# Rise in Alternate Marketing Channels and Spatial Price Transmission: The Case of Indian Agricultural Wholesale Markets

Nikita Gupta[1], Poornima Varma[1], Gopinath Munisamy[2]

August 2023

ABSTRACT

Agricultural supply chains have undergone major transformations in recent years with a rise in alternate marketing channels such as direct selling from farmers to consumers or supply chains with fewer intermediaries. In India, where agricultural products have been sold via government-regulated markets, there is evidence of a rise in alternate marketing channels, especially after the introduction of agricultural marketing reforms in 2003 which allowed direct procurement from farmers. There is no evidence to show whether addition of alternate marketing channels will facilitate faster transmission of price across existing regulated markets or hinder the speed of transmission. Thus, this study investigates the effect of the rise in alternate marketing channels on the speed, magnitude, and significance of price transmission in traditional wholesale markets. Using a bootstrap panel regression, a differential effect on price transmission between market pairs, i.e., an increase in speed but a decline in magnitude, is observed after reforms. Also, a logit model identified an increase in the probability of market integration after reforms. These robust results bode well for farmers' welfare since the results show that effect of price shock in any market can be transmitted to more markets (additional channels) and absorbed faster in the post-reforms context.

**Keywords***:* Alternate Marketing Channels; Price Transmission; Agricultural Market Reforms; Market Structure; Market Performance

***JEL Classification*****:** Q02, Q13, Q18

[1] Indian Institute of Management Ahmedabad, India.
[2] University of Georgia, USA.

## 1.Introduction

Recent years have seen major transformations of global and regional agricultural supply chains with the emergence of new modes of governance and alternate marketing channels ( Reardon et al., 2012; Reardon & Timmer, 2014). The alternate marketing channels include short agricultural supply chains such as direct marketing from farmers to the consumers (Plakias et al., 2020) or intermediated marketing from farmers to private or platform buyers (Dimitri & Gardner, 2019).[3] Evidence from developing countries like India shows a rising trend of direct procurement and platform buyers, e.g., Big Basket (Cohen, 2013; Pritchard et al., 2010). Past work has argued that the shift to short supply chains has improved welfare of farmers – who traditionally faced a large number of intermediaries – due to better price realization (Miyata et al., 2009), and reduction in transaction costs (Nuthalapati et al., 2020). Conventionally, these resource-poor farmers are more vulnerable to price shocks and high transaction costs because of either small size of landholdings or lack of market access (Markelova et al., 2009).The effect of price shocks on any one market and its participants depends on the interconnectedness of markets and the extent of price transmission across markets. That is, market structure is critical to spatial price transmission. The emergence of alternate marketing channels has not only reduced the length of the supply chain, but also affected the fundamental structure of the market and importantly increased the market competition among traders (Ale-Chilet & Itin-Shwartz, 2021).

The Structure-Conduct-Performance (SCP) literature has argued that any change in market structure will impact market performance. In the context of agri-supply chains, market performance can be inferred from price transmission between agricultural wholesale markets

[3] For example, globally, we can see the rise of platform buyers such as COGZ, ProduceMart, and Complete-Farmer transforming the agricultural marketing landscape.

(Acosta et al., 2019). Thus, the recent emergence of alternate marketing channels, i.e. structural change, can affect market performance via effect on the spatial transmission of prices across wholesale markets. Two major components of spatial price transmission are speed and magnitude. The speed of price transmission shows how fast one market responds to shocks in other markets (Stephens et al., 2012). The magnitude of price transmission shows the impact of price shock in one market on price in other markets. With the rise in alternate marketing channels, there can be a reduction in price transmission (magnitude) because, in the new setting, some of the shocks might be absorbed by the alternate channels (A). However, it is also likely that price transmission (magnitude) can increase as market density increases because of addition of alternate channels, thus indirectly alleviating the impact of shocks. While the impact on magnitude can go in either direction, the speed of price transmission may increase due to a rise in the number of total markets, facilitating faster adjustments to shocks. Another pertinent question is whether there has been an increase in the number of integrated markets (with significant price transmission) because of the addition of alternate channels. For instance, two existing traditional markets might be too far apart to show market integration or significant price co-movements. However, indirect price transmission via alternate channels may induce integration. Thus, the spatial price transmission in existing markets in the presence of alternate channels is an empirical issue.

The emerging literature has addressed how differences in marketplace conditions, location and policy factors affect price transmission (Brosig et al., 2011; Kouyaté & Cramon-Taubadel, 2016; Awokuse, 2007). Most studies address either the impact of alternate marketing channels or factors affecting price transmission, with limited attention to the impact of the former on latter. Thus, this study attempts to shed light on spatial price transmission in traditional Indian markets when there is a change in market structure due to addition of alternate marketing channels. This information is critical to policy-making since India's agricultural marketing reforms since early 2000s has been a key contributor to the rise in alternate marketing channels. The primary objective of this study is to examine the effect of the rise of alternate marketing channels on the magnitude and speed of intermarket price transmission in traditional (previously-existing) markets. In addition, the impact of market reforms on the probability of integration, i.e. presence of significant price transmission post-reforms, is assessed.

This study is conducted in the backdrop of agricultural market reforms undertaken in India since early 2000s via amendment of the Agricultural Produce Market Committee (APMC) Act of 1967. Agricultural markets or APMCs in India, regulated by APMC Act did not allow farmers to trade directly with private traders (unregistered at APMC), processors, or manufacturers and restricted them from entering into contract farming or direct marketing. However, the State Agricultural Produce Marketing (Development and Regulation) Act, 2003 (referred to as Model Act) proposed major amendments such as the removal of restrictions on farmers or traders by allowing them to indulge in direct marketing or contract farming. It was an initial attempt by the government to deregulate the agricultural marketing system which led to a rise in alternate marketing channels like direct and private markets. Thus, in the context of the APMC reforms and the rise in alternate marketing channels, this study analyses the impact of alternate marketing channels on the traditional wholesale markets integration in two of the pioneering states: Karnataka and Maharashtra.

Using daily price data during 2003 and 2010 on major paddy-trading markets in Karnataka and Maharashtra with evidence on timing of reforms -structurally and anecdotally – this study has three major finding. First, in the post-reform period, the increase in market competition – due to the rise of alternate marketing channels – has increased the speed with which the effect of a shock gets transmitted from one to another market. Second, there is a decline in the magnitude of price transmission or impact of one market on another. Finally, more market pairs show significant price transmission after reforms, i.e., there is an increase in the probability of market integration. How price signals are transmitted among markets has implications for market efficiency and resource allocation (Frederick et al., 2018). A high speed of price transmission that we noticed post the reforms indicates greater market efficiency as it helps to ensure balance among food deficit and food surplus regions (Baulch, 1997). Also, since there are a greater number of markets to absorb the shock, no one market will be severely impacted by the shock. Thus, this study has important policy implications especially for regions vulnerable to food price shocks.

The rest of the article is organized as follows. Section 2 sets the context of the study through the discussion of APMC reforms while section 3 focuses on the past literature. The conceptual pathways and framework of the study are discussed in section 4. Section 5 describes the data and empirical model used in the analysis. Section 6 and 7 discusses the results and conclusions, respectively.

## 2. The Setting

APMCs, the traditional institutional mechanism to regulate agricultural markets, is entrusted with the responsibility to set up market infrastructure, decide the entry of traders, license and other fees.[4] Although the objective of APMC was to regulate market prices and to safeguard the interest of farmers from distress selling of crops, there were numerous problems and inefficiencies in the system (Banerji & Meenakshi, 2004; Krishnamurthy, 2021; Rawal et al., 2020). The APMCs in several states became corrupt with traders' collusion and high barriers to entry which depressed the prices received by farmers (Banerjee & Meenakshi, 2004). In order to reduce the inefficiency and to address associated issues, the Government of India enacted a "Model APMC Act" in 2003, and advised state governments to adopt them.

[4] As per the Act, the sale in the commodities (cereals, pulses, edible oilseed, fruits, and vegetables and also chicken, goat, sheep, sugar, fish) produced in each region must take place under the ambit of APMC.

The 2003 Act created the provisions for alternate marketing channels such as direct marketing, contract farming, and trade in farmer-markets and private consumer markets by the farmers and buyers (Singh, 2018). The direct marketing implied that private players can set up their markets outside the government-regulated APMCs, and farmers and private buyers were given greater flexibility to transact outside of APMCs, which were not permitted until the enactment of the Model Act.  After reforms, many companies and supermarkets also started setting up collection centres.

The nature and the extension of the implementation of these reforms were left to the state governments. Maharashtra and Karnataka, were rfsectionanked first and second in the APMC rankings based on market reforms in the year 2008 (Reddy, 2016). Karnataka initiated the first phase of reforms in the year 2006 with two phases: the adoption of reforms as per the Model act during 2007-2011, and from 2014, the establishment of Rashtriya e-Marketing Services (ReMS) (Aggarwal et al., 2017). Karnataka Agricultural Produce Marketing (Regulation) Act, 1966, was amended to allow private markets and farmer-consumer markets to be established for greater remuneration to the farmers by increasing competition.[5] Pritchard et al. (2010) in their fieldwork in Karnataka during 2008 and 2009 find various evidence to showcase direct procurement from farmers by large supermarkets and companies like Reliance Fresh. Study by Singh and Singla (2011)  shows that other than Reliance Fresh , there were collection centres opened by More, ABRL(Aditya Birla Retail Limited), HOPCOMS (Horticultural Produce Cooperative Marketing Society) and Heritage Foods India Ltd. As of 2007, there were 17 HOPCOMS in Karnataka which expanded the marketing channel choice for smallholder farmers (Kolady et al., 2007).

[5] https://dpal.karnataka.gov.in/storage/pdf-files/27%20of%201966%20(E).pdf

Maharashtra initiated the first phase of reforms in APMC markets in 2006 by passing the model legislation; Maharashtra Agriculture Produce Marketing (Development and Regulation) Act. It incorporated amendments from the Model Act 2003 regarding direct marketing licenses, single marketing licenses for the whole state, private markets, farmer consumer markets, and contract farming. A survey shows that three years after the beginning of reforms in Maharashtra, 79 direct marketing licenses were granted to retailers and processors along with hundreds of licenses to private retailers for setting mandi stalls (Reardon & Minten, 2011).

## 3. Literature Review

Previous literature has compared traditional and alternate marketing channels in terms of differences in their governance structures and impacts on price, profits and risk spread across stakeholders (Dimitri & Gardner, 2019; Mgale & Yunxian, 2020).[6] Studies have also explored different factors affecting the marketing channel choice of farmers in both high- (Plakias et al., 2020) and low-income countries (Donkor et al., 2021) as well as the impact of alternate marketing channels on farmers' welfare (Goyal, 2010). The general conclusion has been that alternate marketing channels benefit farmers by way of increased competition for their products. In the Indian context, studies have shown that the availability of alternate market channels increased prices received and helps prevent distress selling by farmers (Bhanot et al., 2021; Ale-Chilet & Itin-Shwartz, 2021).

Previous studies of spatial price transmission tend to focus on locational and market characteristics. For instance, the speed of price transmission decreases with distance, but improves with investments in infrastructure such as road, railway, and telephone density, the density of bank branches, and storage facilities (Badiane & Shively, 1998; Minten & Kyle,

[6] http://www.aau.ac.in/data/reports/Impact_of-EmergingMarketingChannels.pdf

1999; Kouyaté & Cramon-Taubadel 2016). Likewise, market size, trade volumes and market information services have been found to be directly proportional to the speed of price transmission (Cudjoe et al., 2010; Brosig et al., 2011). However, policy factors such as external liberalization and/or internal reforms have received limited attention (; Rashid, 2004; Thompson et al., 2002; Zant, 2013). This study fits in the latter context, examining the impact of the rise in marketing channels, due to internal reforms, on spatial price relationships.

**4. Conceptual Basis**

The economic results of market structure and conduct can be measured by market performance, i.e., efficient and well-functioning markets (Bain, 1959). Any changes in the market structural characteristics, like the number of market participants or degree of concentration, affect market participants' competitive behaviour or conduct (Scarborough & Kydd, 1992; Scott, 1995). The entry of direct and private markets affects market structure – changes in the degree of buyer or trader concentration and increased market competition – and thus, impact market performance and efficiency.

Market efficiency is most often inferred from spatial price transmission among markets linked together directly via trade or indirectly via other markets (Baffes, 1991). Spatial price transmission has been typically measured by the law of one price (LOP). It states that the differences in prices in the spatially segregated market should not exceed the transaction costs of trading goods between the two markets. If it does, arbitrage will occur until LOP is met again. Extent of spatial price efficiency has been measured by not only the number of violations of LOP but also the speed of corrections of these violations (Hu & Brorsen, 2017). Figure 1 shows the conceptual basis with a bifurcation of farmers' selling choices, i.e., selling in traditional marketing channels or selling in alternate marketing channels. [7] More specifically,

[7] https://pdf.usaid.gov/pdf_docs/PNADL965.pdf

it looks at the spatial price transmission between the agricultural wholesale Market i and Market j due to alternate marketing channels in which farmers can now sell.

The conceptual basis is best explained with the example in figure 2(a) with two cases. Let us assume that both cases have two mandis (Mandi1 and Mandi2). Case I is when farmers cannot trade in alternate channels. If there is a price shock in Mandi 1, then supply at that mandi will decrease, and say x farmers will shift to Mandi 2 as it offers a higher price than Mandi1. To the extent that supply in Mandi 2 increases, there will be a decrease in price in Mandi 2. Thus, price transmission has taken place from Mandi1 to Mandi 2, i.e., direct effect. In the second case, now consider an alternate marketing channel A in addition to two mandis to which farmers can sell. In this case, a price shock at Mandi 1 will decrease farmers' supply. Say, z farmers will now shift to sell in A, thus causing the price to fall at A. Also, because of the price fall at A, some farmers initially selling at A might shift back to sell at Mandi 2 (say n farmers shift back). Also, because of the price decline in Mandi 1, say y farmers now shift to selling agricultural produce in Mandi 2.

Comparing the two cases, if x is greater than (y+n) means that in Case II, there is less increase in the supply of farmers at Mandi 2 as compared to Case I. Then, in Case II, there will be less impact of price decrease in Mandi 1 on Mandi 2 than in Case I. It means that in Case II, with alternate marketing channels, there is less price transmission compared to Case I. Similarly, if x is less than (y+n), there is a greater supply of farmers at Mandi 2 compared to Case I. Then, in Case II, there will be a greater impact of price decrease in Mandi 1 on Mandi 2 as compared to Case II. It means that in Case II, with the addition of alternate marketing Channel, there is greater price transmission compared to Case I. Thus, with greater choice for farmers to sell in alternate marketing channels, there might be a reduction in magnitude of price transmission because, in the new setting, some of the shock effects might be absorbed by the alternate channels or an increase in price transmission with alternate channels alleviating the shock effect indirectly. Thus it calls for examining the same via empirical analysis.

Another pertinent question is whether there can be an increase in the number of cointegrated agricultural markets. For instance, two agricultural markets (APMC mandis) might be too far apart to show cointegration or for their price series to show any co-movement. However, the mandis that were not directly related may now show a price co-movement between them because of indirect price transmission via alternate channels (figure 2(b)). Thus, if out of eight APMC mandis, earlier only three mandis were cointegrated, now with alternating marketing channels in between, the number of cointegrated mandis might increase to five or six.

## 5. Data and Methodology

This section first outlines data and methods used in the context of Karnataka, a pioneer in implementing the 2003 Model Act. To corroborate these results, the case of Maharashtra is examined then with similar data and methods.

### 5.1 Data and Selection of Markets

The crop that was traded in most Karnataka APMCs during the study period was paddy. Seven APMCs accounted for the majority of paddy volume arrived to APMCs during 2003-07: Devangree, Gangavathi, Manvi, Raichur, Shimoga, Sindhaanur, and T. Narsipura. The spatial market analysis can be done using three types of data, i.e., prices, trade flows, or volume and transaction costs (Barrett, 1996), but this study employs data consistent with most other studies (Goodwin & Piggott, 2001; Svanidze & Götz, 2019). The wholesale prices (APMC modal price) data were obtained for each market from the website of AGMARKNET (Agricultural Marketing Information Network).[8] Since daily data was unavailable for several dates, simple average monthly price series are generated. The analysis is done for 2003 to 2010, i.e., 48

[8] https://agmarknet.gov.in

months before and after 2007. For some markets, data was missing for some of the months, which might indicate no paddy trade during those months. The missing values (< 5% of sample) were interpolated using the cubic splines method.

The data for intermarket distance has been calculated using Google maps. If there are two or more roads connecting the markets, then the length of the road with the shortest distance between the two markets is chosen. The data for volume traded in each APMC market is obtained from AGMARKNET. The data for all other control variables used in the bootstrap and logistic regression like total road length in the area surrounding markets (a proxy for road infrastructure), agricultural credit in the district of a market, data for district-level rice production, distance to nearest railway station have been obtained from ICRISAT (International Crops Research Institute for the Semi-Arid) district wise data.[9] Table 1 provides variables and their description.

## 5.2 Empirical Model

Previous literature makes use of a two-staged approach, where the first stage captures the dynamics of price transmission in terms of its magnitude and speed in the long- and short-run or absolute difference in prices across two markets for measuring the degree of price dispersion (Brosig et al., 2011). In the second stage, these coefficients are linked to structural factors like market infrastructure, government policy, market reforms, or other determinants of market integration (Goodwin & Schroeder, 1991; Svanidze & Götz, 2019). This study also uses a similar approach of conducting a two-stage analysis.

### 5.2.1 First Stage

Figure 3 presents the various components of the first stage. The first step is to find any structural break between 2003 to 2010 for APMC's wholesale average prices. A breakpoint unit

[9] http://data.icrisat.org/dld/

root test indicated that several months of 2007 are likely candidates (Perron, 1997) . The month of January 2007 is then selected, and tested for a structural break using the Wald test (Andrews & Ploberger, 1994). The null hypothesis of no break at specified breakpoints (2007M01) is rejected. Thus, the break date chosen is January 2007 based on both Wald and unit-root breakpoint test yielding two sets of price series from 2003-2006 and 2007-2010.

The next step is to conduct the augmented Dickey-Fuller tests for identifying stationarity i.e., integration order of each of the series. The latter is often done in levels and first differences to detect the integration order (Wooldridge, 2015). The Engle-Granger cointegration test is conducted if time series for all markets are integrated in the same order (Engle & Granger, 1987). Then a Vector Error Correction Model (VECM) is to be employed for assessing the magnitude and speed of price transmission (Engle & Granger, 1987; Johansen, 1991). If series are not cointegrated, then the vector autoregressive model (VAR) is used for coefficient estimation. Formally, the VECM is specified:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{n} \beta_i \Delta y_{t-i} + \sum_{i=1}^{n} \delta_i \Delta x_{t-i} + \varphi z_{t-1} + \mu_t, \qquad (1)$$

where $y$ is price in market 1and $x$ is price in market 2 and, $z_{t-1}$ is the error correction term (ECT). More specifically, the OLS residuals from the following long-run cointegration regression:

$$y_t = \beta_0 + \beta_1 x_t + \epsilon_t \qquad (2)$$

is employed to define : $z_{t-1} = y_{t-1} - \beta_0 - \beta_1 x_{t-1}$.

The term error-correction relates to the fact that the last period deviation from long-run equilibrium (error) influences the short-run dynamics of the dependent variable. Thus, the coefficient of $z_{t-1}$ or $\varphi$ measures the speed at which $y$ returns to equilibrium after a change in $x$. Also, $\delta$ or the coefficient of $\Delta x_{t-i}$ shows short term impact of one market on another (in equation 1), while $\beta_1$or coefficient of $x_t$ in equation (2) shows the long-run impact of one market on another (in equation 2). In addition to the above steps, additional robustness tests are conducted to obtain insights into causality and asymmetry in price transmission (section 6.2).

### 5.2.2 Second Stage

In the second stage, cointegrating coefficients and error correction terms (ECT) obtained from the first stage are regressed on the dummy for 'before' and 'after' reforms (time dummy) while controlling for factors commonly employed in the literature: road infrastructure = log of total road length in area surrounding markets (proxy for road infrastructure); market distance = log (distance between two markets), production difference = log (absolute difference in total rice production in districts having those markets), railway distance = log of sum of distance to nearest railway station, and volume ratio = ratio of log of average volume for market 1 to market 2 before and after reforms.

Three equations in the second stage are:

$Y^c_{it}$= Cointegrating Coefficients from market pairs (21 for Karnataka)

$$Y_{it}^{c} = \alpha + \beta_1 Post + \sum_{i=2}^{6} \beta_i X_i + \mu_{it} \qquad (3)$$

$Y^e_{it}$= Error Correction Term

$$Y_{it}^{e} = \alpha + \beta_1 Post + \sum_{i=2}^{6} \beta_i X_i + \mu_{it} \qquad (4)$$

and the logistic regression

$$L_i = \ln\left(\frac{p_i}{1-p_i}\right) = \beta 1 Post + \sum_{i=2}^{6} \beta i X i \qquad (5)$$

- $p_i$: Dummy=1(if the cointegrating coefficient is significant) otherwise, 0

Since these models' dependent variable is an estimated parameter rather than an observed variable, test statistics do not have standard distribution and may have heteroscedasticity. Thus, to obtain efficient parameter estimates, bootstrapped standard errors are used. Also, with cross-sectional variation for market pairs and variation by time, i.e., before and after the reforms, potential options include panel or pooled regression. The Lagrange multiplier test is employed to compare panel and pooled regression, while the Hausman test checks for the specification bias (fixed or random effects). Other diagnostics, as noted in figure 3, include tests for serial correlation, normality, heteroskedasticity, and multicollinearity using variance inflating factor.

## 6. Results

In this and following sections, to focus on second stage results, most of the cointegration tests and results from first stage are presented in the supplementary appendix. First, the plot of the price series for selected Karnataka markets are shown in figure 4(a) with the structural break date. Note the increase in monthly average price in all markets after the break date. Also, monthly prices in some markets like Devangree and Sindhanur tend to be higher than those in other markets like Manvi and Shimoga. There has been increase also in the standard deviation of prices in the 'after' sample (Table 2 (a)).

Using the unit root test and autocorrelation function (ACF), Table A1(a) in the appendix shows that price series before and after reforms for all markets of Karnataka are not stationary at levels. However, after first differencing, the null hypothesis of unit root is rejected, i.e., they all become stationary. Thus, all price series are integrated of order 1 to proceed with the cointegration test. Table A1(b) shows results from the cointegration tests for which lags were chosen using Akaike Information Criteria (AIC). Since the log of price series was regressed for cointegration, the $\beta$ in that table directly presents the price transmission elasticity. Table A2(b) shows that before the emergence of alternate channels (2003-2006), only 3 market pairs out of a total of 21 market pairs were co-integrated (as inferred from significant tau statistic in the cointegration test). However, post-reform - after the rise of alternate channels (2007-2010), 20 market pairs out of a total 21 are cointegrated. Results point to lower price transmission in the latter period. For example, a change in Gangavati price by 10 percent leads to change in Manvi price by 84 percent before the reforms. After the reforms, there is a reduction in price transmission elasticity, i.e., a change in Gangavati price by 10 percent leads to change in Manvi price by only 2 percent.

Next, the speed of price transmission is inferred from ECT, which is expected to be negative and significant to ensure convergence. Table A1(c) in Appendix presents results from before and after reforms. Nearly ten of the market pairs show an increasing convergence speed, but the rest are mixed with some showing a decline and others showing no convergence. For instance, ECT is -0.14 for the market pair Gangavathi and Manvi before the reform, but becomes -0.643 after the reform.

From the cointegration analysis, market pairs generally show an increase in the speed of price transmission and a large number of markets are co-integrated after as compared to before reforms. Table 3(a) shows the results of bootstrap regression for Karnataka where the cointegration coefficient is regressed on the before-after dummy (Post) along with other control variables as mentioned in the specification earlier. A panel specification with fixed effects was validated by the Lagrange multiplier and Hausman tests. Model 4 has the highest R square and largest number of controls. The negatively significant coefficient of the reform dummy (-2.236) suggests that on an average, the price transmission elasticity decreased after the reforms, ceteris paribus. Also, the coefficient on road infrastructure is significantly positive indicating its critical importance to price transmission.

The effect of reforms on speed of price transmission can be inferred from Table 3(b) which shows that on average there is a significant increase in the speed of price transmission in the 'after' sample (model 6, 0.107). In model 6, all other variables are insignificant apart from production difference which is significantly positive. The latter indicates that markets located in regions with greater differences in production tend to have higher speed of price transmission.

The observable change in the speed and magnitude of price transmission post the reforms might be driven by one or two market pairs. Thus, to rule out this possibility, the reform effect on the number of integrated markets is considered next. Recall from table A2(b) that after the reforms (2007-2010), most markets have significant tau statistics in the cointegration test. To further confirm this, an empirical test is undertaken using a logit model. Table 3(c) shows that the probability of markets being cointegrated significantly increases after the break date (4.679). Thus, with new channels increasing market competition in the post-reform sample, there is

- a decrease in the magnitude of price transmission,
- an increase in the speed of price transmission, and
- an increase in the probability of market integration with actual data revealing that more markets are indeed cointegrated after reforms.

While the results on speed of price transmission and the probability of market integration are consistent with previous studies, one result warrants additional discussion. There is a significant decrease in the price transmission elasticity between existing markets after reforms. In most of the earlier studies, policy variables like liberalization or reforms increased both the speed and magnitude of price transmission (Krivonos, 2004). Also, market place variables like size and locational characteristics such as improvement of road density increased both price transmission elasticity and time taken to adjust to shocks increased price transmission elasticity (Brosig et al., 2011; Kouyaté and Cramon-Taubadel, 2016). A plausible reason for this differential effect on speed and magnitude in this study is the addition of an indirect channel for price transmission between existing markets (via private and direct markets) in addition to the direct transmission channel (via existing markets). The overall effect on magnitude of price transmission is thus dependent on combination of transmission via both channels. Because alternate marketing channel (indirect channel) is absorbing the effect of price change in one existing market on another (as discussed in section 3.1), there is decline in price transmission elasticity. However, the addition of indirect channel is aiding in the process of transmission of price information, such that existing markets take less time to correct any deviations from equilibrium and hence, greater speed. That is, new channels observed after the 2003 Model Act implementation, serve as shock absorbers for the existing markets. Dahlgran and Blank (1992) argue that the reduction in the price transmission elasticity could be due to the indirect transmission of shocks between existing markets via alternate channels, where some of the shocks may be absorbed by the alternate channels.

### 6.1 Corroborating the results

Since many states adopted reforms by 2010 in different degrees and stages, it is difficult to produce a counterfactual. However, there is a parallel case – Maharashtra, an early adopter of the 2003 Model Act – to help corroborate the findings from Karnataka. The crop selected again for analysis is rice, as it is amongst the most traded crops in APMCs during the study period. Six APMCs accounting for 90 percent of volume traded are selected: Achalpur, Nagpur, Pune, Sangli, Solapur, and Tumsar (table 2(b)).

Similar to Karnataka, the chosen study period is 2003-2010. For each of these markets, the process noted in figure 3 was repeated. The null hypothesis of no structural break in January 2007 is rejected for all markets with high level of significance. Thus, similar to Karnataka, the series was divided into 48 months before and after reforms. Note from figure 4(b) that both the mean and variability of prices have increased after the break date. For each time period (before and after reforms) and each market pair, the cointegration test was performed after testing for unit root (Table A2(a) in the supplementary appendix). The cointegrating coefficient, ECT and indicator variable of cointegration (logit mode) are then regressed on the post dummy along with other control variables described earlier (same as for Karnataka).

Results show that there is an increase in the number of market pairs showing significant cointegration (from 2 to 7 market in the pre- and post-reform periods) in Table A2(b) in the supplementary appendix. Again, results point to a pattern similar to those observed in the Karnataka case: decrease in the magnitude of price transmission (elasticity) as in table 4(a), the coefficient in model 6 being -0.944 and significant; an increase in the speed of price transmission (table A3(c)) with significantly positive coefficient of 0.187 (table 4(b)) and an increase in the probability of markets integrated, post-reform, table 4(c), coefficient 3.114 which is statistically significant.[10]

**6.2 Robustness checks**

This section outlines many robustness checks of results reported in the two previous sections. Note first that a bivariate (pairwise) cointegration test was chosen over multivariate cointegration because the latter does not account for heterogeneity in time-series i.e., assumes same relationship between time series of all market pairs.

The next check is the potential endogeneity of independent variables in the panel and logit models due to the omitted variable bias (error term can be correlated with *X*). A Ramsey test was used to test the null hypothesis ($H_0$) of no omitted variables. The F statistic is 1.33 (p value 0.28) for equation (4) in both states. However, this test cannot be used for panel and logit models. To further test for endogeneity, the predicted residuals' correlation with hypothesized endogenous variables was computed. Most correlation coefficients are statistically insignificant. Moreover, the variance inflation factor is less than two for all models.

[10]Results on Granger causality tests and impulse response functions (IRF) are available from authors on request. Post-reforms, some markets have become leaders, while IRFs indicate that for all markets, there has been a decrease in the overall time taken to return back to equilibrium in response to a shock after 2006.

Finally, there might be asymmetry in the responsiveness of prices because of trader's ability to hold stocks. Also, markets might respond more swiftly to increases than a decreases in prices. Thus, tests of asymmetric effects on the speed and magnitude of price transmission are conducted: threshold autoregressive (TAR), momentum TAR and threshold VECM (Goodwin and Holt, 1999; Goodwin and Piggott, 2001). Reported results are generally consistent with those reported in the appendix, but a few asymmetries are observed: Achalpur with Sangli, Solapur, Tumsar and Nagpur (TAR); Achalpur and Pune (MTAR); and Achalpur with Sangli, Solapur, Tumsar and Nagpur (TVECM). It is also observed that adjustment to increasing deviations from long run are at faster rate than adjustment to decreasing deviation from long run.

**6.3 Policy implications**

This study has important policy implications for regions vulnerable to price shocks due climatic, economic and social factors. The world is witnessing a rise in different types of shocks related to weather, climate change, policy, or economic shocks, which adversely affect food prices. Both the frequency and intensity of droughts and floods are increasing worldwide. Low-income countries employing a greater number of farmers, with very small land holdings and limited means to adapt to the shocks, are adversely affected by food price shocks. This study shows that introduction of alternate marketing channels leads to greater price transmission speed and thus greater market efficiency. Since, post reforms, the markets will be fast to respond to shocks, it will help eliminate localized scarcity during floods or famines, and thus farmers will not suffer from lower prices and distress selling. With greater number of markets integrated post the reforms, there is better distribution of price shocks across multiple markets such that no market is severely impacted by price shock. It bodes well for farmer welfare. Thus, policies should be designed so as to incentivize the rise of alternate marketing channels.[11]

## 7. Conclusion

This paper evaluates the effect of alternate marketing channels and possible increase in market competition as a result of APMC market reforms in India on intermarket spatial price transmission. The analysis was carried out for two states, Karnataka and Maharashtra, that were pioneers in adopting the reforms. Following APMC reforms in those states, and along with an increase in alternate marketing channels, there is an increase in the speed of price transmission. High-price transmission speed implies that markets are functioning efficiently. Interestingly, while the speed of spatial price transmission increases, the magnitude of price transmission decreases. While earlier studies have found both speed and magnitude to move in the same direction, this study finds a differential impact on both speed and magnitude. Markets with high price transmission speed achieved due to increased marketing channels will help absorb shock faster without any one region getting severely impacted. Results also suggest that policies that increase marketing channels can increase the probability of markets being cointegrated. These results are robust to alternative specifications accounting for endogeneity and price asymmetry. Policies or initiatives that increase competition bode well for farmers' welfare and for achieving market efficiency.

This study is somewhat limited by data availability on alternate channels. Including them in future analyses will help assess overall price transmission among existing and new channels. Depending on the nature of trade among these channels – bidirectional or discontinuous – and on nonstationary transaction costs, alternative techniques may be

[11] The Indian government passed three farm bills in 2020 to further agricultural market reforms. However due to political resistance, the government had to eventually repeal these bills. Though the implications of these additional farm bills need not be the same as the APMC reforms, a closer look at their potential to improve competition is a topic for future research.

appropriate for detecting price transmission.  Understanding changes to volume traded is also critical to uncovering price dynamics between existing and new markets.

## References


Acosta, A., Ihle, R., & von Cramon-Taubadel, S. (2019). Combining market structure and econometric methods for pricetransmission analysis. *Food Security*, *11*(4), 941–951. https://doi.org/10.1007/s12571-019-00951-w

Aggarwal, N., Jain, S., & Narayanan, S. (2017). *The Long Road to Transformation of Agricultural Markets in India*. *41*, 9.

Ale-Chilet, J., & Itin-Shwartz, B. (2021). *Do Marketing Channel Reforms Increase Competition? Evidence from Indian Produce Markets*.

Andrews, D. W., & Ploberger, W. (1994). Optimal tests when a nuisance parameter is present only under the alternative. *Econometrica: Journal of the Econometric Society*, 1383–1414.

Awokuse, T. O. (2007). Market reforms, spatial price dynamics, and China's rice market integration: A causal analysis with directed acyclic graphs. *Journal of Agricultural and Resource Economics*, 58–76.

Badiane, O., & Shively, G. E. (1998). Spatial integration, transport costs, and the response of local prices to policy changes in Ghana. *Journal of Development Economics*, *56*(2), 411–431.

Baffes, J. (1991). Some Further Evidence on the Law of One Price: The Law of One Price Still Holds. *American Journal of Agricultural Economics*, *73*(4), 1264–1273. https://doi.org/10.2307/1242454

Bain, J. S. (1959). Industrial Organization. John Willey and Sons. *Inc., New York*, *14*.

Banerji, A., & Meenakshi, J. V. (2004). Buyer Collusion and Efficiency of Government Intervention in Wheat Markets in Northern India: An Asymmetric Structural Auctions Analysis. *American Journal of Agricultural Economics*, *86*(1), 236–253.

Barrett, C. B. (1996). Market analysis methods: Are our enriched toolkits well suited to enlivened markets? *American Journal of Agricultural Economics*, *78*(3), 825–829.

Baulch, B. (1997). Testing for food market integration revisited. *The Journal of Development Studies*, *33*(4), 512–534.

Bhanot, D., Kathuria, V., & Das, D. (2021). Can institutional innovations in agri-marketing channels alleviate distress selling? Evidence from India. *World Development*, *137*, 105202. https://doi.org/10.1016/j.worlddev.2020.105202

Blanchard, O. J., & Quah, D. (1988). *The dynamic effects of aggregate demand and supply disturbances*.

Brosig, S., Glauben, T., Götz, L., Weitzel, E. B., & Bayaner, A. (2011). The Turkish wheat market: Spatial price transmission and the impact of transaction costs. *Agribusiness*, *27*(2), 147–161.

Cohen, A. J. (2013). Supermarkets in India: Struggles over the organization of agricultural markets and food supply chains. *U. Miami L. Rev.*, *68*, 19.

Cudjoe, G., Breisinger, C., & Diao, X. (2010). Local impacts of a global crisis: Food price transmission, consumer welfare and poverty in Ghana. *Food Policy*, *35*(4), 294–302.

Dahlgran, R. A., & Blank, S. C. (1992). Evaluating the Integration of Contiguous Discontinuous Markets. *American Journal of Agricultural Economics*, *74*(2), 469–479. https://doi.org/10.2307/1242501

Dimitri, C., & Gardner, K. (2019). Farmer use of intermediated market channels: A review. *Renewable Agriculture and Food Systems*, *34*(3), 181–197.

Donkor, E. A., Garnevska, E., Siddique, M. I., & Donkor, E. (2021). Determinants of Rice Farmer Participation in the Direct Marketing Channel in Ghana. *Sustainability*, *13*(9), 5047. https://doi.org/10.3390/su13095047

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, 251–276.

Fackler, P. L., & Goodwin, B. K. (2001). Spatial price analysis. *Handbook of Agricultural Economics*, *1*, 971–1024.

Frederick, B., Cho, G. D., & Kim, I. S. (2018). Asymmetric Price Transmission in the Domestic Rice Market in South Korea. *Korean Journal of Agricultural Economics*, *59*(3), 205–223.

Goletti, F., Ahmed, R., & Farid, N. (1995). Structural determinants of market integration: The case of rice markets in Bangladesh. *The Developing Economies*, *33*(2), 196–198.

Goletti, F., & Babu, S. (1994). Market liberalization and integration of maize markets in Malawi. *Agricultural Economics*, *11*(2–3), 311–324.

Goodwin, B. K., & Holt, M. T. (1999). Price transmission and asymmetric adjustment in the US beef sector. *American Journal of Agricultural Economics*, *81*(3), 630–637.

Goodwin, B. K., & Piggott, N. E. (2001). Spatial Market Integration in the Presence of Threshold Effects. *American Journal of Agricultural Economics*, *83*(2), 302–317. https://doi.org/10.1111/0002-9092.00157

Goodwin, B. K., & Schroeder, T. C. (1991). Cointegration tests and spatial price linkages in regional cattle markets. *American Journal of Agricultural Economics*, *73*(2), 452–464.

Goyal, A. (2010). Information, direct access to farmers, and rural market performance in central India. *American Economic Journal: Applied Economics*, *2*(3), 22–45.

Hu, Z., & Brorsen, B. W. (2017). Spatial Price Transmission and Efficiency in the Urea Market. *Agribusiness*, *33*(1), 98–115. https://doi.org/10.1002/agr.21475

Johansen, S. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. *Econometrica*, *59*(6), 1551–1580. https://doi.org/10.2307/2938278

Kolady, D., Krishnamoorthy, S., & Narayanan, S. (2007). *An "Other" Revolution? Marketing cooperatives in a new retail context: A case study of HOPCOMS in India*.

Kouyaté, C., & Cramon-Taubadel, S. (2016). Distance and border effects on price transmission: A meta-analysis. *Journal of Agricultural Economics*, *67*(2), 255–271.

Krishnamurthy, M. (2021). Agricultural market law, regulation and resistance: A reflection on India's new 'farm laws' and farmers' protests. *The Journal of Peasant Studies*, *48*(7), 1409–1418. https://doi.org/10.1080/03066150.2021.1998001

Krivonos, E. (2004). *The impact of coffee market reforms on producer prices and price transmission*. The World Bank.

Markelova, H., Meinzen-Dick, R., Hellin, J., & Dohrn, S. (2009). Collective action for smallholder market access. *Food Policy*, *34*(1), 1–7. https://doi.org/10.1016/j.foodpol.2008.10.001

McNew, K., & Fackler, P. L. (1997). Testing market equilibrium: Is cointegration informative? *Journal of Agricultural and Resource Economics*, 191–207.

Mgale, Y. J., & Yunxian, Y. (2020). Marketing efficiency and determinants of marketing channel choice by rice farmers in rural Tanzania: Evidence from Mbeya region, Tanzania. *Australian Journal of Agricultural and Resource Economics*, *64*(4), 1239–1259.

Minten, B., & Kyle, S. (1999). The effect of distance and road quality on food collection, marketing margins, and traders' wages: Evidence from the former Zaire. *Journal of Development Economics*, *60*(2), 467–495.

Miyata, S., Minot, N., & Hu, D. (2009). Impact of Contract Farming on Income: Linking Small Farmers, Packers, and Supermarkets in China. *World Development*, *37*(11), 1781–1790. https://doi.org/10.1016/j.worlddev.2008.08.025

Negi, D. S., Birthal, P. S., Roy, D., & Khan, M. T. (2018). Farmers' choice of market channels and producer prices in India: Role of transportation and communication networks. *Food Policy*, *81*, 106–121.

Nuthalapati, C. S., Sutradhar, R., Reardon, T., & Qaim, M. (2020). Supermarket procurement and farmgate prices in India. *World Development*, *134*, 105034.

Perron, P. (1997). Further evidence on breaking trend functions in macroeconomic variables. *Journal of Econometrics*, *80*(2), 355–385.

Plakias, Z. T., Demko, I., & Katchova, A. L. (2020). Direct marketing channel choices among US farmers: Evidence from the Local Food Marketing Practices Survey. *Renewable Agriculture and Food Systems*, *35*(5), 475–489. https://doi.org/10.1017/S1742170519000085

Pritchard, B., Gracy, C. P., & Godwin, M. (2010). The Impacts of Supermarket Procurement on Farming Communities in India: Evidence from Rural Karnataka. *Development Policy Review*, *28*(4), 435–456. https://doi.org/10.1111/j.1467-7679.2010.00491.x

Rashid, S. (2004). Spatial integration of maize markets in post-liberalised Uganda. *Journal of African Economies*, *13*(1), 102–133.

Rawal, V., Patel, S., & Pais, J. (2020). *The Political Economy of Agricultural Market Reforms*.

Reardon, T. A., & Minten, B. (2011). The quiet revolution in India's food supply chains. *Internat. Food Policy Research Institute*.

Reardon, T., & Timmer, C. P. (2014). Five inter-linked transformations in the Asian agrifood economy: Food security implications. *Global Food Security*, *3*(2), 108–117.

Reardon, T., Timmer, C. P., & Berdegue, J. (2012). The rapid rise of supermarkets in developing countries: Induced organizational, institutional and technological change in agri-food systems. In *The Transformation of Agri-Food Systems* (pp. 71–90). Routledge.

Reddy, A. A. (2016). Status of Market Reforms in India. *Indian Farming*, *66*, 33–37. https://doi.org/10.2139/ssrn.3037093

Scarborough, V., & Kydd, J. (1992). *Economic analysis of agricultural markets: A manual* (Vol. 5). Natural Resources Institute.

Scott, G. J. (1995). *Prices, products, and people: Analyzing agricultural markets in developing countries*. Lynne Rienner Publishers.

Singh, S. (2018). Reforming agricultural markets in India. *Economic and Political Weekly*, *53*(51), 15–18.

Singh, S., & Singla, N. (2011). *Fresh Food Retail Chains in India: Organisation and Impacts*.

Stephens, E. C., Mabaya, E., Cramon-Taubadel, S. von, & Barrett, C. B. (2012). Spatial Price Adjustment with and without Trade*. *Oxford Bulletin of Economics and Statistics*, *74*(3), 453–469. https://doi.org/10.1111/j.1468-0084.2011.00651.x

Svanidze, M., & Götz, L. (2019). Determinants of spatial market efficiency of grain markets in Russia. *Food Policy*, *89*, 101769.

Thompson, S. R., Sul, D., & Bohl, M. T. (2002). Spatial market efficiency and policy regime change: Seemingly unrelated error correction model estimation. *American Journal of Agricultural Economics*, *84*(4), 1042–1053.

Wooldridge, J. M. (2015). *Introductory econometrics: A modern approach*. Cengage learning.

Zant, W. (2013). How is the liberalization of food markets progressing? Market integration and transaction costs in subsistence economies. *The World Bank Economic Review*, *27*(1), 28–54.

Figure 1: Conceptual Framework

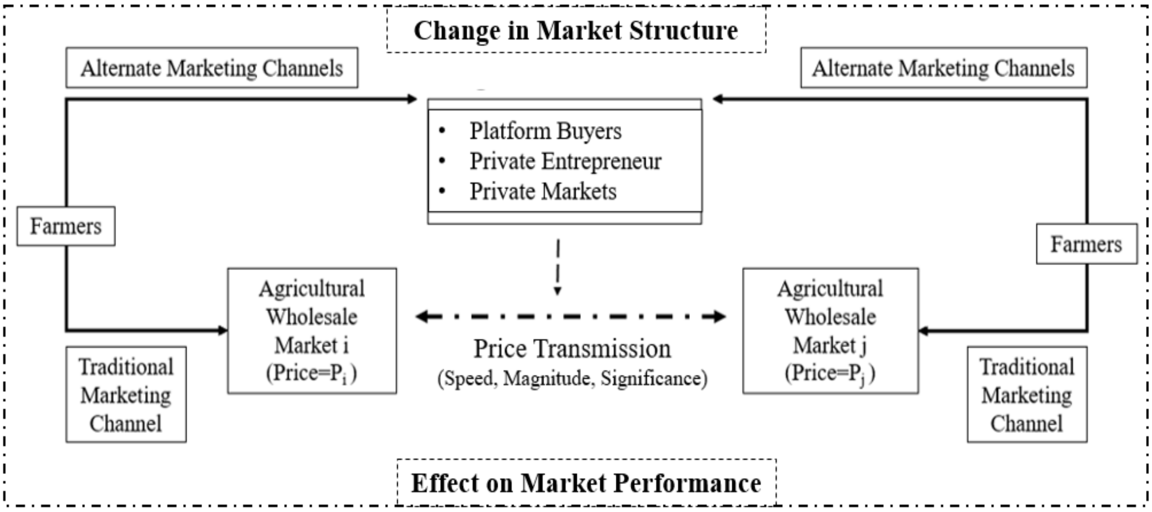



Figure 2(a): Impact of Alternate Marketing Channels on Price Transmission: Differential Effect on the speed and magnitude.

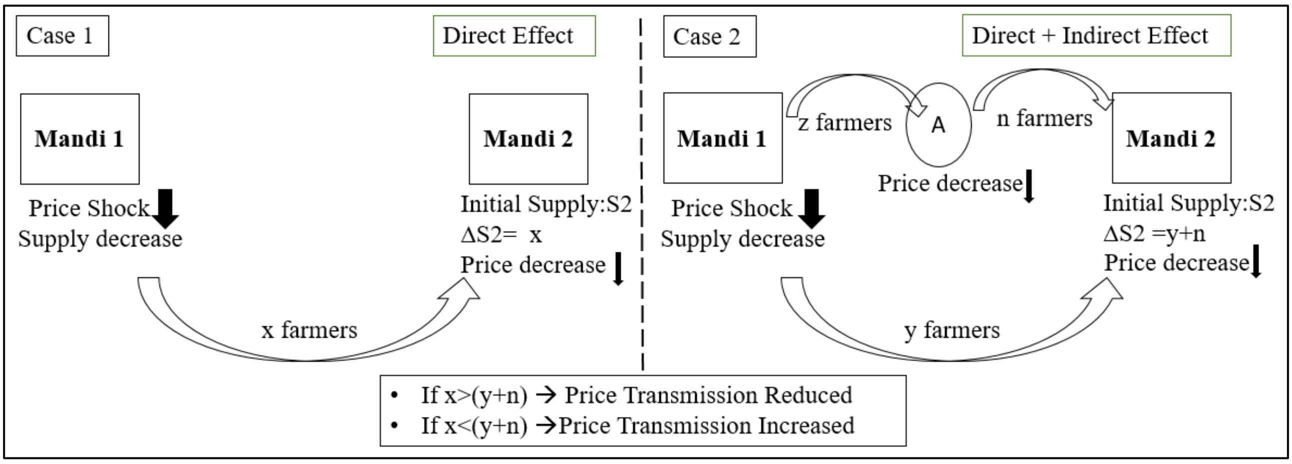



Figure 2(b): Existing markets (APMC mandis) connected via Alternate Channels

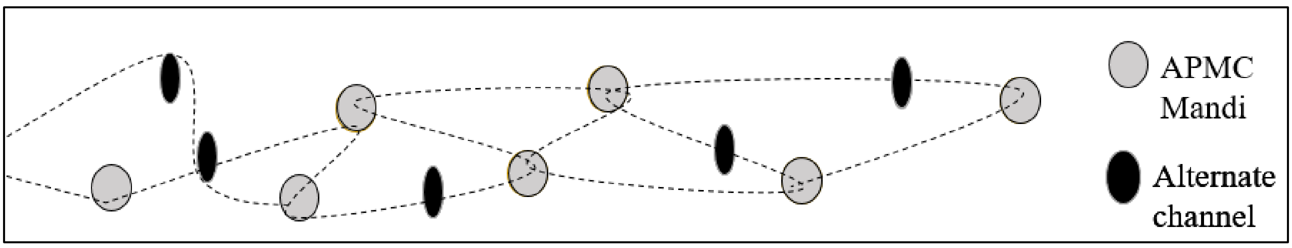


Figure 3: Summary of steps for analysis

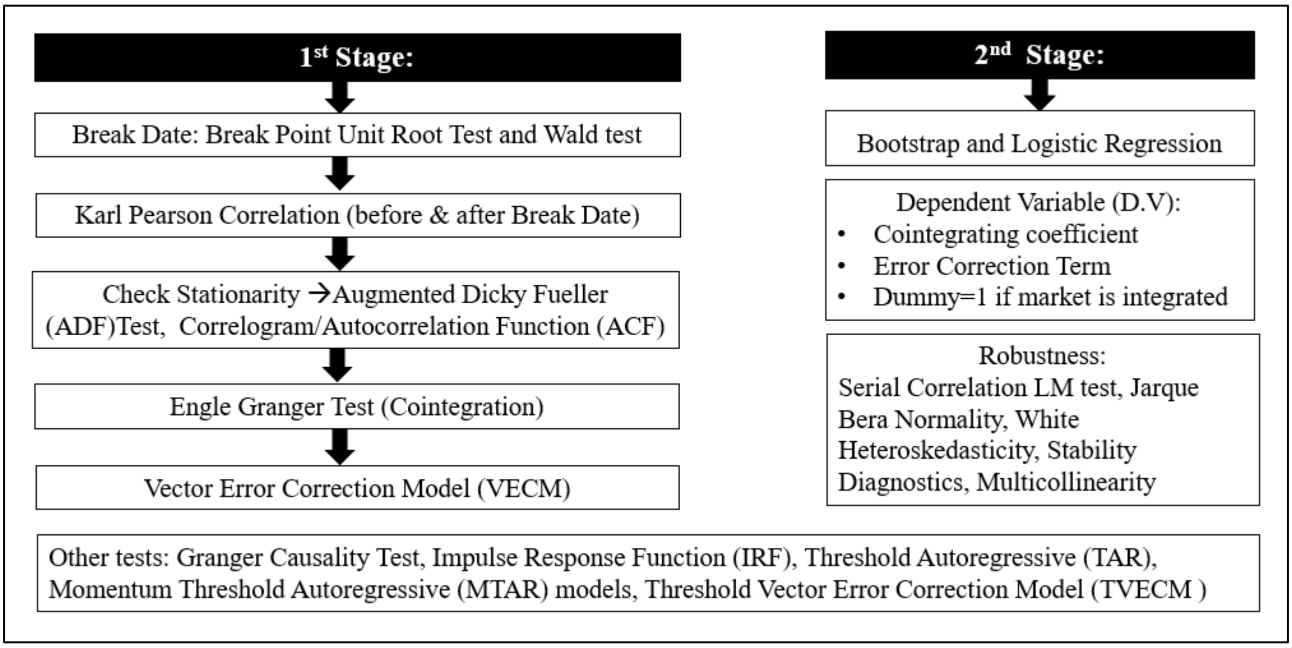
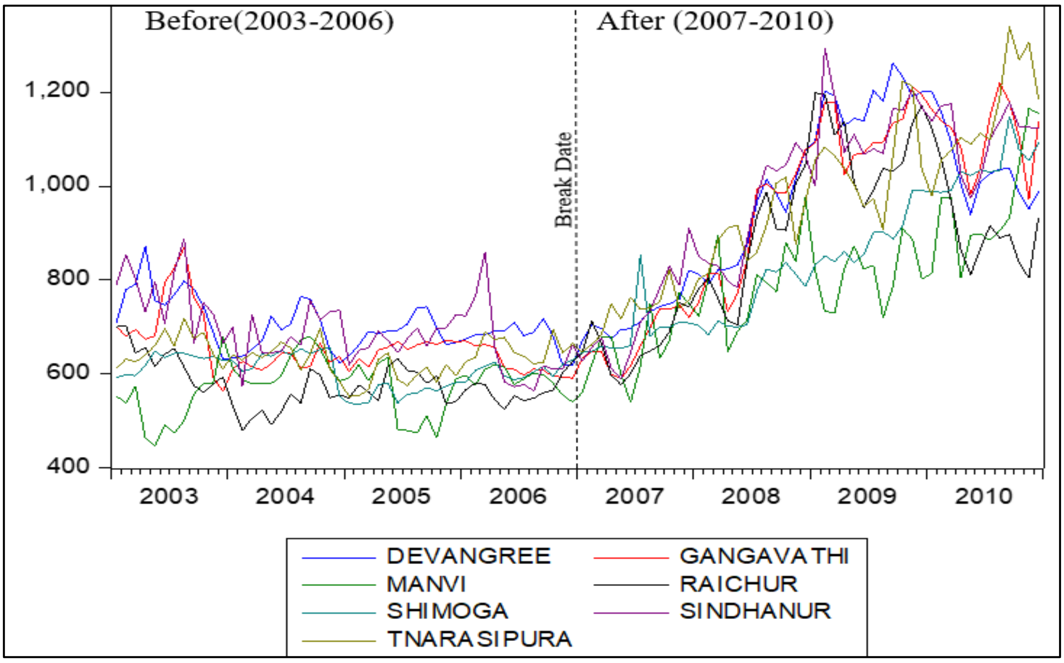



Figure 4(a): Average monthly (Modal) Price (in Rupees) of paddy for the selected APMC markets in Karnataka




*Note: The above graph shows the monthly average price series of seven selected markets in Karnataka on x axis and years on y axis. The dotted vertical line at January (2007) shows the break date, which divides the series into two parts, i.e., before and after 2007.*

Table 1: Description of Variables and data source

| Variable name | Variable Description | Source |
|---|---|---|
| Post | Dummy which is 0 for years 2003-2006 and 1 for years 2007-2010 | Author's own calculation |
| Road Infrastructure | Log of total road length in area surrounding markets (proxy for road infrastructure) | ICRISAT –District Level Data (http://data.icrisat.org/dld/) |
| Market Distance | Log of distance between the two markets(km) | Calculated using Google Maps |
| Production Difference | Log of difference in rice production in districts where the two markets are located | ICRISAT –District Level Data (http://data.icrisat.org/dld/) |
| Railway Distance | Log of Sum of distance to nearest railway station | Directory of wholesale agricultural produce assembling markets in India (https://agmarknet.gov.in/Others/dwapdir.pdf) |
| Volume Ratio | Ratio of log of average volume for market 1 to market 2 | Agmarknet (https://agmarknet.gov.in/) |

Table 2: Summary statistics of the monthly price series (in Rupees) of paddy for the selected markets in Karnataka

| | Devangree | Gangavathi | Manvi | Raichur | Shimoga | Sindhanur | T.Narasipura |
|---|---|---|---|---|---|---|---|
| Before(2003-2006) | | | | | | | |
| Mean | 702.6 | 653.8 | 572.5 | 578.2 | 606.0 | 694.1 | 635.3 |
| Median | 692.2 | 647.6 | 580.1 | 571.2 | 609.7 | 685.4 | 636.8 |
| Maximum | 872.2 | 869.2 | 680.0 | 703.4 | 656.8 | 887.8 | 718.6 |
| Minimum | 618.4 | 563.5 | 446.3 | 479.7 | 536.5 | 564.0 | 552.5 |
| Standard Deviation | 53.1 | 60.2 | 58.7 | 48.7 | 35.2 | 76.7 | 38.4 |
| Observations | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| After(2007-2010) | | | | | | | |
| Mean | 962.9 | 950.1 | 804.5 | 881.5 | 843.7 | 972.5 | 958.6 |
| Median | 987.1 | 1014.7 | 803.9 | 893.5 | 837.5 | 1038.0 | 970.5 |
| Maximum | 1262.1 | 1219.3 | 1165.1 | 1198.2 | 1148.1 | 1293.6 | 1339.0 |
| Minimum | 670.6 | 590.5 | 540.0 | 577.4 | 646.0 | 590.0 | 646.8 |
| Standard Deviation | 183.5 | 202.7 | 137.4 | 175.8 | 145.9 | 191.0 | 179.0 |
| Observations | 48 | 48 | 48 | 48 | 48 | 48 | 48 |

Table 3(a): Bootstrap Regression to find the effect of reforms on the price transmission elasticity for Karnataka

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Post | .232* | -2.215*** | -2.22*** | -2.236*** |
| | (.132) | (.619) | (.664) | (.777) |
| Road Infrastructure | | 43.777*** | 43.7*** | 44.072*** |
| | | (10.61) | (11.154) | (13.226) |
| Production Difference | | | .089 | .032 |
| | | | (.526) | (.574) |
| Volume Ratio | | | | -1.397 |
| | | | | (4.222) |
| Constant | .111 | -178.371*** | -178.268*** | -178.246*** |
| | (.116) | (43.414) | (45.699) | (54.188) |
| Observations | 42 | 42 | 42 | 42 |
| R-squared | .156 | .557 | .558 | .561 |

*Note: Standard errors are in parentheses; *** p<.01, ** p<.05, * p<.1 [This model is panel fixed effects estimation with cointegrating coefficient as the dependent variable].*

Table 3(b): Bootstrap Regression to find the effect of reforms on the speed of price transmission for Karnataka

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Post | .056 | .127** | .135** | .115** | .108* | .107* |
| | (.064) | (.058) | (.065) | (.059) | (.06) | (.057) |
| Road Infrastructure | | -1.269** | -1.402** | -1.161** | -1.037* | -1.027 |
| | | (.531) | (.564) | (.489) | (.603) | (.633) |
| Market Distance | | | .052 | -.062 | -.065 | -.066 |
| | | | (.079) | (.103) | (.115) | (.103) |
| Production Difference | | | | .056* | .062* | .061** |
| | | | | (.028) | (.032) | (.029) |
| Railway Distance | | | | | .039 | .039 |
| | | | | | (.03) | (.029) |
| Volume Ratio | | | | | | .026 |
| | | | | | | (.311) |
| Constant | .18*** | 5.352** | 5.773** | 4.925** | 4.262* | 4.197 |
| | (.034) | (2.172) | (2.266) | (1.949) | (2.456) | (2.655) |
| Observations | 42 | 42 | 42 | 42 | 42 | 42 |
| R-squared | .019 | .173 | .179 | .241 | .267 | .267 |

*Note: Standard errors are in parentheses; *** p<.01, ** p<.05, * p<.1 [This mode is run with error correction term (calculated from VECM) as the dependent variable].*

Table 3(c): Logistic Regression to find effect of reforms on probability of markets being integrated for Karnataka

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Post | 4.043*** | 4.356*** | 4.548*** | 4.533*** | 4.494*** | 4.679*** |
| | (.97) | (1.165) | (1.297) | (1.303) | (1.289) | (1.36) |
| Road Infrastructure | | -4.531 | 2.637 | 2.934 | 4.255 | 2.682 |
| | | (7.773) | (9.241) | (9.583) | (10.072) | (10.288) |
| Market Distance | | | -3.003 | -3.139 | -3.201 | -3.149 |
| | | | (1.837) | (2.198) | (2.232) | (2.227) |
| Production Difference | | | | .061 | .111 | .27 |
| | | | | (.535) | (.544) | (.588) |
| Railway Distance | | | | | .306 | .262 |
| | | | | | (.605) | (.606) |
| Volume Ratio | | | | | | -4.389 |
| | | | | | | (5.778) |
| Constant | -1.792*** | 16.651 | -5.923 | -6.967 | -13.535 | -3.092 |
| | (.624) | (31.592) | (36.02) | (37.083) | (39.666) | (41.885) |
| Observations | 42 | 42 | 42 | 42 | 42 | 42 |
| Pseudo $R^2$ | .476 | .482 | .537 | .537 | .541 | .551 |

*Note: Standard errors are in parentheses; *** p<.01, ** p<.05, * p<.1 [This logistic mode is run with dummy dependent variable which takes the value 1 if market pairs are significantly cointegrated (as inferred from tau statistic in Engle granger pairwise cointegration test).*

## Supplementary Appendix

### Unit root and cointegration test results

Table A1(a): Unit Root test for Karnataka

| Before (2003-2006) | Series at Level | | First difference series | |
|---|---|---|---|---|
| **Market** | **ADF t-statistic** | **Unit root** | **ADF t-statistic** | **Unit root** |
| Devangree | -2.4583 | Yes | -4.311*** | No |
| Gangavathi | -2.124 | Yes | -5.986*** | No |
| Manvi | -2.5884 | Yes | -7.184*** | No |
| Raichur | -2.6484 | Yes | -6.465*** | No |
| Shimoga | -2.1391 | Yes | -6.646*** | No |
| Sindhanur | -0.6053 | Yes | -10.371*** | No |
| Tnarasipura | 0.19678 | Yes | -8.334*** | No |
| **After (2007-2010)** | | | | |
| Devangree | -1.7876 | Yes | -5.517*** | No |
| Gangavathi | -1.4836 | Yes | -6.030*** | No |
| Manvi | -2.3426 | Yes | -6.724*** | No |
| Raichur | -1.6261 | Yes | -4.814*** | No |
| Shimoga | -1.1357 | Yes | -7.350*** | No |
| Sindhanur | -1.902 | Yes | -7.217*** | No |
| Tnarasipura | -1.8027 | Yes | -6.616*** | No |

*Note: Devangree represents the log of the monthly price series of market Devangree*

Table A1(b): Engle Granger (EG) Cointegration Test for Karnataka

| Market Pairs | Beta(EG) | p value | AIC Lag length (EG) | Cointegra tion(EG) | tau statistic (EG) |
|---|---|---|---|---|---|
| **Before (2003-2006)** | | | | | |
| Devangree and Gangavathi | 0.495 | 0.002 | 1 | 1 | -4.392** |
| Gangavathi and Manvi | -0.842 | 0.001 | 0 | 0 | -3.461 |
| Manvi and Raichur | -0.831 | 0.003 | 0 | 0 | -3.337 |
| Raichur and Shimoga | -0.174 | 0.328 | 0 | 0 | -2.220 |
| Shimoga and Sindhanur | -0.032 | 0.833 | 0 | 0 | -2.301 |
| Sindhanur and Tnarasipura | 0.083 | 0.583 | 0 | 0 | -3.267 |
| Tnarasipura and Devangree | 0.288 | 0.149 | 0 | 0 | -3.412 |
| Devangree and Manvi | -0.819 | 0.024 | 0 | 0 | -2.862 |
| Gangavathi and Raichur | 0.531 | 0.011 | 0 | 0 | -3.138 |
| Manvi and Shimoga | 0.69 | 0.101 | 0 | 0 | -2.639 |
| Raichur and Sindhanur | 0.491 | 0.005 | 0 | 0 | -3.446 |
| Shimoga and Tnarasipura | 0.802 | 0.000 | 1 | 0 | -3.446 |

| | | | | | |
|---|---|---|---|---|---|
| Sindhanur and Devangree | 0.222 | 0.166 | 1 | 0 | -3.590 |
| Tnarasipura and Gangavathi | 0.227 | 0.192 | 0 | 0 | -3.159 |
| Devangree and Raichur | 0.668 | 0.004 | 0 | 0 | -3.317 |
| Gangavathi and Shimoga | -0.062 | 0.731 | 0 | 0 | -2.316 |
| Manvi and Sindhanur | -0.281 | 0.102 | 0 | 1 | -4.613** |
| Raichur and Tnarasipura | 0.013 | 0.944 | 0 | 0 | -3.334 |
| Shimoga and Devangree | 0.076 | 0.711 | 0 | 0 | -2.277 |
| Sindhanur and Gangavathi | 0.652 | 0.001 | 0 | 1 | -5.359*** |
| Tnarasipura and Manvi | 0.133 | 0.750 | 0 | 0 | -2.587 |
| **After (2007-2010)** | | | | | |
| Devangree and Gangavathi | 1.148 | 0.000 | 8 | 0 | -2.645 |
| Gangavathi and Manvi | 0.024 | 0.8716 | 1 | 1 | -5.055*** |
| Manvi and Raichur | 0.004 | 0.972 | 1 | 1 | -5.030*** |
| Raichur and Shimoga | -0.054 | 0.347 | 0 | 1 | -5.423*** |
| Shimoga and Sindhanur | -0.089 | 0.255 | 0 | 1 | -5.403*** |
| Sindhanur and Tnarasipura | 0.224 | 0.024 | 1 | 1 | -5.646*** |
| Tnarasipura and Devangree | 0.12 | 0.192 | 1 | 1 | -5.326*** |
| Devangree and Manvi | -0.099 | 0.451 | 1 | 1 | -5.062*** |
| Gangavathi and Raichur | 1.428 | 0.000 | 0 | 1 | -5.019*** |
| Manvi and Shimoga | -0.397 | 0.294 | 1 | 1 | -5.232*** |
| Raichur and Sindhanur | 1.355 | 0.000 | 0 | 1 | -4.586** |
| Shimoga and Tnarasipura | -0.112 | 0.393 | 0 | 1 | -5.395*** |
| Sindhanur and Devangree | 1.08 | 0.000 | 0 | 0 | -2.502 |
| Tnarasipura and Gangavathi | 0.207 | 0.041 | 1 | 1 | -5.573*** |
| Devangree and Raichur | 1.129 | 0.000 | 0 | 1 | -3.878* |
| Gangavathi and Shimoga | -0.066 | 0.414 | 0 | 1 | -5.373*** |
| Manvi and Sindhanur | 0.099 | 0.492 | 1 | 1 | -5.161*** |
| Raichur and Tnarasipura | 0.131 | 0.067 | 1 | 1 | -5.492*** |
| Shimoga and Devangree | -0.051 | 0.463 | 0 | 1 | -5.419*** |
| Sindhanur and Gangavathi | 0.939 | 0.000 | 0 | 1 | -5.686*** |
| Tnarasipura and Manvi | 0.172 | 0.182 | 1 | 1 | -5.074*** |

Table A1(c): Vector Error Correction Mechanism (VECM) for Karnataka

| | **Error Correction term (ECT)** | |
|---|---|---|
| **Market Pair** | **Before (2003-2006)** | **After(2007-2010)** |
| Devangree and Gangavathi | -0.532 | 0.02 |
| Gangavathi and Manvi | -0.14 | -0.643 |
| Manvi and Raichur | -0.299 | -0.041 |

| | | |
|---|---|---|
| Raichur and Shimoga | -0.003 | -0.009 |
| Shimoga and Sindhanur | -0.016 | -0.016 |
| Sindhanur and Tnarasipura | -0.061 | -0.315 |
| Tnarasipura and Devangree | -0.13 | -0.204 |
| Devangree and Manvi | -0.151 | -0.442 |
| Gangavathi and Raichur | -0.284 | -0.208 |
| Manvi and Shimoga | -0.261 | -0.662 |
| Raichur and Sindhanur | -0.133 | -0.191 |
| Shimoga and Tnarasipura | 0.001 | -0.169 |
| Sindhanur and Devangree | -0.283 | 0.061 |
| Tnarasipura and Gangavathi | -0.296 | -0.087 |
| Devangree and Raichur | -0.372 | -0.314 |
| Gangavathi and Shimoga | -0.053 | -0.075 |
| Manvi and Sindhanur | -0.095 | -0.087 |
| Raichur and Tnarasipura | -0.059 | 0.027 |
| Shimoga and Devangree | -0.01 | -0.049 |
| Sindhanur and Gangavathi | -0.516 | -0.636 |
| Tnarasipura and Manvi | -0.083 | -0.702 |

Table A2(a): Unit Root test for Maharashtra

| **Before** | **Series at Level** | | **First difference series** | |
|---|---|---|---|---|
| **Market** | **ADF t- statistic** | **Unit root** | **ADF t-statistic** | **Unit root** |
| Achalpur | 0.36 | Yes | -9.5*** | No |
| Nagpur | 0.15 | Yes | -5.748** | No |
| Pune | 0.59 | Yes | -10.38*** | No |
| Sangli | 0.26 | Yes | -8.48*** | No |
| Solapur | 1.68 | Yes | -9.06*** | No |
| Tumsar | 0.70 | Yes | -4.88*** | No |
| **After** | | | | |
| Achalpur | -0.01 | Yes | -6.88*** | No |
| Nagpur | 1.67 | Yes | -6.16*** | No |
| Pune | 1.79 | Yes | -7.04*** | No |

| | | | | |
|---|---|---|---|---|
| Sangli | 1.28 | Yes | -3.72*** | No |
| Solapur | 3.87 | Yes | -3.25*** | No |
| Tumsar | 0.85 | Yes | -10.63*** | No |

*Note: Achalpur represents the log of the monthly price series of market achalpur.*

Table A2(b): Engle Granger (EG) Cointegration Test for Maharashtra

| Market Pairs | Beta(EG) | p value | AIC Lag length (EG) | Cointegration(EG) | tau statistic (EG) |
|---|---|---|---|---|---|
| **Before (2003-2006)** | | | | | |
| Achalpur and Nagpur | 0.65 | 0.002 | 5 | 0 | -2.04 |
| Achalpur and Pune | 0.31 | 0.02 | 4 | 1 | -3.19* |
| Achalpur and Sangli | 0.61 | 0.41 | 5 | 0 | -1.43 |
| Achalpur and Solapur | 1.77 | 0.07 | 4 | 0 | -3.04 |
| Achalpur and Tumsar | 0.34 | 0.31 | 5 | 0 | -1.61 |
| Nagpur and Pune | 0.42 | 0.00 | 0 | 0 | -2.39 |
| Nagpur and Sangli | 0.98 | 0.18 | 0 | 0 | -1.43 |
| Nagpur and Solapur | 1.58 | 0.11 | 0 | 0 | -1.27 |
| Nagpur and Tumsar | 0.89 | 0.00 | 1 | 0 | -2.35 |
| Pune and Sangli | 3.65 | 0.001 | 0 | 0 | -2.84 |
| Pune and Solpaur | 5.85 | 0.00 | 3 | 0 | -1.86 |
| Pune and Tumsar | 1.54 | 0.001 | 0 | 0 | -2.26 |
| Sangli and Solapur | 0.89 | 0.00 | 7 | 1 | -5.07*** |
| Sangli and Tumsar | 0.12 | 0.19 | 2 | 0 | -2.66 |
| Solapur and Tumsar | 0.15 | 0.04 | 0 | 0 | -0.61 |
| **After (2007-2010)** | | | | | |
| Achalpur and Nagpur | 0.02 | 0.83 | 3 | 1 | -5.14*** |
| Achalpur and Pune | -0.001 | 0.99 | 3 | 1 | -5.07*** |
| Achalpur and Sangli | 0.02 | 0.81 | 3 | 1 | -5.14*** |
| Achalpur and Solapur | 0.03 | 0.73 | 3 | 1 | 5.17*** |
| Achalpur and Tumsar | 0.02 | 0.78 | 3 | 1 | -5.06*** |
| Nagpur and Pune | 0.97 | 0.00 | 0 | 0 | -1.48 |

| | | | | | |
|---|---|---|---|---|---|
| Nagpur and Sangli | 1.33 | 0.00 | 4 | 0 | -1.69 |
| Nagpur and Solapur | 0.91 | 0.00 | 8 | 0 | -2.79 |
| Nagpur and Tumsar | 1.08 | 0.00 | 1 | 0 | -3.07 |
| Pune and Sangli | 1.16 | 0.00 | 1 | 0 | -2.08 |
| Pune and Solpaur | 0.70 | 0.00 | 5 | 0 | -1.89 |
| Pune and Tumsar | 0.85 | 0.00 | 9 | 1 | -4.23*** |
| Sangli and Solapur | 0.65 | 0.00 | 3 | 0 | -1.26 |
| Sangli and Tumsar | 0.75 | 0.00 | 1 | 0 | -2.42 |
| Solapur and Tumsar | 1.01 | 0.00 | 1 | 0 | -1.29 |

Table A2(c): Vector Error Correction Mechanism (VECM) for Maharashtra

| | **Error Correction term (ECT)** | |
|---|---|---|
| **Market Pair** | **Before (2003-2006)** | **After(2007-2010)** |
| Achalpur and Nagpur | -0.37 | -0.52 |
| Achalpur and Pune | -0.29 | -0.53 |
| Achalpur and Sangli | -0.09 | -0.63 |
| Achalpur and Solapur | -0.27 | -0.58 |
| Achalpur and Tumsar | -0.03 | -0.52 |
| Nagpur and Pune | -0.08 | -0.15 |
| Nagpur and Sangli | 0.02 | -0.11 |
| Nagpur and Solapur | -0.06 | -0.02 |
| Nagpur and Tumsar | -0.02 | -0.25 |
| Pune and Sangli | -0.02 | 0.21 |
| Pune and Solpaur | -0.15 | -0.09 |
| Pune and Tumsar | -0.04 | -0.005 |
| Sangli and Solapur | -0.90 | -0.11 |
| Sangli and Tumsar | -0.13 | -0.14 |
| Solapur and Tumsar | -0.02 | -0.09 |