependencies**, a multivariate cointegration approach is necessary to capture the simultaneous price linkages across markets. The presence of co-integration would indicate that **paddy prices in different markets move together over time, despite short-term fluctuations**.

The Vector Error Correction Model (VECM) was used to analyse short-run and long-run price adjustments further. This model extends traditional **Vector Autoregression (VAR) models** by incorporating **error correction mechanisms**, making it particularly well-suited for studying **markets that exhibit long-term equilibrium relationships but short-term deviations** (Engle & Granger, 1987). In agricultural markets, price transmission is often delayed due to **transportation lags, market frictions, and supply chain inefficiencies**, making VECM a more appropriate tool than standard VAR models, which do not account for equilibrium restoration.

The **Granger Causality Test** was also applied to identify **the direction of price influence among markets**. This test evaluates whether past price movements in one market can statistically predict future price changes in another, thereby identifying **dominant price-leading markets and dependent follower markets** (Granger, 1969). Understanding these causal linkages is crucial for policymakers aiming to **enhance market efficiency, reduce price volatility, and design targeted interventions**.

This study ensures high methodological reliability and empirical robustness by integrating a rigorous **econometric framework with robust data preprocessing procedures**. The findings derived from these models will provide **empirical evidence to guide policy recommendations for market stabilization, price forecasting, and improved farmer incomes**. This study’s contribution lies in its **comprehensive methodological approach**, combining structural break analysis, long-run and short-run market integration assessments, and causal inference, thereby enhancing the understanding of **spatial price transmission mechanisms in India’s paddy markets**.



**Fig 1. Selected major paddy markets in India and their geographical location**

**Results & Discussion:**

**Determination of Structural Break**

Table.1 depicts the structural breaks in the series that are found by employing sequentially determined Bai and Perron L+1 test.

**Table 1. Structural break points of paddy in selected markets**

|  |  |
| --- | --- |
| **Market** | **Break Point - I** |
| Kota | April, 2012 |
| Attabira | October. 2013 |
| Sindhanur | February, 2012 |
| Dahod | November, 2012 |
| Bhatapara | May, 2012 |

Source: The authors.

Note: Breaks are given in Month, Year

The Bai and Perron L+1 method insights sequentially determined breaks for paddy price series. One structural break points for all the five markets of paddy are occurring in the year of 2012 except in Attabira market after the steep rise in Minimum Support Price (MSP) for paddy from Rs.1120 to Rs.1250 per quintal for common grade and from Rs.1130 to Rs.1280 per quintal for grade A paddy during the 2011-12 and 2012-13 marketing season. This marked an increase in MSP by 13.64 per cent and 13.27 per cent respectively for common grade and grade A paddy from previous years and aimed to ensure that farmers received a fair price for their produce a midst fluctuating market conditions.

**Figure 2. Graph Showing Structural Break Points of paddy in selected markets**

|  |  |  |
| --- | --- | --- |
| Kota | Attabira | Sindhanur |
|  |  |  |
| Dahod | Bhatapara |
|  |  |

 Source: Authors’ own calculation

An assessment of the descriptive statistics of paddy prices and arrivals in the major markets (Table 2) demonstrated noticeable differences in market price. The mean price of paddy in the markets increased by 40-50 per cent from period -I to II. The highest paddy price was recorded in Kota Rs.23.10 per kg and Rs.38.45 per kg during period I and II respectively, suggesting limited production and increased import from other market, while Attabira and Dahod exhibited the lowest price i.e. Rs.6.65 per kg in period-I and Rs.12,08 per kg in period -II. Highest arrival of paddy found in Kota with 2042.59 qtl and 2069.73 qtl in successive periods, while lowest arrival noted in Attabira as the market is one of the major producer markets of paddy with seasonal arrival. The price series across the selected markets show skewness, ranging from -0.85 to 0.28, indicating a longer left tail in the distribution, however, for period -II, skewness, ranging from -0.39 to 0.37 indicating distribution is nearly symmetric overall. Additionally, most of the markets displayed negative kurtosis values, indicating a platykurtic distribution.

The month wise CAGR for paddy prices and arrival were calculated using an exponential growth function, revealing significant growth in each of the selected markets and are shown in Table 3. In Sindhanur market, most of the months have showed maximum increase in CAGR values for market arrival, while the CAGR has decreased in Bhatapara market from period I to period II. However, a positive change in CAGR of price was observed in Bhatapara market from period I to II. Decrease in rate of CAGR can be clearly observed for market price in Kota market from period I to Period II. Highest growth in market arrival was observed in Attabira market during November and March month for period I & II respectively. On the other side, lowest growth in market arrival was observed in Kota market during August and November during period I and II respectively. In both the period highest growth in market price found in Attabira market and same as that of lowest in Kota market.

` The CDV index is utilized to assess the instability or variability within the data. In this analysis, the instability of both market arrivals and paddy prices in the selected markets has been evaluated using this index and shown in Table 4. In period -I, variability in prices is more pronounced than market arrival. Variability in market arrival is found highest in Kota market with an index of 12.10 per cent, while Bhatapara market showed the lowest value with index of 5.95 per cent. Variability in prices were quite high in all the five markets, however, Attabira market showed the highest variability with an index of 15.14 per cent. In period -II, variability in market arrival is found highest in Attabira market with an index of 17.50 per cent, while Bhatapara market showed the lowest value with index of 4.21 per cent. Kota market showed the highest variability in price with an index of 21.89 per cent.

The analysis of monthly seasonal indices (Figure 4) highlighted distinct seasonal price variations across different paddy markets in India. The Bhatapara market exhibited the highest index in September (107.02), while the lowest was in the Kota market in October (89.25). Notably, the indices across markets peaked during the months leading up to the harvest (primarily November) as shown in figure 3, attributed to the scarcity of paddy supply. The majority of the markets experienced the highest variations from October to November, except for Kota and Dahod, where September registered the most significant variation. The lowest price indices were typically observed in July, with reduced indices noted in May and June due to increased market arrivals.

**Table 2. Summary statistics of market arrival and price of paddy in selected market**

Arrival in Qtl & Price in Rs./kg (2009-10 to 2022-23)

|  |  |  |
| --- | --- | --- |
|  | PERIOD - I | PERIOD - II |
| Kota | Attabira | Sindhanur | Dahod | Bhatapara | Kota | Attabira | Sindhanur | Dahod | Bhatapara |
| **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** |
| Mean | 337.42 | 17.91 | 369.33 | 9.94 | 258.75 | 12.68 | 21.32 | 9.98 | 272.91 | 12.68 | 207.96 | 25.76 | 466.29 | 16.2 | 236.07 | 21.81 | 14.22 | 14.56 | 183.31 | 19.55 |
| Standard Deviation | 517.91 | 2.53 | 595.41 | 1.61 | 156.80 | 1.64 | 11.91 | 1.17 | 147.59 | 1.55 | 369.49 | 5.67 | 1473.85 | 2.31 | 179.00 | 1.99 | 13.40 | 1.22 | 108.04 | 2.45 |
| Kurtosis | 3.26 | -0.64 | -0.12 | -0.09 | -0.85 | -0.29 | -0.03 | 0.04 | 3.43 | 1.15 | 9.20 | -0.62 | 93.91 | -1.56 | 39.79 | 1 | 4.33 | -0.81 | 8.99 | -0.47 |
| Skewness | 1.99 | 0.28 | 1.26 | -0.09 | 0.47 | -0.07 | 0.73 | 0.2 | 1.50 | -0.85 | 2.89 | 0.37 | 9.15 | 0.1 | 4.86 | -0.39 | 1.97 | 0.12 | 2.26 | -0.13 |
| Minimum | 1.33 | 13.41 | 0.19 | 6.65 | 53.61 | 9.07 | 1.76 | 7.34 | 85.90 | 7.99 | 0.01 | 15.54 | 0.35 | 13.1 | 6.60 | 14.49 | 2.24 | 12.08 | 38.22 | 14.23 |
| Maximum | 2042.59 | 23.1 | 1902.71 | 12.8 | 602.05 | 16.32 | 49.41 | 12.73 | 786.71 | 15.8 | 2069.73 | 38.45 | 15616.06 | 20.4 | 1788.07 | 26.5 | 69.29 | 17.52 | 746.46 | 25.98 |

*Source: Authors’ own calculation, Note: A - Arrival, P- Price*

**Table 3. CAGR of market arrival and price of paddy in selected market (2009-10 to 2022-23)**

(at 5 per cent significance)

|  |  |  |
| --- | --- | --- |
|  | **PERIOD - I** | **PERIOD - II** |
| **Kota** | **Attabira** | **Sindhanur** | **Dahod** | **Bhatapara** | **Kota** | **Attabira** | **Sindhanur** | **Dahod** | **Bhatapara** |
| **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** |
| January | 0.9788 | 0.9514 | 0.7783 | 1.1159 | 1.2383 | 1.0499 | 1.2420 | 1.0461 | 0.8703 | 1.1193 | 0.9468 | 0.9862 | 1.1558 | 1.0798 | 0.7704 | 0.9979 | 0.9758 | 1.0181 | 1.0045 | 1.0082 |
| February | 1.0489 | 0.9636 | 1.0587 | 1.1197 | 1.1136 | 1.0535 | 0.9846 | 1.0387 | 0.8186 | 1.1097 | 0.9385 | 0.9893 | 3.4288 | 1.0864 | 0.8554 | 0.9954 | 0.9570 | 1.0137 | 0.9957 | 1.0021 |
| March | 1.2921 | 0.9878 | 1.0000 | 1.1159 | 1.2745 | 1.0407 | 1.1390 | 1.0505 | 0.7940 | 1.1073 | 0.9529 | 1.0011 | 3.6072 | 1.0959 | 0.8599 | 1.0019 | 1.0198 | 1.0145 | 0.9457 | 1.0017 |
| April | 0.8694 | 0.9659 | 1.0000 | 1.1159 | 1.7147 | 1.0770 | 1.0984 | 1.0700 | 1.0309 | 1.1104 | 1.0155 | 1.0150 | 2.4732 | 1.1026 | 0.8916 | 1.0071 | 0.9387 | 1.0140 | 0.9954 | 1.0068 |
| May | 1.5977 | 0.9275 | 1.0771 | 1.1159 | 1.5649 | 1.0201 | 1.1325 | 1.0416 | 0.9954 | 1.0920 | 1.0004 | 1.0145 | 0.4338 | 1.1027 | 0.8682 | 1.0138 | 0.8985 | 1.0083 | 0.9748 | 1.0025 |
| June | 0.8970 | 0.8740 | 0.9122 | 1.1159 | 1.1581 | 1.0104 | 1.0886 | 1.0297 | 0.8563 | 1.0472 | 0.9450 | 1.0199 | 0.4657 | 1.1040 | 0.8860 | 1.0054 | 0.9219 | 1.0066 | 1.0334 | 1.0116 |
| July | 0.8723 | 0.8933 | 0.9674 | 1.0710 | 1.1148 | 0.9847 | 0.9992 | 1.0398 | 0.7938 | 1.0296 | 1.0330 | 1.0142 | 2.0184 | 1.1026 | 0.8940 | 1.0001 | 0.9308 | 1.0137 | 1.0388 | 1.0086 |
| August | 0.1663 | 0.9608 | 1.0000 | 1.0710 | 1.5402 | 0.9684 | 1.2003 | 1.0502 | 0.7899 | 1.0269 | 1.1581 | 1.0163 | 0.9466 | 1.0947 | 0.8348 | 1.0083 | 0.9288 | 1.0136 | 1.0506 | 1.0147 |
| September | 0.2210 | 0.9702 | 1.0000 | 1.0710 | 1.6881 | 0.9906 | 0.9128 | 1.0597 | 0.8770 | 1.0286 | 1.3433 | 1.0298 | 0.8909 | 1.0884 | 0.8452 | 1.0069 | 0.9082 | 1.0159 | 0.9788 | 1.0075 |
| October | 0.5418 | 0.9170 | 1.0000 | 1.0710 | 1.5564 | 0.9948 | 0.9795 | 1.0149 | 1.0292 | 1.0378 | 0.9288 | 1.0184 | 0.8909 | 1.0847 | 0.8683 | 1.0070 | 0.8864 | 1.0167 | 0.9832 | 1.0025 |
| November | 0.7608 | 0.8927 | 1.8756 | 1.0878 | 1.7986 | 0.9852 | 1.0343 | 1.0139 | 0.7210 | 1.0463 | 0.8948 | 1.0060 | 0.8605 | 1.0767 | 0.8385 | 1.0071 | 0.9055 | 1.0186 | 1.0575 | 1.0023 |
| December | 1.0921 | 0.9186 | 0.9083 | 1.0878 | 1.6153 | 0.9768 | 0.9415 | 0.9564 | 0.7565 | 1.0439 | 0.9510 | 1.0105 | 0.8545 | 1.0823 | 0.7673 | 1.0087 | 0.8552 | 1.0201 | 1.0146 | 1.0043 |

*Source: Authors’ own calculation, Note: A - Arrival, P- Price*

**Table 4. Variation in market arrival and price of paddy in selected market (2009-10 to 2022-23)**

|  |  |  |
| --- | --- | --- |
|  | **PERIOD - I** | **PERIOD - II** |
| **Kota** | **Attabira** | **Sindhanur** | **Dahod** | **Bhatapara** | **Kota** | **Attabira** | **Sindhanur** | **Dahod** | **Bhatapara** |
| **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** | **A** | **P** |
| CV ( per cent) | 12.52 | 14.15 | 10.75 | 16.15 | 9.68 | 12.90 | 7.14 | 11.69 | 6.78 | 12.24 | 9.42 | 22.03 | 17.73 | 14.27 | 5.35 | 9.13 | 7.68 | 8.36 | 4.22 | 12.55 |
| CDVI | 12.10 | 14.07 | 10.73 | 15.14 | 7.28 | 12.67 | 6.56 | 10.39 | 5.95 | 12.20 | 9.38 | 21.89 | 17.50 | 2.85 | 4.50 | 9.00 | 6.63 | 7.22 | 4.21 | 12.42 |

*Source: Authors’ own calculation, Note: A - Arrival, P- Price*

|  |  |
| --- | --- |
| **Fig 3. Seasonal indices of market arrival of paddy in selected markets** | **Fig 4. Seasonal indices of market price of paddy in selected markets** |
|  |  |

*Source: Authors’ own calculation*

The analysis of average de-seasonalized values for each month indicated that prices were highest in the Kota market and lowest in Dahod, influenced by the volume of paddy arriving in the Kota market and its impact on local prices (Table 5). Moreover, the average de-seasonalized prices across months displayed consistency within the respective markets.

 Additionally, the Intra-year Price Rise (IPR) and Average Seasonal Price Variation (ASPV) were most pronounced in the Kota market and least in the Attabira market (Table 6). The IPR ranged from 8.86 per cent to 20.17 per cent, while the ASPV varied from 8.32 per cent to 18.32 per cent.

**Table 5. Average de-seasonalized monthly prices in paddy (2009-10 to 2022-23).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Kota | Attabira | Sindhanur | Dahod | Bhatapara |
| January | 23.36 | 14.55 | 19.22 | 13.10 | 17.64 |
| February | 23.64 | 14.65 | 19.23 | 13.11 | 17.63 |
| March | 23.72 | 14.81 | 19.17 | 13.08 | 17.58 |
| April | 23.66 | 14.94 | 19.38 | 13.07 | 17.57 |
| May | 23.59 | 14.94 | 19.52 | 13.09 | 17.57 |
| June | 23.60 | 14.96 | 19.46 | 13.04 | 17.53 |
| July | 23.56 | 14.79 | 19.32 | 13.03 | 17.47 |
| August | 23.25 | 14.64 | 19.33 | 13.03 | 17.46 |
| September | 23.35 | 14.55 | 19.32 | 13.07 | 17.51 |
| October | 23.50 | 14.49 | 19.23 | 13.06 | 17.49 |
| November | 23.32 | 14.45 | 19.14 | 12.99 | 17.48 |
| December | 23.30 | 14.56 | 19.03 | 13.00 | 17.44 |

*Source: Authors’ own calculation*

**Table 6. Growth and variation in seasonal price index**

|  |  |  |
| --- | --- | --- |
| MARKET | IPR (per cent) | ASPV (per cent) |
| Kota | 20.17 | 18.32 |
| Attabira | 8.68 | 8.32 |
| Sindhanur | 13.00 | 12.20 |
| Dahod | 9.94 | 9.47 |
| Bhatapara | 13.92 | 13.01 |

*Source: Authors’ own calculation*

N.B. \* for 10 per cent, \*\* for 5 per cent and \*\*\* for 1 per cent level of significance

**Stationarity Check:**

Prior to undertaking the co-integration analyses, a thorough evaluation of the univariate time-series properties of the dataset was conducted. This preliminary analysis was essential to ascertain whether all the price series exhibit non-stationarity and are integrated of the same order. To this end, the Augmented Dickey-Fuller (ADF) test, as formulated by Dickey and Fuller (1979), was applied to the price series of major paddy markets.

The results of the ADF test for the price series at levels and their first differences are systematically presented in Table 7. In preparation for this analysis, all price series were converted into natural logarithms to ensure uniformity and comparability. The selection of the appropriate lag length for the ADF test was guided by the Akaike Information Criterion (AIC), ensuring methodological rigour. The findings indicate that while the price series are non-stationary at their levels, they achieve stationarity when subjected to first-differencing. This observation suggests that each series of paddy prices encompasses a single unit root and conforms to an integration of order one. This characteristic is a critical aspect in the context of time-series analysis, laying the groundwork for subsequent co-integration tests, ensuring the robustness and validity of the inferences drawn from the study.

**Table 7: ADF Test for Unit Root in the Prices of Paddy**

|  |  |  |
| --- | --- | --- |
| **Market Center** | **Level** | **First-difference** |
| Kota | -2.3343 | -6.0228\*\* |
| Attabira | -1.0176 | -7.0736\*\* |
| Sindhanur | -2.2831 | -5.2704\*\* |
| Dahod | -2.6864 | -7.0356\*\* |
| Bhatapara | -2.1274 | -6.1947\*\* |

*Source: Authors’ own calculation*

N.B. \* for 10 per cent, \*\* for 5 per cent and \*\*\* for 1 per cent level of significance

**Johansen co-integration:**

This research meticulously explores the inter-state spatial integration of paddy markets through a comprehensive analysis of the enduring linear relationships among paddy prices in five distinct markets: Kota (Rajasthan), Attabira (Odisha), Sindhanur (Karnataka), Dahod (Gujarat), and Bhatapara (Chhattisgarh). The core objective of this study was to quantify and explain the long-term integration dynamics among the selected markets. The results pertaining to a specific combination of the aforementioned paddy markets have been systematically compiled and are presented in Table 8.

The empirical findings derived from this analysis indicates that the prices in the selected paddy markets are integrated in the long-term perspective. This revelation not only underscores the interconnected nature of these markets but also provides insightful implications for the broader understanding of paddy market dynamics within an inter-state framework in India.

**Table 8: Co-integration Results for Inter-State Spatial Integration of Paddy Markets**

|  |  |  |
| --- | --- | --- |
| **Eigen****Value (*λi*)** | **Trace test** | **Maximum eigen value test** |
| **Null** | **Test value** | ***λ*-trace** | **Null** | **Test value** | ***λ*-max** |
| 0.50 | r=0 | 420.89 | 76.07\*\* | r=0 | 123.25 | 34.40\*\* |
| 0.41 | r <=1 | 297.64 | 53.12\*\* | r <=1 | 94.69 | 28.14\*\* |
| 0.37 | r <=2 | 202.95 | 34.91\*\* | r <=2 | 82.10 | 22.00\*\* |
| 0.30 | r <=3 | 120.85 | 19.96\*\* | r <=3 | 62.67 | 15.67\*\* |
| 0.28 | r <=4 | 58.18 | 9.24\*\* | r <=4 | 58.18 | 9.24\*\* |

N.B. \* for 10 per cent, \*\* for 5 per cent and \*\*\* for 1 per cent level of significance. k= Optimal lag selected by the AIC. k=2 for the pre- and post-reform periods. The estimated VAR includes a constant and a trend. The market centres considered are: Kota (Rajasthan), Attabira, (Odisha), Sindhanur (Karnataka), Dahod (Gujurat) and Bhatapara (Chattisgarh).

**Price Transmission**

The results obtained from the pairwise Granger causality test and the Vector Error Correction Model (VECM) offer a detailed and nuanced understanding of the dynamics within India's major paddy markets.

**Granger Causality Test**

 The test results reveal specific directional influences among the paddy markets. For instance, the markets of Kota and Sindhanur are influenced by Dahod and Bhatapara, respectively. This unidirectional causality suggests that price changes in the Dahod and Bhatapara markets could predict subsequent price changes in Kota and Sindhanur. Notably, several markets, such as Kota, Attabira, and Sindhanur, do not significantly influence other markets. This lack of causality could indicate that these markets are more self-contained or influenced by factors not shared with other markets in the study (Table 9).

**Table 9: Granger Causality Test Results for major Paddy Markets of India**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Market | Kota(Independent) | Attabira(Independent) | Sindhanur(Independent) | Dahod(Independent) | Bhatapara(Independent) |
| Fstatistics | P Value | Fstatistics | P Value | Fstatistics | P Value | Fstatistics | P Value | Fstatistics | P Value |
| Kota | - | - | 1.6665 | 0.191 | 0.2856 | 0.751 | 2.4158\* | 0.092 | 0.8391 | 0.434 |
| Attabira | 0.7057 | 0.495 | - | - | 0.3755 | 0.687 | 0.7453 | 0.476 | 0.1995 | 0.819 |
| Sindhanur | 0.8031 | 0.449 | 0.1054 | 0.9 | - | - | 4.2015\*\* | 0.016 | 2.3947\* | 0.094 |
| Dahod | 0.9714 | 0.380 | 0.8046 | 0.449 | 1.2021 | 0.303 | - | - | 0.9216 | 0.399 |
| Bhatapara | 0.999 | 0.370 | 0.3235 | 0.724 | 0.3896 | 0.677 | 0.3896 | 0.677 | - | - |

*Source: Authors’ Own Calculations*

N.B. \* for 10 per cent, \*\* for 5 per cent and \*\*\* for 1 per cent level of significance

**Vector Error Correction Model (VECM)**

From the table 10, The disequilibrium in the Kota, Sindhanur, and Dahod markets adjusts to equilibrium at rates of 32.5 per cent, 35.4 per cent, and 19.56 per cent, respectively. The VECM results also highlight short-term associations among certain markets.

Current prices of Kota were affected negatively by its own and positively by Sindhanur and Dahod market one month lag price with speed of convergence at 42.60 per cent, 17.36 per cent and 22.82 per cent respectively. Also affected by negatively by its own and positively by Sindhanur market two months lag price with speed of convergence at 19.65 per cent and 17.09 per cent respectively. The equation for Kota is mentioned below:

**Kota = -0.3256\*ECT - 0.4260\*Kota(t-1) + 0.2282\*Sindhanur(t-1) + 0.1736\*Dahod(t-1) - 0.1965\*Kota(t-2) + 0.1709\* Sindhanur(t-2)**

Current prices of Attabira were affected negatively by its own, Sindhanur and Dahod market one month lag price with speed of convergence at 63.67 per cent, 22.40 per cent and 24.52 per cent respectively. Also affected by negatively by its own Sindhanur and Dahod market two months lag price with speed of convergence at 32.97 per cent, 20.06 per cent and 14.42 per cent respectively. The equation for Attabira is mentioned below:

**Attabira = - 0.6376\*Attabira(t-1) - 0.2240\*Sindhanur(t-1) - 0.2451\*Dahod(t-1) -0.32978\*Attabira(t-2) - 0.2006\*Sindhanur(t-2) - 0.1442\*Dahod(t-2)**

 Current prices of Sindhanur were affected positively by Kota and Dahod market one month lag price with speed of convergence at 56.24 per cent and 33.05 per cent respectively. Also affected by positively by Kota and Dahod market two months lag price with speed of convergence at 40.30 per cent, and 14.56 per cent respectively. The equation for Sindhanur is mentioned below:

**Sindhanur = -0.3541\*ECT + 0.5624\*Kota(t-1) + 0.3305\*Dahod(t-1) + 0.4030\*Kota(t-2) + 0.1456\*Dahod(t-2)**

 Current prices of Dahod were affected negatively by its own and positively by Kota and Sindhanur market one month lag price with speed of convergence at 52.83 per cent, 44.56 per cent and 24.08 per cent respectively. Also affected by negatively by its own and positively by Sindhanur respectively. The equation for Dahod is mentioned below:

**Dahod = - 0.1956\*ECT – 0.5283\*Dahod(t-1) + 0.4456\*Kota(t-1) + 0.2408\* Sindhanur(t-1) – 0.2777\*Dahod(t-2) + 0.2465\*** **Sindhanur(t-2)**

Current prices of Bhatapara were affected negatively by its own, Kota, Sindhanur and Dahod market one month lag price with speed of convergence at 68.12 per cent, 50.84 per cent, 62.57 per cent and 28.90 per cent respectively. Also affected by negatively by its own, Sindhanur and Dahod market two months lag price with speed of convergence at 39.78 per cent, 26.26 per cent and 24.06 per cent respectively. The equation for Bhatapara is mentioned below:

**Bhatapara = -0.6812\*Bhatapara(t-1) – 0.5084**\***Kota(t-1) – 0.6257\*** **Sindhanur(t-1) – 0.3978\*Bhatapara(t-2) – 0.2626\*Sindhanur(t-2) – 0.2406\*Dahod(t-2)**

**Table 10: VECM coefficient value of Paddy Market Integration**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | D(Kota) | D(Attabira) | D(Sindhanur) | D(Dahod) | D(Bhatapara) |
| ECT | -0.3256\*\*\*(0.0775) | -0.0402(0.0472) | -0.3541\*\*\*(0.0534) | -0.1956\*\*\*(0.0391) | 0.0269(0.0416) |
| D(Kota)-1 | -0.4260\*\*\*(0.0891) | -0.1790(0.1320) | 0.5624\*\*\*(0.1676) | 0.4456\*\*(0.1489) | -0.5084\*\*(0.1943) |
| D(Attabira)-1 | 0.0172(0.0543) | -0.6376\*\*\*(0.0804) | 0.1173(0.1020) | -0.0022(0.0906) | -0.0771(0.1183) |
| D(Sindhanur)-1 | 0.2282\*\*\*(0.0614) | -0.2240\*(0.0909) | 0.0826(0.1154) | 0.2408\*(0.1025) | -0.6257\*\*\*(0.1338) |
| D(Dahod)-1 | 0.1736\*\*\*(0.0450) | -0.2451\*\*\*(0.0666) | 0.3305\*\*\*(0.0845) | -0.5283\*\*\*(0.0751) | -0.2890\*\*(0.0980) |
| D(Bhatapara)-1 | 0.0197(0.0478) | -0.0992(0.0709) | -0.0066(0.0899) | 0.0926(0.0799) | -0.6812\*\*\*(0.1043) |
| D(Kota)-2 | -0.1965\*(0.0764) | 0.0434(0.1305) | 0.4030\*\*(0.1257) | 0.1386(0.1489) | -0.2833(0.1577). |
| D(Attabira)-2 | -0.0398(0.0465) | -0.3297\*\*\*(0.0794) | 0.0239(0.0765) | 0.1379(0.0906) | 0.0207(0.0960) |
| D(Sindhanur)-2 | 0.1709\*\*(0.0526) | -0.2006\*(0.0898) | -0.1180(0.0866) | 0.2465\*(0.1025) | -0.2626\*(0.1086) |
| D(Dahod)-2 | 0.0605(0.0385) | -0.1442\*(0.0658) | 0.1456(0.0634)\* | -0.2777\*\*\*(0.0751) |  -0.2406\*\*(0.0795) |
| D(Bhatapara)-2 | 0.0128(0.0410) | -0.0863(0.0700) | 0.0267(0.0675) | 0.0655(0.0799) | -0.3978\*\*\*(0.0846) |

*Source: Authors’ Own Calculation*

Notes: ECT=*Error Correction Term*; D= first difference operator; [ ] t-statistic

\*\* Significant at level 5 per cent; \* significant at level 10 per cent

**Conclusions:**

This study thoroughly assesses market integration in India's paddy sector by analyzing five major wholesale markets—Kota, Attabira, Sindhanur, Dahod, and Bhatapara—over a 15-year period (2009–2023). The findings reveal that while long-term price integration exists, inefficiencies in short-run adjustments persist due to structural breaks, policy distortions, and supply chain frictions. Some markets, such as Kota and Sindhanur, exhibit stronger long-term price relationships, whereas others, particularly Attabira and Bhatapara, show weaker linkages, suggesting localized barriers to price transmission. The presence of unidirectional causality in price movements highlights that certain markets influence national price formation more significantly than others, underscoring the need for targeted policy interventions to improve market efficiency.

Strengthening market information systems is critical to addressing price asymmetry. Real-time price dissemination through digital platforms, mobile applications, and SMS alerts can empower farmers with better market intelligence. Expanding Agmarknet to provide predictive analytics on expected arrivals and demand trends can help reduce price distortions. Investment in rural transport networks, storage facilities, and warehouse receipt systems is equally important to minimize supply chain disruptions. Enhancing the interoperability of e-NAM across states can further improve price discovery and facilitate seamless trade between regions. Addressing inefficiencies in procurement policies is another priority. Decentralized MSP procurement, adjusted to regional surplus and deficit conditions, can improve price stabilization. A state-level buffer stock approach, where stocks are procured at competitive prices and released strategically, could offer more flexibility than a centralized procurement system. Encouraging direct market linkages through farmer producer organizations (FPOs), contract farming, and cooperatives can reduce intermediary influence, increase farm-gate prices, and ensure a fairer distribution of market benefits.

Market-based risk management tools such as price insurance schemes and futures trading can provide financial protection against sudden price shocks. Expanding these mechanisms, along with climate adaptation strategies such as crop diversification and improved irrigation practices, can enhance market stability and reduce long-term volatility. Beyond immediate interventions, broader reforms in India’s agricultural marketing policies are necessary. Market integration is not solely a function of supply and demand but is shaped by regulatory structures, infrastructure quality, and behavioral dynamics. Strengthening digital connectivity, reducing trade restrictions, and improving logistics can create a more resilient market system. A regionally tailored approach, where states with weak price transmission receive targeted interventions such as better storage and transport infrastructure, can further enhance integration.

While this study provides valuable insights, certain limitations should be acknowledged. The reliance on secondary data, though comprehensive, introduces potential inconsistencies in reporting. Future research could incorporate primary survey data to validate findings. Additionally, the econometric models used assume linear price relationships, whereas real-world markets often exhibit non-linear adjustments. Exploring threshold co-integration models and regime-switching approaches could yield deeper insights. Expanding the study to include more regional trading centers would further enhance understanding of national price linkages and allow for more granular policy recommendations. Addressing these gaps can refine future research and improve market integration strategies.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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